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Dentoskeletal effects of a removable appliance for expansion of the maxillary arch: a postero-anterior cephalometric study

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SUMMARY The aim of this study was to evaluate the dentoskeletal effects of early treatment in the primary or early mixed dentition with a removable appliance with expansion springs, assessed on postero-anterior (PA) cephalograms, in patients with a unilateral posterior crossbite when compared with untreated subjects. The treatment group consisted of 23 subjects, 8 males, and 15 females treated with a removable appliance for the expansion of the maxillary arch. The mean age at the start of expansion (T_1) was 6 years 2 ± 17 months, and 8 years ± 18 months at the end of active therapy and after 1 year of retention (T_2), with an observation interval of 22 ± 7 months. The control group comprised 20 subjects (9 males and 11 females) with an untreated unilateral posterior crossbite. Their mean age was 5 years 9 ± 15 months at the first observation and 7 years and 4 ± 16 months at the second examination. The interval between the two observations was 18 ± 7 months. Nine skeletal and two dental measurements on the transverse plane were assessed. The data from the two groups were compared by means of a Student's *t*-test for independent samples ($P<0.05$).

Positive dental and skeletal effects induced by the therapy were observed at T_2. The width of the upper dental arch and that of the skeletal maxillary transverse dimension were significantly greater ($P < 0.001$) in the treatment group when compared with the controls.

Introduction

Traditionally, occlusal and craniofacial characteristics of malocclusions in growing subjects have been investigated extensively in the sagittal and vertical plane, but only one study has focused on the transverse dental and skeletal components (Alarashi *et al.*, 2003). In the primary and early mixed dentitions, a unilateral posterior crossbite is a common malocclusion, with a prevalence varying from 8 to 16 per cent (Foster and Hamilton, 1969; Kutin and Hawes, 1969; Hanson *et al.*, 1970; Helm, 1970; Köhler and Holst, 1973; Holm, 1975; Larsson, 1975; Ravn, 1975; Kisling and Krebs, 1976; Järvinen, 1981). A crossbite is seldom self-correcting and usually worsens with growth, obstructing maxillary development (Tollaro *et al.*, 1985) and early intervention in the primary dentition is advisable (Tollaro *et al.*, 2002).

Studies on the correction of crossbites at this stage have used different types of appliances. Surprisingly, only a few (Boysen *et al.*, 1992; Erdinç *et al.*, 1999; Baccetti *et al.*, 2001; Cameron *et al.*, 2002; Franchi *et al.*, 2002; Doruk *et al.*, 2004) have analysed the results of upper arch expansion on postero-anterior (PA) cephalograms. PA cephalograms are the ideal method to assess dentoskeletal changes in the transverse plane. Furthermore, the use of an untreated control group of unilateral crossbite patients has not been used in previous studies.

No data are available in the literature on the evaluation of transverse dentoskeletal effects of interceptive therapy in subjects in the primary and early mixed dentition on PA cephalograms. The aim of this study was to evaluate the effects of early treatment in subjects with a unilateral posterior crossbite in the primary or early mixed dentition. A removable appliance with expansion springs was used and the changes were assessed on the PA cephalograms and compared with an untreated control group.

Subjects and methods

Two groups of subjects with a unilateral posterior crossbite were selected from the files of the Department of Orthodontics, University of Florence. The treatment group comprised 23 subjects (8 males and 15 females) treated with a removable appliance for the expansion of the maxillary arch. Active therapy lasted approximately 10 months and was followed by a retention period of about 1 year, when the appliance was worn at night. PA cephalograms of treated patients were analysed regardless of the treatment result. Their average age at the start of expansion (T_1) was 6 years 2 ± 17 months, and at the end of active therapy and after retention (T_2) 8 years ± 18 months. The mean observation interval was 22 ± 7 months.

Twenty subjects (9 males and 11 females) with an untreated unilateral posterior crossbite who refused early treatment after the first evaluation were used as the control group. Their mean age was 5 years 9 ± 15 months at the first observation and 7 years 4 ± 16 months at the second examination. The interval between the two observations was 18 ± 7 months.

All subjects presented with the following features: presence of a unilateral posterior crossbite with a negative posterior transverse interarch discrepancy (PTID). PTID is the difference between the maxillary intermolar width (distance between the central fossae of right and left first primary maxillary molars) and the mandibular intermolar width (distance between the tips of the distobuccal cusps of right and left first primary mandibular molars). In a correct molar relationship, the distobuccal cusp of the first primary mandibular molar occludes with the central fossa of the first primary maxillary molar. Consequently, maxillary and mandibular intermolar widths should be equal and PTID should be zero in an ideal occlusion; primary or early mixed dentition; absence of previous orthodontic treatment and dental trauma and dental anomalies; two consecutive PA cephalograms of good quality with adequate landmark visualization and with minimal or absent rotation of the head, taken at T_1 and T_2; and absence of dentofacial abnormalities or syndromes.

Description and clinical management of the appliance

A removable appliance with two-shaped midpalatal wire springs was used. The springs were constructed of hard 0.6 mm round stainless steel–chromium alloy wire. The anterior spring consisted of two loops and was constructed on a 5-cm-long piece of wire, while the posterior spring comprised three loops constructed on a 6 cm long piece of wire; for both, springs 5 mm for each side, were embedded in the acrylic resin. Adams' hooks were placed on the second primary molars or, in the mixed dentition, on the first molars. Ball clasps were added if necessary to improve retention (Figure 1). The springs were activated every 3–4 weeks with Angle or Tweed pliers. The negative PTID was corrected. A slight over-expansion can be desirable in order to minimize relapse during the retention period.

Methods

Cephalograms in PA projection were taken with the Frankfort plane parallel to the floor, with the front of the head and nose tip in contact with the radiographic cassette. They were hand-traced with a 0.5 mm pencil on 0.003 mm matte acetate tracing paper. All tracings were performed by one author (ED) and were subsequently verified by another investigator (AM). The traced cephalograms were analysed using a digitizing tablet (Numonics, Landsdale, Pennsylvania, USA) and a digitizing software (Viewbox version 3.0 dHAL Software, Kifissia, Greece). The radiographic measurements were converted to life size to eliminate magnification. The cephalometric landmarks used are shown in Figure 2.

Dental points were located on the primary teeth because of the absence of the permanent molars at T_1 in many subjects. To analyse the combined error of landmark location and digitization, 20 randomly selected PA cephalograms were retraced and redigitized after a 2-week period. The standard error deviation for each dimension was calculated from the double determinations using Dahlberg's formula (Houston, 1983). The mean method error was 0.31 ± 0.13 mm.

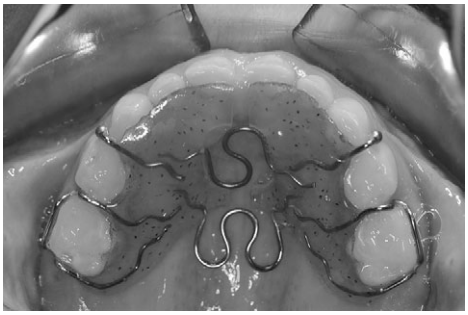

Figure 1 Design of the removable appliance.

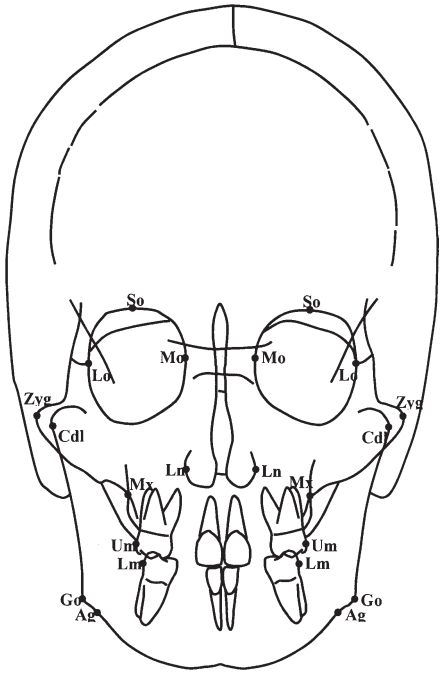

Figure 2 Skeletal landmarks: supraorbitale (So), the superior point of the orbital contour; medio-orbitale (Mo), the most medial point of the orbital contour; latero-orbitale (Lo), the mesial point of the frontal-zygomatic suture; zygomatic (Zyg), the most lateral point of the zygomatic arch; condylar lateral (Cdl), the point located at the lateral pole of the condylar head; maxillare (Mx), the point located at the depth of the concavity of the lateral maxillary contour, at the junction of the maxilla and the zygomatic buttress; lateronasal (Ln), the most lateral point of the nasal cavity; gonion (Go), the point located at the gonial angle of the mandible; and antegonion (Ag), the point located at the antegonial notch. Dental landmarks: upper molar (Um), the most prominent lateral point on the buccal surface of the second primary molar; lower molar (Lm), the most prominent lateral point on the buccal surface of the second primary molar.

Data analysis

The data from cephalometric analysis of the two groups were compared by means of a parametric test (Student's *t*-test) for independent samples ($P < 0.05$).

The distribution of all values followed the Gaussian curve. Neither group showed any statistically significant difference at T_1 for any of the examined measurements (Table 1).

The minor difference in age and observation period between the two groups at T_1 and T_2 allowed a comparison of dentoskeletal changes (T_2–T_1) between the two groups (Student's *t*-test). All statistical computations were performed using the Statistical Package for Social Sciences (Version 12.0, SPSS Inc., Chicago, Illinois, USA).

Results

Descriptive data and statistical comparisons of the skeletal and dental measurements for the two groups from T_1 to T_2 are reported in Table 2.

Dental and skeletal effects induced by the therapy were observed. At T_2, the transverse dimension of the upper dental arch (Um–Um) and the skeletal apical base of the maxilla (Mx–Mx) were significantly greater in the treatment group when compared with the controls. During the observation period, a significant increase was noted in the width of the upper dental arch (Um–Um): in the treatment group, there was an increase of 4.94 ± 1.55 mm, whereas in the controls this was 1.45 ± 1.24 mm. There was also an increase in the skeletal transverse dimension of the apical base of the maxilla (Mx–Mx): for the treatment group the increase in growth was 4.48 ± 1.96 mm and for the controls 2.15 ± 1.54 mm. No differences were found for any other examined variables.

Table 1 Comparison of the two groups at the start of treatment.

Cephalometric measurements	Treated group, $n=23$		Control group, $n=20$		Significance
	Mean	SD	Mean	SD	
Skeletal measurements					
So–So	54.96	3.61	52.91	3.57	NS
Mo–Mo	21.24	2.13	21.29	2.12	NS
Lo–Lo	83.41	5.13	80.48	5.11	NS
Zyg–Zyg	106.65	6.77	102.33	5.73	NS
Cdl–Cdl	95.77	5.61	94.63	4.99	NS
Mx–Mx	54.79	4.05	55.73	4.63	NS
Ln–Ln	24.33	2.10	23.46	1.74	NS
Go–Go	77.83	6.09	76.71	4.54	NS
Ag–Ag	70.65	5.39	67.97	4.42	NS
Dental measurements					
Um–Um	44.26	3.23	42.93	2.58	NS
Lm–Lm	45.77	2.95	44.48	2.77	NS

NS, not significant.

Table 2 Comparison of changes during the observation period.

Cephalometric measurements	Treated group, $n=23$		Control group, $n=20$		Difference	Significance
	Mean	SD	Mean	SD		
Skeletal measurements						
So–So	2.26	1.39	2.26	2.06	0.00	NS
Mo–Mo	1.80	1.05	1.53	0.94	0.27	NS
Lo–Lo	2.69	1.56	2.60	1.92	0.09	NS
Zyg–Zyg	3.46	1.93	2.75	1.42	0.71	NS
Cdl–Cdl	3.21	1.79	2.31	1.42	0.90	NS
Mx–Mx	4.48	1.96	2.15	1.54	2.32	***
Ln–Ln	1.65	1.04	1.13	0.88	0.52	NS
Go–Go	3.37	1.17	3.23	1.50	0.14	NS
Ag–Ag	2.82	1.48	3.40	1.91	–0.58	NS
Dental measurements						
Um–Um	4.94	1.55	1.45	1.24	3.49	***
Lm–Lm	1.75	1.23	1.71	1.07	0.03	NS

***$P < 0.001$.
NS, not significant.

Discussion

A posterior crossbite may cause an anomalous chewing pattern in the mixed dentition (Ben-Bassat *et al.*, 1993; Santos Pinto *et al.*, 2001) that can persist even after correction (Throckmorton *et al.*, 2001). Therefore, early therapy is appropriate and may reduce future problems (De Boer and Steenks, 1997). In the primary dentition, the functional aspects of the malocclusion are often considerable, while usually only minimal anatomical defects are observed. A minimal contraction of the upper arch can produce an interference that induces a lateral shift of the mandible on closure (Tollaro *et al.*, 1985). Grinding of primary canines has been reported to be effective in some cases especially when no negative PTID is present (Thilander *et al.*, 1984; Lindner, 1989). On the contrary, when a contraction of the upper arch is established the elective therapy is expansion of the maxilla (Harrison and Ashby, 2001). In subjects, in whom there was no correction of the crossbite after grinding, a removable appliance has been used successfully as a second phase therapy (Thilander *et al.*, 1984; Lindner, 1989). The effects of early treatment appear to be stable in the majority of patients. Schröder and Schröder (1984) studied the effects of crossbite treatment in 32 children in the primary dentition and found that the permanent teeth erupted in a correct position in 84 per cent without relapse of the primary teeth. They also reported that subjects with incorrect eruption of the permanent teeth had a persistent sucking habit.

The appliance used in the present study has been found to be effective in the correction of posterior crossbites in the primary and early mixed dentitions. The absence of visible components in the appliance and its size make it aesthetic and comfortable for the patient to wear full time. It does not interfere with speech.

The opportunity to vary the amount of the force appears to be important since it allows progressive correction of the transverse anomaly of the upper arch and sequential adaptation of the mandible, which losses the lateral deviation

and returns spontaneously in the correct physiological position. Twenty-two of the 23 examined subjects had a satisfactory correction of the crossbite. The patient without a complete correction gave a very poor co-operation and started with a considerable negative PTID (–7 mm).

A significant increase in the skeletal dimension of the maxillary apical base (Mx–Mx) was also observed. This increase was greater than that reported using different removable appliances in the mixed dentition (Brieden *et al.*, 1984; Erdinç *et al.*, 1999). The young age of the treatment group was probably important in this outcome. As no occlusal radiographs were taken, it would be inappropriate to say that the observed increase in the maxillary apical base width was a consequence of opening of the median palatal suture; however, it is possible when treatment is performed early. However, the removable spring expander is still able to generate considerable forces that in very young children may be able to stimulate the midpalatal suture, especially when the appliance is worn for many hours.

The findings of this research and clinical experience are encouraging when answering the efficacy of the removable spring expander, but studies on long-term stability are necessary.

Conclusions

The correction of a posterior crossbite in the primary or early mixed dentition with a removable spring appliance was found to be effective on both dental and skeletal structures when studied on PA cephalograms.

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