Dento-skeletal effects of mixed palatal expansion evaluated by postero-anterior cephalometric analysis

**ABSTRACT**

**Aim** The aim of this study was to evaluate the dento-skeletal effects of mixed palatal expansion (MPE) on growing patients with a uni- or bilateral posterior crossbite and mild-to-moderate crowding as compared to untreated growing individuals using postero-anterior (PA) cephalometric analysis.

**Materials and methods** A group of 24 patients (18 girls and 6 boys) treated with a Hyrax-type device was compared to an untreated matched control group at T0 (8.6 yrs ± 2.01) and T1 (10 yrs ± 2.00) using PA cephalograms. The cephalometric analysis included eight bilateral skeletal and dental landmarks. The groups were compared using independent sample t-test to estimate dento-skeletal effects on PA cephalograms.

**Results** The treated group showed significant changes for the maxillary width (P<0.001) and upper molar width (P<0.001) when compared to those of the control group.

**Conclusion** MPE may effectively increase transverse dimensions and correct posterior crossbites.

**Keywords** Mixed palatal expansion; Posterior crossbite; Transverse dimension.

**Introduction**

Maxillary expansion has been used for decades to correct transverse deficiency [Cross et al., 2006; Lagravère et al., 2005; Schiffman et al., 2001; da Silva Filho et al., 1995]. Because self-correction is rare, it is specifically indicated in growing patients with primary and mixed dentitions to correct posterior crossbites. If not corrected, posterior crossbites may often worsen [da Silva Filho et al., 1995] and limit maxillary growth [Baccetti et al., 2001; Maspero et al., 2012]. Posterior crossbites can be uni- or bilateral and may fall under different molar classifications [da Silva Filho et al., 1995; Baccetti et al., 2001; Ciavarella et al., 2012]. Maxillary expansion results in an increased transverse maxillary width that allows maxillary and mandibular arch coordination, which sometimes enables the mandible to move forward. Moreover, with the increased transverse width, in patients without a crossbite but mild-to-moderate tooth-size/arch-size discrepancy, maxillary expansion may eliminate the need for extractions [Baccetti et al., 2001; Baccetti et al., 2000; Adkins et al., 1990; Showkatbakhsh et al., 2013; Perillo et al., 2011]. To achieve mainly skeletal changes with only minor dental movements, an expansion protocol consisting of a rapid activation at the first appointment to separate the maxillary halves, followed by slow activation at subsequent appointments has been proposed. Since this protocol uses both rapid and slow activations, it has been called mixed palatal expansion (MEP).

The purpose of this retrospective study was, therefore, to examine the effects of MEP on skeletal and dental structures in growing patients with posterior uni- or bilateral crossbite versus in untreated growing subjects.

**Materials and methods**

The expansion group consisted of patients treated consecutively at the Department of Orthodontics, Second University of Naples, Italy, from January 2008 to December 2010. The following inclusion criteria were used: pre-pubertal age, the presence of a uni- or bilateral posterior crossbite, and good quality postero-anterior (PA) radiographs at the pretreatment (T0), and at the completion of expansion therapy (T1). Additionally, an occlusal radiograph confirming successful separation of the mid palatal suture was obtained. Subjects with previous orthodontic treatment, dental trauma or anomalies, dentofacial abnormalities or syndromes were excluded. Out of 200 subjects examined, 24 patients matched the criteria and were included in the study. The final study group consisted of 6 boys and 18 girls with a mean age of 8.6 years ± 2.01 at T0 and 10 years ± 2.00 at T1.

The cervical-vertebral growth stage of these patients at T0 ranged from CS1 to CS2 according to Baccetti et al. [2002]. The mean duration of the active treatment was 6 months ± 2 and was followed by a retention period of 1 year ± 3. The dento-skeletal changes were compared to an age-matched control group from the cephalometric data published by Athanasiou et al. [1992] (Table 1).
Clinical procedure for MPE
A Hyrax-type expander is bonded to the first upper molars and first deciduous molars or first bicuspids allowing three or four steps to be performed, all in the same day. After the first step with four turns (± 0.25 mm per turn), the patient usually has tenderness on the bonded teeth for 20 to 30 minutes. Then after the second step with two turns, the tenderness shifts to the palatal incisor area for 10-15 minutes, whereas after the third step with one turn, tenderness is felt in the suture area for the same amount of time. The decrease in tenderness on the bonded teeth and/or tenderness in the sutural area may indicate that maxillary halves have already been separated. However, a successful separation can only be confirmed by an occlusal radiograph. In the event of increased palatal suture resistance, a fourth step with two additional turns may be applied. In this case there can be tenderness at the temporal and frontozygomatic areas. Therefore, the number of steps and associated turns depends on how well the suture is digitated. After opening the suture, a slow expansion protocol with one turn every three days is followed until 2 mm overcorrection are obtained. The activation period usually lasts from 3 to 6 months depending on the extent of the maxillary expansion. After the expansion, the Hyrax device is removed to lock the screw with cold acrylic and then re-cemented so that it could be used as a retainer during the retention-phase.

Cephalometric analysis
Dentoskeletal landmarks and related measurements on PA cephalograms at T0 and T1 were hand-traced using 0.5 mm lead on 0.003 mm matte acetate tracing paper. To analyse the PA cephalograms, 8 transversal linear measurements (6 skeletal and 2 dental) were derived for each patient at T0 and T1 by connecting bilateral cephalometric landmarks. All anteroposterior cephalograms were digitised, so linear measurements could be standardised.

Cephalometric landmarks used were: Medio-orbitale (Mo), Latero-Orbitale (Lo), Maxillare (Mx), Mastoid (Ma), Latero-nasal (Ln), Antegonian (Ag), Upper molar (Uxm) and Lower molar (Ldm) [Athanasiou et al., 1992] (Fig. 1).

Statistical analysis
Changes in both groups together with the differences between the groups were evaluated by Student’s t-tests. Individual changes were recorded as change per year to express variation in intervals between films and thereby allowing a comparison with the control group data.

Data were analysed with the Statistical Analysis System (SAS version 9.2, SAS Inc, Cary, NC). The level of significance was set at p<0.05 for all statistical analyses.

Error study
To estimate the error method, 12 randomly selected PA cephalograms were retracted and re-measured 1 week later by the same examiner. Random error was calculated by the Dahlberg’s formula [Dahlberg, 1990].

Results
The method error ranged between 0.5 mm and 0.2 mm for the linear measurements, indicating that there was a good reliability of measurements.

A comparison between the expansion and control groups at T0 revealed different transverse skeletal and dental measurements except for the latero-nasal, antegonial and lower molar widths (Table 2). At T1, both groups showed the following differences: medio-orbitale (P<0.01), latero-orbitale (P<0.05), mastoid (P<0.05) and upper molar width (P<0.001). All these measurements changed more in the MEP group (Table 2).

Following MPE treatment (T0-T1), the expansion group presented increases for the following width measurements: maxillary (P<0.001), upper molar (P<0.001), latero-nasal (P<0.01), mandibular molar (P<0.01), medio-orbitale (P<0.05), and latero-orbitale (P<0.05) widths (Table 2). During the same period (T0-T1), the control group presented changes (increase) of maxillary (P<0.01), latero-nasal (P<0.01) medio-orbitale (P<0.05) and latero-orbitale (P<0.05) widths (Table 2).

All of the transverse skeletal and dental changes,

<table>
<thead>
<tr>
<th>Group</th>
<th>Number</th>
<th>Average age</th>
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<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Male</td>
</tr>
<tr>
<td>MPE group</td>
<td>24</td>
<td>6</td>
</tr>
<tr>
<td>Control group</td>
<td>* 24</td>
<td>-</td>
</tr>
</tbody>
</table>

* Data inferred from age-matched Athanasiou normative increments for postero-anterior analysis.

FIG. 1 Skeletal landmarks.
except mastoid and antegonial variations, were significant in the MPE group (Table 2).

A comparison of yearly incremental changes revealed that all variables except the Mastoid width differed significantly between the groups.

Discussion

During expansion, the force exerted by the expander separate the maxillary halves resulting in the opening of the intermaxillary suture. The separation of the maxillary halves occurs through their lateral rotation with the center located on the fronto-nasal suture or on the sphen-o-occipital synchondrosis [Braun et al., 2000]. Upon new bone formation in the intermaxillary suture, the basal bone width is increased. The early clinical sign of this orthopaedic effect is the appearance of a diastema between the upper central incisors [da Silva Filho et al., 1995], which manifests as a decreased opacity between the two halves of the maxillary bones on occlusal radiographs [Haas, 1961]. The buccal tipping of the posterior teeth is one of the most important side effects of the maxillary expansion. As mentioned earlier, MPE is a maxillary expansion protocol proposed to produce mainly skeletal changes with minor dental side effects. The working hypothesis was that this procedure separates the two maxillary halves at the first appointment so that the forces during the expansion are completely applied to the maxillary bone.

The purpose of this retrospective study was to examine dento-skeletal effects of MPE in growing patients with posterior uni- or bilateral crossbite versus changes in untreated growing subjects. As expected, at the beginning, the MPE patients had less maxillary and less upper molar width than those in the control group. After expansion, maxillary and upper molar widths increased significantly. The two groups overlapped for maxillary width, but upper molar width was still greater, perhaps due to the overcorrection and buccal tipping of the upper molars (Table 2). Because the maxillary and the upper molar width increased by 6.19 and 8.74 mm, respectively, buccal tipping was about 1 mm per side which was expected as the expander was anchored to these teeth. Yearly outcome measures indicated significant increases in all of the transverse skeletal and dental measurements except for mastoid and antegonial width in the MPE group (Table 2).

### Table 2: Descriptive and inferential statistics increments for postero-anterior analysis.

<table>
<thead>
<tr>
<th>Cephalometric Measure (mm)</th>
<th>Initial</th>
<th>Final</th>
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<tbody>
<tr>
<td>MPE Group T0</td>
<td>Control T0</td>
<td>MPE Group T1</td>
</tr>
<tr>
<td>Medio-orbitale (mo-mo)</td>
<td>21.97 ± 2.43</td>
<td>24.47 ± 1.21</td>
</tr>
<tr>
<td>Latero-orbitale (lo-lo)</td>
<td>89.31 ± 4.42</td>
<td>93.34 ± 2.01</td>
</tr>
<tr>
<td>Maxillare (mx-mx)</td>
<td>58.62 ± 4.04</td>
<td>63.51 ± 1.49</td>
</tr>
<tr>
<td>Mastoid (ma-ma)</td>
<td>108.27 ± 6.15</td>
<td>112.76 ± 3.78</td>
</tr>
<tr>
<td>Antegonion (ag-ag)</td>
<td>81.2 ± 6.15</td>
<td>82.53 ± 8.2</td>
</tr>
<tr>
<td>Latero-nasal (ln-ln)</td>
<td>27.01 ± 2.53</td>
<td>27.23 ± 1.29</td>
</tr>
<tr>
<td>Lower molar (lm-lm)</td>
<td>57.58 ± 3.06</td>
<td>58.03 ± 0.28</td>
</tr>
<tr>
<td>Upper-molar (um-um)</td>
<td>56.18 ± 4.03</td>
<td>57.88 ± 0.63</td>
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<table>
<thead>
<tr>
<th>Change After Treatment</th>
<th>Change/year After Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>Final</td>
</tr>
<tr>
<td>MPE Group T1-T0</td>
<td>Control T1-T0</td>
</tr>
<tr>
<td>Medio-orbitale (mo-mo)</td>
<td>1.69 ± 0.78</td>
</tr>
<tr>
<td>Latero-orbitale (lo-lo)</td>
<td>2.71 ± 1.19</td>
</tr>
<tr>
<td>Maxillare (mx-mx)</td>
<td>6.19 ± 1.11</td>
</tr>
<tr>
<td>Mastoid (ma-ma)</td>
<td>2.35 ± 1.92</td>
</tr>
<tr>
<td>Antegonion (ag-ag)</td>
<td>3 ± 2.38</td>
</tr>
<tr>
<td>Latero-nasal (ln-ln)</td>
<td>2.3 ± 1.01</td>
</tr>
<tr>
<td>Lower molar (lm-lm)</td>
<td>1.71 ± 0.6</td>
</tr>
<tr>
<td>Upper-molar (um-um)</td>
<td>8.74 ± 0.77</td>
</tr>
</tbody>
</table>

*P<0.05; **P<0.01; ***P<0.001; ns, not significant
An important side effect of MPE was the significant increase in the lower molar width likely due to a mandibular molar uprighting from a lower position of the tongue and a decreased buccal muscle force exerted on the lower dentition [Adkins et al., 1990; Akkaya et al., 1998]. The standard landmarks made the method error acceptable (0.5 ± 0.2 mm) confirming that the use of PA cephalograms is still a useful method to assess transverse dento-skeletal changes [Defraia et al., 2008].

Although there were numerous studies that investigated transverse changes in the PA cephalograms, they differed from our study because of the initial young age and the use of a different appliance [Defraia et al., 2008], initial old age and lack of observation during the retention period [Cross et al., 2006], lack of a control group [da Silva Filho et al., 1995], and only long-term results [Cameron et al., 2002]. Such heterogeneity was confirmed by the meta-analyses of Lagravère [Lagravère et al., 2005; Lagravère et al., 2005; Lagravère et al., 2006]. Those meta-analysis also highlighted that maxillary expansion changes were more dental than skeletal. The increased upper molar width found in our study was similar to what has been reported elsewhere [Cross et al., 2006; da Silva Filho et al. 1995; Cameron et al., 2002], whereas the increased maxillary width was greater than that shown in the literature [Cross et al., 2006; da Silva Filho et al. 1995; Cameron et al., 2002; Lagravère et al., 2005]. Cross et al. in 2006 found a yearly maxillary width increment of 1.11 mm +/-1.41 mm in 13.4 year-old patients managed by rapid maxillary expansion (RME) compared with the control group in the study of Athanasiou et al. [1992]. A long-term study conducted by Cameron et al. in 2002 on 11.10 year-old patients treated with RME, also showed fewer increases of maxillary and upper molar width compared to our short-term results. Since our patients were younger (8.6 yrs.), with a less skeletal maturity (CS1-CS2), sutures may have exhibited a lower resistance to expansion forces leading to a greater skeletal expansion than patients in Cross at al. 2006 study. In fact, Bell in 1992 reported that early treatment may allow less complex and lower force expansion systems than late treatments and therefore, enhance skeletal response. More recently, Baccetti et al. in 2001 described pronounced skeletal width changes in patients treated before the pubertal peak and greater changes in dental measurements, such as maxillary and mandibular intermolar widths (skeletal expansion versus dental tipping) in the late-treated group. However, our increase in maxillary width was greater than that shown by Silva et al. in 1995 on 8-year-old children treated with RPE effects and without a control group. By contrast, similar outcomes were found by Defraia et al. in 2008 in a sample of 6.2-year-old patients with unilateral crossbite treated with a removable appliance for 10 months followed by a year of retention. This suggests that the more open the suture, the greater gain in skeletal effects.

Conclusion

The current study showed that in pre-pubertal patients the mixed palatal expansion (MPE) was an effective treatment option to improve dento-skeletal transverse dimensions and correct posterior crossbite. This outcome was associated with major skeletal and minor dental changes. Thus, the working hypothesis that separating the two maxillary halves at the first appointment, the expansion forces were completely applied to the maxillary bone, may be confirmed.

References


