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# Three-dimensional evaluation of early crossbite correction: a longitudinal study

Jasmina Primožič*, Stephen Richmond**, Chung How Kau***, Alexei Zhurov** and Maja Ovsenik*

*Department of Dental and Jaw Orthopaedics, Faculty of Medicine, University of Ljubljana, Ljubljana, Slovenia, **Dental Health and Biological Sciences, Dental School, Cardiff University, Heath Park, Cardiff, South Glamorgan, UK and ***Department of Orthodontics, University of Alabama, Birmingham, USA

*Correspondence to*: Assistant Prof. Maja Ovsenik, Department of Orthodontics, Hrvatski trg 6, 1000 Ljubljana, Slovenia. E-mail: maja.ovsenik@dom.si

SUMMARY The aim of this longitudinal study was to assess whether correction of unilateral posterior crossbite in the primary dentition results in improvement of facial symmetry and increase of palatal surface area and palatal volume. A group of 60 Caucasian children in the primary dentition, aged 5.3 ± 0.7 years, were collected at baseline. The group consisted of 30 children with a unilateral posterior crossbite with midline deviation of at least 2 mm (CB) and 30 without malocclusion (NCB). The CB group was treated using an acrylic plate expander. The children's faces and dental casts were scanned using a three-dimensional laser scanning device. Non-parametric tests were used for data analysis to assess differences over the 30 months period of follow-up. The CB children had statistically significantly greater facial asymmetry in the lower part of the face ($P < 0.05$) and a significantly smaller palatal volume ($P < 0.05$) than the NCB children at baseline. There were no statistically significant differences between the two groups at 6, 12, 18, and 30 months follow-ups. Treatment of unilateral posterior crossbite in the primary dentition period resulted in an improvement of facial symmetry in the lower part of the face ($P < 0.05$) and increase of the palatal surface area and palatal volume ($P < 0.001$). At 30 months, relapse was observed in eight children (26.7 per cent). Treatment of unilateral posterior crossbite in the primary dentition improves facial symmetry and increases the palatal surface area and the palatal volume, though it creates normal conditions for normal occlusal development and skeletal growth.

## Introduction

In the primary dentition, unilateral posterior crossbite commonly arises as a result of a narrow maxilla, which forces the mandible to displace laterally into an abnormal position due to the presence of tooth interferences (Malandris and Mahoney, 2004; Primozic *et al.*, 2009).

Functional asymmetry in unilateral posterior crossbite can contribute to mandibular skeletal asymmetry as during the growth period continuous condylar displacement in the glenoid fossa induces differential growth of the condyles (Inui *et al.*, 1999; Kilic *et al.*, 2008). This asymmetrical function reflects different development of the elevator muscles on each side of the jaws leading to a thinner masseter muscle on the crossbite side, which is already seen in the early mixed dentition (Kiliaridis *et al.*, 2000). Furthermore, the level of maximum bite force in children with unilateral posterior crossbite is smaller compared to children with neutral occlusion (Sonnesen *et al.*, 2001). Early corrections of functional problems should prevent adverse dental and facial development (Ninou and Stephens, 1994; Profitt, 2006, Ovsenik 2009; Melink *et al.*, 2010).

Facial asymmetry due to lateral mandibular displacement in unilateral posterior crossbite, if not treated in the primary dentition, may lead to an undesirable growth modification (Ninou and Stephens, 1994; Kilic *et al.*, 2008), which results in facial asymmetry of skeletal origin. Though, early orthodontic treatment seems to be profitable and desirable to create conditions for normal dental and skeletal development (Petrén *et al.*, 2003).

Several methods (Petrén *et al.*, 2003) have been suggested for crossbite correction in the primary dentition period, including active maxillary expansion with an expansion plate. The use of an expansion plate with a midline screw in the primary dentition period may result in some skeletal changes as there is less interdigitation of the midpalatal suture (Melsen, 1975) compared to the use of an expansion plate in the mixed or permanent dentition stages when orthodontic forces are considered only light enough to tip teeth (Ngan and Fields, 1995; Baccetti *et al.*, 2001).

In order to evaluate the benefits of early treatment, facial asymmetry and the skeletal effect of treatment on the upper jaw should be evaluated. Treatment success after correction of unilateral posterior crossbite in the primary dentition is highly questionable as it is very difficult to objectively assess correction of facial asymmetry in small growing children. Orthodontists routinely evaluate transverse discrepancy clinically and on photographs. Although facial photography is an important diagnostic tool in orthodontics, its main disadvantage is that it represents a three-dimensional (3D) subject in two dimensions. Small deviations in camera angulations can give the illusion of improving or worsening the facial images produced. If such images were used to obtain measurements, the results would be inaccurate (Miller *et al.*, 2007).

Furthermore, objective assessment of upper arch expansion is also difficult. Until recently, the transverse discrepancies between the upper and lower jaws were evaluated on study casts mostly by measuring the linear intercanine and intermolar distances (Sillman, 1964; Thilander and Lennartsson, 2002; Petrén and Bondemark, 2008). However, this method could not exclude bias in assessing the transverse dimension due to improper teeth position, for example the buccal teeth tipping.

To overcome these problems, a laser scanner can be used as a soft tissue scanner in order to obtain 3D images of the children's faces. Furthermore, the same scanner can be used to obtain 3D images of study casts. Facial asymmetry can be assessed without the use of reference points or planes, which has been previously reported to be a more accurate method for assessing asymmetry (Benz *et al.*, 2002). The 3D images of study casts can be used to measure palatal surface area and palatal volume (Oliveira De Felippe *et al.*, 2008).

Although a considerable number of studies investigating the effects of correcting posterior crossbites have been conducted, the outcomes are very different (Petrén *et al.*, 2003; Malandris and Mahoney, 2004; Harrison and Ashby, 2009). It has been reported that relapse after early crossbite correction is very frequent (Kurol and Berglund, 1992), while other studies report a success rate of 85 per cent over an 8 year follow-up (DeBoer and Steenks, 1997).

The aim of this longitudinal study was to assess whether correction of unilateral posterior crossbite in the primary dentition period results in improved facial symmetry and increased palatal surface area and palatal volume. The objectives were to assess facial asymmetry, palatal surface area and palatal volume in two groups of children: a group of crossbite (CB) children and a group of non-crossbite (NCB) children.

## Subjects and methods

Ethical approval for this study was gained from the Slovenian Ethical Committee of the Medical University in Ljubljana, Slovenia, and informed consent was obtained from the parents of all subjects.

A group of 60 Caucasian children, aged 3.4–6.7 years (mean 5.2 years, SD 0.7), were included in this study. The NCB group consisted of 30 children (13 boys and 17 girls) without malocclusion, randomly selected from a local kindergarten. In the CB group, there were 30 children (17 girls and 13 boys) with unilateral posterior crossbite, selected from the patients referred to the Department of Pedodontics of the Dental Policlinic Kranj, Slovenia. Only the children in the primary dentition period with all the posterior teeth in crossbite on one side and a midline deviation of at least 2 mm, due to a functional mandibular shift, were included. The functional mandibular shift was assessed clinically by an experienced orthodontist (MO). Nineteen children had a functional shift on the right side, 11 on the left side. Furthermore, type of respiration, deglutition, tongue position, chewing pattern, and deleterious oral habits were recorded and reported elsewhere (Melink *et al.*, 2010, Sever *et al.*, 2010; Volk *et al.*, 2010).

The CB group was treated using an acrylic plate with a midline screw to expand the maxillary arch. The acrylic plate with bite plate was cemented on the upper primary molars. The screw was activated 0.25 mm every 2 days for 4 weeks and an overexpansion of the upper jaw was performed in all the patients. The plate was left in place for 4 more weeks without activation. The bite plate was removed and the acrylic plate was then used as a removable retainer for 4 months. Therefore, the expected expansion in CB subjects would be approximately 3.5 mm, and active therapy was followed by about 4 months of retention.

Laser facial scanning was performed at baseline and at 6, 18, and 30 months follow-ups, while dental impressions were taken and a clinical assessment of malocclusion and orofacial functions was performed at baseline and at 6, 12, 18, and 30 months follow-up visits.

### *Assessment of facial symmetry*

Surface facial images were obtained using two Konica/Minolta Vivid 910 laser scanners angled to capture left and right sides of the face with significant overlap in the anterior part of the face to facilitate registration and merging of the two images to produce one facial shell (Kau *et al.*, 2004).

These devices are eye safe and have scanning time of about 2.5 seconds with a reported manufacturing accuracy of 0.3 mm (http://www.konicaminolta.com). Natural head posture was adopted as this has been shown to be clinically reproducible (Kau *et al.*, 2005). The technique for positioning the patient and image capture has been validated and described elsewhere (Kau *et al.*, 2004).

The 3D data were imported to a reverse modelling software package, Rapidform™ 2006 (@ INUS Technology Inc., Seoul, Korea). Each scan of the face (left and right images) was processed in order to remove unwanted data, registered, and merged to produce a complete facial image. The facial shell was aligned to two planes: the midsagittal plane (Y–Z) and the inner cantus of the eyes (X–Z). To check for left/right symmetry, the original facial shell was flipped horizontally in order to obtain the mirrored facial shell (Figure 1, step 1), and the original and mirrored facial shells were superimposed (Figure 1, step 2). The facial shells were divided into three parts: the upper part was defined as the part of the face above the inner cantus plane, the middle part ranged from the inner cantus plane to the plane through the

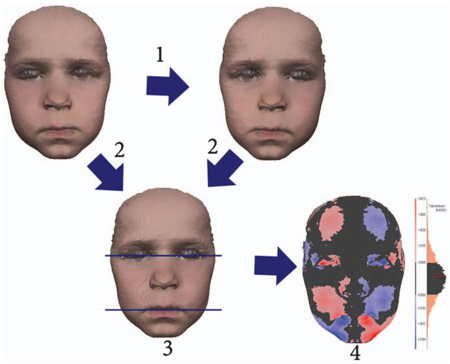


**Figure 1** Assessment of facial symmetry. Construction of the mirrored shell by flipping the original shell horizontally (step 1), superimposition of the original and mirrored shells (step 2), division of the face into three parts (step 3), colour deviation map of the mirrored shells (black colour indicates shell–shell deviations within 0.5 mm that we considered symmetric; red colour indicates the positive, while blue colour the negative differences), and histogram showing the percentage of overlapping of the two shells (step 4).

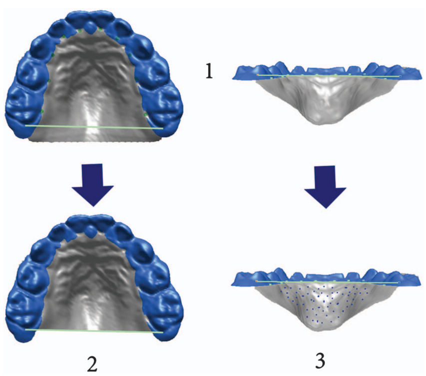


**Figure 2** Assessment of palatal surface area and palatal volume. Definition of the palatal boundaries (step 1), the palatal surface area (step 2, grey area), and the palatal volume (step 3, dotted area).

outer commissures of the lips, and the lower part was below this plane (Figure 1, step 3). The shell-to-shell deviations of the mirrored images were recorded in terms of average shell-to-shell distance. Furthermore, a colour deviation map was generated to show shell–shell deviations of the mirrored images (Figure 1, step 4) and the percentage of mirrored shells overlapping within 0.5 mm was recorded. Facial asymmetry was evaluated in terms of average shell-to-shell distance and shells overlapping within 0.5 mm. The greater is the average distance and the smaller the percentage of overlapping, the greater is the facial asymmetry.

*Assessment of palatal surface area and palatal volume*

Study casts were scanned at a distance of 60 cm with the same Konica/Minolta Vivid 910 laser scanner using a lens with a focal distance of 25 mm. With this lens, the scanner has a reported accuracy of 0.22 mm (Keating, 2004).

Each scan of the study cast was pre-processed to remove unwanted data. In order to measure the palatal surface area and calculate the palatal volume, the boundaries of the palate had to be defined. The gingival plane and a distal plane were used as boundaries for the palate. The gingival plane was created by connecting the midpoints of the dentogingival junction of all primary teeth. The distal plane was created through two points at the distal of the second primary molar perpendicular to the gingival plane (Figure 2, step 1). The palatal surface area (Figure 2, step 2) and the volume (Figure 2, step 3) were then calculated.

*Statistical analysis*

The Statistical Package for Social Sciences Software release 13.0 (SPSS Inc., Chicago, Illinois, USA) was used for data analysis. The balancing of experimental groups by age and gender was tested with a Student's *t*-test and a Fisher's exact test, respectively. After testing, the normality of the data with the Shapiro–Wilk test and Q–Q normality plots, and the equality of variance among the data sets using a Levene test; non-parametric methods were used for data analysis. Nevertheless, the mean and standard deviations are reported for descriptive purposes.

A Friedman test was used to assess the significance of the differences in every facial symmetry parameter (average distance and overlapping) and palatal parameters (surface area and volume) over the time points within each group. When significant interactions were seen, a Bonferroni-corrected Wilcoxon test was used for pairwise comparisons. A Mann–Whitney *U*-test was used to assess the significance of the differences in every parameter between the two groups within each time point. The facial symmetry parameters were analysed for the whole face and for the upper, middle, and lower parts of the face separately.

Moreover, to analyse the changes in the palatal parameters, the normalized changes in palatal surface area and volume were calculated and expressed as percentages of the baseline values. Therefore, the Friedman test was used to test the significance of the differences of these normalized changes over time within each group. A Mann–Whitney *U*-test was used to assess the significance between the two groups within each time point.

The results were considered to be significant at *P*-values below 0.05. Method error for facial symmetry and palatal parameters was calculated using the interclass correlation coefficients, which were at least 0.90.

## Results

The groups were balanced by age and gender ($P > 0.05$). In the NCB group, one, two, and one child left the study at 12, 18, and 30 months, respectively. In the CB group, the number of withdrawals was one, three, and three children at 12, 18, and 30 months, respectively. Even though morphological recordings were not available for these latter children, the occurrence of relapse could be excluded on the basis of the regular follow-up they underwent. On the contrary, a relapse was seen in eight (26.7 per cent) children in the CB group at the end of the observed period of time; however, the full data of these children were kept in the final analysis. Four children (13.3 per cent) exhibited a posterior crossbite, two on the left, and two on the right side. The remaining four children expressed a Class III relationship with a bilateral crossbite and inverse overjet.

The results for the facial symmetry parameters of the whole face and the upper, middle, and lower parts of the face separately are shown in Table 1. Longitudinally, no significant differences of the recorded parameters were seen in the NCB group. On the contrary, in the CB group, significant increases in both, the average distance of the upper part of face and in the overlapping of the lower part of the face were observed ($P < 0.05$). In particular, at the corresponding pairwise comparisons, the overlapping recorded at 18 months was significantly greater as compared to the baseline value. The comparisons between the two groups within each time point for every parameter were not significant, with the exception for the overlapping of the lower part of the face, which was significantly lower in the CB group as compared to the NCB group at baseline ($P < 0.05$).

**Table 1** The facial symmetry parameters in the experimental groups over time and for the whole face and each part of the face separately. Diff., significance of the difference over time point or between the groups; CB, crossbite; NCB, non-crossbite.

| Parameter | Part of the face | Group | Time point | | | | Diff. |
|---|---|---|---|---|---|---|---|
| | | | Baseline | 6 months | 18 months | 30 months | |
| Average distance (mm) | Whole | NCB | 0.44 ± 0.11 | 0.48 ± 0.15 | 0.44 ± 0.12 | 0.44 ± 0.08 | NS |
| | | CB | 0.50 ± 0.15 | 0.57 ± 0.19 | 0.45 ± 0.15 | 0.47 ± 0.12 | NS |
| | | Diff. | NS | NS | NS | NS | |
| | Upper | NCB | 0.39 ± 0.10 | 0.46 ± 0.14 | 0.41 ± 0.13 | 0.41 ± 0.08 | NS |
| | | CB | 0.42 ± 0.10 | 0.48 ± 0.15 | 0.40 ± 0.15 | 0.45 ± 0.12 | $P < 0.05$ |
| | | Diff. | NS | NS | NS | NS | |
| | Medium | NCB | 0.43 ± 0.16 | 0.45 ± 0.17 | 0.44 ± 0.13 | 0.45 ± 0.12 | NS |
| | | CB | 0.51 ± 0.22 | 0.53 ± 0.26 | 0.42 ± 0.15 | 0.47 ± 0.16 | NS |
| | | Diff. | NS | NS | NS | NS | |
| | Lower | NCB | 0.53 ± 0.24 | 0.64 ± 0.48 | 0.48 ± 0.26 | 0.45 ± 0.14 | NS |
| | | CB | 0.67 ± 0.36 | 0.77 ± 0.45 | 0.61 ± 0.49 | 0.52 ± 0.20 | NS |
| | | Diff. | NS | NS | NS | NS | |
| Overlapping (%) | Whole | NCB | 69.27 ± 10.16 | 66.48 ± 10.51 | 68.00 ± 10.90 | 67.82 ± 7.80 | NS |
| | | CB | 63.33 ± 11.23 | 59.88 ± 12.87 | 69.01 ± 10.59 | 65.24 ± 9.90 | NS |
| | | Diff. | NS | NS | NS | NS | |
| | Upper | NCB | 72.85 ± 10.88 | 68.08 ± 11.22 | 72.31 ± 12.45 | 71.43 ± 8.40 | NS |
| | | CB | 70.85 ± 8.70 | 65.13 ± 12.21 | 72.71 ± 12.39 | 68.90 ± 10.44 | NS |
| | | Diff. | NS | NS | NS | NS | |
| | Medium | NCB | 69.66 ± 14.05 | 69.18 ± 14.37 | 66.03 ± 14.14 | 66.15 ± 13.34 | NS |
| | | CB | 61.80 ± 16.54 | 61.20 ± 17.17 | 69.32 ± 14.08 | 64.03 ± 15.64 | NS |
| | | Diff. | NS | NS | NS | NS | |
| | Lower | NCB | 61.80 ± 17.85 | 55.82 ± 19.44 | 65.35 ± 21.22 | 65.53 ± 13.32 | NS |
| | | CB | 50.70 ± 24.12 | 49.91 ± 19.31 | 64.81 ± 16.93* | 60.28 ± 15.79 | $P < 0.05$ |
| | | Diff. | $P < 0.05$ | NS | NS | NS | |

NS, not significant.
*Statistically significantly different as compared to the corresponding baseline value.

**Table 2** The palatal surface area and volume in the experimental groups over time. Diff., significance of the difference over time point or between the groups; CB, crossbite; NCB, non-crossbite.

| Parameter | Group | Time point | | | | | Diff. |
|---|---|---|---|---|---|---|---|
| | | Baseline | 6 months | 12 months | 18 months | 30 months | |
| Surface ($mm^2$) | NCB | 783.5 ± 79.3 | 797.2 ± 90.1 | 830.0 ± 97.0* | 855.2 ± 113.3* | 885.1 ± 107.6* | $P < 0.001$ |
| | CB | 751.5 ± 65.8 | 819.4 ± 100.5* | 823.4 ± 89.3* | 878.6 ± 89.4* | 875.3 ± 93.7* | $P < 0.001$ |
| | Diff. | NS | NS | NS | NS | NS | |
| Volume ($mm^3$) | NCB | 2983.0 ± 472.6 | 3034.6 ± 536.4 | 3208.1 ± 508.7* | 3224.2 ± 751.2* | 3347.2 ± 691.4* | $P < 0.001$ |
| | CB | 2695.6 ± 404.6 | 3076.8 ± 565.8* | 3029.8 ± 512.2* | 3382.0 ± 566.6* | 3273.1 ± 609.1* | $P < 0.001$ |
| | Diff. | $P < 0.05$ | NS | NS | NS | NS | |

NS, not significant.
*Statistically significant different as compared to the corresponding baseline value.

The results for the palatal parameters are shown in Table 2. Longitudinally, significant differences in the palatal surface area and volume were seen in both groups (all differences at $P < 0.001$). At the pairwise comparisons with the baseline values, the two parameters were greater at 6 months in the CB group and at 12, 18, and 30 months in both groups. At the cross-sectional analyses, generally, no significant differences were seen between the groups with the exception for the palatal volume, which was significantly lower in the CB group as compared to the NCB group at baseline ($P < 0.05$).

The results for the normalized changes in the palatal surface area and volume are shown in Figure 3. Within each group, significant increases in the normalized changes of the two parameters were seen over time (all comparisons at $P < 0.001$). More in detail, a clear linear behaviour was seen for the NCB group; for the CB group, a slight change in the slope behaviour of the curve was seen at 12 months. At the cross-sectional analyses between the groups at each time point, significantly greater normalized changes in the palatal surface area and volume were seen for the CB group at 6, 12, and 18 months and at 30 months for the palatal volume only (all comparisons at $P < 0.05$, at least).

## Discussion

Treatment of unilateral posterior crossbite in the primary dentition period is still questionable in respect of cost effectiveness (Tschill *et al.*, 1997; Malandris and Mahoney,

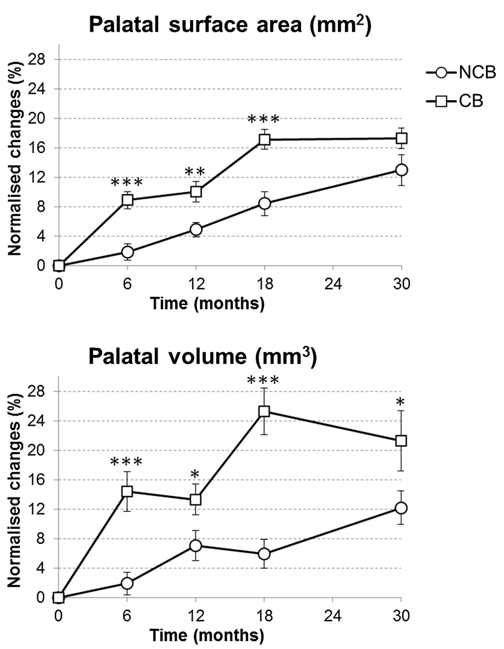


**Figure 3** The normalized changes in the palatal surface area and volume in the experimental groups over time. Data are presented as mean ± standard error of the mean. Significance of the differences between the non0crossbite (NCB) and crossbite (CB) groups at each time point: $*P < 0.05$, $**P < 0.01$, $***P < 0.001$.

2004; Profitt, 2006). It appears that the only indication for correction in the primary dentition is where aesthetics or function may otherwise be compromised (Malandris and Mahoney, 2004).

Different treatment approaches such as selective grinding of teeth, expansion plates and Quadhelix, are used for crossbite correction (Lindner, 1989; Malandris and Mahoney, 2004). In this study, treatment was started in the primary dentition using a cemented acrylic plate with a midline screw for palatal expansion. After correction, the plate was decemented and used as a removable retention plate. The use of an expansion plate has been shown to successfully correct 50 per cent (Lindner, 1989) to 84.4 per cent (Schröder and Schröder, 1984) of posterior crossbites with a functional mandibular shift. In the present study, the success rate was 72.4 per cent, with 27.6 per cent of children showing relapse. However, in the present study, a slightly different treatment protocol was used compared to the reported studies (Schröder and Schröder, 1984; Lindner, 1989), which may have influenced the treatment outcome.

Several previous studies (Mulick, 1965; Sutton, 1968; Shah and Joshi, 1978; Burke, 1979; Pirttiniemi, 1998; Haraguchi *et al.*, 2008) have discussed possible causes of facial asymmetry. It has been suggested that the normal asymmetry of the human face primarily originates from the innate functional and structural differences between the cerebral hemispheres, suggesting that brain and skull base asymmetry could be the cause of facial asymmetry (Pirttiniemi, 1998). On the other hand, other studies concluded that environmental influences were the most likely cause. Habitual chewing on one side has been reported to lead to increased skeletal development on the ipsilateral side (Shah and Joshi, 1978). Others have also discussed the possibility that facial asymmetry is simply a response of functional adaptation to asymmetrical masticatory activity (Vig and Hewitt, 1975).

It has been reported that in unilateral posterior crossbite in the primary dentition, facial asymmetry is a result of a lateral mandibular displacement resulting in a deviation of the chin towards the crossbite side (Malandris and Mahoney, 2004). The greatest facial asymmetry of crossbite children was seen in the lower part of the face at baseline and was significantly greater compared to children without malocclusion, which is in accordance with previous studies (Primozic *et al.*, 2009). Though the facial asymmetry of the lower part of the face in the CB children was probably a result of the functional mandibular shift that was present in all of these children at baseline.

However, after treatment and at follow-ups, the asymmetry of the lower part of the face in the CB children decreased and it was not significantly different from the NCB children. Furthermore, the pattern of mastication of the CB children of this study was examined before and after treatment and reported elsewhere (Sever *et al.*, 2010). These authors report that the children with crossbite had a significantly different pattern of mastication compared to the non-crossbite children. However, after treatment, the pattern of mastication changes and is not significantly different from the pattern of the non-crossbite children (Sever *et al.*, 2010). Treatment of the unilateral posterior crossbite with an expansion plate has influence on the position of the mandible in centric occlusion and corrects facial asymmetry in the lower part of the face.

In order to assess skeletal effects of early treatment on the upper jaw, the palatal surface area and volume were calculated on 3D digital images of study casts. Both the palatal surface area and palatal volume of the treated group statistically significantly increased after treatment, according to previous evidence (Primozic *et al.*, 2009). Furthermore, increase of the palatal volume from baseline to 6 months was significantly greater in the treated group, showing that treatment with the expansion plate in the primary dentition period has a skeletal effect. The employed protocol, which involved the use of a cemented appliance during active expansion and a semi-slow rate of expansion (0.25 mm every 2 days) may have played a role in the favourable effects of the therapy. At 12 months, the palatal volume of the CB children slightly diminished, while the NCB children showed a linear increase in palatal volume through the whole period of follow-up. This slight decrease at 12 months in the palatal volume of CB children could be the result of relapse that occurs after expansion of the upper jaw and has been reported in previous studies (Kurol and Berglund, 1992; Thilander and Lennartsson, 2002; Petrén *et al.*, 2003). At 30 months follow-up, both palatal surface area and volume remained mostly unchanged in the CB children and there were no significant differences between the CB and NCB children at 12, 18, and 30 months follow-up. It seems that treatment of the unilateral posterior crossbite in the primary dentition period creates conditions for normal occlusal and craniofacial development.

Relapse occurs very frequently after correction of unilateral posterior crossbite in the primary dentition period (Petrén *et al.*, 2003; Harrison and Ashby, 2009). In this study, relapse occurred in eight children (26.7 per cent); however, only half of them exhibited a unilateral posterior crossbite (13.3 per cent), two on the left, and two on the right side. The remaining four children expressed a Class III relationship with an inverse overjet. Facial asymmetry persisted also in these children, which is in accordance with a previous study (Haraguchi *et al.*, 2008), reporting a high percentage of pre-pubertal Class III patients with facial asymmetry. The high percentage of relapse, reported in this and in previous studies (Petrén *et al.*, 2003; Harrison and Ashby, 2009), should be further elucidated. It has been reported that one of the causes for unilateral posterior crossbite is a mild bilateral constriction of the upper jaw (Malandris and Mahoney, 2004; Primozic *et al.*, 2009), which was shown also in this study. However, based on the results of this study, no significant difference was found between the CB and NCB children at 30 months follow-up, though the mild bilateral constriction of the upper jaw can be excluded as a cause of relapse.

Children with posterior crossbite have asymmetrical muscle function during chewing or clenching, meaning that the anterior temporalis is more active and the masseter less active on the crossbite than on the non-crossbite side (Andrade Ada *et al.*, 2009, Sever *et al.*, 2010). Furthermore, altered muscle function associated with posterior crossbite can reduce the bite force in crossbite children (Sonnesen *et al.*, 2001; Sonnesen and Bakke, 2007). It has been shown that the anterior temporal and masseter muscle activity at rest position differed significantly between the crossbite and control groups, and higher muscle activity was found on the crossbite side, but the respective differences were eliminated after maxillary expansion (Ingervall and Thilander, 1975; Kecik *et al.* 2007).

On the other hand, Ferrario *et al.* (1999) report high within-group variations of muscular activity in the crossbite subjects compared to the non-crossbite subjects. The authors explain that the cause of this high variability could be that each crossbite subject develops a slightly different muscular scheme to avoid (or reduce) the occlusal interferences. This could also explain why relapse after treatment of unilater posterior crossbite occurs in some subjects, regardless of the size of the upper jaw. Though it seems that after expansion, a retention protocol in terms of correction of the muscular function should be profitable. In order to elucidate this problem, further research is needed.

## Conclusions

Treatment of unilateral posterior crossbite in the primary dentition improves facial symmetry in the lower part of the face. A further favourable outcome of treatment is the skeletal effect of the therapy on the maxillary structures in terms of increase of the palatal surface area and volume. Though, treatment of unilateral posterior crossbite in the primary dentition also creates conditions for normal occlusal and craniofacial development. However, a more efficient retention protocol should be studied to avoid the high frequency of relapse observed after early treatment.

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