Original article

Asymmetric molars’ mesial rotation and mesialization in unilateral functional posterior crossbite and implications for interceptive treatment in the mixed dentition

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Summary

Introduction: Symmetric transverse expansion is the main outcome of the early treatment in subjects with unilateral functional posterior crossbite. The aim of this study was to analyse mesial rotation and mesialization of upper first molars as sagittal parameters to be corrected in the treatment of these patients during the mixed dentition.

Methods: Digital dental cast measurements (rotation and mesialization) were performed in a sample of 48 subjects with unilateral posterior crossbite (UPXB; 19 males and 29 females, mean age 10.2 ± 1.2 years) and in a control group of 35 subjects with normal Class I occlusion (17 males and 18 females, mean age 9.9 ± 1.3 years). An independent sample t-test, the Mann–Whitney test, Fisher’s exact test, and Pearson correlation were used for statistical comparison.

Results: The amount of upper molar rotation was significantly greater in the experimental group when compared with the control group. A clinically significant ‘upper molar rotation’ (UMR) was present in 66.7 per cent of the subjects with UPXB versus 5.7 per cent of the control group. The UMR group presented also a significant mesialization of upper first molars when compared with the control group. In the experimental group, there was a significant difference between rotation and mesialization in the right and left side and a correlation has been found between these two variables and the amount of Class II molar relationship at the crossbite side.

Limitations: This is an epidemiological case–control study and the discussed effects of an early correction of the asymmetric upper molars’ migration are only speculations based on an association relationship.

Conclusions: The findings of this study show an asymmetric upper first molars’ migration (rotation and mesialization) in unilateral functional posterior crossbite versus a control group. An early evaluation and correction of the molars’ migration during the mixed dentition should be considered in order to obtain a correct inter-occlusal sagittal molar relationship, space for an adequate eruption of permanent teeth, and perhaps reduce the need of a following fixed appliance treatment in the permanent dentition.
Introduction

Unilateral posterior crossbite (UPXB) with mandibular shift is commonly found in young children and adolescents in the primary and mixed dentition, and its reported incidence ranges from 7 per cent to 23 per cent of the population (1–3). Many studies describe the main characteristics of UPXB, such as the maxillary contraction (4) and the mandibular functional shift (3, 5). The latter causes a lower midline (ML) deviation towards the crossbite side (3, 6). An asymmetric inter-occlusal sagittal molar relationship with a Class II relationship at the crossbite side and a Class I in the contralateral side (or, respectively, I and III) (6). Masticatory function alterations (7) are also present together with a malfunctioning temporomandibular joint (8) and jaw muscles (9, 10).

The treatment of subjects with UPXB in the mixed dentition is recommended to obtain a correct mandibular position, a symmetric occlusion, to re-establish a good masticatory function and to prevent future structural and functional problems (4, 11–13). The outcomes considered for successful treatment of UPXB patients in the mixed dentition are frequently related to the transverse dimension (13–15) such as the correction of the crossbite and the elimination of the mandibular functional shift. The early treatment usually consists in a bilateral and symmetrical palatal expansion using devices such as quad-helix, rapid palatal expander, or removable plates (14, 15). Nevertheless asymmetries can also be present in the upper arch (16), and studies report of asymmetric transverse discrepancies in UPXB (17, 18). The symmetrical palatal expansion in UPXB in the mixed dentition does not always lead to a full correction of the MLs discrepancy and of the asymmetric inter-occlusal sagittal molar relationship that could require a follow-up orthodontic treatment to be corrected.

Rotational and anterior–posterior position of upper first molars and the possible difference between the crossbite and non-crossbite sides, which could have had an influence on the upper ML deviation and the inter-occlusal sagittal molar relationship, should be taken into consideration in the diagnosis and treatment of UPXB patients in the mixed dentition.

Precedent studies have analysed the degree of first molar rotation and mesialization in different types of malocclusions (19–23). Henry (19) found that in 83 per cent of Class I and Class II malocclusions, the mesiobuccal cusp was mesial to its proper position and that the tooth was rotated around the palatal root and the mesio-palatal cusp. Liu and Melsen (20) reported 85 per cent of mesio-rotated first molars in subjects with Class II first division malocclusion, whereas Giuntini et al. (21), in a sample of 120 subjects with Class II malocclusion in the mixed dentition, detected 84 per cent of patients with mesial rotation of the upper first molars. No significant results have been found regarding first molar anterior–posterior position in Class II and Class II subdivision malocclusions (22, 23). There are no studies in UPXB.

The clinical relevance of molar rotation and mesialisation control and correction in UPXB in the mixed dentition pertains to at least two main aspects:

1. Improvement of the inter-occlusal molar relation in the sagittal plane (24, 25). The correct relation between the central buccal cusp of the lower first molar and the central fossa of the upper first molar assures the stability of the early treatment and favours the achievement of a Class I molar relationship in the permanent dentition.

2. Gain of space in the arch perimeter (21, 26–29) for eruption of permanent teeth. The distal movement of the mesio-buccal cusp in relation to the mesio-palatal cusp (i.e. rotation around the mesio-palatal cusp) can contribute significantly to space management. In case of extreme mesial rotation of the upper permanent first molar, when the first molar is included in the upper dental arch perimeter with its oblique diameter instead of its mesio-distal diameter, maximal orthodontic molar derotation (approximately 30 degree) leads to a maximal gain of arch space of approximately 2.5 mm (29). This is confirmed by Braun et al. (27), who calculated a value of space gaining in the arch perimeter of 2.1 mm when de-rotating upper first molars by approximately 20 degree. Giuntini et al. (21) investigated a sample of subjects in the mixed dentition with Class II malocclusions and stated that there was an average gain in upper arch perimeter of approximately 1.5 mm per side, as the average amount of first molar rotation to be treated orthodontically was 16.3 degree.

The aim of the present study was to analyse the amount of upper first molars’ rotation and mesialization in subjects with UPXB versus a control group in the mixed dentition and the relationship between upper first molars’ rotation, mandible deviation (lower ML deviation), and the asymmetric inter-occlusal sagittal molar relationship. An early treatment of asymmetric upper first molars’ migration in UPXB might reduce the need of a following fixed appliance treatment in the permanent dentition.

Materials and methods

The position of upper first molars was examined in experimental and control groups and the obtained values were compared. The size of the samples enrolled in the two groups under investigation was calculated, assessing the difference between the buccal cusp angles (DBCA) as a main outcome, fixing a power (β) of 90 per cent and an α of 5 per cent, and considering a difference of 2 degree in the means (μ) of the outcome between the two groups as clinically significant, with an SD (σ) of 2.52 degree estimated from previously published data (19).

This is an epidemiological case–control study and was conducted as an investigation of upper first molars’ sagittal position on dental casts of 48 subjects with UPXB (19 males and 29 females, mean age 10.2 ± 1.2 years) and a control group of 35 subjects (17 males and 18 females, mean age 9.9 ± 1.3 years). The subjects with UPXB malocclusion satisfied the following inclusion criteria:

1. Class I malocclusion (lower incisors occlude on or immediately behind upper incisors’ palatal cingula) (28);
2. UPXB malocclusion with an asymmetric inter-occlusal sagittal first molar relationship. The mandibular ML deviates by 2 ± 1 mm to the crossbite side;
3. Intermediate mixed dentition phase (30) that is characterized by the presence of fully erupted permanent incisors and first molars and by the presence of the deciduous canine, first molar, and second molar.
4. no previous orthodontic treatment;
5. absence of craniofacial anomalies;
6. absence of crowding;
7. absence of tooth aplasia or supernumerary teeth;
8. absence of severe tooth decay; and
9. absence of alterations in shape and size of the molars, premolars, and canines.

The enrolment criteria for the control group replicated those for the UPXB subjects, with the exception of the presence of UPXB.
All dental casts of the patients were selected sequentially and supplied by private dental offices. All patients previously accepted and signed in the informed consent that their records might be reviewed for research purposes. The dental casts were scanned by the same rater using the Nobil-Metal Sinergia Scan (Nobil-Metal S.p.a., Villafranca d’Asti, AT, Italy) at the orthodontic laboratory ORTOVIT, in Gorle, and the measurements were carried out on the occlusal images of the casts by means of the Ortho Analyzer computerized software (3Shape, Copenhagen, Denmark).

**Dental cast measurements**

The images of the scanned dental casts were imported into the program 3Shape Ortho Analyzer and analysed by the same rater.

The rater performed the following operations for each patient:

1. to set of the upper arch occlusal plane, which was based on the identification of the following three points in the upper arch, and to use it as a reference plane (Figures 1 and 2) (31):
   - the most incisal point of the upper central incisors,
   - the mesio-palatal cusp of the upper right first molar, and
   - the mesio-palatal cusp of the upper left first molar
2. to measure the amount of upper first molars’ mesial rotation;
3. to measure the amount of upper first molars’ mesialization;
4. to rate the lower ML deviation; and
5. to evaluate the inter-occlusal sagittal first molar relationship.

**Rotation of upper first molars.**

The rotation of molars was assessed by referring to the raphe line that was identified by an anterior and a posterior point along the mid palatal raphe (32).

Lebret (33) showed that only the apex of the palatal vault along the mid palatal raphe remained stable during growth. Subsequently, Almeida et al. (34) reported that the medial points of the palatal rugae are the most stable in the palate, confirming the relatively stability of the mid palatal raphe region and its suitability as a reference to measure changes in tooth position over time.

The following measurements were carried out:

- Buccal Cusp Angle 16 (BCA16): the angle between the raphe line and a line through the buccal cusps of the upper right first molar (Figure 3);
- Buccal Cusp Angle 26 (BCA26): the angle between the raphe line and a line through the buccal cusps of the upper left first molar (Figure 3);
- Average Buccal Cusp Angle (ABCA): the mean value between BCA16 and BCA26 in the individual subject; and
- DBCA: the value given by the difference between BCA16 and BCA26 in the individual subject.

**Mesialization of upper first molars**

The mesialization of upper first molars was defined as molar depth (MD) and assessed from the mesio-palatal cusp of these molars by referring to a reference line perpendicular to the raphe and passing

![Figure 1. Occlusal view of an upper dental cast with the occlusal plane.](https://example.com/image1)

![Figure 2. Sagittal view of an upper dental cast with the occlusal plane.](https://example.com/image2)

![Figure 3. Occlusal view of an upper dental cast with upper molar rotation measurements (BCA16 and BCA26). BCA = buccal cusp angle.](https://example.com/image3)
through the most distal point of the retro-incisal papilla (Figure 4). The following measurements were carried out:

- Molar Depth 16 (MD16): distance from the mesio-palatal cusp of 16 to the reference line;
- Molar Depth 26 (MD26): distance from mesio-palatal cusp of 26 to the reference line;
- Average Molar Depth (AMD): the mean value between MD16 and MD26 in the individual subject; and
- Difference Molar Depth (DMD): the value given by the difference between MD16 and MD26 in the individual subject.

Lower ML deviation

A sagittal plane through the raphe was identified and the distance between this plane and a point corresponding with the lingual frenum on the lower central incisors was measured.

Inter-occlusal sagittal first molar relationship

Angle’s classification was used to define the inter-occlusal sagittal first molar relationship. The right and left first molar relationships were scored in millimetres.

Method error

The measurement error was assessed by the method of Dahlberg. The accuracy of measurements and rater repeatability was tested using the interclass correlation coefficient (ICC) applied to a comparison between plaster and digital models measurements and to measurements recorded twice at an interval of 1 month in 11 randomly selected patients. ICC was interpreted as follows: values not more than 0.20 showed poor agreement; from 0.21 to 0.30, slight agreement; from 0.31 to 0.40, fair agreement; from 0.41 to 0.60, moderate agreement; from 0.61 to 0.70, substantial agreement; from 0.71 to 0.80, strong agreement; from 0.81 to 0.99, almost perfect agreement; and 1, perfect agreement.

Statistical analysis

Descriptive statistics (arithmetic mean, standard deviation, and minimum and maximum values) was calculated for all dental cast measures in both groups. The BCA16, MD16, and lower ML values of 11 randomly selected patients were measured both on digital and plaster models, and the ICC was used in order to assess repeatability of these measurements. Intra-rater repeatability of digital dental cast measurements was tested by asking the rater to repeat the measurements in the same 11 subjects 1 month after the initial analysis and calculating the relative ICC. Shapiro–Wilk and Levene tests revealed that BCA16, BCA26, and ABCA were normally distributed, whereas DBCA, MD16, MD26, AMD, and DMD were not. Independent sample t-test was used for comparison of the variables BCA16, BCA26, and ABCA in the UPXB group versus the control group. An analysis of variance followed by a post hoc Mann–Whitney test was used to analyse the other variables. The clinical condition of ‘upper molar rotation’ (UMR) in the experimental group was defined using the mean value of ABCA in the control group with the addition of 2 SDs. MD was also analysed in the UMR group in order to assess the quantity of molars’ migration (rotation and mesialization) in these patients. A Pearson correlation was used to study the relation between the molar rotation and MD at the crossbite side, mandibular deviation (lower ML deviation), and the inter-occlusal sagittal first molar relationship. The significance level used in the study was 0.05.

Results

The measurement error found with Dahlberg’s method was smaller than 0.5 degree. Regarding accuracy of the measurements the ICC values for BCA16, MD16, and lower ML deviation were 0.83, 0.89, and 0.85, respectively, indicating an almost perfect agreement. Regarding intra-rater repeatability, ICC values indicated an almost perfect rater repeatability of the measurements BCA16, MD16, and lower ML deviation, with values of 0.91, 0.90, and 0.86, respectively.

Descriptive statistics and comparison tests (the t-test for BCA16, BCA26, and ABCA and the Mann–Whitney test for the others variables) on dental cast variables in experimental versus control groups are reported in Table 1. BCA16, BCA26, and ABCA in the experimental group were larger when compared with the control group, and statistically significant differences were found for these three variables \( (P = 0.000) \). DBCA and DMD were significantly larger in the experimental group than in the control group (respectively \( P = 0.032, P = 0.000 \)).

The threshold value for the assessment of the clinical condition UMR in individual subjects was 9.62 degree + 6.9 degree = 16.5 degree (the mean value of ABCA + 2 SDs in the control group). Subjects in the experimental group who presented with UMR (ABCA values greater than 16.5 degree) were 32/48 = 66.7 per cent, while the prevalence rate was 2/35 = 5.7 per cent in the control group. The difference between the two prevalence rates analysed using Fisher’s exact test was highly significant \( (P = 0.000) \). MD was also analysed in the UMR group and descriptive statistics and comparison tests versus control group (Mann–Whitney test) are reported in Table 2. MD16, MD26, and AMD in the UMR group were smaller when compared with the control group, and statistically significant differences were found for these three variables \( (P = 0.041, P = 0.034, P = 0.026, \text{respectively}) \). DMD was significantly larger in the UMR group than in the control group \( (P = 0.000) \).

All of the UPXB subjects presented with an asymmetric inter-occlusal sagittal first molar relationship, specifically a greater Class II occlusion at the crossbite side. The amount of Class II was 3.21 ± 1.16 mm (max: 7 mm, min: 1.75 mm) at the crossbite side and 1.28 ± 1.13 mm (max: 5.25 mm, min: 0) at the non-crossbite side. In the UMR groups, 75 per cent of molars at the crossbite side presented an amount of Class II of 3.5 mm and over. There was not correlation between the lower ML (1.75 ± 1.10) deviation and
Table 1. Descriptive statistics and statistical comparisons results ($P$ values) on dental cast variables in the experimental group versus the control group. UPXB = unilateral posterior crossbite; BCA = buccal cusp angle; ABCA = average buccal cusp angle; DBCA = difference between buccal cusp angle; MD = molar depth; AMD = average molar depth; DMD = difference molar depth; SD = standard deviation.

<table>
<thead>
<tr>
<th></th>
<th>UPXB $n = 48$</th>
<th>Class I $n = 35$</th>
<th>Difference</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MEAN</td>
<td>SD</td>
<td>Min</td>
<td>Max</td>
</tr>
<tr>
<td>BCA16 (*)</td>
<td>20.25</td>
<td>5.16</td>
<td>11.1</td>
<td>35.9</td>
</tr>
<tr>
<td>BCA26 (*)</td>
<td>17.32</td>
<td>4</td>
<td>10.1</td>
<td>25.6</td>
</tr>
<tr>
<td>ABCA (*)</td>
<td>18.79</td>
<td>4.16</td>
<td>10.65</td>
<td>30.75</td>
</tr>
<tr>
<td>DBCA (*)</td>
<td>3.95</td>
<td>3</td>
<td>0.2</td>
<td>11.8</td>
</tr>
<tr>
<td>MD16 (mm)</td>
<td>24</td>
<td>1.88</td>
<td>19.67</td>
<td>28.08</td>
</tr>
<tr>
<td>MD26 (mm)</td>
<td>24.2</td>
<td>1.86</td>
<td>18.91</td>
<td>27.72</td>
</tr>
<tr>
<td>AMD (mm)</td>
<td>24.1</td>
<td>1.76</td>
<td>20.43</td>
<td>27.9</td>
</tr>
<tr>
<td>DMD (mm)</td>
<td>0.97</td>
<td>0.82</td>
<td>0.05</td>
<td>3.74</td>
</tr>
</tbody>
</table>

* $P < 0.05$; *** $P < 0.001$.

Table 2. Descriptive statistics and statistical comparisons results ($P$ values) on dental cast variables in the UMR group versus the control group. UPXB = unilateral posterior crossbite; ABCA = average buccal cusp angle; MD = molar depth; AMD = average molar depth; DMD = difference molar depth; SD = standard deviation.

<table>
<thead>
<tr>
<th></th>
<th>UPXB with ABCA &gt; 16.5 $n = 33$</th>
<th>Class I $n = 35$</th>
<th>Difference</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MEAN</td>
<td>SD</td>
<td>Min</td>
<td>Max</td>
</tr>
<tr>
<td>MD16 (mm)</td>
<td>23.74</td>
<td>1.78</td>
<td>19.67</td>
<td>27.03</td>
</tr>
<tr>
<td>MD26 (mm)</td>
<td>24.08</td>
<td>1.68</td>
<td>20.81</td>
<td>27.37</td>
</tr>
<tr>
<td>AMD (mm)</td>
<td>23.91</td>
<td>1.61</td>
<td>20.43</td>
<td>26.69</td>
</tr>
<tr>
<td>DMD (mm)</td>
<td>1.05</td>
<td>0.76</td>
<td>0.05</td>
<td>3.24</td>
</tr>
</tbody>
</table>

* $P < 0.05$; *** $P < 0.001$.

The degree of upper first molars’ rotation (BCA16 and BCA26) was measured using the angle between the raphe line and a line through the buccal cusps. This dental cast measurement was the most sensitive, in agreement with the original findings by Henry (19). This can be explained by the fact that first molar rotation occurs around the palatal root of the tooth (27) whereby the two buccal cusps are more expressive of the rotation than the mesial ones. Furthermore, Giuntini et al. (21) evaluated the degree of mesial rotation of upper first molars in Class II malocclusions using buccal and mesial cusp angles, and they stated that the standard deviations for BCAs were consistently smaller than those for the mesial cusps angles. According to them, the greater inter-individual variability for the mesial cusp angles could be related also to the anatomical variations of the mesio-palatal cusp of the upper permanent first molar with the possible presence of the Carabelli cusp. On the other hand, MD16 and MD26 were measured from the palatal cusp to a reference line perpendicular to the raphe and passing through the most distal point of the retro-incisal papilla. The palatal cusp of upper first molars is less expressive of the rotation (27) and is more representative of the mesialization of these teeth.

Discussion

The aim of the present study was to analyse upper first molars’ mesial rotation and mesialization in subjects with UPXB and the relationship between upper first molars’ migration, lower ML deviation, and asymmetric inter-occlusal sagittal first molar relationship. A more accurate upper maxillary observation might have an impact on clinical practice, since it gives more diagnostic elements and might have implications in the future treatment of UPXB patients.

Method

A single rater scanned all the dental casts and oriented them according to the occlusal plane. The accuracy of the digital measurements was demonstrated comparing them with measurements on plaster model using the ICC. The rater attended a period of training before starting the project to ensure the reliability of the measurements on the digital models. The intra-rater repeatability for the values considered was evaluated using the ICC and was almost perfect. Analyses of the individual cases selected to calculate the ICC showed that the errors were to some extent due to inaccuracies in the identification of the references points on the first molars. An identification of the reference points before scanning the study models will be considered in the future.
presented a significant amount of upper first molars’ mesialization, on average 1.08 mm on the right side (MD16) and 0.54 mm on the left side (MD26) more than the control group. In the UMR, there was a significant mesial migration of upper first molars that consisted in a rotation of 16.52 degree and over and a mesialization of 0.81 mm on average more than the control group. These outcomes suggest, according to previous studies (21, 25–27, 29), that in the presence of an ABCA greater than 16.52 degree (from 17 degree to 30.8 degree) and of a mesialization of 0.81 mm, upper first molars’ de-rotation and distalization should be required in 32/48 (66.7 per cent) subjects with UPXB in the mixed dentition to achieve a full correction of the molar relationship and a maximum gain of space in the arch perimeter of more than 2 mm (1.5 mm from de-rotation and 0.81 mm from distalization) per side.

The average values given by the DBCA (DBCA = 3.95 degree) and the molar mesialization (DMD = 0.97 mm) on the right and left side were also higher in the experimental group compared with the control group, and the differences were significant (P = 0.032 and P = 0.000, respectively). These findings indicate, according to the results of previous studies (16–18), the presence of asymmetries in the upper arch in patients with UPXB implying the possibility for an early correction of upper first molars’ rotation and mesialization carried out in an asymmetrical way (35).

All the subjects in the experimental group presented with a lower ML deviation to the crossbite side (ML = 1.75 ± 1.10 mm) and with an asymmetric inter-occlusal sagittal molar relationship (the Class II at the crossbite side was 3.21 ± 1.16 mm and at the non-crossbite side was 1.28 ± 1.13 mm) related to the mandibular functional shift (3, 6). However, there was no correlation between the lower ML deviation and the inter-occlusal sagittal molar relationship, and on the other hand, there was a linear positive correlation between molar rotation and the Class II molar at the crossbite side and a linear negative correlation between MD and the Class II molar at the crossbite side. This might indicate the influence of molar rotation and mesialization, together with the functional shift of the mandible (3, 6), on the inter-occlusal sagittal molar relationship at the crossbite side.

The presence of asymmetric mesial migration of upper first molars in the UPXB patients could be a consequence of the crossbite (36) or could play a role in the crossbite development. However, the correction of upper first molars’ mesial migration was not considered in previous studies regarding the early treatment of UPXB (13, 14, 20, 24) that generally recommend only a symmetrical maxillary expansion. The findings of the present study suggest that an evaluation of upper first molars’ mesial migration in UPXB patients in the mixed dentition should be carried out. In the presence of upper molars’ migration, an early correction should be recommended using appliances that in addition to upper arch expansion permit a symmetrical (37, 38) or asymmetrical (39, 40) de-rotation and distalization of these teeth. The early de-rotation and distalization would have the aim to obtain a correct inter-occlusal sagittal molar relationship and space for an adequate eruption of permanent teeth and perhaps reduce the need of a following fixed appliance treatment.

Limitations

The degree of mesial rotation and mesialization of upper first permanent molars, lower ML deviation, and asymmetric inter-occlusal sagittal molar relationship were assessed in dental casts of subjects with UPXB compared with subjects with normal Class I occlusion, both in mixed dentition. We acknowledge that a radiographic examination gives more information on the skeletal characteristics of the maxilla and mandible in order to better understand the aetiological factors involved in the asymmetries of the upper arch in patients with UPXB and this will be considered in future studies. However, the aim of this study was to increase the attention that has been given in UPXB patients to maxillary arch sagittal parameters in terms of both diagnosis and choice of treatment device without pretending to identify the causal factors.

Another limitation is represented by the fact that only the first molars’ position was studied in the upper arch. A more general evaluation of possible asymmetries in the upper arch of UPXB patients will be considered in a future study.

This is an epidemiological case-control study that proves the higher amount of upper molars’ mesial rotation and mesialization in UPXB patients versus a control group and suggests the evaluation and correction of this migration during the mixed dentition. The effects of an early correction of upper first molars’ migration discussed in this article are speculations based on an association relationship and should be verified with a randomized controlled clinical study.

Conclusion

The outcomes of the study revealed that:

- Upper first molars’ rotation (BCA16, BCA26, and ABCA) of subjects with UPXB in the mixed dentition is greater when compared with the control group subjects and the difference is statistically significant.

- The clinical condition of UMR found in 66.7 per cent of the subjects with UPXB and associated with molars’ mesialization suggest the need for an early diagnosis and orthodontic correction of molars’ mesial migration to gain an improvement of the inter-occlusal sagittal molar relationship and space in the arch perimeter and perhaps reduce the need for a following fixed appliance treatment.

- The differences between upper first molars’ rotation (DBCA) and mesialization (DMD) in the right and left sides were significantly larger in the experimental group than the control group, suggesting the need for an asymmetric correction of molars’ migration.

- There was a linear correlation between molar rotation (P = 0.037) and molar mesialization (P = 0.002) and the amount of Class II molar at the crossbite side, indicating a possible influence of molars’ migration on the inter-occlusal sagittal molar relationship in the UPXB patients.

Acknowledgements

The authors would like to thank the orthodontic laboratory, ORTOVIT, in Gorle, for kindly lending the Nobil-Metal Sinergia Scan and the 3Shape Ortho Analyzer computerized software.

Conflicts of interest

None declared.

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