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Original Article

Early anterior crossbite correction through posterior bite opening: a 3D superimposition prospective cohort study

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Summary

Objectives: To assess the effectiveness, clinical performance, and potential adverse effects of early anterior crossbite correction through opening of the bite.

Subjects and methods: The sample consisted of 16 consecutive patients (8.0 ± 0.9, range: 6.2–9.3 years) with dental anterior crossbite in the mixed dentition who were treated through posterior bite opening. Patients were prospectively followed until a minimum of 6 months post-treatment and there were no drop-outs.

Results: In 14 patients (87.5 per cent), the anterior crossbite was corrected. Results remained stable without any retention regime. Active treatment of the successfully treated cases lasted 2.5 months (range: 0.6–8.9). Crossbite correction of central incisors was achieved by a 2.05 mm (range: 0.97–5.45) forward movement and 9.25° (range: 2.32–14.52°) buccal inclination of the crowns ($P < 0.05$). The antagonists showed spontaneous adaptation of their position in the opposite direction ($P < 0.05$). No important adverse effects were recorded.

Limitations: This was a non-comparative controlled study, on a limited sample.

Conclusions: Bite opening is a promising, simple, and non-compliance approach for early dental anterior crossbite correction. The technique of 3D superimposition and analysis of digital models used here, allowed precise evaluation of single tooth movement in all three planes of space.

Introduction

Anterior crossbite refers to malocclusion resulting from lingual position of maxillary anterior teeth in relationship to the mandibular anterior teeth. The reported prevalence of anterior crossbite in the mixed dentition varies between 1.6 per cent and 7.9 per cent (1–4).

According to its origin, it can be differentiated into skeletal and dental crossbite (5, 6). Skeletal crossbite is associated with a concave skeletal and soft tissue profile and usually requires more extensive interventions to be managed (7). Dental (or dentoalveolar) anterior crossbite is a more localized problem and more easily managed. It may result from over-retention of deciduous teeth, irregular eruption pattern, or simple malposition of permanent teeth.

Early correction of crossbite, even in early mixed dentition, is indicated to prevent potential interferences with normal growth of the jaws and disturbances of neuromuscular or temporomandibular joint function, especially when there is asymmetry associated with functional shift of the mandible. If left untreated, it can cause permanent dental, skeletal, or soft tissue disharmonies or increase the risk of temporomandibular or neuromuscular imbalances at a later stage (8–10). Earlier intervention in the primary dentition may not be advisable since the problem is self-corrected in approximately half of the cases, and the patient is not expected to have significant benefits from such an early correction (2).

Several methods have been used for anterior crossbite correction in the mixed dentition, including removable and fixed appliances (11). However, patient compliance is essential for successful treatment with removable appliances (12). Fixed appliances do not demand such a high level of compliance but are associated with time-dependent adverse effects, such as white spots and root resorption, and may have a negative impact on patients' oral health-related quality of life (13).

For these reasons, simpler methods, without the use of any orthodontic appliance, have been suggested to correct anterior crossbite during mixed dentition (14, 15). Namely, bilateral occlusal build-ups were bonded on the mandibular second primary or first permanent molars, and this allowed for spontaneous anterior crossbite correction. This approach can be quite promising, especially for uncooperative or disabled children. However, it has only been presented in a few case reports (14, 15) and has not been comprehensively tested yet.

Thus, the aim of the present prospective cohort study was to assess the effectiveness, clinical performance, and potential adverse effects of this simple method of early anterior crossbite correction.

Materials and methods

The present study was conducted according to the ethical principles described in the Declaration of Helsinki (version 2013). Written informed consents were obtained from the patients and their parents prior to enrolment in the study, to allow the use of their standard clinical records and dental casts for research purposes.

Sample

Sixteen consecutive patients (11 males and 5 females; mean age at treatment start: 8.0 ± 0.9, range: 6.2–9.3 years) were included in the study according to the following eligibility criteria: no active caries, mixed dentition, anterior crossbite (at least one permanent maxillary incisor), adequate space for labial movement of the teeth in crossbite, no extreme functional shift (>4 mm), no posterior crossbite, no evidence of Class III skeletal pattern (as assessed through clinical evaluation), no previous orthodontic treatment, and no other orthodontic intervention until the follow-up visit, performed at a minimum of 6 months post-treatment. All patients were treated at a private practice in Cologne (Germany), operated by three orthodontists, according to the practice protocol. Patient recruitment started at February 2013 and ended at March 2015 based on the presence of the primary investigator in the practice. Four subjects were already in active treatment at the start of the study and their pre-treatment files were retrospectively examined for eligibility. The other 12 subjects were prospectively enrolled.

Treatment process

Patient history, clinical examination, extraoral and intraoral photos, dental casts with construction bite (centric occlusion), and panoramic radiographs were obtained before treatment start (T0) according to the practice protocol.

At the start of the treatment, the occlusal surfaces of the lower right and left mandibular second primary molars or first permanent molars (if the primary molars were not present or were mobile) were cleaned, dried, and acid etched with 37 per cent phosphoric acid for 20 seconds. The etched surfaces were then washed and carefully dried. A layer of primer was applied (Orthosolo Universal Bond Enhanser, Ormco, CA, USA) and resin-modified glass ionomer cement (Ultra Band-Lok Blue, Reliance Orthodontic Products, 1540 West Thorndale Ave, Itasca, IL 60143) was placed to build up an occlusal plane and light cured for 30 seconds. This procedure aimed to raise the bite approximately 1–2 mm more than that of an edge-to-edge anterior occlusal relationship in order to permit labial movement of the tooth/teeth in crossbite (Figure 1A and 1B).

Patients and parents were instructed that if any of the occlusal build-up was lost, they should make an appointment to replace it. Patient recalls were scheduled every 4-5 weeks. Brushing and proper oral hygiene were encouraged. During recall visits, the resin occlusal plane was raised to the initial level in cases where the positive overbite did not permit labial movement of the tooth/teeth in crossbite. Immediately after correction of anterior crossbite and attainment of positive overjet, the occlusal build-ups were removed (Figure 1C).

Follow-up

Recall controls were scheduled every 6–8 weeks, without performing any orthodontic intervention or retention procedure, until further orthodontic treatment for other problems was planned and implemented. Follow-up assessments (T1) including clinical examination, extraoral and intraoral photos, and dental casts with construction bite (centric occlusion) were performed at 6–17 months after active treatment. Six months was set as the minimum follow-up period and was extended as much as possible based on the presence of the primary investigator in the practice. Additionally, at T1, all patients filled in a questionnaire retrospectively assessing pain and discomfort during mastication and speech, and temporomandibular joint (TMJ) pain during the first week and at the next weeks of treatment. These answers were recorded on a 0–10 scale, with 0 marked as 'not at all' and 10 marked as 'extreme'. Furthermore, an open question allowed patients to report any other issues that they considered important in each period.

Figure 1. Intraoral photos of a patient treated for anterior crossbite with opening of the bite. (A) Pre-treatment condition; (B) Opening of the bite for spontaneous crossbite correction (blue-coloured occlusal pads); and (C) End result after 2.6 months.

After the completion of the data collection, the dental casts were scanned in the Dental School of the University of Bern, using a 3D surface scanner (stripe light/LED illumination; accuracy < 20 µm; Laboratory scanner D104a, Cendres+Métaux SA, Rue de Boujean 122, CH-2501 Biel/Bienne) to obtain the 3D Standard Tessellation Language (STL) models used in the study. Each maxillary 3D mesh consisted of approximately 325 000 vertices, and each mandibular consisted of 300 000 vertices. The dental casts were obtained according to the regular protocol of the practice, through alginate impressions (Tetrachrom Alginat, KANIEDENTA GmbH & Co. KG, Herford, Germany), which were poured with plaster (Alabaster Klasse 3, Wiegelmann Dental GmbH, Bonn, Germany) within the day when the impression was taken.

Data collection

The following data were collected at T0 and at T1: age, TMJ signs and symptoms (pain and noise at rest and during jaw movement), teeth in crossbite, overjet and overbite of all permanent upper incisors that were fully erupted, anterior and total maxillary and mandibular crowding, Angle Class (molars), duration of active treatment, patient compliance to appointments, teeth where the resin was placed, additions of occlusal bite plane performed due to losses or inadequate height, and length of follow-up.

Questionnaire data assessing pain and discomfort during mastication and speech, and TMJ pain were collected at T1.

Based on the results of a previous study (16), serial scanned 3D dental models obtained at T0 and T1 were superimposed on a small area of the palate including the medial two-third of the third rugae and the area 5 mm dorsal to them (Figure 2), using Viewbox 4 software (version 4.1.0.1 BETA, dHAL Software, Kifissia, Greece). Maximum congruence of the two models is expected in the specific reference area due to its anatomical form stability (17–22), which was also not directly affected by treatment (16).

The software's iterative closest point algorithm (ICP) (23) was implemented using the following settings: 100 per cent estimated overlap of meshes, matching point to plane, exact nearest neighbour search, 100 per cent point sampling, and 50 iterations. Furthermore, in the T0 model, the clinical crowns of the teeth of interest were selected to assess tooth movement that occurred due to treatment and growth from T0 to T1 (16). These were the permanent central incisors in crossbite at T0 and any contralateral tooth available in both models, which served as control. A control tooth was available in 11 patients, whereas in the rest 5 patients no such tooth was present in both casts. Thus, following each cast superimposition, the pre-selected teeth crowns of interest at T0 were superimposed individually on the respective teeth crowns at T1, using the same settings. The origin of the reference axes for recording tooth movement was positioned at the crown centroid of each tooth of interest on the T0 model (24). Two of the axes were placed on the occlusal plane, parallel and perpendicular to the midline palatal suture, and the third axis was perpendicular to these two (Figure 3). In this way, tooth translation and rotation (inclination, tip, and rotation) from T0 to T1 were recorded relative to a three-axis reference system.

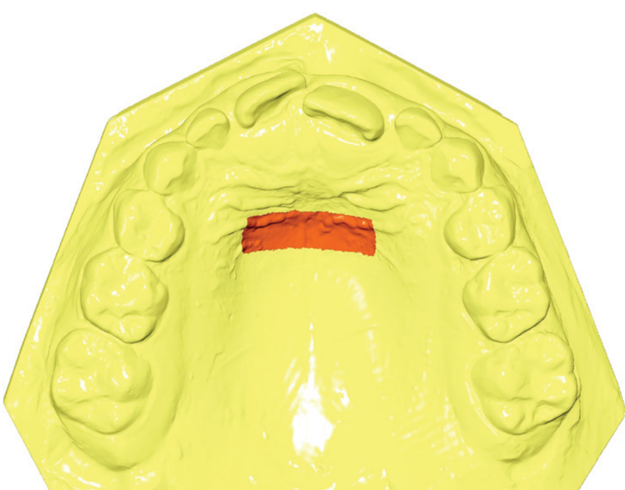

Figure 2. The palatal area used as reference for superimposition of serial models (red).

The potential movement (adaptation) of lower incisors following the crossbite correction was also tested in cases where one mandibular central incisor was in crossbite at T0, while the contralateral tooth was not, and these teeth had contact with the upper teeth in maximal intercuspation (n = 11, in 10 of them the crossbite was corrected; 2 were excluded due to cast imperfections in the mandibular incisor area). Since no morphologically stable areas are known in the mandibular casts of growing patients, to be used as superimposition references, superimpositions in the mandible were performed on all the available posterior teeth that were not significantly repositioned during the T0-T1 period, as assessed through visual inspection. The clinical crowns of these teeth were used for superimposition; the technique, including software settings and the origin and orientation of the reference axes where tooth movements were recorded, was similar to that used for the maxillary arch. In eight cases, the first permanent and the first and second primary molars were used, whereas in the remaining three, only the first permanent molars were used. These mandibular superimposition results were visually inspected by two researchers (G.V. & N.G.) and were judged to be satisfactory.

Statistical analysis

Statistical analysis was carried out by using the SPSS (v.20.0, SPSS Inc., USA) software. Raw data were tested for normality of distribution with the Shapiro-Wilk test; due to evidence of non-normality in some variables, parametric and non-parametric statistics were applied, as required.

To evaluate measurement error in overbite, overjet, and crowding evaluation, 30 measurements were repeated by the same examiner after a 2 week washout period. Intraexaminer agreement was tested with the paired Student's t-test and the intraclass correlation coefficient [intraclass correlation coefficient (ICC); absolute agreement, two-way fixed model]. Mean differences between repeated measurements were also calculated.

Results

The paired Student's t-test showed no statistically significant difference between the repeated measurements ($P > 0.05$). The ICC showed perfect agreement for overjet (mean: 0.95; 95 per cent confidence interval: 0.86–0.98), overbite (mean: 0.96; 95 per cent confidence interval: 0.88–0.99), and crowding (mean: 0.99; 95 per cent confidence interval: 0.98–0.99) measurements. The mean difference between repeated measurements was 0.03 mm (95 per cent confidence interval: −0.27–0.33) for overjet, 0.11 mm (95 per cent confidence interval: −0.05–0.26) for overbite, and −0.05 mm (95 per cent confidence interval: −0.18–0.08) for crowding.

In total, 16 patients with anterior crossbite, who fulfilled the inclusion criteria, were included in the study and there were no

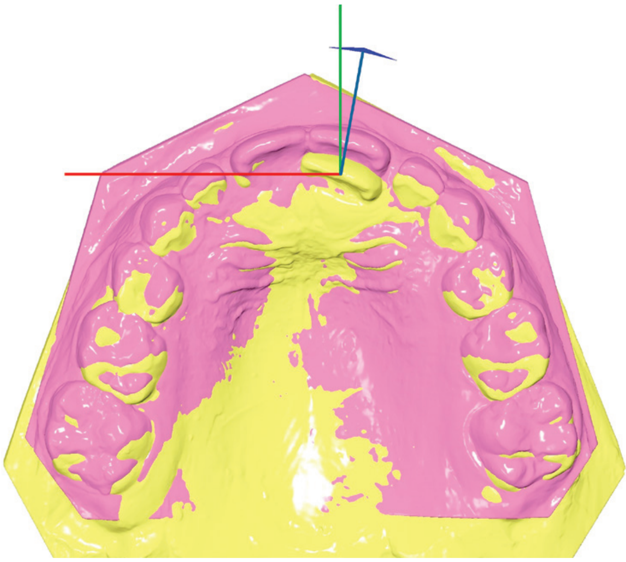

Figure 3. Superimposed pre-treatment (light green) and follow-up (purple) maxillary models. The axes where movement was recorded were parallel to the midline palatal suture (Y: green, antero-posterior movement; positive: anterior), perpendicular to the midline (X: red, lateral movement; positive: right), and perpendicular to the occlusal plane (Z: blue, vertical movement; positive: up). Rotation of each tooth around the X (red; inclination, positive: buccal crown for the maxilla and lingual crown for the mandible), Y (green; tip, positive: left for the maxilla and right for the mandible), and Z (blue; rotation, positive: right buccal) axis was also recorded.

drop-outs. In seven patients, occlusal resin was placed at the mandibular second primary molars, whereas in nine patients at the mandibular first permanent molars. In two patients, occlusal resin was lost twice and had to be replaced and in other four patients this happened once. Compliance of all 16 patients with recall appointments was good. In 14 of them, the anterior crossbite was corrected (87.5 per cent). Results remained stable during the follow-up period without using any retention regime. Patients were followed for a median of 9.6 (range: 6.0–19.9) months after the end of active treatment, which lasted 2.5 (range: 0.6–8.9) months concerning the 14 successfully treated cases. The detailed patient sample characteristics and treatment results are provided in Table 1.

In two cases, treatment did not succeed, and the crossbite was planned to be corrected at a later stage during full fixed appliance treatment, since no significant functional shift was present. Both had two anterior teeth in crossbite, whereas one case had a mild (1/4 cusp) Class III relationship both at T0 and T1. In contrast, most of the successfully treated cases had one tooth in crossbite, and no successful case had a Class III dental relationship (Table 1).

3D superimpositions of serial dental casts showed that crossbite correction of central incisors was achieved by a 2.05 mm (range: 0.97–5.45) forward movement and 9.25° (range: 2.32–14.52°) buccal inclination of the crowns. These values were significantly different from those of the contralateral control teeth that were not in crossbite (Table 2) (Figure 3). In one case, two corrected lateral incisors showed a similar correction (2.01 mm mean forward movement and 12.50° buccal crown inclination). A similar pattern of change in tooth position was observed in the central incisors of the two cases where treatment failed. 1.72 mm (range: 1.24–2.20) of forward movement and 6.31° (range: 5.52–7.09°) of buccal crown inclination were observed. However, this was not enough to achieve correction.

The mandibular central incisors that were the antagonists of the teeth in crossbite, moved −0.93 mm posteriorly (range: −2.39–−0.16) and showed 4.15° (range: −3.04–8.76°) lingual crown inclination. These values were significantly different from those of the contralateral control teeth that were the antagonists of teeth, which were not in crossbite (Table 3) (Figure 4).

Apart from 7 patients that reported moderate to severe discomfort during mastication (5–8 of 10) at the first week of treatment, no other important adverse events were reported by the patients (Table 4).

Discussion

The present study is the first to perform a prospective evaluation of the performance of a quite simple, non-compliance approach for treating anterior crossbite of dental origin in the mixed dentition. This concerned simply opening of the bite using cemented bite planes on the posterior teeth. Thus, this approach is expected to have much lower costs than the conventional approaches of removable or fixed appliances (25). Results were quite promising since the crossbite was corrected in 14 out of the 16 patients in a relatively short period of time, which was comparable to that required with the conventional approaches (26). No important adverse effects were reported by the patients apart from some discomfort during mastication on the first week of treatment, which was also documented previously for fixed appliance treatment of anterior crossbite (27). Results remained stable after treatment, which is also in line with the situation with conventional approaches (28). Furthermore, the technique for 3D superimposition and analysis of 3D dental models used here, which allows for precise evaluation of single tooth movement in all three planes of space, is suggested as a powerful tool for studying both clinical and research questions.

Raising the bite for anterior crossbite correction has been previously reported in a primary dentition case (29). Following case reports (14, 15) have shown favourable results of this technique also in the mixed dentition. However, no study has evaluated a cohort of such cases so far. Here, we prospectively followed a group of patients to assess the performance of this approach.

Based on the present results, this approach can be suggested for anterior crossbite correction during the early and intermediate mixed dentition phases in patients with Class I or Class II malocclusion and corresponding skeletal pattern. A prerequisite, met in all cases where this approach was implemented, was the availability of adequate space for the labial movement of the incisor, even in cases where lack of space was present in other places of the arch. All cases with a single tooth in crossbite were successfully treated (n = 11), whereas 2 out of the 5 cases with more than one teeth in crossbite failed. Thus, this approach is highly effective in cases with a single tooth in crossbite. Unfortunately, the cases which failed are too few to draw valid conclusions for the reasons of failure. However, from the available data we can suggest that through the present method, in most cases, crossbite correction is achieved within 3 months and in case of non-correction, one should not insist for a period longer than 9 months.

3D superimposition of the dental casts revealed the pattern of movement from the crossbite to the non-crossbite position and the consequent adaptive movements of the antagonists in the mandible. More technical details of this technique have been presented previously (16). In the present study, contralateral teeth within each jaw that were not in crossbite were used as controls. Results showed that correction was achieved by forward movement and buccal crown inclination of the maxillary teeth in crossbite, whereas the opposing mandibular teeth showed adaptive posterior repositioning and lingual crown inclination.

Table 1. Detailed patient sample characteristics. Regarding continuous variables, median values are presented, accompanied by range values shown in parentheses.

	Age at T0 (years)	Treatment duration (T0-Tf) (months)	Follow-up (Tf-T1) (months)	Teeth in crossbite at T0	Tooth type in crossbite at T0	Angle class at T0[a]	Overjet at T0[b] (mm)	Overjet at T1[b] (mm)	Overbite at T0[b] (mm)	Overbite at T1[b] (mm)	Maxillary crowding at T0 (mm)	Maxillary crowding at T1 (mm)	Mandibular crowding at T0 (mm)	Mandibular crowding at T1 (mm)
Treatment succeeded *N* = 14 (9 m, 5 f)	7.9 (6.2, 9.3)	2.5 (0.6, 8.9)	9.6 (6.0, 17.7)	1 (1, 4)	#21: *n* = 6, #11: *n* = 5, (#11, #21): *n* = 2, (#12-#22): *n* = 1	Class I: *n* = 11, ¼ Class II: *n* = 2, ½ Class II: *n* = 1	Crossbite: −1.5 (−1.1, −2.4) Control: 1.9 (0.4, 4.0)	Crossbite: 1.7 (0.1, 3.4) Control: 2.0 (0.5, 3.8)	Crossbite: 1.4 (−0.4, 3.3) Control: 1.4 (−1.5, 3.8)	Crossbite: 2.2 (0.0, 5.1) Control: 3.2 (0.0, 4.9)	Anterior: 0.3 (−4.5, 4.8) Total: 0.3 (−4.5, 6.2)	Anterior: 0.3 (−5.0, 4.7) Total: 0.3 (−5.8, 6.5)	Anterior: 0.5 (−3.1, 2.2) Total: 0.1 (−3.1, 2.6)	Anterior: −0.3 (−3.2, 1.6) Total: −0.3 (−3.2, 2.6)
Treatment failed *N* = 2 (2 m)	8.5 (8.1, 8.8)	10.3 (8.0, 12.5)	14.5 (9.1, 19.9)	2 (2, 2)	(#11, #21): *n* = 1, (#11, #12): *n* = 1	Class I: *n* = 1, ¼ Class III: *n* = 1	Crossbite: −2.4 (−1.7, −3.5) Control: -	Crossbite: −1.6 (0.7, −2.0) Control: -	Crossbite: 2.5 (1.0, 3.8) Control: -	Crossbite: 0.9 (0.1, 2.0) Control: -	Anterior: −3.0 (−4.8, −1.2) Total: −3.0 (−4.2, −1.8)	Anterior: −5.2 (−5.6, −4.8) Total: −0.7 (−1.9, 0.5)	Anterior: −1.4 (−2.2, −0.5) Total: −1.3 (−3.1, 0.5)	Anterior: −1.4 (−2.2, −0.5) Total: −1.3 (−3.1, 0.5)
Total *N* = 16 (11 m, 5 f)	8.0 (6.2, 9.3)	2.6 (0.6, 12.5)	9.6 (6.0, 19.9)	1 (1, 4)	-	-	Crossbite: −1.7 (−1.1, −3.5) Control: 1.9 (0.4, 4.0)	Crossbite: 1.6 (−2.0, 3.4) Control: 2.0 (0.5, 3.8)	Crossbite: 1.5 (−0.4, 3.8) Control: 1.4 (−1.5, 3.8)	Crossbite: 2.2 (0.0, 5.1) Control: 3.2 (0.0, 4.9)	Anterior: −0.4 (−4.8, 4.8) Total: −0.4 (−4.5, 6.2)	Anterior: −0.3 (−5.6, 4.7) Total: 0.3 (−5.8, 6.5)	Anterior: 0.1 (−3.1, 2.2) Total: 0.1 (−3.1, 2.6)	Anterior: −0.4 (−3.2, 1.6) Total: −0.3 (−3.2, 2.6)

The contralateral teeth were used as controls. M, males; f, females; Tf, Treatment finished.
[a]No change at T1.
[b]Measured at the central incisors in crossbite at T0.

Table 2. Movement of the corrected-maxillary teeth in crossbite compared with the contralateral control teeth of the 14 successfully treated cases.

		X (mm)	Y (mm)	Z (mm)	X-rotation (°)	Y-rotation (°)	Z-rotation (°)
Successful cases (*n* = 14)	Central incisor corrected (*n* = 14)[a]	−0.09 (−1.10, 0.79)	2.05 (0.97, 5.45)	−0.38 (−2.10, 2.41)	9.25 (2.32, 14.52)	1.84 (−8.00, 10.88)	−0.12 (−5.01, 4.22)
	Central incisor control (*n* = 10)	−0.18 (−0.84, 1.04)	0.29 (−0.63, 1.51)	−0.31 (−1.78, 1.97)	−1.31 (−7.44, 7.27)	1.79 (−8.11, 12.62)	−0.13 (−9.19, 9.61)
	P-value[b]	0.639	0.000*	0.815	0.000*	0.815	0.682

Median values are presented, accompanied by range values in parentheses.

X, lateral movement (positive: right); Y, antero-posterior movement (positive: anterior); Z, vertical movement (positive: up/apical); X-rotation, inclination (positive: buccal crown); Y-rotation, tip (positive: left); Z-rotation, rotation (positive: right buccal).

[a]In three cases, measurements of two such teeth were averaged.

[b]Mann–Whitney *U*-test.

$^*P < 0.05$.

Table 3. Movement of the antagonists of the maxillary teeth in crossbite.

	X (mm)	Y (mm)	Z (mm)	X-rotation (°)	Y-rotation (°)	Z-rotation (°)
Central incisor corrected (*n* = 11)[a]	0.09 (−0.42, 0.93)	−0.93 (−2.39, −0.16)	0.50 (−0.76, 1.95)	4.15 (−3.04, 8.76)	−1.77 (−3.66, 3.26)	0.18 (−5.43, 7.94)
Central incisor control (*n* = 9)[b]	−0.19 (−0.97, 0.37)	−0.26 (−1.25, 0.49)	0.39 (−0.29, 1.21)	−0.77 (−3.03, 3.07)	−1.85 (−3.67, 1.27)	−1.40 (−5.94, 4.99)
P-value[c]	0.342	0.025*	0.732	0.002*	0.849	0.239

The antagonists of contralateral teeth that were not in crossbite, or of teeth where crossbite was not corrected, were used as controls. All these teeth were mandibular central incisors. Median values are presented, accompanied by range values in parentheses.

X, lateral movement (positive: right); Y, antero-posterior movement (positive: anterior); Z, vertical movement (positive: up/occlusal); X-rotation, inclination (positive: lingual crown); Y-rotation, tip (positive: right); Z-rotation, rotation (positive: right buccal)

[a]In three cases, measurements of two such teeth were averaged.

[b]In one case, measurements of two such teeth were averaged. This was the only case of the group were antagonists of teeth in uncorrected crossbite was used.

[c]Mann–Whitney *U*-test.

$^*P < 0.05$.

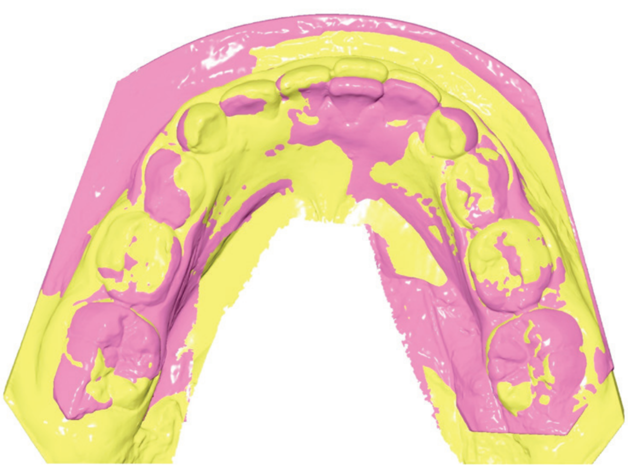

Figure 4. Superimposed pre-treatment (light green) and follow-up (purple) mandibular models on the first permanent and the first and second primary molars, showing the spontaneous lingual reposition of teeth 41 and 42, following the correction of the antagonist teeth in crossbite. Note that only minor tooth movement occurred at the contralateral teeth.

We assume that maxillary tooth movement was induced by tongue forces, exerted to the crossbite teeth during function, such as speech and swallowing, as well as during rest. Mandibular tooth movement could occur also as an adaptation to the new equilibrium established by the opening of the bite and the new position of the maxillary teeth (30). Another possibility could be that forces exerted during healing of the possible occlusal trauma of these lower incisors caused this reaction, as it has been shown previously for pathologically migrated teeth after periodontal treatment (31). Apart from the direct benefits deriving from anterior crossbite correction that were explained earlier, repositioning of the mandibular teeth within the arch could also be beneficial in terms of reducing the risk of recession (32). Indeed, a previous study (33) reported that 1 year following anterior crossbite correction, there was approximately a 1 mm reduction of vestibular recessions of these teeth, reduced mobility and thickening of the periodontal tissues, compared with pre-treatment condition and to the contralateral teeth that were not in crossbite. It was speculated that the normalization of the masticatory forces stabilized the tooth in the periodontium and led to the improvement of the periodontal status. However, in the present study, we showed spontaneous lingual repositioning of the lower incisors within the arch following the crossbite correction. Thus, we suggest that the improvement of the periodontal status can be attributed, among others, to the repositioning of the tooth in a more favourable position within the alveolar envelope (32). During correction and especially after removing the occlusal pads, temporary occlusal trauma may occur until the anterior teeth achieve a more stable occlusal relation. However, this occurs also inevitably during treatment with fixed appliances and is fully reversible (32).

Overeruption of teeth that do not bite with antagonists during treatment was not expected due to limited length of treatment. Indeed, minimal vertical changes in incisor position were evident

Table 4. Responses of patients to the questionnaire assessing adverse effects of treatment with 0 corresponding to 'not at all' and 10 corresponding to 'extreme'.

	Mastication pain	Mastication discomfort	Speech pain	Speech discomfort	TMJ Pain	Other remarks
First week	0 (0, 3)	3 (0, 8)	0 (0, 1)	0 (0, 3)	0 (0, 0)	–
Next weeks	0 (0, 0)	0 (0, 5)	0 (0, 1)	0 (0, 0)	0 (0, 0)	–

Median values are presented, accompanied by range values in parentheses.

during the observation period. For the same reason, any significant effect on vertical dimension of the face is also not expected. Previous studies have shown that even with more extensive approaches, it is difficult to change the vertical dimension of the face using conservative orthodontic approaches (34). On the other hand, overbite was increased during the observation period, as expected for this age group in untreated subjects (35, 36). This increase in overbite could also have contributed to the stable results achieved without any retention measure.

The main advantage of this approach is that minimum compliance is required. The patient should simply attend regular appointments and inform the practice if a bite plate is debonded, so that it can be timely replaced. Recent studies have shown that patients are not compliant with prescribed wear times even when they know that their compliance is objectively recorded (12). Patient compliance with removable appliances, which would be a valid alternative of the current approach, has been shown to be sufficient, in general, for retention purposes, but not adequate for active tooth movement (12). Regarding the second alternative for anterior crossbite correction, which is fixed appliance treatment, it would be beneficial in terms of adverse effects, patient compliance, and satisfaction, if orthodontists could avoid or reduce treatment time with fixed appliances (37, 38). In any case, most patients will inevitably receive fixed appliances following the establishment of permanent dentition for the correction of other orthodontic problems. Care providers also benefit from more efficient treatments (39).

Limitations

This was a prospective study following consecutively treated patients. However, although significant differences between test and control teeth were detected, the sample size could still be considered limited, especially regarding the cases where treatment failed. This did not allow for drawing safe conclusions regarding the reasons which could lead to failure. Furthermore, the questionnaire part used for assessing adverse effects was referring to the past, and thus results should be interpreted accordingly. Finally, comparisons of changes in tooth positions induced by treatment were performed with contralateral teeth of the same patient. No alternative treatment approach was tested. Comparative studies are needed to better understand the performance of this approach, in contrast also to other approaches.

Conclusions

Bite opening is a promising, simple approach for dental anterior crossbite correction in the mixed dentition, which has high success rates and requires minimum level of compliance. Correction was achieved by forward movement and buccal crown inclination of the maxillary teeth in crossbite, whereas the opposing mandibular teeth showed adaptive posterior repositioning and lingual crown inclination. Future comparative studies should test this approach in terms of effectiveness, efficiency, adverse effects, costs, and long-term stability, in comparison with common alternatives, such as removable Hawley type appliances with springs or expansion screws.

Conflict of Interest

None to declare.

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