Review

Functional changes after early treatment of unilateral posterior cross-bite associated with mandibular shift: a systematic review

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SUMMARY The objective of this systematic review was to investigate whether oral functional asymmetry in children treated for unilateral functional posterior cross-bite disappears after orthodontic treatment with a resulting normalisation of oral functions. A literature search was carried out using PubMed, Web of Science and the Cochrane Library to locate longitudinal studies reporting on clinical oral functional changes, recorded by methods including masseter muscle thickness, bite force, masticatory/chewing cycle or electromyographic masticatory muscle activity, following the treatment of unilateral functional posterior cross-bite. All potential articles were initially screened according to their title and abstract, the full text of selected articles was evaluated, and the final study selection was made based on the pre-defined criteria. Data extraction was subsequently carried out. The initial literature search identified 736 articles, with 12 articles fulfilling pre-defined criteria. Although there was a lack of high-quality prospective studies, based on the available evidence, results suggest that the abnormal masticatory cycle associated with functional posterior unilateral cross-bite tends to normalise following early cross-bite treatment. Masticatory muscle activity shows an increase after early functional unilateral posterior cross-bite treatment, and this activity approaches normal levels. Insufficient evidence was available to conclude on maximal molar bite force or masticatory muscle thickness changes following early treatment of functional unilateral posterior cross-bite. Results should be interpreted with caution due to the lack of high-quality controlled studies. Well-designed prospective studies with large patient samples and long-term follow-up are necessary before making reliable conclusions concerning change in functional asymmetry following unilateral functional posterior cross-bite correction.

KEYWORDS: systematic review, unilateral posterior cross-bite, maxillary expansion, bite force, electromyography, ultrasound, masticatory cycle, chewing cycle

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Introduction

Posterior cross-bite is reported to occur in approximately 8–22% of malocclusions (1, 2). Most commonly, in 80–97% of cases, posterior cross-bite in growing individuals presents as a functional cross-bite, implying that the cross-bite is associated with a functional mandibular shift (3). The presence of functional cross-bite seems to decrease in prevalence from the deciduous to the mixed dentition (1, 3, 4).

Functional posterior cross-bites have a component of mandibular functional lateral shift towards the cross-bite side (1, 3, 5). This is usually associated with
asymmetric activity of the masticatory muscles (6, 7). Children with unilateral posterior cross-bite have a tendency towards irregular, reverse or contralateral masticatory cycles due to the functional mandibular shift (8–10). Functional and dental asymmetry may lead to reverse-sequencing chewing cycles on the cross-bite side (10).

Asymmetric functional activity of the masticatory muscles has been recorded by surface electromyography (sEMG) measurements comparing the cross-bite and non-cross-bite sides (7, 11). This asymmetric activity can result in thinner masticatory muscles on the cross-bite side (12, 13) than on the normal side. The differences between the cross-bite and non-cross-bite sides in masseter muscle thickness may also result in a decrease in maximal molar bite force when compared to control children without cross-bite (12, 14). As the elevator masticatory muscles on the cross-bite side ‘train’ to a lesser degree than those on the normal side, this may lead to thinner masticatory muscle fibres (15) and lower bite force levels (16).

A previous systematic review (17) looking into the relationship between posterior cross-bite and functional aberrations found that children with posterior cross-bite can have reduced bite force and asymmetric muscle function during chewing or clenching. Nevertheless, this systematic review was mainly based on cross-sectional functional observations in the presence of a posterior cross-bite rather than functional changes subsequent to cross-bite treatment. The question arising is one of cause and effect, and whether a pre-existing functional muscular asymmetry leads to the development of a cross-bite, or whether the creation of a cross-bite due to problems such as bad habits leads to functional asymmetry. Our assumption, although not directly evaluated in the present study, is that a cross-bite may lead to an oro-facial functional asymmetry. The present hypothesis is therefore that with treatment of the functional unilateral posterior cross-bite and elimination of the functional mandibular shift, normalisation of the oro-facial functional asymmetry occurs.

The aim of the present study was to investigate, using systematic review methodology, whether in children treated orthodontically for unilateral posterior cross-bite, the functional asymmetry disappears after treatment, resulting in a normalisation of muscle function.

Materials and methods

The reporting of the present systematic review was based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines (18). A review protocol was not published and the study was not registered.

Search strategy

A literature search was carried out, by two independent reviewers, using PubMed, Web of Science and the Cochrane Library with the last search being carried out in March 2014, and updated on January 2015. The keywords used were a combination of ‘posterior crossbite’ or ‘maxillary expansion’ and one of the following search terms: ‘early treatment’; ‘muscle thickness’; ‘bite force’; ‘masticatory cycle’; ‘reverse-chewing cycle’; ‘electromyography’; ‘ultrasound’. Studies were retrieved with no date, language or publication status restrictions. Reference list of selected articles were hand-searched to locate other potentially relevant articles, as were authors names having worked significantly in the field of study.

Eligibility criteria

Eligibility criteria, which were defined prior to undertaking the literature search, were the following.

1 Types of studies: Longitudinal prospective studies evaluating functional outcomes both prior to and following the treatment of functional unilateral posterior cross-bite in growing children. No language, publication date or publication status restrictions were imposed. Cross-sectional studies were excluded.

2 Types of participants: Only studies carried out on growing children were included so that maxillary expansion would be possible without surgically assisted procedures. Adults, as well as studies including patients with cleft lip and palate, craniofacial syndromes, or medical compromised patients were excluded. Animal studies were equally excluded. Only studies with more than 10 children were included, excluding case reports or case series.

3 Types of intervention: Treatment of functional unilateral posterior cross-bite in the primary or mixed dentition in children to eliminate a functional unilateral posterior cross-bite.
permanent dentition was excluded, as was treatment of anterior, and not posterior, cross-bite.

4 Types of outcome measures: The outcome of interest was the functional measurement (representing muscles or chewing cycle), by one of various methods, before and after functional unilateral posterior cross-bite treatment.

Study selection

The study selection was carried out by two independent reviewers. Initially, all potential articles were screened according to their title and abstract. Following this primary selection, the full text of all selected articles was evaluated, and the final selection was made based on the pre-defined eligibility criteria. If there was disagreement between the reviewers, they met to reach a consensus decision.

Data collection

The following data were extracted from each of the included articles:

1 Publication data;
2 Number of patients;
3 Age of patients;
4 Control groups;
5 Treatment characteristics;
6 Outcome: functional measurements;
7 Time points of measurements; and
8 Main findings

The selected articles, based on the functional measurements, were subsequently divided into four groups:

1 Masticatory/chewing cycle;
2 sEMG;
3 Muscle thickness by means of ultrasound; and
4 Bite force.

Risk of bias in individual studies

A risk of bias assessment was carried out as proposed by Andrade et al. (17), which was based on pre-established characteristics (19, 20). This assessment evaluated study design, sample size, selection description, measurement methods, blinding, statistics and the presence of confounding factors. A point system was used categorising the quality of each study as low, medium or high.

Summary measures and synthesis of results

The difference in means was the main intended summary measure, comparing pre-treatment and post-treatment functional measurements. Combining the results in the form of a meta-analysis using the random-effects model was planned if enough studies were located within each individual functional measurement and if homogeneity could be assumed.

Results

Study selection

The initial literature search identified a total of 736 articles. From these articles, 35 were pre-selected based on the title and abstract. Following this, based on the preset eligibility criteria, a total of 12 articles were selected for final inclusion (Fig. 1). Articles excluded following the initial pre-selection are listed in Table 1 with reasons for exclusion. According to the functional measurements recorded, the included articles were divided with a total of 6 articles pertaining to the masticatory/chewing cycle, 3 articles pertaining to sEMG measurements, 1 article pertaining to the masticatory/chewing cycle and to sEMG measurements, 1 article pertaining to masseter muscle thickness measurements and bite force measurements and 1 article pertaining to bite force measurements. As can be understood by the above description, two studies used more than one functional measurement.

Fig. 1. Flow diagram summarising literature search.
The characteristics of the included studies are presented in Table 2. The sample sizes ranged from 14 to 280 patients with patients treated when they were from 4 to 13 years of age, using a number of appliances such as the quadhelix, expansion plates, a modified Haas expander, a fixed edgewise bracket system and occlusal grinding. Five studies (42%) had control groups.

### Study characteristics

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#### Table 1. List of excluded articles listed in alphabetical order of first author, with the principal reason for exclusion

<table>
<thead>
<tr>
<th>Author/year</th>
<th>Article title</th>
<th>Reason for exclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alarcón et al., 2000</td>
<td>Effect of unilateral posterior cross-bite on the electromyographic activity of human masticatory muscles</td>
<td>Cross-sectional</td>
</tr>
<tr>
<td>Andrade et al., 2009</td>
<td>Electromyographic activity and thickness of masticatory muscles in children with unilateral posterior cross-bite</td>
<td>Cross-sectional</td>
</tr>
<tr>
<td>Andrade Ada et al., 2010</td>
<td>Characteristics of masticatory muscles in children with unilateral posterior cross-bite.</td>
<td>Cross-sectional</td>
</tr>
<tr>
<td>Arat et al., 2008</td>
<td>Muscular and condylar response to rapid maxillary expansion. Part 1: electromyographic study of anterior temporal and superficial masseter muscles</td>
<td>Both unilateral and bilateral cross-bite children</td>
</tr>
<tr>
<td>Castelo et al., 2007</td>
<td>Masticatory muscle thickness, bite force and occlusal contacts in young children with unilateral posterior cross-bite</td>
<td>Cross-sectional</td>
</tr>
<tr>
<td>Castelo et al., 2008</td>
<td>Facial dimensions, bite force and masticatory muscle thickness in preschool children with functional posterior cross-bite</td>
<td>Cross-sectional</td>
</tr>
<tr>
<td>Castelo et al., 2010</td>
<td>Maximal bite force, facial morphology and sucking habits in young children with functional posterior cross-bite</td>
<td>Cross-sectional</td>
</tr>
<tr>
<td>Castelo et al., 2010</td>
<td>Evaluation of facial asymmetry and masticatory muscle thickness in children with normal occlusion and functional posterior cross-bite</td>
<td>Cross-sectional</td>
</tr>
<tr>
<td>de Boer and Steenks, 1997</td>
<td>Functional unilateral posterior cross-bite. Orthodontic and functional aspects</td>
<td>Study not directly measuring functional factors</td>
</tr>
<tr>
<td>Gumossoy et al., 2014</td>
<td>Ultrasonography in the evaluation of the mid-palatal suture in rapid palatal expansion</td>
<td>Study not directly measuring functional factors</td>
</tr>
<tr>
<td>Kiliaridis et al., 2007</td>
<td>Ultrasonographic thickness of the masster muscle in growing individuals with unilateral cross-bite</td>
<td>Cross-sectional</td>
</tr>
<tr>
<td>Lam et al., 1999</td>
<td>Mandibular asymmetry and condylar position in children with unilateral posterior cross-bite</td>
<td>Study not directly measuring functional factors</td>
</tr>
<tr>
<td>Lindner et al., 1986</td>
<td>Maxillary expansion of unilateral cross-bite in preschool children</td>
<td>Study not directly measuring functional factors</td>
</tr>
<tr>
<td>Lippold et al., 2008</td>
<td>Analysis of condylar differences in functional unilateral posterior cross-bite during early treatment – a randomised clinical study</td>
<td>Study not directly measuring functional factors</td>
</tr>
<tr>
<td>Lippold et al., 2013</td>
<td>Early treatment of posterior cross-bite – a randomised clinical trial</td>
<td>Study not directly measuring functional factors</td>
</tr>
<tr>
<td>Martín et al., 2000</td>
<td>Kinesiographic study of the mandible in young patients with unilateral posterior cross-bite</td>
<td>Cross-sectional</td>
</tr>
<tr>
<td>Pinto et al., 2001</td>
<td>Morphological and positional asymmetries of young children with functional unilateral posterior cross-bite</td>
<td>Study not directly measuring functional factors</td>
</tr>
<tr>
<td>Perttiniemi et al., 1990</td>
<td>Relationship between craniofacial and condyle path asymmetry in unilateral cross-bite patients</td>
<td>Cross-sectional</td>
</tr>
<tr>
<td>Primozic et al., 2009</td>
<td>Early cross-bite correction: a three-dimensional evaluation</td>
<td>Study not directly measuring functional factors</td>
</tr>
<tr>
<td>Primozic et al., 2013</td>
<td>Three-dimensional evaluation of early cross-bite correction: a longitudinal study</td>
<td>Study not directly measuring functional factors</td>
</tr>
<tr>
<td>Sever et al., 2011</td>
<td>Relationship between masticatory cycle morphology and unilateral cross-bite in the primary dentition</td>
<td>Cross-sectional</td>
</tr>
<tr>
<td>Sonnesen et al., 2001</td>
<td>Bite force in pre-orthodontic children with unilateral cross-bite</td>
<td>Cross-sectional</td>
</tr>
</tbody>
</table>
Risk of bias and synthesis of results

The results of the assessment of within-study bias by means of a quality assessment are shown in Table 2 with studies being given a grading of low, medium or high quality. None of the studies were graded as high quality. The majority of the studies \((n = 9)\) were of medium quality, while three were of low quality. Synthesis of results by means of a meta-analysis was not possible due to the large heterogeneity between studies in terms of samples, methods and functional measurements. Instead, a crude evaluation of each functional measurement was carried out whereby studies finding no differences following treatment were weighted against those finding differences following treatment to come up with an overall result (Table 3). Where only one study was present, there was considered to be not enough evidence.

Results of individual studies

Masticatory/chewing cycle. Concerning assessment of the masticatory cycle before and after the treatment of posterior cross-bite, seven relevant studies were identified \((8–10, 21–24)\). Six of the studies looked at subjects treated with expansion of the upper dental arch with the use of an appliance, and one study looked at subjects where occlusal grinding had been performed to resolve the functional unilateral posterior cross-bite. Only four of the studies included a comparison to an untreated control group.

All of the included articles found that before treatment, there was a higher prevalence of a reverse-cycle chewing pattern in the cross-bite samples than in normal control children \((8–10, 24)\) or in the cross-bite versus the non-cross-bite side \((21–23)\). After the completion of treatment, however, there was a normalisation of the chewing pattern in four studies \((21–24)\), whereas the remaining three studies \((8–10)\) found that although treatment tended to lower the prevalence of the reverse-cycle chewing pattern, it did not lead to a normalisation of the patients’ abnormal cycle shape (in comparison with control individuals or the non-cross-bite side). In these studies, the prevalence of the reverse-cycle chewing pattern was still apparent more often in the treated cross-bite side than in the normal control groups or the initially non-cross-bite sides of the patients.

sEMG. Four articles fulfilled our eligibility criteria and had evaluated masticatory muscle activity using sEMG \((7, 11, 24, 25)\). The treatment used in these studies was maxillary expansion with retention after the end of the treatment. Two of the four studies included control groups in their study design.

All four studies performed sEMG measurements in the rest position. The asymmetric activity of the masseter and temporalis muscles in three of the studies was normalised following treatment \((7, 11, 24)\). Nevertheless, one study \((25)\) showed a normalisation only of masseter muscle and no significant changes with regard to the temporalis muscle.

sEMG measurements were recorded during mastication in three of the four included articles. Two studies found an elimination of the functional asymmetry in masseter and temporalis muscle activity following cross-bite treatment \((11, 24)\), while one study found that this establishment of functional symmetry was maintained 12 months after treatment \((24)\). On the other hand, one study did not find any significant difference of the functional asymmetry in masseter and temporalis muscle activity immediately after cross-bite treatment \((25)\).

sEMG measurements during clenching were carried out by all four studies \((7, 11, 24, 25)\) with similar results reported. Following cross-bite treatment, the masseter and temporalis muscles in the cross-bite side showed a normalisation of the initial asymmetric muscle activity.

sEMG measurements during swallowing were also measured in two studies. One study \((7)\) found no difference in masseter of temporalis activity between the cross-bite and non-cross-bite sides either before or after treatment. On the contrary, the other study \((24)\) suggested that the asymmetric activity of the masseter and temporalis muscles before treatment was eliminated by treating the cross-bite.

Masticatory muscles thickness. Regarding masticatory muscle thickness in children with functional unilateral posterior cross-bite measured with ultrasonography, only one study fulfilled our eligibility criteria \((26)\). This study, however, did not present cross-bite and non-cross-bite side muscle thickness findings separately and did not include a control group making it impossible to draw any conclusions.

Bite force. In relation to bite force and its changes following treatment in children with functional uni-
<table>
<thead>
<tr>
<th>Author/ year</th>
<th>Functional measurements</th>
<th>Sample</th>
<th>Mean age</th>
<th>Control group</th>
<th>Appliance used for expansion</th>
<th>Time point: before/after/post</th>
<th>Quality assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ben-Bassat et al., 1993</td>
<td>Masticatory cycle</td>
<td>$n = 65$ (36 females, 29 males) ($n = 75$ in mixed dentition)</td>
<td>8 - 8 ± 1.6 years</td>
<td>$n = 10$ (5 females, 5 males)</td>
<td>Removable appliance with or without occlusal coverage</td>
<td>Yes/Yes/-</td>
<td>Medium</td>
</tr>
<tr>
<td>Brin et al., 1996</td>
<td>Masticatory cycle</td>
<td>$n = 24$ (17 females, 7 males) ($n = 34$ in mixed dentition)</td>
<td>9.5 years</td>
<td>$n = 10$ (5 females, 5 males) mean age: 9.8 years</td>
<td>Removable expansion plate</td>
<td>Yes/-/6 months</td>
<td>Medium</td>
</tr>
<tr>
<td>Castelo et al., 2010</td>
<td>Bite force/ Muscle thickness</td>
<td>$n = 23$ (14 females, 9 males) a) deciduous $n = 11$ b) mixed $n = 12$</td>
<td>a) 5.0 ± 0.4 years b) 6.0 ± 0.6 years</td>
<td>None reported</td>
<td>Removable expansion plate</td>
<td>Yes/-3 months and 6 months</td>
<td>Low</td>
</tr>
<tr>
<td>De Rossi et al., 2009</td>
<td>sEMG</td>
<td>$n = 27$ (15 females, 12 males) ($n = 27$ in mixed dentition)</td>
<td>8 - 6 years (Range 6.9 - 10.9 years)</td>
<td>None reported</td>
<td>Bonded acrylic-splint appliance</td>
<td>Yes/Yes/-</td>
<td>Medium</td>
</tr>
<tr>
<td>Kecik et al., 2007</td>
<td>sEMG</td>
<td>$n = 35$ (20 females, 15 males) ($n = 66$ in mixed dentition)</td>
<td>10.6 ± 1.4 years</td>
<td>$n = 31$ (18 females, 13 males) mean age: 9.8 ± 1.6 years</td>
<td>Quadhelix</td>
<td>Yes/-3 months</td>
<td>Medium</td>
</tr>
<tr>
<td>Maffei et al., 2014</td>
<td>sEMG</td>
<td>$n = 14$ (8 females, 6 males) ($n = 14$ in mixed dentition)</td>
<td>9 years (Range 6.4 - 13.5 years)</td>
<td>None reported</td>
<td>Modified Haas Expander</td>
<td>Yes/Yes/-</td>
<td>Low</td>
</tr>
<tr>
<td>Martin et al., 2012</td>
<td>sEMG/ Masticatory cycle</td>
<td>$n = 25$ (15 females, 10 males) ($n = 55$ in mixed dentition)</td>
<td>12.5 years (Range 10 - 14 years)</td>
<td>$n = 30$ (15 females, 15 males) age-matched</td>
<td>Quadhelix and fixed edgewise bracket system</td>
<td>Yes/Yes/1 year</td>
<td>Medium</td>
</tr>
</tbody>
</table>
lateral posterior cross-bite, we identified two studies (26, 27). The results of one of the studies (26), however, could not be considered as reliable in the present systematic review as the authors did not present cross-bite and non-cross-bite side bite force findings separately and did not include a control group making it impossible to draw any conclusions.

The only remaining study (27) found that maximum bite force at the level of the first molars was lower in the cross-bite than in the non-cross-bite side before treatment, but this was not statistically significant. Following treatment, the bite force remained lower (statistically significant) on the cross-bite side, but after four months of retention, there were no differences in bite force between the cross-bite than non-cross-bite sides. Moreover, there was a significant increase in bite force in the cross-bite side from the end of treatment to four months after retention, whereas this was not the case in the non-cross-bite side. Nevertheless, the bite force level before treatment, after expansion and after retention was significantly lower in the cross-bite children when compared to untreated children with normal occlusion.

Discussion

Summary of evidence

The present systematic review aimed to identify all longitudinal prospective studies investigating functional changes following the early treatment of
functional unilateral posterior cross-bite. The outcomes evaluated were masticatory cycle, sEMG activity, masticatory muscle thickness and bite force. The outcomes of the seven included articles assessing the masticatory cycle varied with some suggesting a normalisation of the masticatory cycle, while others proposing that the frequency of reverse-cycle chewing pattern, although it was reduced, was maintained even after cross-bite treatment. When evaluating all of the evidence, however, more evidence points towards the normalisation of the masticatory cycle following early functional unilateral posterior cross-bite treatment. Four studies looking into temporalis and masseter muscle sEMG activity during the rest position, mastication, clenching or during swallowing, all provided similar general results. After the end of cross-bite treatment, any pre-existing asymmetries in muscle activity between the cross-bite and non-cross-bite sides were normalised. We could not arrive at any reasonable conclusions concerning masseter muscle thickness due to the absence of any assessable studies. The only article evaluated that looked at bite force found a mean increase in bite force on the cross-bite side following cross-bite correction and thus a normalisation of this functional variable. However, due to the presence of only one article on this subject, the evidence was considered to be insufficient to draw any reasonable conclusions.

Summarising the results, after the early treatment of functional unilateral posterior cross-bite, it can be said that there is normalisation of the pre-treatment functional asymmetry, suggesting that the structural asymmetry, namely the unilateral posterior cross-bite, pre-exists the oro-facial functional asymmetry and not the other way around. If the causality was the other way around, then one could expect that the oro-facial functional asymmetry would be maintained even following cross-bite treatment.

Unilateral functional posterior cross-bite is associated with a habitual mandibular shift. This mandibular shift leads to an asymmetric activity of the masticatory muscles and thus an asymmetric training effect as recorded by maximal molar bite force measurements. However, orthodontic treatment of the unilateral posterior cross-bite eliminates the need for the functional mandibular shift. This brings about an eventual symmetrical functional charge of the muscles and a symmetrical training effect of the muscles, given the appropriate length of time for the muscles to recover.

**Limitations**

Our systematic review has several limitations. The quality of the included studies varied from medium to low, without any high-quality studies located. Moreover, the numbers of studies identified were very few, and their methodologies and reporting of the results were not homogeneous. Sample sizes were often inadequate and confounding factors were not considered in any study. An error of the method analysis also was included in five of the twelve included studies, similarly to the inclusion of a control group which was only found in five of the twelve studies.

Temporomandibular disorders, such as masticatory muscle pain and disc displacement, were not at all examined in the current study. However, a recent systematic review (28) has nicely covered these areas and so it was chosen not to include studies looking into these factors of the masticatory system. The authors of that study reported that it was not possible to establish an association between posterior cross-bite, muscle pain and disc displacement.

The potential influence of different orthodontic treatment modalities to correct functional unilateral posterior cross-bite in children cannot be overlooked. The type of treatment and the appliance used varied between the different studies included in the present systematic review. One might argue that some of the differences in the findings among studies could be related to a specific treatment modality. Given that
the correction of functional unilateral posterior cross-bite was desired in each treated sample and that this was achieved, thus eliminating the functional mandibular shift, there is no reason to believe that this is the case. More likely is the notion that the selection of the sample in each study may have influenced the findings, and this may be more relevant than the specific type of treatment as patient characteristics are often more deterministic of outcome than treatment characteristics.

Future research

Well-planned and controlled prospective longitudinal studies, using randomisation if possible, should be undertaken to answer the question of changes in functional asymmetry following early treatment of functional unilateral posterior cross-bite. Examiners should be blinded whenever possible, sample sizes should be adequate and determined using appropriate sample size estimation methods, and error of the method measurements should be systematically carried out. Studies investigating multiple functional outcomes would also be useful. Normal functional changes due to growth should not be overlooked. Finally, long-term studies should be carried out where patients are long out of retention to investigate the stability of any functional changes, provided that the cross-bite correction has remained stable.

Conclusions

1. The abnormal masticatory cycle (reverse-pattern chewing cycle) associated with functional posterior unilateral cross-bite tends to normalise following early cross-bite treatment.
2. Masticatory muscle activity shows an increase after early functional unilateral posterior cross-bite treatment, and this activity approaches normal levels.
3. There is lack of evidence describing changes in maximal molar bite force or masticatory muscle thickness following early treatment of functional unilateral posterior cross-bite.
4. The presence of a unilateral posterior cross-bite pre-exists the functional asymmetry, and treating the cross-bite can also normalise asymmetric functional aberrations.

Ethical approval

Ethical approval is not applicable for this type of research.

Funding

This research was carried out without funding.

Conflicts of interest

The authors declare no conflict of interests.

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12. Castelo PM, Gavião MB, Pereira LJ, Bonjardim LR. Masticatory muscle thickness, bite force, and occlusal contacts in


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