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## Original article

# Slow or rapid palatal expansion for early treatment of unilateral posterior crossbite? Evaluation of the reverse chewing cycles correction

Maria G. Piancino\*, Francesca Talpone, Teresa Vallelonga, Gianluigi Frongia, Cesare L. Debernardi, Pietro Bracco

Chair Department of Orthodontics and Gnathology-Masticatory Function, University of Turin, Italy

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## ABSTRACT

**Objectives:** It is well established that patients with a unilateral posterior crossbite, when chewing on the affected side, show an increased frequency of reverse chewing cycles. It was hypothesized that the correction of reverse cycles may be due to the characteristics of the therapy. The aim was to investigate the prevalence of reverse chewing patterns in children with unilateral posterior crossbite before and after treatment with Function Generating Bite (FGB).

**Materials and methods:** Twenty children, (9 boys, 11 girls; age, mean  $\pm$  SD,  $7.5 \pm 1.1$ ), 10 with a right and 10 with a left posterior unilateral crossbite were selected. Mandibular movements during chewing soft and hard boluses were measured with a kinesiograph (K7 -I, Myotronics Inc. Tukwila, Washington, USA).

**Results:** The results showed a significant difference when comparing the percentage of reverse chewing patterns, before and after therapy with FGB, during chewing on the crossbite side both with soft and hard bolus ( $p < 0.0001$ ). No significant differences were observed during chewing on the non-crossbite side.

**Discussion:** The results of this study confirmed that FGB corrects both the dental and functional asymmetries. Knowing that the rapid palatal expansion does not correct the masticatory function, it is of clinical relevance, for the orthodontists, the knowledge and the understanding of the functional outcomes with different therapies.

**Conclusions:** The type of treatment and the biomechanics of the appliance used are of great importance for the correction of the reverse chewing cycles and for rebalancing the functional asymmetry of children with unilateral posterior crossbite.

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\* Corresponding author: Dental School Department of Orthodontics and Gnatology, University of Turin, via Nizza 230 - 10126 Torino, Italy.

E-mail address: [mariagrazia.piancino@unito.it](mailto:mariagrazia.piancino@unito.it) (M.G. Piancino).

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## 1. Introduction

Recent papers have been written evaluating the short and long term effects of the crossbite correction using slow or rapid palatal expansion<sup>1–4</sup>.

The studies on the rapid palatal expansion show significant changes after therapy regarding the palate and airways dimensions, but the long term effects are not in agreement and some improvements are not maintained over the years<sup>3,5–8</sup>. Studies about slow expansion are not homogeneous<sup>9–11</sup>.

Despite unclear results<sup>11,12</sup>, slow and rapid expansion of the maxilla are among the most used orthodontic treatment all over the world, due to the fact that decreased maxillary transverse dimension, narrow palate and dental crossbite relationship in the frontal plane are often associated and are common malocclusions to deal with in the everyday practice<sup>11,12</sup>. The prevalence of crossbite has been established in literature in a range of 8–22%<sup>13</sup> depending on the areas and population characteristics.

Half of the crossbites are classified as unilateral posterior crossbites, meaning that they involve one or more teeth in the premolar and/or molar region of one side only of the dental arch<sup>14</sup>. This malocclusion may appear at a very early stage in development, during the eruption of the primary teeth and, later, it can involve the permanent dentition as well. It may originate from a skeletal or dental malrelationship, or both, and may lead to a mandibular displacement and/or a skeletal asymmetry.

For these reasons it is considered a worsening malocclusion, leading to an irreversible structural asymmetry at the end of growth, which may or may not be compensated in adulthood and increasing the risk of developing a temporomandibular disorder<sup>15–19</sup>.

It is well established that patients with a unilateral posterior crossbite, when chewing on the affected side, show an increased frequency of reverse sequencing chewing cycles in the frontal plane<sup>20–23</sup>. Reverse chewing cycles are characterized by altered muscular activation corresponding to altered kinematics and altered pattern morphology<sup>24</sup>. They occur on the crossbite side only, being the chewing cycles on the non-affected side normal; this is the reason why a unilateral posterior crossbite is characterized by dental and functional asymmetries<sup>25</sup>.

Dental and skeletal asymmetries may be prevented by early orthodontic therapy<sup>23,26–30</sup>, we know that the most common therapies successfully used by orthodontists to correct dental crossbite, do not rebalance the functional asymmetries after therapy<sup>20,23,31</sup>.

In this study, it was hypothesized that the correction of reverse chewing cycles may be due to the characteristics of the therapy.

The aim of this study was to investigate the prevalence of reverse sequencing chewing cycles in children with a unilateral posterior crossbite before and after slow expansion therapy with Function Generating Bite (FGB) to evaluate if the appliance corrects not only the dental malocclusion, but the masticatory asymmetry as well.

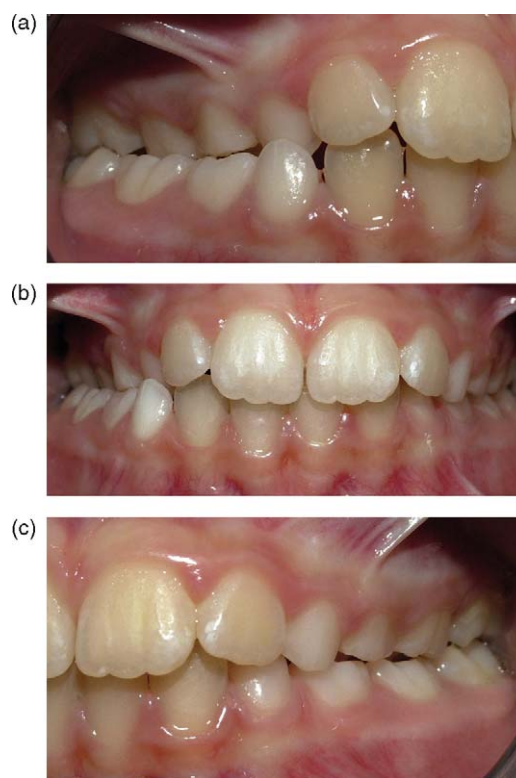
## 2. Materials and methods

Twenty children, (9 boys, 11 girls; age, mean  $\pm$  SD,  $7.5 \pm 1.1$ ), 10 with a right and 10 with a left posterior unilateral crossbite were selected from patients referred to the Department of Orthodontics, University of Turin, Italy. Before entering the study, informed consent was obtained from all parents.

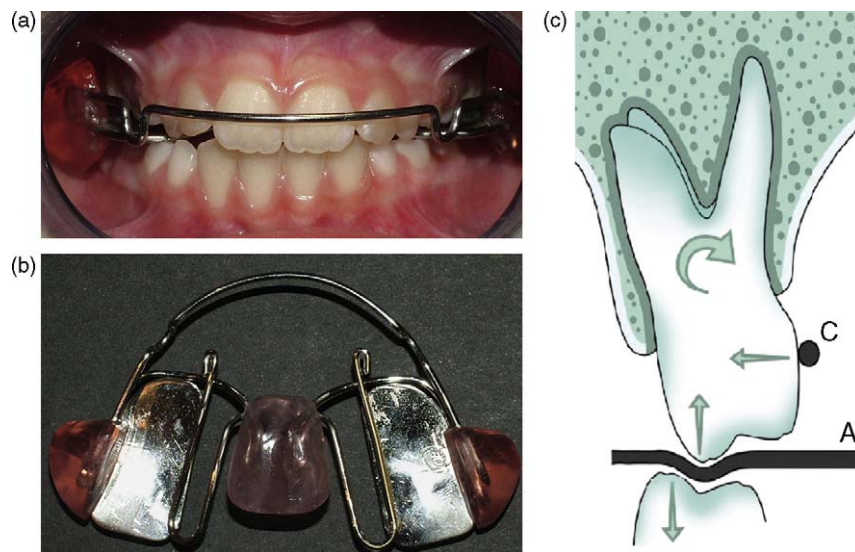
The inclusion criteria were: right or left unilateral posterior crossbite, mixed dentition, without any sign or symptom of myofascial disorders and no previous orthodontic therapy.

Each patient was treated with the functional appliance: "Function Generating Bite" (FGB) (Fig. 2a). The appliances were individually manufactured<sup>32</sup> and made of acrylic resin and resilient stainless steel, with posterior metallic bite planes preventing the teeth from intercusp contact (Fig. 2b,c). At the end of treatment, the buccal cusps of the upper teeth, which were previously in crossbite (Fig. 1a,b,c), overlapped the lower teeth (Fig. 3 a,b,c), thus providing the appropriate physiological stimuli from peripheral receptors and proprioceptors. The recordings of chewing cycles were carried out before treatment and after 4 months retention of the correction of the malocclusion.

Mandibular movement was measured with a kinesiograph (K7 -I, Myotronics Inc. Tukwila, Washington, USA) which measures jaw movements within an accuracy of 0.1 mm<sup>33</sup>. Subjects were instructed to chew for a time-period of 10 s for each experimental session with a soft (chewing gum) and then



**Fig. 1 – Right unilateral posterior crossbite malocclusion of a child 7,2 years old, before therapy. a) right lateral view, b) frontal view c) left lateral view.**



**Fig. 2 – Function Generating Bite (FGB): a) FGB in the mouth; b) view of the appliance from above; c) biomechanics of the appliance.**

with a hard (winegum) bolus. The kinematic signals were analyzed with custom made software (University of Turin, Torino, Italy).

The statistical analysis was performed by the chi-square test to evaluate differences in the percentage of reverse chewing cycles before and after therapy.

### 3. Results

The results showed a significant difference when comparing the percentage of reverse chewing patterns in the frontal plane, before and after therapy on the crossbite side. Before therapy the percentage of reverse chewing cycles was 66 per cent when chewing a soft and 70 per cent when chewing a hard bolus. After therapy it was 12 per cent ( $p < 0.0001$ ), and 13 per cent ( $p < 0.0001$ ) respectively.

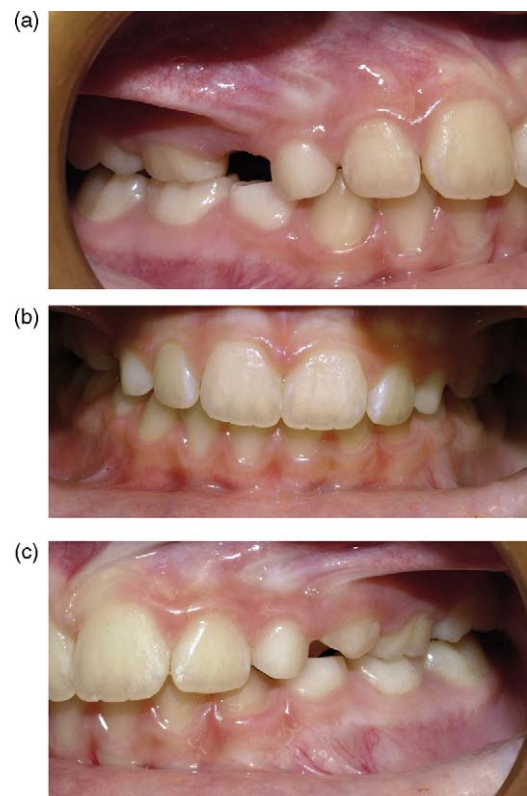
No statistically significant differences were observed, during chewing on the non-crossbite side, before and after therapy. The percentage of reverse chewing cycles was 11 per cent for both the soft and hard bolus before therapy, 12 per cent for soft ( $p < 0.8$ ) and 10 per cent for hard bolus ( $p < 0.3$ ) after therapy. (Fig. 5)

### 4. Discussion

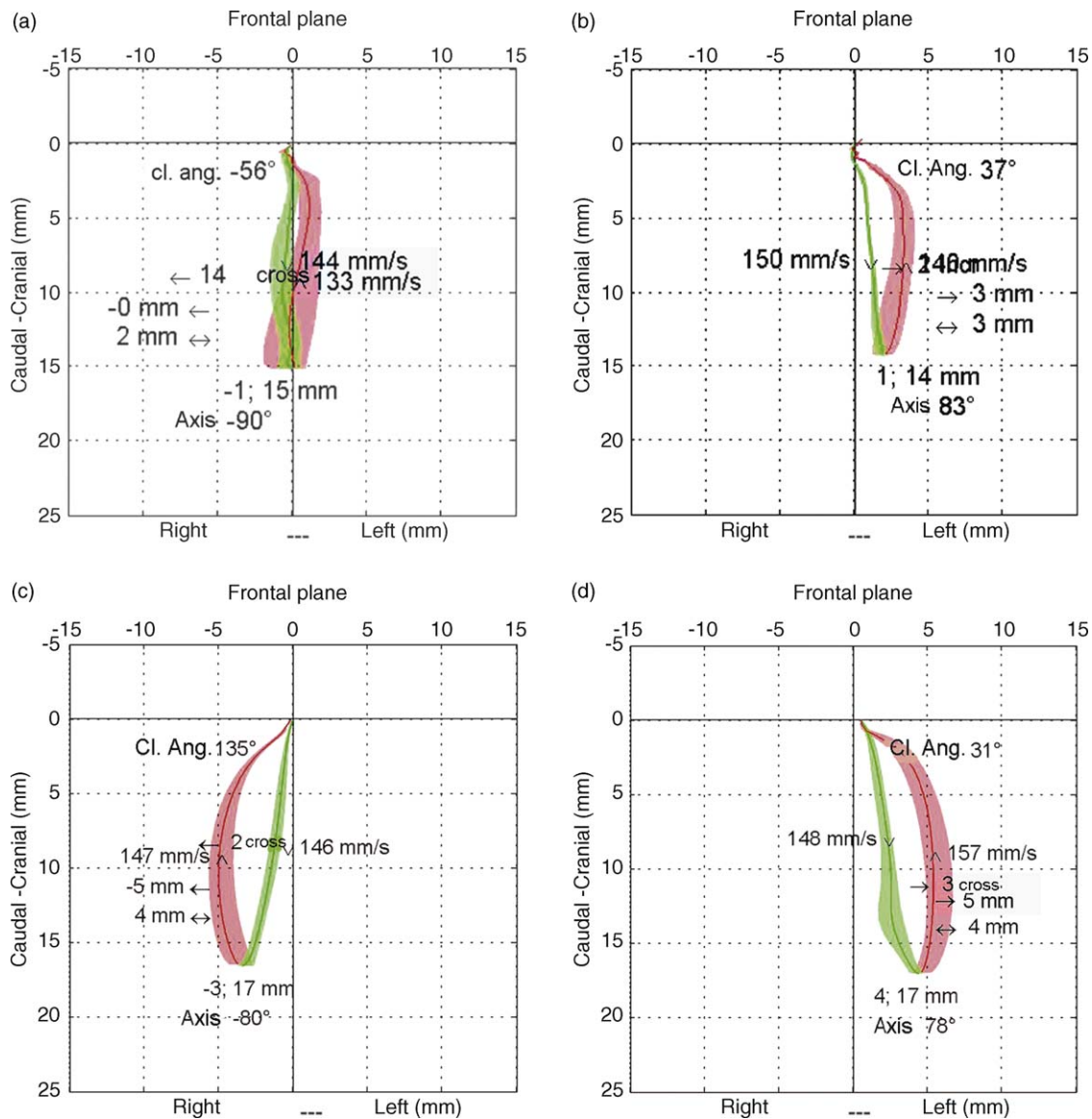
The results of the present study showed that the percentage of reverse sequencing chewing cycles, during chewing on the crossbite side, was significantly reduced after slow expansion treatment with Function Generating Bite (FGB) suggesting that this appliance corrects not only the anatomical dental relationship, but the masticatory function also (Figs. 3 and 4). No significant differences were found during chewing on the non-crossbite side after treatment (Fig. 5).

The results in literature regarding the correction of reverse chewing cycles after therapy are not in agreement, depending on the type of appliance used.

Ben-Bassat et al.<sup>31</sup> and Brin et al.<sup>20</sup>, showed that successful dental treatment of a unilateral posterior crossbite with palatal expansion, did not eliminate the reverse sequencing chewing cycles. As a limitation of these studies the selection of the group of patients is not homogeneous, being the appliances used different, both fixed and removable.



**Fig. 3 – Occlusion of the child in fig. 1 after crossbite correction with FGB: a) right lateral view; b) frontal view; c) left lateral view.**

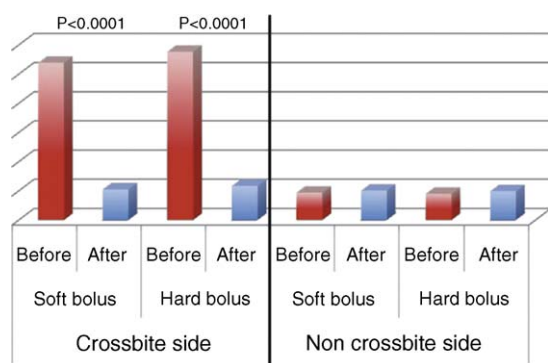


**Fig. 4 – Chewing patterns, in the frontal plane, before (a,b) and after (c,d) therapy with FGB. a) mean chewing pattern during chewing on the right, crossbite side, before therapy. The chewing cycles show a reverse direction of closure and a very anomalous pattern. b) mean chewing pattern during chewing on the left, normal side, before therapy. Comparing the chewing patterns on the right and left side before therapy, the functional asymmetry is evident. c) mean chewing pattern during chewing on the right, corrected side. d) mean chewing pattern during chewing on the left, normal side, after therapy. Comparing the chewing patterns on the right and left side after therapy, the functional symmetry is restored.**

Throckmorton et al.<sup>23</sup>, evaluated masticatory cycles in children strictly selected and homogeneously treated with rapid palatal expansion; this study is highly reliable, but it did not obtain any reduction in the percentage of the reverse sequencing chewing patterns after therapy. The authors speculated that the reverse sequencing persists after dental correction of the unilateral posterior crossbite because this malocclusion develops during the eruption of the primary dentition, and has an influence on the developing central pattern generator, establishing the reverse-sequencing type of chewing pattern which is then resistant to change.

Considering the importance of the neural motor control<sup>34-37</sup> on the mandibular movement especially during chewing and considering the consequences of the functional asymmetry on the growing structures of the stomatognathic system, it is of clinical relevance for the orthodontists the knowledge and the understanding of the different functional outcome with different therapies.

On the basis of the results of this study, we can say that slow expansion with Function Generating Bite (FGB) corrects both the dental and functional asymmetries. One reason for this successful therapy may be due to the characteristics of the



**Fig. 5 – Comparison of the percentage of reverse chewing cycles before and after therapy during chewing a soft and a hard bolus on the crossbite side and on the non-crossbite side.**

appliance and, especially, to the posterior metallic bite planes, previously described, which prevent the upper and lower teeth from opposing occlusal contacts during the orthodontic movement (Fig. 3 a,b,c). The action of the posterior bite planes is based on biomechanical principles. Two forces are simultaneously applied to move the teeth in crossbite: one is the horizontal force of the spring (from the palate to the vestibule) and the other is the vertical force of the metallic bite plane with upward direction for the upper teeth and downward direction for the lower teeth. The metallic bite planes have a role, not only in the general prevention of the occlusal contacts, but they contribute to a bodily movement of the teeth in crossbite exerting a reciprocal force on the upper and lower teeth simultaneously. Being made of resilient stainless steel, they are smooth and let the mandible, the upper and the lower teeth free to slide avoiding occlusal contacts and dental forced position.

With the rapid palatal expansion therapy, it is not possible to prevent the opposing occlusal contacts; it is true that the movement of the teeth is bodily, but it is completely forced by the appliance and the lower teeth are not involved at all.

Inputs from tooth mechanoreceptors<sup>38,39</sup> are, of course, critical for masticatory control and they are directly related to the biomechanics of the appliance used. It is intriguing to hypothesize that when opposing occlusal contacts occur, the central nervous system directly receives refined peripheral inputs from periodontal, muscular, oral receptors and a strict motor control of the mandibular movement, with very little freedom, is established to avoid the occlusal contacts<sup>21,25</sup>.

It has been demonstrated that reverse sequencing chewing cycles are disknetic chewing cycles with altered muscular activation<sup>24</sup>. When they are represented in high percentage during chewing on one side only, as it happens in patients with unilateral posterior crossbite<sup>21</sup>, the activity of the masseter of the crossbite side, is reduced in comparison with the normal side, resulting a functional asymmetry. The reduction in the percentage of reverse sequencing chewing cycles is of utmost importance for decreasing the altered muscular activity and the functional asymmetry<sup>13</sup>.

In conclusion the results of this study confirmed that slow expansion with Function Generating Bite (FGB) corrects both the dental and functional asymmetries. The improvement of masticatory function should be the real aim of the early orthodontic therapy to prevent the biological impact of the asymmetric function on the growing structures of the young patients. The type of therapy and the biomechanics of the appliance used are of great importance for the correction of the reverse sequencing chewing cycles and for rebalancing the functional asymmetry of children with unilateral posterior crossbite.

## 5. Conflict of interest

The authors have reported no conflicts of interest.

## Acknowledgement

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## Riassunto

**Obiettivi:** Sappiamo dalla letteratura che i pazienti con un morso incrociato monolaterale posteriore, quando masticano dal lato affetto da crossbite, sviluppano una maggiore frequenza di cicli masticatori inversi. È stato ipotizzato che la correzione dei cicli inversi può dipendere dal tipo di terapia. L'obiettivo è stato studiare la prevalenza dei cicli masticatori inversi in bambini con morso incrociato posteriore monolaterale, prima e dopo il trattamento con Function Generating Bite (FGB).

**Materiali e metodi:** Venti bambini, (9 maschi, 11 femmine, di età, media  $\pm$  SD,  $7,5 \pm 1,1$ ), dei quali 10 con morso incrociato monolaterale a destra e 10 con morso incrociato monolaterale a sinistra sono stati selezionati. I movimenti mandibolari durante la masticazione del bolo molle e del bolo duro sono stati registrati con un kinesiografo (K7-I, Myotronics Inc. Tukwila, Washington, USA).

**Risultati:** I risultati hanno mostrato una differenza significativa, confrontando la percentuale di cicli masticatori inversi, prima e dopo la terapia con FGB, durante la masticazione dal lato del morso incrociato sia con bolo molle che con bolo duro ( $p < 0,0001$ ). Nessuna differenza significativa è stata osservata durante la masticazione dal lato sano prima e dopo terapia.

**Discussione:** I risultati di questo studio hanno confermato che l'apparecchio FGB corregge sia le asimmetrie dentali che funzionali. Sapendo che l'espansione rapida del palato non corregge la funzione masticatoria, è di rilevanza clinica, per gli ortodontisti, la conoscenza e la comprensione dei risultati funzionali con terapie diverse.

**Conclusione:** Il tipo di trattamento e la biomeccanica dell'apparecchiatura utilizzata sono di grande importanza per la correzione dei cicli masticatori inversi e per il riequilibrio della dissimmetria funzionale nei bambini con morso incrociato monolaterale posteriore.

## Résumé

**Objectif:** Les patients ayant un articulé croisé postérieur unilatéral, au moment de la mastication dans le coté affecté, montrent une fréquence accrue de cycles de mastication inversée. C'est une donnée consolidée. On a établi l'hypothèse que la correction des cycles

inversés pouvait dépendre des caractéristiques du traitement. Le but a été donc de rechercher la prévalence des modèles de mastication inversée chez des enfants avec articulé croisé (cross-bite) postérieur unilatéral, avant et après le traitement avec le système Function Generating Bite (FGB).

**Matériels et methods:** 20 enfants (9 garçons, 11 filles; âge moyen  $\pm$  ES  $7.5 \pm 1,1$ ); on en a choisi 10 avec un articulé croisé unilatéral à droite et 10 à gauche. Les mouvements mandibulaires pendant la mastication de bols mous et de bols durs ont été mesurés à l'aide d'un kinésiographe (K7-I, Myotronics Inc. Tukwila, Washington, États-Unis).

**Résultats:** Les résultats ont mis en évidence une différence significative lorsqu'on compare le pourcentage de modèles de mastication inversée, avant et après le traitement avec FGB, pendant la mastication aussi bien de bols durs que de bols mous, du côté du crossbite ( $p \leq 0,0001$ ). Aucune différence significative n'a été observée pendant la mastication du côté sans cross-bite.

**Discussion:** Les résultats de cette étude ont bien confirmé que le FGB corrige aussi bien les asymétries dentaires que fonctionnelles. En sachant que l'expansion palatine rapide ne corrige pas la fonction de mastication, les orthodontistes doivent être au courant et maîtriser les résultats fonctionnels des différents traitements.

**Conclusions:** Le type de traitement et la biomécanique de l'appareil utilisé revêtent une importance cruciale pour la correction des cycles de mastication inversée et pour rééquilibrer l'asymétrie fonctionnelle chez les enfants présentant une occlusion croisée postérieure unilatérale.

## Resumen

**Objetivos:** Es sabido que los pacientes con una mordida cruzada posterior unilateral cuando mastican en la parte afectada tienen una frecuencia incrementada de ciclos masticatorios invertidos. Se estableció la hipótesis de que la corrección de los ciclos invertidos podía depender de las características del tratamiento. El objeto fue investigar la prevalencia de los patrones masticatorios invertidos en los niños con mordida cruzada posterior unilateral, antes y después del tratamiento con el sistema FGB (Function Generating Bite).

**Materiales y métodos:** Fueron seleccionados 20 niños (9 chicos, 11 chicas; edad media  $\pm$  DE  $7.5 \pm 1,1$ ); 10 sujetos con mordida cruzada derecha y 10 sujetos con mordida cruzada izquierda. Los movimientos mandibulares durante la masticación de bolos duros y de bolos blandos fueron medidos por medio de un kinesiógrafo (K7-I, Myotronics Inc. Tukwila, Washington, EE UU).

**Resultados:** Los resultados evidenciaron una diferencia significativa al comparar el porcentaje de patrones de masticación invertida, antes y después del tratamiento con FGB, en la masticación en el lado afectado, tanto con bolos duros como con bolos blandos ( $p \leq 0,0001$ ). No se observó ninguna diferencia significativa en la masticación en el lado sin mordida cruzada.

**Discusión:** Los resultados de este estudio confirmaron que el sistema FGB corrige tanto las asimetrías dentarias como funcionales. A sabiendas de que la expansión palatina rápida no corrige la función masticatoria, para los ortodoncistas tiene gran relevancia clínica saber y entender los resultados funcionales de los diferentes tratamientos.

**Conclusiones:** El tipo de tratamiento y la biomecánica del aparato utilizado tienen una marcada importancia para corregir los ciclos masticatorios invertidos y para reequilibrar la asimetría funcional en los niños que están afectados por mordida cruzada posterior unilateral.

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