REVISTA DE ODONTOLOGIA DA UNESP
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Original Article

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Rapid maxillary expansion in the treatment of the functional posterior crossbite: joint noise and electromyographic activity analysis

Expansão rápida da maxila no tratamento da mordida cruzada posterior: análise de ruídos articulares e atividade eletromiográfica

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How to cite: Pimentel DJB, Magri LV, Melchior MO, Marañón-Vásquez GA, Matsumoto MAN, Mazzetto MO. Rapid maxillary expansion in the treatment of the functional posterior crossbite: joint noise and electromyographic activity analysis. Rev Odontol UNESP. 2019;48:e20190038. https://doi.org/10.1590/1807-2577.03819

Resumo

Introdução: A expansão rápida da maxila (RME) reduz o risco de desenvolvimento de distúrbios estruturais e funcionais no sistema estomatognático. **Objetivo:** Analisar os efeitos desta intervenção como tratamento para a mordida cruzada posterior, relacionados à ocorrência de ruídos nas articulações temporomandibulares e à atividade eletromiográfica dos músculos masseter e temporal anterior. **Material e método:** 13 meninas e 7 meninos, independentemente do tipo de maloclusão, com idade média de 9 anos (±3), foram tratadas com RME. Por meio de eletrovibratografia analisou-se ruídos nas articulações temporomandibulares, e de eletromiografia de superfície a atividade dos músculos mastigatórios antes (T0) e após 3 meses do final do tratamento proposto (T1). As comparações entre os lados afetado e não afetado pela mordida cruzada foram realizadas utilizando-se o teste de Mann-Withney. As comparações de antes e após o tratamento foram realizadas pelo teste de Wilcoxon (nível de significância: 5%). **Resultado:** Não houve diferença significativa na eletrovibratografia entre os lados afetado e não afetado pela mordida cruzada, tanto em T0 como em T1 ($p>0.05$); do lado sem mordida cruzada observou-se diminuição do pico de amplitude dos ruídos articulares após a expansão rápida da maxila ($p<0.05$). Na análise da eletromiografia estática foram observadas diferenças inter-lados antes e após o tratamento, uma vez que a mastigação deliberada unilateral apresentou maior atividade de assimetria em T0 para ambos os lados, o que foi corrigido após o tratamento ($p<0.05$), melhorando a mastigação funcional padrão. **Conclusão:** O tratamento proposto para mordida cruzada posterior funcional não levou à ocorrência de ruídos articulares e melhorou o padrão funcional da atividade eletromiográfica durante a mastigação ao final do tratamento.

Descritores: Mordida cruzada posterior; expansão rápida da maxila; ortodontia interceptativa; mastigação; eletromiografia de superfície; ruído articular.

Abstract

Introduction: The rapid maxillary expansion (RME) reduces the risk of developing structural and functional disorders in the stomatognathic system. **Objective:** To examine the effects of the RME as a treatment for the posterior crossbite, related with the electromyographic activity of the masticatory muscles and the TMJ noises in a population of children. **Material and method:** 13 girls and 7 boys, regardless of the type of malocclusion, with a mean age of 9 years old (± 3), were treated with RME.

The electrovibratography analyzed the TMJ noise, and the electromyography analyzed the masticatory muscles before treatment (T0) and after three months of a short-term follow-up (T1). The comparisons of the affected and unaffected sides by the crossbite were performed using Mann-Whitney's test, and to compare data before and after treatment the Wilcoxon's test was used (level of significance: 5%) **Result:** No significant differences were found in the parameters of joint noise in comparison to the sides affected and unaffected by the crossbite, in both T0 and T1 ($p>0.05$); only the side without the crossbite observed decrease in the peak amplitude of the joint noises after treatment. In the static electromyographic analysis, inter-side differences were observed before and after treatment, since the deliberate unilateral chewing showed greater asymmetry activity in T0 for both sides, which has been corrected after treatment, improving the functional chewing. **Conclusion:** The proposed treatment did not lead to the occurrence of joint noises and improved the functional pattern of electromyographic activity during chewing at the end of treatment.

Descriptors: Crossbite; palatal expansion technique; orthodontics, interceptive; mastication; surface electromyography; joint noise.

INTRODUCTION

The posterior crossbite (PXB) is defined as a horizontal discrepancy in the relationship between the arches, that is, a type of malocclusion where the buccal cusp of at least one upper posterior teeth are in occlusion with the center of its antagonist tooth fossa[1]. It is one of the most prevalent malocclusions in deciduous and mixed dentition, affecting from 8 to 24% of the general population[2,3]. Approximately 67% to 79% of the cases of PXB are characterized by producing functional dental interference changes in the jaw position at maximum intercuspation (IP) on the cross bite side. This condition is known as functional PXB and occurs when it is associated with a mandibular deviation[4].

It has been shown that there is morphological change in the relationship between the upper and lower dentition in patients with PXB and positioning of the condyle-fossa on both sides[5]. The displacement of the mandibular condyle on these patients can alter the balance between form and function, and it may be a factor in the development of future stomatognathic system dysfunctions, e.g. the development of temporomandibular joints (TMJ) noises[6]. Moreover, it has been reported that the PXB is usually associated with asymmetric activity of the masticatory muscles.

The masticatory muscles elevators at the PXB side have a lower degree of muscle activity compared to the side without this condition, which can lead to thinner masticatory muscle fibers. In relation to the chewing cycles, children with PXB have an irregular trend, or contralateral reverse cycles due to the functional shift of the mandible. The presence of functional and dental asymmetry can lead to reverse masticatory cycles on the crossbite side[7].

The early treatment of PXB, besides correcting the malocclusion, improve the physiology and the healthy development of the muscles and TMJ[6]. The early intervention (from 5 years old - primary dentition) on this malocclusion is considered the best option for treatment, because it influences on the development of the occlusion and face. The most commonly used devices for rapid maxillary expansion (RME) are the Haas and Hyrax expanders. Highly used for RME, it is a well-known appliance: the Haas and Hyrax expanders present tooth-muco-supported and tooth-supported only, respectively. The Haas expander features a metallic support structure with bands for dental anchoring, such as the Hirax expander, but plus acrylic resin support that is juxtaposed to the palatine mucosa[8].

It has been suggested that the treatment with the fixed PXB expander apparatus decreases the functional changes present in this kind of patients. The discrepancies reported above regarding the condylar position can be eliminated with the RME treatment; however, some researchers found no improvement in the positioning of the condyles after the treatment[9]. The RME reduces the asymmetric craniofacial development, reducing the risk of developing structural and functional disorders in the stomatognathic system[10]. Considering the structural and functional changes introduced by the RME, few studies in the scientific literature investigated the joint noise and the activity of the masticatory muscles in children with PXB before and after treatment.

Take this into account, this study aimed to examine the effects of the rapid maxillary expansion as a treatment for the posterior crossbite, related with the electromyographic activity of the masseter and anterior temporalis muscles and the TMJ noises in a population of children between 6 and 12 years old. The hypothesis of the study is that the proposed treatment provides the balanced electromyographic activity of the masticatory muscles without altering the TMJ biomechanics related to joint noises.

MATERIAL AND METHOD

Design

Quasi-experimental, prospective, quantitative, longitudinal study without control group.

Sample

The sample was calculated using the SAS - Statistical Analysis System (SAS, Cary, NC, USA), based on previous studies, determining the participation of 20 children for the present study. Initially, 213 children were evaluated from a preventive orthodontics service at the School of Dentistry of Ribeirão Preto, University of São Paulo, of whom 30 were selected according to the inclusion and exclusion criteria. Eight were excluded due to craniofacial malformations, for presenting symptomatology of TMD, presence of active or high risk of cavities development or excluded because the follow-up discontinuing. After that, 20 children (13 female and 7 male) were included in the study and assessed, with no gender or race distinction in mixed dentition and presence of PXB, with indication of RME as a treatment. The mean age was 9 years old (± 3), (varying between 6 and 12 years old). The exclusion criteria were the presence of palatal torus, systemic order problems such as diabetes and obesity (BMI ≥ 30 kg / m2), signs and symptoms of painful TMD, genetic syndromes, craniofacial deformities such as cleft lip and palate, dental defects, high-risk and / or caries activity, cognitive and / or mental disorders, or who had already undergone previously speech therapy or orthopedic orthodontic treatment.

This study was approved by the Research Ethics Committee of the School of Dentistry of Ribeirão Preto (University of São Paulo). All those responsible for the children signed the free and informed consent term.

Clinical Evaluation

Children were evaluated seated in a dental chair and the diagnosis of the clinical PXB was performed according to the following criteria, by an expert dentist in orthodontics and calibrated by peers of the same specialty: the patient in maximum intercuspation position (IP) should present a slight jaw deviation and at least one upper posterior tooth with the buccal cusp occluded in the central antagonist fossa; and the manipulation of the mandible in centric relation position, the PXB should not be evidenced.

Orthodontic Procedures

It was initially requested an evaluation to complete the orthodontic records of the patients, which consisted of cephalometric and panoramic radiographies, study models and intra- and extra-oral photographs. The documentation was necessary to complement the orthodontic diagnosis and to confirm the indication of RME.

After the initial test and confirmation of the diagnosis, the Haas apparatus was made (Figure 1). The first permanent molars were separated with orthodontic elastic and after separation, prefabricated orthodontic bands were adapted. Orthodontic elastic tabs (Morelli 60.04.201) were selected for these teeth, and prefabricated orthodontic bands (Morelli 40.02) were adapted. The upper arch molding was performed with Jeltrate alginate (Dentsply - Caulk). The bands were carefully transferred to the mold for further casting with the Mossoro white plaster stone - Alfa special type. Once the plaster model was obtained, the modified Haas breaker apparatus was made.

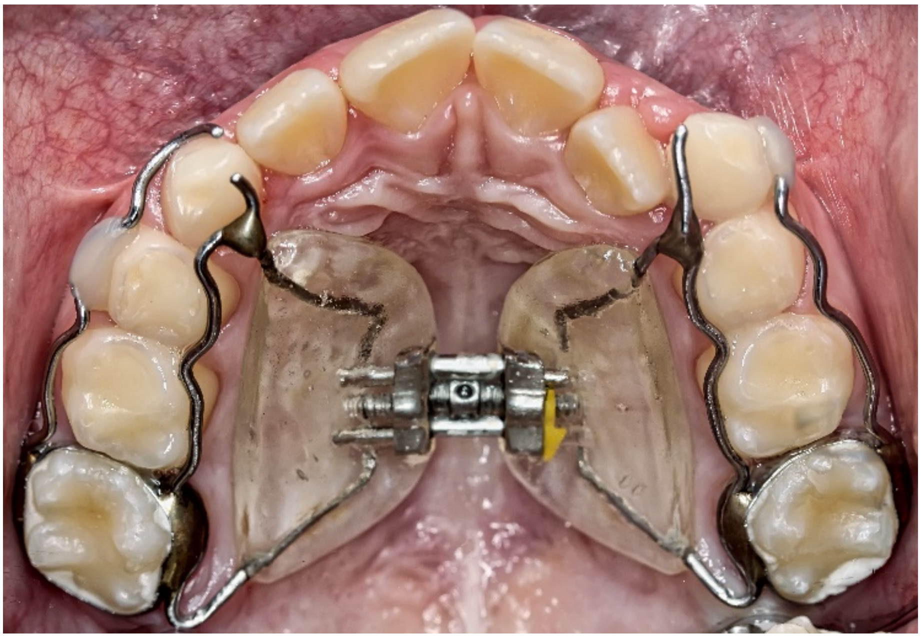

Figure 1. Haas expander.

They were then made with stainless steel wire (1.0 mm), two bars adapted to the buccal and palatal of the first permanent molars and deciduous molars and canines, and welded bands of the first permanent molars with silver solder. With the expansion screw fixed and centered about the sutures to the second deciduous molar level, the acrylic was placed on the Ortho-Class apparatus for mucosal support. The anterior limit of the apparatus should not cover the palatine ridges laterally, the acrylic should be extended to 5.0 mm from the free gingival margin, and the back region should include the first permanent molars. After finishing and polishing, the apparatus is cemented to the first molars with Ultra-Lok Bond (Reliance Orthodontic) photopolymerizable adhesive and wire rods glued to the molars and canines with photopolymerizable composite resin (Transbond XT - 3M).

After cementing, the screw was turned a full turn (1.0 mm) following the protocol recommended by Haas[8]. After the initial activation, the responsible for the patient was instructed to activate the device daily with ¼ turn every 12 hours. The patient was evaluated every 7 days after the beginning of the activation to check the maxillary expansion to the overcorrection of PXB, which was verified by the opening of the sutures and the contact of the vestibular aspects of the palatal cusps of the first molars with plans inclined tongue of the buccal cusps of the first molars.

The occlusal radiography was obtained before the activation of the expander and soon after the end of the activations. After confirming the opening of the sutures, it was done with the screw locking wire ligature # 0010 mm and fluid resin (Natural Flow, New DFL). The patient remained in contention for 3 months (no activation) for reorganizing the fibers and bone formation. After 3 months of restraint, a final occlusal radiography was performed to observe the bone formation in the sutures. Once the retention period was over, the palatine breaker was removed and an upper removable appliance with vestibular retaining clips was installed in the upper first permanent molars along with a Hawley lip arc wire in 0.7 mm and acrylic palate to stabilize the occlusion and perioral muscles.

Electrovibratography and Electromyography Surface

It was conducted the examination of the electrovibratography (SonoPAK QS-System, BioReserch, Inc., Milwaukee, Wisconsin) in order to analyze the joint sounds. The exam sequence performed was: after accommodation of the patient, orientation of look in the direction of the screen and note the maximum comfortable opening measures, including the overbite and the lateral deflection of the mandible during mouth opening using a digital caliper (Mitutoyo, Brazil), positioning of the amplifier and piezoelectric sensors was performed in subject. The examination was performed with the patient doing movements of mouth opening and closing following the simulation provided by software, in real time on the computer screen. After a period of 10 seconds, the test is recorded in the computer and the software by BioResearch®, finds the points where is the noise through the cursor "FindVibration" in the software toolbar. The evaluated parameters were: Total (total amount of vibration energy, measured in Hertz – Hz), Peak Amplitude (the point of highest vibration intensity measured in Pascals - Pa) and Peak Frequency (the point of highest intensity of vibration energy, measured in Hertz – Hz).

Children were also submitted to the examination of EMG according to the Shewman Protocol (Myotrace 400, 8 channels, Noraxon®)[11]. Bipolar surface silver/silver chloride, disposable (Hall Industry and Trade LTD) electrodes were placed on the skin over the masseter and anterior temporalis muscles positioned parallel to the bundles of the muscle fibers and a reference electrode was set approximately 10 mm above the glabella. The EMG evaluation was performed during the following tests:

- Rest at the sitting and the standing position (Rest);
- Two maximum voluntary contractions (MVC) of three seconds each, with interval of 2 seconds between them (Functional Clench);
- One MVC for 10 seconds to evaluate the fatigue (Long Clench);
- Unilateral chewing performed to the right and left with chewing gum (Trident®) for 10 seconds each (Chewing – cross and not crossed sides);
- Habitual chewing with chewing gum for 10 seconds (Habitual Chewing).

All the clinical and instrumental evaluations were previously made to correct the PXB (T0) and three months after fixing the circuit breaker apparatus (T1).

Statistical Analysis

The comparisons of the affected and unaffected sides by the PXB were performed using Mann-Whitney's test for the electrovibratographic and electromyographic analysis. Changes after the RME were analyzed by the Wilcoxon's test to compare data before and after treatment for both analyzes. The significance level was 5%.

RESULT

No significant differences were found in the parameters of peak of frequency, peak of amplitude or the total integral joint noises in the comparison between the cross and not crossed sides by the PXB, in the comparison of T0 and T1 (after RME) ($p>0.05$) (Table 1). Before the treatment, the sample showed no differences in the parameters of joint noises in the inter-sides comparison; and after RME, there were no increase or reduction of the electrovibratography variables described below.

Table 2 shows changes in the parameters of joint noises after RME, there were no significant differences in the peak of frequency, peak of amplitude or the total integral joint noises on the crossed side. On the not crossed side, it was observed a significant decrease in the peak of amplitude of the joint noise after RME ($p<0.05$), but not for the other studied parameters.

Regarding the electromyographic analysis, no significant differences were observed when comparing the crossed side with the not crossed, before and after RME, except for the cross side at the unilateral chewing assessment in relation to the masseter and anterior temporalis muscles and not crossed side to masseter muscles, both in the pre-treatment time (Table 3). Both sides showed no significant changes after RME, except for the masseter muscles on both cross and not crossed sides, while acting as a work side in the deliberate unilateral chewing. Although, no statistically significant difference was observed ($p>0.05$), the difference between the cross and not crossed was lower after the RME in all tests performed (Table 3).

Table 1. Comparison of the temporomandibular joint noises variables – electrovibratography assessment (Peak of Frequency, Peak of Amplitude and Total Integral Joint Noises) between the cross and not crossed sides (unilateral posterior crossbite), considering the moments before (T0) and after (T1) rapid maxillary expansion (RME)

Joint noise analysis	T0			T1		
	Cross	**Not Crossed**	***Difference***	**Cross**	**Not Crossed**	***Difference***
Total (Hz)	5.43	6.83	1.39	3.45	3.89	0.44
Peak Amplitude (PA)	0.47	0.44	0.03	0.315	0.25	0.06
Peak Frequency (Hz)	54.45	43.85	10.6	73.25	91.5	18.25

Hz = Hertz; PA = Pascal. *Statistically significant difference ($p<0.05$). Source: Own elaboration.

Table 2. Changes in the temporomandibular joint noises variables – electrovibratography assessment (Peak of Frequency, Peak of Amplitude and Total Integral Joint Noises) (T0 vs. T1) considering the moments before (T0) and after (T1) rapid maxillary expansion (RME)

Joint noise analysis	Cross Side			Not Crossed Side		
	T0	**T1**	***Difference***	**T0**	**T1**	***Difference***
Total (Hz)	54.45	73.25	18.8	43.85	91.5	47.65
Peak Amplitude (PA)	0.47	0.315	-0.155	0.44	0.255	-0.185 *
Peak Frequency (Hz)	5.4	3.45	-1.985	6.83	3.895	-2.935

Hz = Hertz; PA = Pascal; T0 = initial assessment; T1 = three months after RME. *Statistically significant difference. Wilcoxon Test ($p<0.05$). Source: Own elaboration.

Table 3. Comparison of the electromyographic activity (masseter and anterior temporalis muscles) between the cross and not crossed sides, considering the moments before (T0) and after (T1) rapid maxillary expansion (RME)

	Electromyographic Activity					
	T0			T1		
	Cross	Not Crossed	*Difference*	Cross	Not Crossed	*Difference*
Rest (uV)						
masseter	2.45	2.43	0.23	2.978	2.974	0.04
anterior temporal	3.25	4.3	1.04	3.33	3.39	0.06
Functional clench (uV)						
masseter	92.19	86.54	5.65	82.95	82.94	0.01
anterior temporal	104.8	97.16	7.64	104	100.5	-3.5
Long clench (uV)						
masseter	169.6	169.1	0.5	155.6	155.3	0.3
anterior temporal	175	167.6	7.4	167.1	172.3	5.2
Chewing – cross side (Hz)						
masseter	8.68	14.51	5.83 *	15.17	16.66	1.49
anterior temporal	12.88	17.41	4.53 *	16.36	17.43	1.07
Chewing – not crossed side (Hz)						
masseter	15.12	8.59	6.52 *	15.91	14.73	1.18
anterior temporal	17.62	13.01	4.61	17.76	16.36	-1.4
Habitual Chewing (Hz)						
masseter	11.04	10.93	00.11	13.98	13.21	0.77
anterior temporal	13.13	14.11	0.98	14.76	14.1	0.66

Hz = Hertz; *Uv* = microvolts; T0 = initial assessment; T1 = three months after RME. *Statistically significant difference. Mann-Whitney Test ($p<0.05$). Source: Own elaboration.

DISCUSSION

Children with posterior crossbite usually show mandibular reversed movements during chewing and that are often asymmetrical, which may lead to problems in the orofacial structures causing adverse effects in the TMJ, in the masticatory muscles and face growth[2,12,13]. To fix this transverse discrepancy, it must be taken into account the early childhood treatment. Besides improving the aesthetic and craniofacial growth, it can improve the impaired respiratory conditions, such as obstructive sleep apnea and oral breathing[14,15].

Despite the negative impact of unilateral PXB on the morphological symmetry of the TMJ and the functioning of the stomatognathic system, its association with joint noises is still controversial. When clinically assessing joint noises, associated with the subjects' reports, in a longitudinal study, Michelotti et al.[16] found a significant association between this altered occlusion and the presence of subjective joint clicking and concluded that the unilateral crossbite in adolescents increases the risk of reporting joint sounds around 10 years later[16]. The asymmetry of the positioning between the mandible condyle has been described as the most superior and posterior crossbite side than on the opposite side[12]. Subsequent neuromuscular adaptations that acquire the mandibular position cause morphological changes in muscle tissue and in their composition, leading to asymmetric mandibular growth, aesthetic disharmony and severe functional changes in the masticatory muscles and TMJ, increasing the chances of TMD signs and symptoms development[12,16,17].

Differently from the study by Michelotti et al.[16], the joint noises were investigated in this study by electrovibratography. Although it presents high sensitivity and low specificity, the values found by means of this instrumental evaluation were low since the initial evaluation, and no significant differences were observed between the crossed and non-crossed sides ($p>0.05$), considering the moments evaluated (pre and post ERM). However, with a more detailed analysis, it was possible to realize that there was a decrease in the electrovibratographic values after RME, for both sides (cross and not crossed), despite of this, there was only significant difference for the Amplitude Peak in the not crossed side. The Amplitude Peak is an examination of the EVG parameter, it refers to the point of highest intensity of vibration of the joint noise, measured as "pascal" unit (Pa). As the joint sounds were already low, the only difference observed in this parameter was probably the point of maximum intensity of the sound vibrations, which after treatment showed the reduction of the vibration most clearly for the not crossed side ($p<0.05$).

It is necessary take into account that the sample was composed of children and that at this stage of life, the TMD signs and symptoms are mild and/or subclinical, and that the presence of PXB can contribute to the development of TMD, since it causes orofacial myofunctional imbalance[12]. Studies have shown that the mild to moderate TMD symptoms found in children tends to worsen in adolescence and adulthood, especially for females, if untreated or at least accompanied by a competent professional[16]. Similar results were found, but with significant differences between the cross (most intense) and not crossed sides, which disappeared after the maxillary expansion[18].

The electromyography surface test performed in the sample showed higher activity of the balancing side during deliberately chewing with gum (left and right unilateral mastication), both in the cross (for masseter and anterior temporalis) and not crossed side (for masseter) ($p<0.05$). This may be due to changes in the masticatory cycle, the common occlusal change studied[2,19]. Physiologically, during bilateral and unilateral chewing with normal occlusion, it is expected the work side to be more active, it is the side that receives the most masticatory loads; the chewing cycle occurs in the drop form, being tilted to the work side, so that the cusps of the posterior teeth triturate the food efficiently, which ensures good performance and craniofacial development[19].

In unilateral posterior crossbite, there is an inverted relationship of the upper and lower dental cusps, which leads to a kinematic lower jaw movements and altered activity compared to the not crossed side[13]. This electromyographic behavior is more common for the cross side, in which the alteration of the mandibular kinematics movement is more evident, however, in this study, both the cross and not crossed sides showed decreased activity when acting as a work side during the chewing test, indicating that the opposite side to the crossbite may also be influenced by this malocclusion, especially when there are inverted chewing cycles, that is, the mandibular path shaped as an inverted drop, directed to the balancing side and not to the work side[13].

After the crossbite correction, it is possible to observe the increased activity of the muscles evaluated, while they were acting at the work side during deliberate chewing (right and left), with a significant difference to masseter ($p<0.05$). That is, the EMG showed that the RME allowed the balance of the muscles for both right and left sides. This situation favored the better positioning of the jaw and thus enabled its symmetrical growth once the patient is in active growth phase[10,18,19]. The same occurred during chewing on the not crossed side. In view of these results it can be said that, despite not having been a greater activity for the masseter muscles compared to the previous moment, as would be ideal, there was a tendency to the spontaneous functional adaptation of the mandibular biomechanics. Perhaps a longer period of follow-up could reveal this new relationship, which is a point to be considered in future study designs.

For other static EMG tests (resting, functional clench and long clench), no significant difference was observed. In a previous study[20], the comparison of electromyographic symmetry indexes between adolescents with and without crossbite (control group) revealed that the asymmetry of muscle activity, although higher than that of healthy adults, was not associated with the presence of unilateral crossbite, both for static and dynamic tasks. However, the influence of this malocclusion on asymmetry indices has already been observed in adults with unilateral crossbite[21]. Probably, in the period of childhood and adolescence this association is not easily evidenced due to the presence of other variables, such as dental development and diet for example. Thus, the comparison between the crossed and non-crossed sides allowed for a more subtle analysis that revealed a smaller difference of activity between the sides after the RME for all tests, indicating that the proposed treatment contributed to the balance and development of the stomatognathic system. Perhaps a longer follow-up of these patients could reveal major changes that take longer to occur, but the period of three months was enough to observe that the changes occurred in order to favor the morpho physiology system in question as a whole.

The main limitations of this study are associated with the absence of a control group for comparison of normal parameters, besides the follow-up time that could be extended for a period of six months to one year, and the completion of the TMJ analysis with image exams. However, such restrictions may be justified by the difficulty of obtaining samples of control children in research centers, the loss of patients during the execution of a clinical trial, especially after completion of treatment, which depend on the availability of the responsible person and school activities, and finally the costs and exposure to ionizing radiation during the TMJ imaging examinations.

CONCLUSION

Children aged between 6 and 12 years old with unilateral posterior crossbite are not a population with a significant presence of joint noises in TMJ, but they have electromyographic activity of asymmetry of the masseter and anterior temporalis muscles during chewing on the cross and not crossed sides. Rapid maxillary expansion as a treatment for unilateral posterior crossbite condition does not lead to the occurrence of noises in the TMJ and improves the functional pattern of the EMG activity during the performance of the chewing in a short-term follow-up (three months) after treatment completion.

ACKNOWLEDGEMENTS

The authors thank the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) for the financial support.

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CONFLICTS OF INTERESTS

The authors declare no conflicts of interest.

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Received: April 2, 2019
Accepted: September 17, 2019