Original Article

Evaluation of Electromyography and Muscle Contraction in the Use of Myofunctional Appliances: A Systematic Review

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Abstract

Background: Electromyography (EMG) is the study of muscle function through the analysis of electrical signals generated spontaneously or during voluntary contractions. EMG plays an important role in the diagnosis of facial muscles during orthodontic treatment related to neuromuscular involvement and facial pain associated with the use of myofunctional appliances. Orofacial muscle function plays an important role in the formation of an ideal occlusion during childhood growth. Orofacial muscles that can affect the development of dental occlusion are the tongue, masseter and buccinator muscles, and orbicularis oris. Triangular Force Concept is the concept of balance between the three muscles. Early detection of the imbalance of the three muscles can prevent malocclusion in children. One of the treatment for malocclusion in children with orthodontic problems is the use of myofunctional appliances, both removable and fixed. Removable myofunctional appliances that can be used such as activators, twin- blocks, bionators, Frankel function regulators and sanders. While fixed myofunctional appliances that can be used such as Herbst, Jasper jumper and RME.

Objectives: To systematically review electromyography and its relation to muscle contraction in the use of myofunctional appliances as a treatment for malocclusion in children.

Methods: Data collection was carried out by searching literature on article search sites, namely Pubmed, Cochrane, Wiley, Google Scholar and Science direct which were published from 2016 to 2021, the search was carried out in March 2016 - May 2021. Data search was carried out systematically using keywords. Electromyography, Muscle contractions, Myofunctional appliances, Children and adolescents.

Results: After eliminating duplicate articles, the title and abstract of each article were analyzed in 441 articles which were excluded from 408 articles. The full-text articles in the remaining 33 articles were re-analyzed and 29 articles were excluded. The complete text of the journal article and fulfills the eligibility is 4 articles.

Conclusion: Surface electromyography is a useful tool for monitoring muscle activity. After functional therapy resulted in changes in masticatory muscle activity. Myofunctional appliances that promote the correction of malocclusion are capable of causing neuromuscular changes which in turn result in muscle balance and harmonious jaw development.

Keywords: Electromyography, muscle contraction, myofunctional appliances, children and adolescents.

DOI: 10.47750/pnr.2022.13.S04.108

BACKGROUND

Electromyography

Electromyography (EMG) is the study of muscle function through the analysis of electrical signals generated spontaneously or during voluntary contractions.1 The structural basis of electromyography is the motor unit, consisting of a group of muscle fibers that work together and the motor neurons that control them. When a motor neuron triggers an action potential, all the muscle fibers in the motor unit contract. This electric potential dissipates in the surrounding tissue.2 The first contributions made with the application of electromyography were in the fields of neurology and neuroscience, later progressing to other specialties including dentistry, with the aim of evaluating the functioning of the masticatory system, the outcomes of patients undergoing corrective craniomandibular treatment or orthognathic surgery , in addition, are diagnostic elements of temporomandibular disorders, hyper or hypo muscle activity, or different degrees of malocclusion depending on muscle contractions that determine facial morphology.3,4,5

Although electromyographic findings may not be pathognomonic for a particular disease, or may provide a definitive diagnosis on their own, they are very important.1 There are 2 types of electromyography: intramuscular electromyography and surface electromyography.6 The needle electrode is inserted through the skin into the muscle to be explored for intramuscular EMG recording.1,6 The needle electrode records the action potential of each motor unit individually, therefore, information about function an integral part of the entire motor system is obtained from mild voluntary contraction of the studied muscles.6,7 They provide a high-quality and specific record that allows identification of different neurological diseases affecting each component of the motor unit, neuromuscular junction and muscle.1,8 However, Intramuscular electromyography does not allow electrical activity throughout the muscle, and can even cause infection and discomfort.6 Surface electrodes are used for surface electromyography (EMGs) that are placed on the skin covering the muscle.1 Surface electrodes detect overlapping motor unit action potentials and are summed of many muscle fibers.6,7 They offer no risks or complications, they explore larger muscle areas and can spontaneously register signals from adjacent muscles, therefore, they are not specific, however, they serve to evaluate changes in global muscle electrical activity during rest, stress and maximal muscle contraction. Basically, they evaluate contraction patterns and changes in amplitude.1,6,8,9

The reliability and precision of the surface electromyography will depend on the position of the electrode in relation to the muscle under study, skin impedance and external noise.5,6 To reduce skin impedance and improve skin-electrode contact, it is necessary to scrub the skin, clean it with alcohol and shave the hair.6 ,9 Age, sex, temperature, stress, and skin thickness are physiological factors that can also affect electromyographic signals.4,6 Many muscles are involved in chewing, swallowing and phonation: temporalis, masseters, medial and lateral pterygoids, digastric, mylohyoid, geniohyoid , mental, oral orbicularis, among others, however, the muscles that have been studied mostly in electromyography are transient and bulk muscles, because they are more accessible, larger and easier to locate, showing acceptable results.3,6,8,10

The temporalis muscle is a wide, flat, fan-shaped muscle that lines the temporal fossa. Contraction of its anterior and middle fibers elevates the jaw and closes the mouth. Contraction of its anterior fibers is also involved in propulsion and contraction of the posterior fibers in retropulsion of the mandible. The temporalis muscle is very sensitive to occlusal disturbances and is responsible for positioning the mandible in a vertical direction.10 The masseter muscle is a rectangular, short, strong and thick muscle, which extends from the zygomatic arch to the angle of the jaw, covers the jaw laterally, lifts the jaw firmly and closes the mouth. Contraction of the superficial muscle fibers involves propulsion, whereas contraction of the deep fibers is involved in mandibular retropulsion.11

For the location of the temporal muscle the electrode is placed two centimeters above the zygomatic arch, and two centimeters behind the outer canthus of the eye and for the masseter muscle the electrode is placed one centimeter lower than the angle of the mandible, although this muscle is limited easily by palpating the muscle contractions when clenching the teeth.8 The maxillofacial complex consists of the skeletal system, the muscular system and the teeth, which in conditions of functional harmony provide a balanced occlusion. Muscle dysfunction is a factor that causes or affects the appearance of malocclusion, temporomandibular joint dysfunction, myofascial pain, fatigue, among other problems that can be detected through electromyography. EMG is a useful method for evaluating orofacial muscle rehabilitation in children undergoing orthopedic treatment.12,13

Malocclusion

Malocclusion is a form of maxillary and mandibular relationship that deviates from the standard form that is accepted as the normal form. Normal occlusion is defined in which the upper and lower jaws are in contact with each other in all positions and movements of the mandible.14 Dental malocclusion is an misalignment problem that can lead to serious oral health complications, as the teeth will not be able to perform vital functions if they are not aligned. Malocclusion can be caused by a lack of dentofacial balance. This dentofacial balance is not caused by one factor alone, but by several influencing factors. The influencing factors are heredity, environment, growth and development, ethnicity, function, and pathology. Malocclusion can lead to disturbances in mastication, speech, higher sensitivity to trauma, periodontal disease and aesthetic disturbance.15 Malocclusion which is a change in the maxillary growth process and the position of the teeth can also result in physical, psychological and social consequences.16

Malocclusion may not be life-threatening but it is an important public health problem, which has had a major impact on individuals and society in terms of discomfort, social and functional limitations.16 Harmony between the nervous system, blood supply, and proper dental occlusion is essential for developing the process. normal mastication. Therefore, any disturbance in the position of the teeth causes malocclusion and consequently masticatory disorders.17,18 Masticatory disorders in the form of discomfort when chewing, the occurrence of pain in the TMJ and can also cause headaches and neck pain. Although malocclusion is not life-threatening, it can be considered a public health problem due to its high incidence rate. Malocclusion shows the third highest prevalence among oral pathology, dental caries and periodontal disease and is a public dental health problem worldwide.15 Physical appearance and attractiveness have important roles in interpersonal, communication and interaction. Hence, malocclusion may have a negative effect on social relationships, and this will in turn affect self-image. Malocclusion, like many other dental disorders, has a profound impact on the aesthetics and psychosocial behavior of adolescents, thereby affecting their self-esteem.18,19

Among preschool children, the most common conditions are anterior open bite, excessive overjet, Class II malocclusion, and posterior crossbite.21 Proffit (1986) said that malocclusion is mainly caused by genetics, genetics has a tendency to determine facial proportions and soft tissue contours. and the size of the teeth and jaws. Mild and moderate malocclusions may occur even in the absence of bad habits or environmental factors, but very severe malocclusions may have a genetic component and an environmental component. (McDonald & Ireland, 1998) said the etiology of most malocclusions is usually multifactorial.14 Malocclusion in children occurs due to multifactorial related oral habits, such as finger sucking, nail biting (onychophagia), tongue sticking out, lip biting and bruxism. Finger sucking is the most common childhood habit.21 The prevalence of sucking within 3 years of age ranges from 66% to 88%.21,22

Previous studies noted that 23.3% of the 1946 Japanese children examined had a finger sucking habit. The habit of finger sucking is ascribed to instinct, and it can increase the ability to eat and drink ood using the mouth and tongue. However, children who persist in non-nutritive sucking beyond childhood are more likely to have underlying psychological disorders. Finger sucking has harmful effects, it has been reported that thumb sucking affects not only tooth growth and occlusal development, such as maxillary protrusion, open bite, and posterior cross-bite, but also the development of oral function including abnormal swallowing habits and speech defects. According to previously reported findings, sucking habit should be considered as a major influencing factor in the etiology of malocclusion in children.22

Myofunctional appliances

Myofunctional appliances are defined as devices for treating facial and oral muscle dysfunction.23 Myofunctional appliances are used in interceptive treatment procedures. One of the recommended treatments in the growing age is treatment using a myofunctional appliances. This appliances is only effective in children who are growing, especially those who have not passed the pubertal growth spurt. The use of my functional appliances aims to modify growth by utilizing, removing or guiding muscle function, jaw growth, tooth eruption, to correct malocclusion and treat jaw discrepancies.23,24 Myofunctional appliances can change the function of the oral and facial muscles and to eliminate oral habits, such as prolonged thumb sucking and nail biting, tongue thrusting, mouth open at rest, poor mastication, and poor tongue and mouth posture, orthodontists also use my functional appliances as an adjunct to the treatment of temporomandibular joint disorders (TMD).22,25

My functional appliances are classified into two, namely removable devices and fixed devices. There are two types of removable devices, namely active removable devices, which are devices used to move the teeth and passive removable appliances, which are devices used to move teeth. to maintain the position of the teeth after treatment is complete, or maintain room after the initial extraction. Removable my functional appliances that can be used such as activator, twin-block, bionator, Frankel function regulator and sanders. Whereas fixed my functional appliances that can be used such as Herbst, Jasper jumper and RME.

Materials And Methods

Data source

Data collection was carried out by searching literature on article search sites, namely google search, Pubmed, Cochrane, Wiley, Google Scholar and Science direct which were published from 2016 to 2021, the search was carried out in March 2016 - May 2021. Data search was carried out systematically using words Key Electromyography, Muscle contraction, Myofunctional appliances, Children and adolescents.

Research Criteria

Inclusion criteria

Published articles from 2016-2021.

Articles in English.

Scientific articles that have been published and are available online.

An article that examines malocclusion in children and adolescents who are treated using my functional appliances both removable and fixed in this regard in relation to electromyographic evaluation and muscle contractions.

Exclusion criteria

Articles included in systematic reviews, literature reviews, case reports, and editorials.

Articles that cannot be accessed for free.

Data collection

The data that will be used in this research is secondary data. The data is obtained from the articles searched in the article database which will then be reviewed according to the research criteria set by the researcher. Literature searches were carried out on online databases, namely google, Pubmed, Cochrane, Wiley, Google Scholar and Science direct searches using the keyword are Electromyography, Muscle contractions, Myofunctional devices, Children and adolescents found 441 articles. Articles found in online databases (N=441) using keywords, namely Electromyography, Muscle contractions, Myofunctional devices, Children and adolescents

Results

After eliminating duplicate articles, the title and abstract of each article were analyzed in 441 articles which were excluded from 408 articles. The full-text articles in the remaining 33 articles were re- analyzed and 29 articles were excluded. The complete text of the journal article and meets the eligibility of 4 articles will be reviewed and entered into the synthesis table.

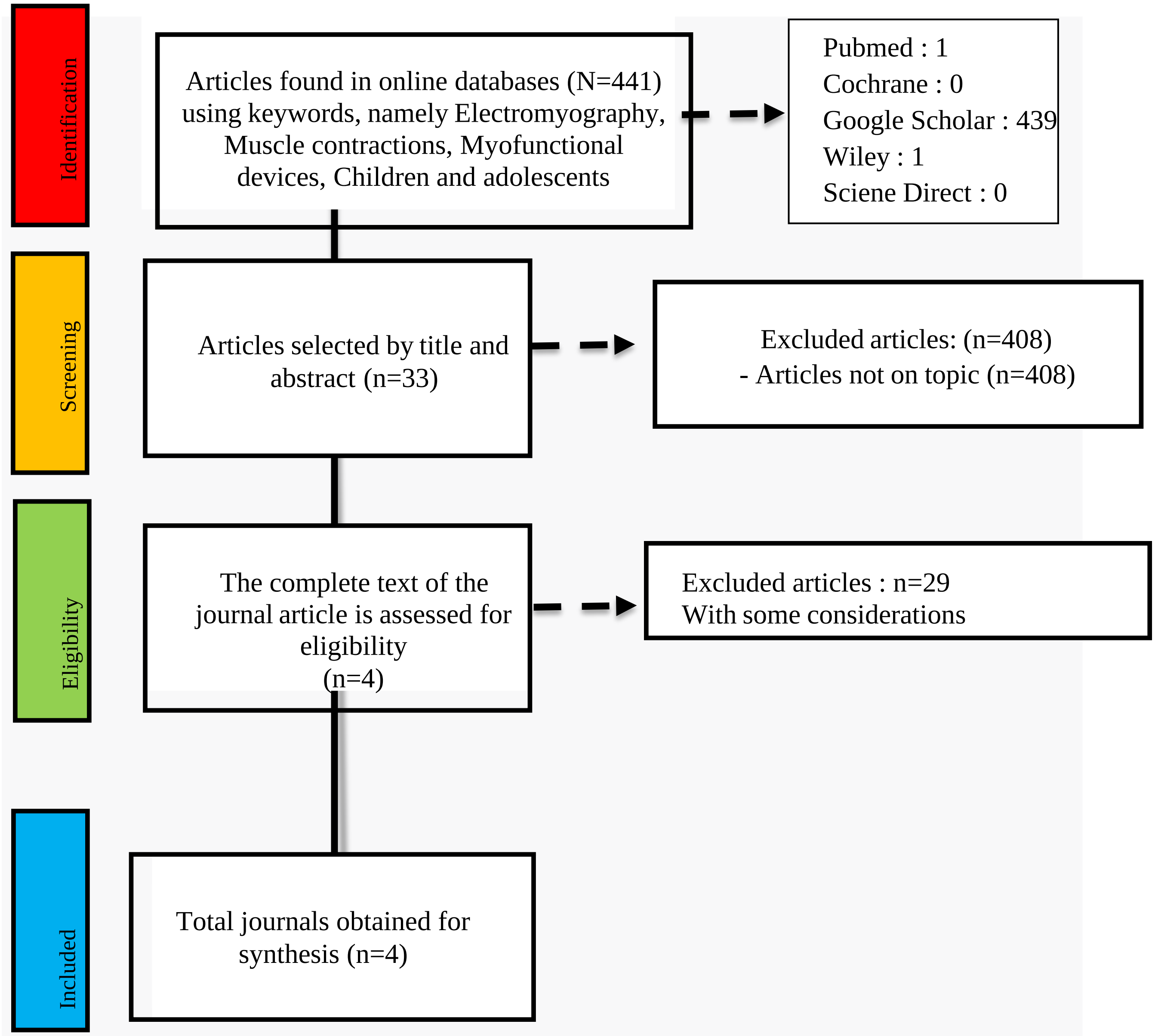

Figure 1. Diagram showing the selection of articles for review

Table 1. Study descriptive data included

No.	Author/ Year	Title	Study Design	Malocclusion Criteria	Type of Intervention	Statistic analysis	Study Conclusion
1.	Elena Di Palma, et all 2017	Effects of The Functional Orthopaedic Therapy on Masticatory Muscles Activity	Prospektif	Angle Class II, division I malocclusion	In the research sample group, the sample used a sander. Assessing surface electromyograph y (sEMG) activity of masticatory muscles before and after functional orthopedic therapy with the Sander apparatus.	Wilcoxon Signed-Rank Test	sEMG evaluations allow to quantify the impact of occlusion on masticatory muscle activity and to control that the functional orthopaedic therapy maintain a good muscular coordination
2.	Diego Jesus Brandariz Pimentel, et all 2018	Rapid Maxillary Expansion in The Treatment of The Functional Posterior Crossbite: Joint Noise and Electromyographic Activity Analysis	Quasi-experimental, prospektif, quantitatif, longitudinal study without control group	Posterior crossbite	All research samples use the RME tool and no control group	Mann-Whitney's test Wilcoxon's test	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.
3.	Ambrosina Michelotti, et all 2018	Evaluation of Masticatory Muscle Activity in Patients with Unilateral Posterior Crossbite Before and After Rapid Maxillary Expansion	Prospektif	Unilateral Posterior Crossbite (UPCB)	In the research sample group, the sample used the RME tool. In the control group, the	Paired and unpaired t-test or Wilcoxon-signed rank and Mann–Whitney U sample did not receive any treatment using any tools.	UPCB does not contribute to an asymmetric activation of AT and MM during functional tasks. The treatment of UPCB by RME did not determine a more symmetric activity of the assessed muscles. test, ANOVA or Friedman test and chi- squared test were used in statistical

							analysis
4.	Hong Hong, et all 2021	Electromyographic Features and Efficacy of Orofacial Myofunctional Treatment for Skeletal Anterior Open Bite in Adolescents : an Exploratory Study	Exploratory sutdy	Skeletal Anterior Open Bite (SAOB)	The first study sample group with SAOB malocclusion cases the second study sample group with normal occlusion. SAOB subjects were given OMT for 3 months, and EMGA was compared between before and after OMT.	Wilcoxon signed rank tests dan t- test	SAOB subjects showed abnormal OMS features including aberrant swallowing patterns and weak masticatory muscles, which were interrelated with the craniofacial dysmorphology features including a greater anterior facial height and incisor protrusion. Furthermore, OMT contributes to OMS harmonization, indicating its therapeutic prospect in SAOB.

Discussion

From table 1, we can see several journals that reviewed removable and fixed myofunctional devices used as malocclusion therapy, including sander and RME devices. On the use of the sander appliance, before treatment, all children had good muscle balance, with the EMG index within the reference value.24,25 After treatment, all EMG indices remained within the reference value, and no significant difference before treatment was found (table 2).

The present study assessed a group of adolescent patients with Angle Class II malocclusion; the study was designed to gain some information on the neuromuscular effects of the treatment with Sander appliance. Currently, EMG allows to supervise and investigate some of the main muscles involved in chewing, deglutition and head posture and motion (masseter, temporalis, anterior digastric and sternocleidomastoid), obtaining well reproducible results when standardised protocols are used.24,25 Additionally, sEMG is being used to assess the activity of facial muscles, analyzing the effects of malocclusion and orthodontic treatment on muscular activity.24,26

In the current study, the comparison between the EMG pre and post-treatment data allowed to evaluate the effects of the orthopaedic-functional therapy on muscular function. After treatment, all subjects maintained a good muscular equilibrium (POC index: right-left side within muscle; Activity Indeed, occlusal stability has been shown to be related to muscular performance: subjects with a high occlusal stability reveal shorter times of contraction and wider EMG potentials during mastication when compared to patients with a lower occlusal stability.24,31 In 9-year-old children with Class II malocclusion, interceptive orthodontic treatment improved the form and function of perioral muscles.32 One of the limitation of the current study, as of other investigations30,32 is the lack of a long-term follow up: patients were analyzed only up to 1 year after the end of therapy. Considering its lack of dangerous and painful procedures, sEMG can be longitudinally repeated in post-treatment patients. The patients analyzed in the present study are currently longitudinally followed up to control their masticatory and muscular function until treatment stabilization and maturation of the stomatognathic system.

Table 2. Electromyographic variables calculated for 10 patients before and after functional orthopedic therapy.

	Pre-treatment		Post-treatment		
Variable	Mean	SD	Mean	SD	p-value
POC masseter (%)	86.48	3.29	87.45	2.39	NS
POC temporalis (%)	87.17	1.70	86.59	3.35	NS
TC (%)	8.09	1.45	8.85	1.03	NS
Activity indeks (%)	- 3.77	6.37	- 0,04	7.48	NS
Impact (μV/μV· s %)	107	24	103	18	NS

POC: percentage of overlap coefficient (left-right muscle symmetry index) TC: torsion coefficient (potential of lateral displacement component)

Activity index: temporalis muscle activity relative to masseter muscle activity Comparisons were made with the Wilcoxon Marked Rank Test.

NS, not significant ($p > 0.05$).

Additionally, the current study assessed a limited group of patients with both mixed and permanent dentitions. Indeed, each subject acted as control of her/ himself, and this limited the effect of sample heterogeneity. Longterm studies with larger samples are required. On the use of the RME appliance, 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. 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).

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.33,34 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.35

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.33,36 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 teethtriturate the food efficiently, which ensures good performance and craniofacial development.36

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.34 This electromyographic behavior is more common for the cross side, in which the alteration of the mandibular kinematics movement is more index: masseter vs. temporalis; Torque coefficient: laterodeviant couples), without statistical significant variations.27,28,29 Together with conventional clinical and cephalometric assessments, the evaluation of the effects of orthopaedic-functional therapy should include objective functinal measurements to quantify the final result of the new occlusal condition in the wider context of the stomatognathic apparatus of the patient. In the clinical practice, surface EMG can be used to this scope.30

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.34

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			
Rest (uV)	Cross	Not Crossed	Difference	Cross	Not Crossed	Difference
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.

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.36,37 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.

In a third journal also using the RME appliance, the present study investigated whether individuals with UPCB have more asymmetric activity of the jaw muscles, and assessed whether the correction of UPCB contributes to more symmetric jaw muscle activity during standardized functional tasks. The findings of this study confirm the null hypotheses, that is patients with UPCB do not present more asymmetric AT and MM muscle activity as compared to UPCB-free controls, and that maxillary expansion does not determine a more symmetric activation of both AT and MM. In this study, an innovative EMG approach was used. This method, through the standardization of the EMG signals and normalizing the data as a percentage of the MVC effort on cotton rolls, reduces the biological noise, allows comparisons between subjects5 and is widely used and validated in normal subjects and in patients with TMD.3,5,24,38

The aim of this study was testing the effect of cross bite with mandibular side shift on masticatory muscle asymmetry. This occlusal condition is characterized by a discrepancy between centric occlusion (CO) and centric relation (CR), which determines an asymmetrical position of the condyles in the glenoid fossa.39 Hence, in the current study, the clinical manoeuvre described by Dawson40 was used to select study participants. This clinical manoeuvre is commonly used to distinguish between functional and morphologic crossbite, and to detect the CR position and the discrepancy between CO and CR. In this study, all participants had a posterior unilateral crossbite in CO but not CR, with a shift CR–CO.

This study has a few limitations. First, most of the EMG indices were computed using the MVC. MVC is dependent on the participant's compliance. Although all the participants were verbally encouraged during the experimental tasks, MVC values recorded may be slightly different across the time points. However, the RMS algorithm, used for the computation of the indices, analysed the 3 seconds of the test with the highest EMG amplitude, providing a normalized estimate of the MVC. Therefore, it may be assumed that variations of MVC across the conditions did not significantly affect the outcome measures. Second, in this study, the dental contacts were not recorded, although interferences between the upper and dental arches were reported to influence the EMG indices.41 Third, ASIM and SMI analysis were performed using adult normative values. This may raise questions concerning the validity of the analysis and the interpretation of the data. However, on the other hand there is no evidence suggesting that the threshold of muscular asymmetry is or should be different between adults and children.

In the fourth journal on orofacial myofunctional therapy (OMT), which is often considered as an adjunct to conventional orthodontic treatment, has been shown to be efective in harmonizing the OMS based on its improvement of musculature and orofacial function. Degan W42 highlighted that myofunctional therapy associated with the removal of sucking habits contributed to a better and faster amelioration of the swallowing pattern and the tongue rest position. Korbmacher43 demonstrated that an appliance-based orofacial muscle training protocol exhibited 65% efectiveness in altering habitual mouth breathing to nasal breathing. However, a recent systematic review and meta-analysis found that although myofunctional treatment in the deciduous and mixed dentition children appeared to be promising to correct anterior open bite, the quality of the existing evidence was questionable.44 Moreover, inadequate attention has been paid to the correlation between the OMS and morphological features in SAOB and the potential benefits of OMT regarding the myofunctional status and orthodontic treatment.

Infuence of OMT on EMGA in SAOB, By comparing the measurements, it was found that mentalis muscle activity at rest, and the activity of anterior temporalis, masseter muscle and anterior digastric in the ICP increased signifcantly (P<0.05) after OMT; however upper orbicularis activity and mentalis muscle activity decreased signifcantly (P<0.05) after OMT, suggesting that OMT might contribute to normalization of the OMS by strengthening the muscles associated with mastication in the ICP and relaxing the perioral muscles during lip sealing (Table 4).

	TA				MM				DA		
	Before μV	After μV	T μV	*P*	Before μV	After μV	T μV	*P*	Before μV	After μV	
REST	1.60 (1.25, 2.30)[a]	1.45 (1.20, 1.85)	−0.32±0.87[b]	0.147	0.95 (0.80, 1.40)	1.45 (1.20, 1.85)	0.41±0.78	0.06	0.90 (0.75, 1.60)	1.00 (0.70, 1.30)	−0
ICP	37.2 (31.5, 58.8)[a]	62.1 (51.2, 84.7)	25.4 (7.20, 31.9)	0.001	26.3±12.2[b]	60.6±37.6	34.4±30.2	**0.003**	4.49±1.94	8.68±3.88	
LIP	1.85 (1.30, 2.65)[a]	1.70 (1.15, 2.10)	−0.41±0.98[b]	0.132	1.40 (0.95, 1.95)	1.45 (0.90, 1.55)	−0.10 (−0.55, 0.15)	0.158	1.80 (1.30, 3.40)	1.35 (0.90, 1.55)	−1
SWA	2.45 (1.40, 5.05)[a]	3.00 (1.60, 6.40)	0.75±3.63[b]	0.820	3.65 (2.15, 5.45)	3.40 (2.05, 5.15)	−0.15±2.78	1.000	8.70 (6.95, 11.05)	7.80 (5.85, 16.5)	−0.60 (−2.30, 1.10)

	UO				ME		
	Before μV	After μV	T μV	*P*	Before μV	After μV	T μV
REST	1.10 (1.00, 1.40)	1.10 (0.80, 1.50)	0.00 (−0.30, 0.30)	0.916	5.20 (1.80, 7.10)	2.50 (1.65, 4.90)	−0.80 (−2
ICP	2.30 (1.90, 2.90)	2.20 (1.80, 2.90)	−0.20 (−0.60, 1.00)	0.489	3.90 (3.05, 8.10)	6.15 (3.95, 12.1)	0.45 (−1.3
LIP	15.5 (12.4, 18.7)	3.20 (1.80, 8.10)	−10.4±3.53	0.001	18.8±8.51	9.86±4.56	−8.97±6.
SWA	23.7 (16.8, 26.5)	10.4 (6.90, 18.4)	−10.1±8.13	0.002	34.8±18.8	20.6±12.6	−14.3±8.

Wilcoxon signed rank test was used for skew distribution data, t-test was used for normal distribution data, α=0.05

TA, temporal muscle; MM, masseter muscle; DA, anterior digastric; UO, upper orbicularis; ME, mentalis muscle; REST, mandibular rest; ICP, maximum voluntary contraction in the intercuspal position; LIP, lip sealing; SWA,swallowing

[a] Median (25%, 75%)

[b] Mean±standard deviatio

Previous studies have shown that chewing exercise contributes to improvements in masticatory disturbances and defciencies by infuencing the functional capacity and increasing the strength of the masticatory muscles45,46, which is consistent with our results. Furthermore, according to the high prevalence of harmful oral habits, such as mouth breathing and tongue thrust swallowing, among subjects with SAOB and the relationship of these habits with orofacial myofunctional disorder, lip-pressing training and tongue training were designed to correct the harmful oral habits and abnormal tongue forces by establishing patterns of nasal breathing and physiological swallowing. Former studies have demonstrated that OMT can signifcantly change the tongue posture by establishing patterns of nasal breathing and physiological swallowing.47,48 Our results support the efcacy of OMT in altering the OMS. Combined with the fndings discussed above, OMT is efective in correcting harmful habits and harmonizing OMS abnormalities, indicating that OMT as one of adjuvant orthodontic therapies is benefcial to the treatment of SAOB patients. For patients in the growth and development stage, in whom the malocclusion or craniofacial deformities has not yet formed, it is important to raise awareness of harmful oral habits and provide early intervention with well-directed OMT to help rebalance the OMS for facial bone growth. For patients in whom malocclusion or craniofacial deformities has already developed, combining OMT with conventional orthodontic treatment may help reduce the difculty of treatment by harmonizing abnormal OMS. However, there have been few studies on the efects of OMT on the improvement of craniofacial morphology in SAOB patients. Further research is needed to evaluate the morphological changes of SAOB patients after OMT and confrm the long-term efects of OMT as an adjunct to conventional orthodontic treatment. It is worth noting that genetic factors should also be taken into account.

Conclusion

There are various myofunctional devices that can be used in the treatment of pediatric malocclusion, both removable and fixed in this regard in relation to electromyographic evaluation and muscle contraction. Removable myofunctional devices that can be used such as activators, twin-blocks, bionators and Frankel function regulators. While fixed myofunctional devices that can be used such as Herbst and Jasper jumper. Muscle dysfunction results in occlusion, not only of the muscles of mastication but also of all muscles involving swallowing, breathing, phonation and chewing, so muscle rehabilitation as part of corrective treatment should be considered. Class II malocclusion is a common problem in consultation, these individuals show decreased functional muscle activity, therefore, treatment with a myofunctional appliance is usually an option, with the aim of using the forces exerted by the muscles of mastication, tongue, cheeks and lips. causes neuromuscular changes that result in muscle balance with further harmonious jaw development. The physiological variables of age and sex must be taken into account, because in patients with normal occlusion, the electrical activity of muscles differs in terms of sex. In addition, as shown in this article, the ideal age for treatment with myofunctional appliances is during or near the peak of pubertal growth for effective results in a shorter period of time. Investigation of the electromyographic activity of the masticatory muscles is useful in everyday clinical practice, not only for evaluating treatment outcomes, but also for determining treatment duration and avoiding relapse.

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