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ORIGINAL ARTICLE

Orthodontic intervention combined with myofunctional therapy increases electromyographic activity of masticatory muscles in patients with skeletal unilateral posterior crossbite

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Abstract

Objective. The aim of this study was to evaluate the electromyographic activity of both the temporalis and masseter muscles and the mastication type of patients with skeletal unilateral posterior crossbite before and after orthodontic treatment and speech therapy. ***Methods.*** A total of 14 patients with skeletal unilateral posterior crossbite (eight females and six males), between 6–13 years of age, underwent electromyographic evaluation of their masseter and temporalis muscles in mandibular rest, habitual mastication and isometry. The subjects were assessed with regard to mastication type before and after orthodontic treatment and speech therapy. The data obtained during mandibular rest and habitual mastication were normalized in terms of the mean values of isometry. The Student's *t*-test was used for paired samples to compare the mean values of electromyographic activity ($p < 0.05$). ***Results.*** The masseters during habitual mastication presented higher electromyographic activity after both treatments ($p = 0.0458$). There was no significant difference between the contralateral masseters in terms of mandibular rest or habitual mastication before or after either treatment ($p > 0.05$). During habitual mastication, after the treatments, the temporalis muscle on the malocclusion side showed higher electromyographic activity than the contralateral side ($p = 0.0263$). Prior to therapy, all of the patients exhibited chronic unilateral mastication ($n = 14$) and 13 patients exhibited bilateral mastication after treatment. ***Conclusions.*** Orthodontic intervention combined with myofunctional therapy in patients with skeletal unilateral posterior crossbite provided an increase in the electromyographic activity of the masseter and temporalis muscles during mandibular rest and habitual mastication, with predominantly bilateral mastication.

Key Words: *Unilateral posterior crossbite, surface electromyography, functional myotherapy, masticatory muscles*

Introduction

Skeletal unilateral posterior crossbite (SUPC) is an occlusal alteration in the transverse plane that rarely corrects itself in the transition from primary to permanent dentition. The prevalence of SUPC is high in the deciduous and mixed dentitions. This condition should be treated immediately after diagnosis to prevent the developmental impairment of the dental arches and possible facial asymmetry [1].

The cause of this malocclusion is multifactorial, involving muscular forces from the interposition of the tongue and suction habits, such as thumb and dummy sucking, alongside mastication preference, among other factors. Such predisposing factors generate structural imbalance with disproportionate growth between the maxilla and the mandible, as well as functional imbalance, thereby displacing teeth and alveolar bone to undesirable positions [1], which can lead to alterations of the stomatognathic functions.

Muscular imbalance in mandibular rest, speech, mastication and swallowing may cause favourable conditions for the development, maintenance or relapse of the malocclusion [2,3]. Therefore, orthodontic treatment should envisage not only the correction of the malocclusion but also the re-establishment of the altered stomatognathic functions present in this type of malocclusion.

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Analysis of the masticatory muscle activity in patients with malocclusion can yield useful information on the functional impact of morphological discrepancies. The correction of SUPC can be combined with speech therapy to target this type of malocclusion to minimize the imbalance of the mastication musculature by means of isotonic and isometric exercises. This approach would provide an environment in which muscles function as closely to normal as possible [4].

Muscular activity can be investigated by means of surface electromyography, which is a technique used to assess the bioelectric capacity of the musculature [5] and to monitor several of the main muscles involved in mastication (the masseter, temporalis and suprahyoid muscles). In patients with SUPC, the electromyographic activity (EMG) of the masseter and temporalis muscles during mastication is higher on the SUPC side compared with the non-SUPC side [6].

The assessment of muscular activity during mastication and mandibular rest, both in SUPC and after its correction, will significantly contribute to myofunctional and orthodontic therapy, as the muscular activity may interfere with the stabilization of the occlusal correction [7].

The aim of this study was to assess the EMG activity of the masseter and temporalis muscles, as well as the mastication type, in patients with SUPC before and after orthodontic treatment and speech therapy.

Materials and methods

The population of this study consisted of all patients that were beginning orthodontic treatment for correction of SUPC between March 2008 and March 2009 in the Orthodontic Clinic of the Pontifícia Universidade Católica do Paraná, Curitiba, Brazil.

The patients' inclusion criteria were the presence of SUPC and a predominantly nasal breathing mode. The exclusion criteria were the presence of severe craniofacial anomalies, temporomandibular disorders, neuropathies, previous orthodontic treatment or speech therapy of any type and the use of medication that could interfere with the electromyographic results.

The cohort consisted of 14 patients with SUPC. The patients' parents/guardians signed a free and informed consent form authorizing their participation in this study. Clinical, dental, speech and electromyographic examinations were performed with approval from the Ethics Committee of the PUCPR (534/07).

Dental examination

The diagnosis of SUPC and the analysis of the other established criteria used to establish the cohort were conducted by orthodontists.

Speech examination

The speech exam consisted of the assessment of the mastication type, which was performed by means of visual inspection. The patients were asked to open their mouths during the mastication of three raisins. Additionally, the patients were asked which side they used to chew (left, right or both). The mastication type was classified as alternate bilateral, when both sides were used alternately in a balanced manner; bilateral simultaneous, when the food was automatically divided and chewed by the molar teeth on both sides at the same time; preferential unilateral, when chewing occurred predominantly on one side but occasionally on the other side; chronic unilateral, when chewing occurred exclusively on one side (the SUPC side) with no occlusal contact on the opposite side; and anterior, when chewing occurred using the anterior teeth and, occasionally, the dorsum of the tongue. If the food was not chewed properly, the patient was considered as not having performed the masticatory function [8].

The assessment of the mastication type was conducted before and after the orthodontic treatment and speech therapy.

Electromyographic examination

The electromyographic examination was aimed at recording the EMG activity of the masseter muscle and the anterior belly of the temporalis muscle, bilaterally, at two stages: before (stage 1) and after (stage 2) orthodontic and speech therapies.

The EMG recording was performed using an electromyography system (EMG System do Brasil, Sao Paulo, Brazil) with eight channels, 2000× amplification, a 20-Hz high-pass filter, a 500-Hz low-pass filter and a 12-bit analogue-to-digital (A/D) converter in combination with data-acquiring hardware (AqDados) with a sampling frequency of 2000 Hz per channel.

The EMG tests were conducted at the electromyography laboratory of the PUCPR. The action potentials of the muscles were obtained using simple differential active electrodes (EMG System do Brasil, Sao Paulo, Brazil) composed of two parallel pure silver (Ag) rectangular bars (10 × 2 mm), which were separated by 10 mm and fixed in a 23 × 21 × 5 mm acrylic resin capsule. The active electrodes had an entrance impedance of 10 GΩ, a common-mode rejection ratio (CMRR) of 130 dB and a 20× gain.

Prior to the EMG tests, the patch of skin on which the electrodes would be affixed was wiped with 70% alcohol to remove excess grease, facilitating adhesion and the capture and transmission of the electric potentials arising from muscle contraction.

An isometry test was used to determine the appropriate area for affixation of the electrodes, which were placed over the superficial portion of the masseter muscle (on the belly of the muscle), 2 cm above the

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angle of the mandible and on the anterior belly of the temporalis muscle. To eliminate the acquisition of noises from the electromyographic signals, a monopolar electrode attached to a grounding wire was placed on the manubriosternal joint. The electrodes were fixed to the skin using Transpore® adhesive tape (3 M do Brasil, Sumaré, Brazil), such that the silver plates were positioned perpendicular to the direction of the tested muscle fibres [9].

At the time of EMG testing, the patients were seated on a chair with straight back support, without a head rest, with their hands and forearms on their thighs and the plantar area of their feet resting on a rubber mat for insulation against static electricity. Their head was straight and the Frankfurt plane was parallel to the floor, as instructed by the International Society of Electrophysiology and Kinesiology [9,10].

The electromyographic tests were conducted with three repetitions each. The positions tested were mandibular rest, habitual mastication and maximum voluntary contraction in the intercuspal position (ICP), according to the following protocol:

(1) Resting for 10 s: The patient was instructed to relax his/her facial musculature, refrain from swallowing and hold the teeth out of occlusal contact and the tongue on the floor of the mouth, while breathing normally. The analysis time was set at 10 s.
(2) Habitual mastication for 10 s: The clinician placed three raisins in the patient's mouth with gloved hands, instructing him/her to place the raisins onto the occlusal surfaces of their molars and chew them as usual for 10 s. The analysis time was set at 10 s.
(3) Isometry for 10 s: The mandible was placed in the ICP and the clinician placed three raisins onto the right molars and three onto the left, asking the patient to press the raisins as hard as he/she could without swallowing during the EMG data capture process. For the purpose of the isometry test, the first 2 s of each data collection period were ignored, and the next 2–5 seconds were included, with a 3-minute break between each test to prevent signs of possible muscle fatigue. This test of maximum voluntary contraction was used as a reference with which to normalize the electromyographic signal, as recommended by the International Society of Electrophysiology and Kinesiology [10].

Using the equipment's software, the electromyographic signals were processed in the time domain by calculating the root mean square (RMS) and expressing it in μV as raw data.

Orthodontic treatment and speech therapy

The orthodontic treatment aimed to correct the SUPC by rapid maxillary expansion using a modified Haas Expander appliance. The treatment was conducted during an average period of 6 months at the Orthodontic Clinic of the PUCPR.

The speech therapy consisted of organizing the mastication types in sessions, which occurred during the same visits as the orthodontic follow-ups, i.e. fortnightly throughout the treatment period. The patients were instructed to perform exercises to move food during mastication, alternating muscle activity between the right and left sides in a balanced manner. The patients were asked to chew the same number of times on each side in front of the mirror, thus initiating the process of re-education to achieve an alternating bilateral mastication type, within their capabilities, avoiding the overload of a single side.

The speech therapist encouraged the repetition of this activity at home, recommending 20 movements to be performed 3-times a day at meal times. The parents supervised the instructions and were encouraged to reinforce the correction of mastication type to facilitate the success of the orthodontic treatment.

Upon the removal of the Haas Expander, the patients were again subjected to speech therapy tests and electromyographic examination as part of their orthodontic and speech therapy follow-ups. All of the tests were conducted by the same researcher throughout this study.

The patients who presented simultaneous bilateral mastication at stage 2 would be regarded as 'target met', as this was the preferred outcome due to the resulting preservation of the masticatory function balance.

Statistical analysis

The data from the evaluation of mastication type were expressed in percentages and compared at stages 1 and 2. Statistical analysis was conducted based on the data obtained from the assessments during mandibular rest and habitual mastication, which were normalized in terms of the mean values of isometry (individual reference values). The Student's *t*-test was used for paired samples for comparisons of the mean values of electromyographic activity between stages 1 and 2 and between different muscles on the sides with and without SUPC. The statistical tests were performed at a significance level of 5% ($p < 0.05$).

Results

A total of 14 patients participated in this study (eight females and six males), with an average age of 9 years (range = 6 years and 4 months to 13 years and 5 months). Of the 14 patients, 11 exhibited SUPC on the right side and three on the left.

Table I shows the mean values of the EMG activity for the masseter and temporalis muscles on the SUPC side at stages 1 and 2 during mandibular rest and habitual mastication. The masseter muscle, during

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Table I. The mean values and standard deviations of the electromyographic activity of the masseter and temporalis muscles on the side with skeletal unilateral posterior crossbite at stages 1 and 2, during both mandibular rest and habitual mastication.

Muscles	Position	Stage 1, X ± SD	Stage 2, X ± SD	*p*-value
Masseter	Resting	0.1447 ± 0.0843	0.2233 ± 0.2508	NS
	Mastication	0.4729 ± 0.1930	0.5740 ± 0.2818	0.0458*
Temporalis	Resting	0.2056 ± 0.1398	0.2437 ± 0.1481	NS
	Mastication	0.5340 ± 0.1901	0.6673 ± 0.5112	NS

NS, non-significant.
* Statistically significant different ($p < 0.05$).

Table II. The mean values and standard deviations of the electromyographic activity of the masseter muscles on the sides with and without SUPC at stages 1 and 2, during both mandibular rest and habitual mastication.

Stages	Position	Masseter muscle side with SUPC, X ± SD	Masseter muscle side without SUPC, X ± SD	*p*-value
1	Resting	0.1447 ± 0.0843	0.1496 ± 0.0790	NS
	Mastication	0.4729 ± 0.1930	0.4625 ± 0.1337	NS
2	Resting	0.2233 ± 0.2508	0.2404 ± 0.1967	NS
	Mastication	0.5740 ± 0.2818	0.6215 ± 0.2880	NS

NS, non-significant.

Table III. The mean values and standard deviations of the electromyographic activity of the temporalis muscles on the sides with and without crossbite at stages 1 and 2, during both mandibular rest and habitual mastication.

Stages	Position	Temporalis muscle side with SUCP, X ± SD	Temporalis muscle side with SUCP, X ± SD	*p*-value
1	Resting	0.2056 ± 0.1398	0.1717 ± 0.1024	0.0044*
	Mastication	0.5340 ± 0.1901	0.4984 ± 0.1724	NS
2	Resting	0.2437 ± 0.1481	0.1661 ± 0.1572	0.0047*
	Mastication	0.6673 ± 0.5112	0.5193 ± 0.1836	0.0263*

NS, non-significant.
* Statistically significant difference ($p < 0.05$).

habitual mastication, showed a higher EMG activity at stage 2 compared with stage 1 ($p = 0.0458$).

Tables II and III show the mean values of the EMG activity of both the masseter and temporalis muscles, respectively, on the sides with and without SUPC at stages 1 and 2 during mandibular rest and habitual mastication.

No statistically significant difference was observed between the masseter muscles on the side with or without SUPC during mandibular rest and habitual mastication at stages 1 and 2 ($p > 0.05$, Table II).

Before (stage 1) and after (stage 2) orthodontic and speech therapy treatment, the temporalis muscle on the SUPC side exhibited higher EMG activity than the same muscle on the side without SUPC during mandibular rest ($p < 0.05$). During habitual mastication, following orthodontic and speech therapy treatment, the temporalis muscle on the SUPC side exhibited higher EMG activity compared with the same muscle on the side without SUPC ($p = 0.0263$, Table III).

Table IV shows the results of the mastication type assessment of patients with SUPC at stages 1 and 2.

Table IV. Results from the evaluation of the mastication type in patients with skeletal unilateral posterior crossbite at stages 1 and 2.

Mastication type	Stage 1, *n* (%)	Stage 2, *n* (%)
Alternate bilateral	0	8 (57.14)
Simultaneous bilateral	0	5 (35.72)
Preferential unilateral	0	1 (7.14)
Chronic unilateral	14 (100)	0
Anterior	0	0
Does not perform function (ineffective chewing)	0	0

Discussion

Understanding myofunctional behaviour resulting from the different types of malocclusion facilitates treatment planning with a multidisciplinary approach [2]. In the present study, the contralateral masseter and temporalis muscles demonstrated balance during mastication in the presence of SUPC (Tables II

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and III). After the orthodontic and myofunctional interventions, there was an increase in EMG activity in both muscles on the affected side, despite an occasional lack of statistical significance (Table I). For the temporalis muscle, the SUPC side showed higher EMG activity than the unaffected side during mastication at stage 2, thus demonstrating a lack of harmony between the contralateral muscles (Table III). Furthermore, a predominance of the bilateral mastication type was observed following orthodontic and speech interventions.

While the contralateral masseter muscles showed balanced EMG activity during mandibular rest and habitual mastication (Table II) at stage 1, the temporalis muscle on the SUPC side exhibited higher EMG activity than the contralateral muscle during mandibular rest (Table III). These results are somewhat similar to those described by Alárcon et al. [5], who observed that, in tests during mandibular rest in patients with SUPC, no difference was observed between the EMG activity of the masseter and temporalis muscles between the sides with and without SUPC. Nonetheless, there have been reports of higher EMG activity in the mastication muscles on the SUPC side compared with the contralateral side during unilateral mastication [6], mandibular rest and maximum voluntary contraction [11]. This result was expected because all of the patients in that cohort had a unilateral mastication type, typical of patients with SUPC. Long-term unilateral mastication results in the sole stimulation of the malocclusion side [3,12]. The fact that no EMG difference was observed between the sides may have been due to the low numbers in this cohort and the age of the studied population, which coincides with the mixed dentition phase and several associated physiological changes. These changes can interfere not only with occlusal stability but also with muscle function.

Orthodontic intervention combined with myofunctional therapy generated an increase in EMG activity in all of the studied muscles; however, this increase was not always statistically significant during mandibular rest and habitual mastication, either on the side with SUPC or on the side without SUPC (Table I). Multidisciplinary intervention was positively associated with the increase in EMG activity on the corrected side. Such an increase is believed to have occurred because the occlusal correction provided greater tooth contact for chewing. In addition, the change in mastication type allowed the side with SUPC to increase its muscle activity. Consequently, an improvement in spatial proprioception was observed, which improved food chewing coordination and resulted in an efficient mastication musculature [12].

An increase in EMG activity after speech therapy was also observed in other studies [13–15]. The performance of isometric exercises increased the maximum voluntary contraction and the resistance to muscle fatigue in healthy individuals [13]. Isometric exercises directed at the labial musculature promoted an increase in muscle activity in mouth-breathing patients with no nasal obstruction [14]. Isometric exercises performed with a facial exercise device, equipment designed to stimulate buccinator activity, increased the EMG activity of that muscle and reduced the activity of the masseter muscle in bruxists [15]. However, the present study was designed to address the correction of SUPC and the mastication type with specific isotonic exercises. In the presence of a normal occlusion, attainment of the greatest possible availability of tooth surfaces for chewing and guidance regarding the organization of mastication type during a 6-month period was believed to be sufficient to re-establish the stability of muscle activity.

The mastication type was corrected in the majority of patients. Only one (7.14%) showed a preferential unilateral mastication type at stage 2, suggesting the possibility of side dominance or lack of biofeedback to drive the automation of a bilateral mastication type. In addition to the prevalence of the bilateral mastication type and EMG increase at stage 2, it was observed that the masseters continued to exhibit balanced EMG activity during both mandibular rest and habitual mastication (Table II), suggesting that the multidisciplinary intervention reflected positively on the power increase and maintenance of the muscular balance. This balance will certainly be a determining factor that promotes harmony in craniofacial growth. The masseters are responsible for mandibular lifting, contributing primarily with their strength during food chewing. The balance between the contralateral temporalis muscles may not yield significant clinical outcomes, as the main function of these muscles is the positioning and posture of the mandible [12]. Many studies have investigated the EMG activity of the mastication muscles in patients with SUP; however, there is a shortage of studies that have investigated the EMG activity of such muscles following orthodontic correction, which compromises the comparison of the results obtained in the present study with those obtained in other studies.

Despite being a preliminary study with a small cohort, the results of this study showed that orthodontic intervention combined with myofunctional therapy in patients with SUPC provided an increase in the EMG activity of the masseter and temporalis muscles. Longitudinal multidisciplinary studies involving the use of isometric and isotonic exercises with EMG activity control by biofeedback, led by speech therapy and combined with orthodontics, may help to elucidate EMG and stomatognathic functions in SUPC, as well as the possible causes of relapse.

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References

[1] Enlow DH, Hans MG. Essentials of facial growth. Philadelphia, PA: Saunders; 1996.
[2] Altmann EB. Myofunctional therapy and orthognatic surgery. Int J Orofacial Myology 1987;13:2–12.
[3] Trawitzki LVV. Fonoaudiologia nas deformidades dentofaciais junto à equipe de cirurgia ortognática. In Felício CM, Trawitzki LVV, editors. Interfaces da medicina, odontologia e fonoaudiologia no complexo cérvico-facial. Barueri: Prófono; 2009.
[4] Berretin-Felix G, Jorge TM, Genaro KF. Intervenção fonoaudiológica em pacientes submetidos à cirurgia ortognática. In: Fernandes FDM, Mendes BCA, Navas ALPGP, editors. Tratado de Fonoaudiologia. São Paulo: Rocas; 2010.
[5] Alarcón JÁ, Martín C, Palma JC. Effect of unilateral posterior crossbite on the electromyographic activity of human masticatory muscles. Am J Orthod Dentofacial Orthop 2000;118: 328–34.
[6] Ferrario VF, Sforza C, Serrao G. The influence of crossbite on the coordinated electromyographic activity of human masticatory muscles during mastication. J Oral Rehabil 1999;26: 575–81.
[7] Rodrigues KA, Ferreira LP. Eletromiografia dos músculos masseteres na mastigação habitual em indivíduos com e sem má oclusão. Rev Dental Press Ortodont Facial 2003;6: 107–14.
[8] Felício CM, Ferreira CL. Protocol of orofacial myofunctional evaluation with scores. Int J Pediatr Otorhinolaryngol 2008; 72:367–75.
[9] Pedroni CR, Borini CB, Bérzin F. Electromyographic examination in temporomandibular disorders - evaluation protocol. Braz J Oral Sci 2004;3:526–9.
[10] Merletti R. Standards for reporting EMG data. Politecnico di Torino. Italy: International Society of Electrophysiology and Kinesiology (ISEK); 1999.
[11] Souza LT, Pereira BR, Ignácio SA, Tanaka O, Oliveira JHG, Marquezan M, et al. Estudo eletromiográfico dos músculos masseter e temporal em indivíduos com mordida cruzada posterior unilateral. Braz Oral Res 2006;20:210.
[12] Douglas CR. Tratado de fisiologia aplicado à fonoaudiologia. São Paulo: Robe Editorial; 2002.
[13] Thompson DJ, Throckmorton GS, Buschang PH. The effects of isometric exercise on maximum voluntary bite forces and jaw muscle strength and endurance. J Oral Rehabil 2001;28: 909–17.
[14] Schievano D, Rontani RM, Bérzin F. Influence of myofunctional therapy on the perioral muscles. Clinical and electromyographic evaluations. J Oral Rehabil 1999;26:564–9.
[15] Jardini RS, Ruiz LS, Moysés MA. Electromyographic analysis of the masseter and buccinator muscles with the pro-fono facial exercise use in bruxers. Cranio 2006;24:29–37.

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