Original Article

Effect of surgically assisted rapid maxillary expansion on masticatory muscle activity: A pilot study

Access this article online
Website: www.amsjournal.com
DOI: 10.4103/2231-0746.83152
Quick Response Code:

Cássio E. Sverzut, Karinna Martorelli, Roberto Jabur, Alice D. Petri, Alexandre E. Trivellato, Selma Siéssere[1], Simone C. H. Regalo[1]
Department of Oral and Maxillofacial Surgery and Periodontology, and [1]Department of Morphology, Stomatology and Physiology, Ribeirão Preto, School of Dentistry, University of São Paulo, São Paulo, Brazil

Address for correspondence:
Prof. Simone Cecílio Hallak Regalo, Avenida do Café, s/n – Bairro, Monte Alegre, 14040-904 Ribeirão Preto, São Paulo, Brazil.
E-mail: schregalo@forp.usp.br

ABSTRACT

Background: The aim of the present study was to analyze the electromyographic (EMG) activity of masseter and temporal muscles of adult patients submitted to surgically assisted rapid maxillary expansion (SARME) before and after the surgery. **Materials and Methods:** The sample consisted of 19 adults, with ages ranging from 20 to 47 years (mean 25.4 years), with bilateral posterior cross bite requiring SARME treatment. The electromyographic activity of masseter and temporal muscles was analyzed before treatment (T1) and after the surgical procedure (T2). The mean interval between the two electromyographic analyses was 15 days. **Results:** The muscular active was electromyographically analyzed during the clinical situation of habitual gum chewing (10 sec), dental clenching (4 sec), mouth opening and closing (10 sec), rest (10 sec), protrusion (10 sec), and right and left laterality (10 sec). The measured differences between T1 and T2 data were evaluated using the paired t-test (SPSS 17.0 for Windows). The electromyographic analysis showed that the activity of the masseter and temporal muscles decreased significantly after the SARME in all the clinical situations after the surgery. **Conclusion:** According to the results of the present study, individuals after SARME surgery presented patterns of electromyographic contraction similar to those developed by dentate individuals during the movements of mandibular excursion.

Keywords: Electromyography, masticatory muscles, surgically assisted rapid maxillary expansion

INTRODUCTION

A sufficient transverse maxillary dimension is a critical requirement of a stable and functional occlusion.[1] When this dimension is inappropriate, a uni and/or bilateral posterior crossbite is present and the treatment is essential to correct these transverse maxillary deficiencies.

Orthopedic rapid palatal expansion in skeletally immature patients is the procedure of choice to correct this condition in that age group. Nonetheless, this treatment modality in skeletally mature patients can produce unwanted effects, such as lateral tipping and/or extrusion of posterior teeth, periodontal membrane compression, root resorption, alveolar bone bending, fenestration of the buccal cortex, palatal tissue necrosis, inability to open the midpalatal suture, pain, and instability of the expansion.[1-3] Therefore, skeletally mature individuals should be submitted to treatment that involves the use of orthodontic expansion appliance and/or maxillary osteotomies, namely surgically assisted rapid maxillary expansion (SARME).

Many areas of medicine, dentistry, physical therapy and speech therapy include superficial electromyographic (EMG) exams, which help to obtain diagnoses, establishing more accurate prognoses, and accompanying muscular performance during various types of treatment.[4,5]

EMG analysis of masticatory muscles provides useful data regarding the functional impact of morphological discrepancies and permits functional evaluation in patients subject to surgical treatment to correct occlusal discrepancies.[6] Although the SARME has been routinely used for treatment of posterior uni or bilateral cross bite, only few studies can be found in the scientific literature, which evaluate the behavior of these muscles to this treatment

modality in adult patients.

Thus, the present study aimed to evaluate the effect of SARME on EMG activity of masseter and temporalis muscles in adults before and immediately after the SARME surgery to observe what occurs with the EMG activity of the masticatory muscles.

MATERIALS AND METHODS

Group selection

Nineteen patients (6 males and 13 females) with ages ranging from 20 to 47 years (mean 25.4 years) were included in this study. They were selected from 44 consecutive patients treated in the Oral and Maxillofacial Clinic at the School of Dentistry. The inclusion criteria were good health status, minimum transversal maxillary discrepancy of 5 mm, absence of anteroposterior and vertical maxillary discrepancies, SARME as the unique surgical procedure and absence of complications during the surgical procedure and maxillary expansion. The exclusion criteria were smoking, metabolic bone diseases (e.g., hyperparathyroidism, vitamin C deficiency), chronic use of corticoids before or during treatment, parafunctional habits (e.g., bruxism), and temporomandibular joint dysfunction.

The study was previously approved by the Ethics Committee at FORP/USP. All subjects were informed about the purpose and potential risks of the study and, once agreed, they signed an Informed Consent Term, as required by resolution 196/96 issued by the National Health Council.

Surgical procedure

All patients included in this study had received the same surgical intervention and had the same surgeon. The surgical procedure performed under local anesthesia was that basically described by Bell and Jacobs.[7] A horizontal incision was made through the mucoperiosteum above the mucogingival junction in the depth of the buccal vestibule, extending from the mesial area of the first molar to the distal area of the canine. The lateral and anterior maxillary wall was exposed from the lateral aspect of the pyriform rim to the zygomatic maxillary buttress by mucoperiosteal elevation. A micro-reciprocating saw was used to make a horizontal osteotomy about 5 mm above the apices of the teeth from the posterior aspect of the zygomatic buttress to the inferolateral aspect of the pyriform rim. A vertical incision in the upper lip frenulum was performed, allowing access to the planned site of the interincisal osteotomy. Afterwards, an osteotomy was made in the midline between the central incisor's roots, using a microsagittal saw. An immediate expansion of the maxilla was performed by driving the Sverzut's chisel in this previous osteotomy parallel to the palate for approximately 1.0 to 1.5 cm. The forefinger was positioned on the incisive papilla to feel the chisel as it transected the palatal bone. After the complete introduction in the previously osteotomized site, the chisel was handled in a rotation movement until the separation was reached. Then, the previously cemented orthodontic appliance was activated 8 turns (2.0 mm), resulting in a clinically visible separation of midpalatal suture. No additional expansion was attempted for 5 days postoperatively, and then, one-quarter turn was done twice a day until the desired amount of expansion was achieved. Afterwards, the width of the maxillary arch was maintained by stabilizing the appliance, either by passing a piece of wire through the hole in the expansion device screw and looping it around the anterior guide hole rod, or by adding cold-curing acrylic resin to the central portion of the expansion device [Figures 1 and 2]. Except for swelling and hematoma, no postoperative problems were noticed and pain was minimal in all cases.

EMG analysis

Electromyographic analysis was performed using a *MyoSystem-Br1* (São Paulo, Brazil) electromyographer with differential active electrodes (silver bars 10 mm apart, 10 mm long, 2 mm wide, 20 gain, input impedance 10 GX and 130 dB at 60 Hz common mode rejection ratio). Surface differential active electrodes were placed on the skin, previously cleaned with alcohol, bilaterally on both masseter muscles and on the anterior portion of the temporalis. A ground electrode was also used and fixed on the skin over the sternum region. The electromyographical signals were analogically amplified with a gain of 1000, filtered by a pass-band of 0.01–1.5 kHz and sampled by a 12-bit A/D converter with a 2 kHz sampling rate. The signals were digitally filtered by a pass-band filter of 10–500 Hz for data processing.

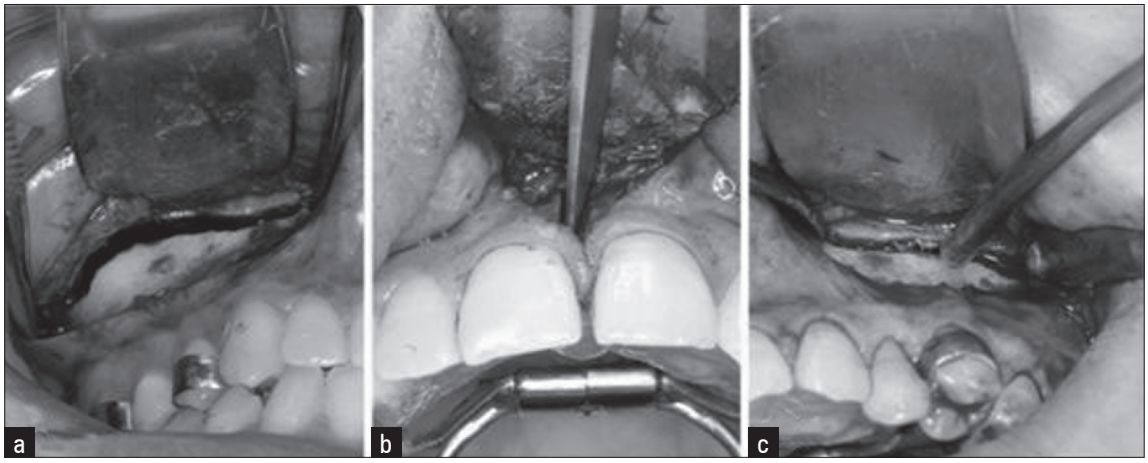

Figure 1: Surgical procedure: osteotomy performed from zygomatic buttress to pyriform rim at the right side (a), the chisel positioned into the osteotomy at the midline (b), left side (c)

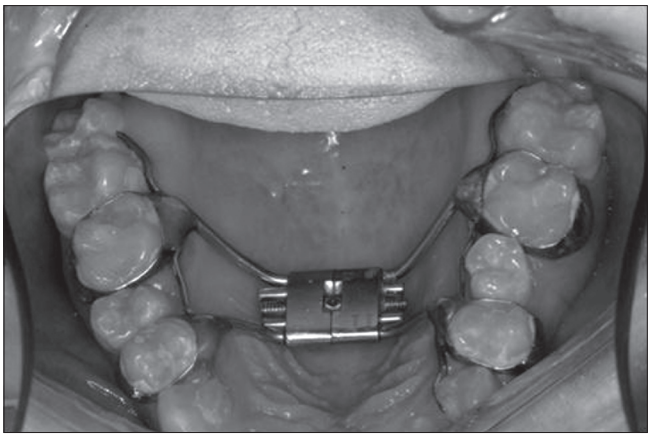

Figure 2: Mirror image showing the Hyrax palatal expander applied in this study

The volunteers' skin was prepared by performing skin asepsis with alcohol and, if necessary, trichotomy. The electrodes were fixed by bands of adherent tape, allowing total contact between the electrode uptake bars and the skin. We followed the localization, orientation, and tests for placing the electrodes as suggested by the *European Recommendations for Surface Electromyography* of the SENIAM project.[8,9]

The electromyographical signals were captured before and 15 days after surgery in habitual gum chewing (10 sec), dental clenching (4 sec), mouth opening and closing (10 sec), rest (10 sec), protrusion (10 sec) and right and left laterality (10 sec) with subjects comfortably seated in an office-type chair, with their arms next to their body and hands on their thighs. The analyzed muscles were the right masseter (RM), left masseter (LM), right temporalis (RT), and left temporalis (LT).

RESULTS

The paired t-test (*SPSS 17.0 for Windows*) was used to compare the electromyographic data of the temporal and masseter muscles in root mean square (RMS) during all conditions, before and after 15 days of surgery data. The level of significance was set at $P = 0.05$. RMS electromyographic values of each muscle evaluated at the beginning (T1) and at the end of treatment (T2). The electromyographic analysis showed that the activity of the masseter and temporal muscles decreased significantly after the SARME in all the clinical situations after the surgery [Table 1].

Table 1: Root mean square average, standard deviation and statistical significance of electromyographic activity, pre- and post-treatment (n = 19)

Condition/ muscle	Pre treatment (T1) Mean SE	Post treatment (T2) Mean SE	Paired *t* Test *P*
Dental Clenching			
Right Temporalis	88.51 ± 12.14	45.48 ± 5.19	0.00**
Left Temporalis	81.37 ± 13.24	39.98 ± 6.57	0.00**
Right Masseter	93.39 ± 15.59	31.57 ± 3.97	0.00**
Left Masseter	91.34 ± 15.54	33.67 ± 4.28	0.00**
Habitual Gum Chewing			
Right Temporalis	49.06 ± 5.45	21.68 ± 1.58	0.00**
Left Temporalis	45.40 ± 7.03	21,91 ± 2.33	0.00**
Right Masseter	50.60 ± 6.80	29.29 ± 8.21	0.05*
Left Masseter	45.46 ± 6.00	20.29 ± 2.51	0.00**
Opening and closing			
Right Temporalis	27.97 ± 7.98	11.73 ± 2.35	0.05*
Left Temporalis	22.76 ± 4.66	21.32 ± 4.50	0.82
Right Masseter	22.61 ± 7.45	28.01 ± 7.77	0.61
Left Masseter	18.75 ± 2.98	13.48 ± 1.84	0.14
Rest			
Right Temporalis	9.14 ± 2.11	5.35 ± 0.48	0.08*
Left Temporalis	7.16 ± 0.62	6.77 ± 0.99	0.74
Right Masseter	5.33 ± 0.61	4.98 ± 0.24	0.59
Left Masseter	6.00 ± 0.57	5.07 ± 0.26	0.14
Protrusion			
Right Temporalis	8.51 ± 1.95	5.57 ± 0.49	0.15
Left Temporalis	12.96 ± 4.81	8.48 ± 1.56	0.38
Right Masseter	21.14 ± 3.93	18.64 ± 2.76	0.60
Left Masseter	25.55 ± 4.25	27,78 ± 3.89	0.70
Right laterality			
Right Temporalis	12.72 ± 3.52	9.82 ± 1.16	0.43
Left Temporalis	7.88 ± 1.21	7.12 ± 0.85	0.61
Right Masseter	11.18 ± 2.08	7.15 ± 0.84	0.81
Left Masseter	14.79 ± 2.11	13.59 ± 1.67	0.65
Left laterality			
Right Temporalis	6.98 ± 1.07	5.41 ± 0.55	0.20
Left Temporalis	10.22 ± 1.39	12.67 ± 1.59	0.25
Right Masseter	15.00 ± 2.52	11.01 ± 1.89	0.21
Left Masseter	9.11 ± 0.97	7.06 ± 0.71	0.20

$^{**}P < 0.01$; $^{*}P < 0.05$

DISCUSSION

The scope of this study was not to compare subjects with normal occlusion and subjects with posterior crossbite but to verify the EMG activity in masticatory muscles of subjects that had undergone SARME before and immediately after the surgery. Therefore, the control group comprised the subjects themselves before SARME and not normocclusive subjects. This analysis is important in order to verify what happens with the masticatory muscle activity after a procedure of this magnitude and make a correlation with the signs and symptoms that patients present immediately after the surgery, especially after a new occlusal relationship.

The stomatognathic system constitutes a functional and physiologic interdependent entity of muscles, maxilla, mandible, dental arches, occlusal relationships, and temporomandibular articulations. In this present study, the electromyographic analysis was fundamental to permit the evaluation of muscle behavior and activity in different clinical conditions after correction of maxillary transverse deficiencies by SARME.

SARME basically consists of selected osteotomies performed at sutures and buttress of the facial skeleton reaching weakening the bone resistance to expanding forces generates by the orthodontic appliance. The areas of resistance to lateral forces in the midface are the pyriform aperture (anterior support), the zygomatic buttress (lateral support), the pterygoid junction (posterior support), and the midpalatal synostosed suture (median support). The SARME has been done for a long time in adults with a mature skeleton and many different methods have been described in the literature, ranging from osteotomies on the anterior and lateral aspect of maxilla[3] to osteotomies that basically replicated a subtotal LeFort I osteotomy.[2]

This treatment modality is indicated on transverse maxillary deficiencies of more than 5 mm in a skeletally mature patient, arch length discrepancies with maxillary incisors in an acceptable vertical and sagittal position, a V-shaped maxilla with a narrow anterior segment if extractions are not desired, to increase the maxillary arch perimeter, to correct posterior crossbite, to widen the maxillary arch as a preliminary procedure to orthognathic surgery, to widen maxillary hypoplasia associated with clefts of the palate, and to overcome the resistance of the sutures when orthopedic maxillary expansion has failed.[1-3,7]

Once a more adequate occlusal relationship had been achieved with the SARME, we expected a more balanced muscle activity, increasing the esthetic and functional outcomes. However, the muscular response to the changes was incompletely understood due the short postoperative period analyzed.

Before treatment, adults with posterior crossbite presented high values of EMG activity for the masseter and temporal muscles analyzed in all conditions, including rest. This is likely due to bone and muscular changes in the stomatognathic system of individuals with malocclusion.[10,11] In habitual gum chewing and dental clenching, there was a statistically significant difference in the activities before and after SARME ($P < 0.01$). In mouth opening and closing and at rest, just for the right temporal muscle, the data was statistically significant ($P < 0.05$). In addition, there was no significant difference in the activities of both muscles for protrusion and right and left laterality.

The EMG activity of masticatory muscles during rest is increased in patients with stomatognathic system dysfunctions compared to healthy individuals.[12-14] After having corrected the transversal maxillomandibular relationship using SARME, masseter and temporal muscle activity decreased in the rest condition. This possibly could reflect the adaptation and reprogramming of the musculature to the new occlusion. The presence of EMG activity during rest after SARME demonstrates that masticatory muscles are not in the ideal state of relaxation and great variability observed in the EMG recordings demonstrates neuromuscular complexity in the position of mandibular rest.

The mastication is considered one of the most important functions of the stomatognathic system, in which a well balanced neuromuscular activity occurs as a result of the interrelationship between the components of the stomatognathic system, proprioception, cerebral masticatory centers, and occlusion.[15] Therefore, any change in these components, such as the occlusion, temporomandibular joint or in the masticatory muscles, results in decrease of the masticatory function.[16] Miyauchi *et al*.,[17] analyzed the factors related to the masticatory movements and found that the occlusion was the most important component. The SARME results in a gradual increase of the maxillary transversal distance, substantially altering the relationship between the mandibular and maxillary teeth. In our study, the subjects showed an important change in the pattern of muscular activity during mastication. The masticatory cycles tended to return to normal during the postoperative period and the mean data observed in the preoperative period were always higher than those observed 15 days after the surgery.

The maximal dental contact is obtained during dental clenching, resulting in a larger contact area between mandibular and maxillary teeth. Ferrario *et al*.,[18] evaluated the activity of the mastication muscles and the number of dental contacts in young adults. The authors observed decreased muscle activity in subjects with less dental contacts, explaining the direct correlation between these factors. We observed decreased activity of the masseter and temporal muscles after SARME. This decrease was statistically significant ($P < 0.05$) for both muscles and can be explained by the change in dental contacts. Furthermore, the altered maxillomandibular relationship and the discomfort generated by the new occlusal condition have been proposed as additional factors. Leung and Hägg[19] quoted that the changes in muscular activity during the orthopedic treatment was a result of the occlusal instability, changes in the dentition relationship, bone repositioning, and the new skeletal configuration.

Nevertheless, the need is highlighted to reevaluate patients after a larger interval, when results of SARME are supposed to be stabilized. At this point, occlusion would be more engaged, and musculature would have more time to adapt to new skeletal conditions and functions of the stomatognathic system.

CONCLUSION

Considering the specific conditions of this study, it can be concluded that SARME significantly decreased the EMG activity of the masseter and temporal muscles. These findings suggest that the alterations in EMG activity should be considered as an additional exam to evaluate the treatment and stability of SARME. Nonetheless, further studies that analyze longer postoperative periods are necessary for a complete understanding of the influence of SARME on the masticatory muscles.

REFERENCES

1. Silverstein K, Quinn PD. Surgically-assisted rapid palatal expansion for management of transverse maxillary deficiency. J Oral Maxillofac Surg 1997;55:725-7.
2. Chung CH, Woo A, Zagarinsky J, Vanarsdall RL, Fonseca RJ. Maxillary sagittal and vertical displacement induced by surgically assisted rapid palatal expansion. Am J Orthod Dentofacial Orthop 2001;120:144-8.
3. Glassman AS, Nahigian SJ, Medway JM, Aronowitz HI. Conservative surgical orthodontic adult rapid palatal expansion: Sixteen cases. Am J Orthod 1984;86:207-13.
4. De Felício CM, Freitas RL, Vitti M, Regalo SC. Comparison of upper and lower lip muscle activity between stutterers and fluent speakers. Int J Pediatr Otorhinolaryngol 2007;71:1187-92.
5. Regalo SC, Vitti M, Hallak JE, Siéssere S, Pagnano VO, Semprini M. Electromyographic analysis of upper and lower fascicles of the orbicularis oris muscle in deaf individuals, in mandibular rest position, compared to hearers. Electromyogr Clin Neurophysiol 2006;46:211-5.
6. Galo R, Vitti M, Mattos Mda G, Regalo SC. Masticatory muscular activation in elderly individuals during chewing. Gerodontology 2007;24:244-8.
7. Bell WH, Jacobs JD. Surgical-orthodontic correction of horizontal maxillary deficiency. J Oral Surg 1979;37:897-902.
8. Hermens HJ, Freriks B, Disselhorst-Klug C, Rau G. Development of recommendations for SEMG sensors and sensor placement procedures. J Electromyogr Kinesiol 2000;10:361-74.
9. Hermens HJ, Freriks B, Merletti R. European recommendations for surface electromyography – results of the SENIAN project. 1999, Chapt.2, Deliverable. 8, p. 13-58.
10. Ferrario VF, Serrao G, Dellavia C, Caruso E, Sforza C. Relationship

between the number of occlusal contacts and masticatory muscle activity in health young adults. J Craniomandibular Pract 2002;20:91-7.
11. Zuccolotto MC, Vitti M, Nóbilo KA, Regalo SC, Siéssere S, Bataglion C. Electromyographic evaluation of masseter and anterior temporalis muscles in rest position of edentulous patients with temporomandibular disorders, before and after using complete dentures with sliding plates. Gerodontology 2007;4:105-10.
12. Liu ZJ, Yamagata K, Kasahara Y, Ito G. Electromyographic examination of jaw muscles in relation to symptoms and occlusion of patients with temporomandibular joint disorders. J Oral Rehabil 1999;26:33-47.
13. Pinho JC, Caldas FM, Mora MJ, Santana-Penin U. Electromyographic activity in patients with temporomandibular disorders. J Oral Rehabil 2000;27:985-90.
14. Santos CM, Vitti M, de Mattos Mda G, Semprini M, Paranhos Hde F, Regalo SC. Electromyographic analysis of the upper and lower fascicles of the orbicular oris muscle, in edentulous patients, before and after complete denture implantation. Eletromyogr Clin Neurophysiol 2003;43:315-20.
15. Orchardson R, Cadden SW. The scientific basis of eating. Mastication. London: Linden R.W.A.; 1998. p.76-121.
16. Kim SK, Kim KN, Chang IT, Heo SJ. A study of the effects of chewing patterns on occlusal wear. J Oral Rehabil 2001;28:328-34.
17. Miyauchi S, Nakaminami T, Nishio K, Maruyama T. Chewing pattern in posterior crossbite. Classification of chewing pattern in the frontal plane. Nihon Hotetsu Shika Gakkai Zasshi 1989;33:938-51.
18. 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.
19. Leung D, Hägg U. An electromyographic investigation of the first six month of progressive mandibular advancement of the Herbst appliance in adolescents. Angle Orthod 2001;17:177-84.

Cite this article as: Sverzut CE, Martorelli K, Jabur R, Petri AD, Trivellato AE, Siéssere S, *et al*. Effect of surgically assisted rapid maxillary expansion on masticatory muscle activity: A pilot study. Ann Maxillofac Surg 2011;1:32-6.

Source of Support: Nil, **Conflict of Interest**: None declared.