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Masticatory muscle function three years after surgical correction of class III dentofacial deformity

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Abstract. Individuals with dentofacial deformities have masticatory muscle changes. The objective of the present study was to determine the effect of interdisciplinary treatment in patients with dentofacial deformities regarding electromyographic activity (EMG) of masticatory muscles three years after surgical correction. Thirteen patients with class III dentofacial deformities were studied, considered as group P1 (before surgery) and group P3 (3 years to 3 years and 8 months after surgery). Fifteen individuals with no changes in facial morphology or dental occlusion were studied as controls. The participants underwent EMG examination of the temporal and masseter muscles during mastication and biting. Evaluation of the amplitude interval of EMG activity revealed a difference between P1 and P3 and no difference between P3 and the control group. In contrast, evaluation of root mean square revealed that, in general, P3 values were higher only when compared with P1 and differed from the control group. There was an improvement in the EMG activity of the masticatory muscles, mainly observed in the masseter muscle, with values close to those of the control group in one of the analyses.

Keywords: electromyography; mastication; orthognathic surgery.

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Individuals with dentofacial deformities benefit from orthognathic surgery to correct skeletal morphology. Orthognathic surgery, in combination with orthodontic treatment, corrects the dentofacial deformity, and improves occlusal contacts[5–8,17], masticatory efficiency[5], the electromyographic (EMG) activity of the masticatory muscles[2,9,11,14,23], the bite force[3–7,12,13,17] and the thickness of the masseter muscle[15].

Other studies detected no changes in masticatory efficiency, in the EMG activity of masticatory muscles or in bite force 12–18 months after surgery[18], 2 years after surgery regarding bite force and occlusal contacts[5], or in muscle activity per unit of bite force 3 years after surgery[24,25]. No improvement in bite force was detected 5 years after surgery[19].

In an investigation of functional changes after combined treatment with orthodontics and orthognathic surgery in individuals with dentofacial deformities, Yang *et al.*[22] detected a worsening of bite force and masticatory efficiency 3 months after surgery, with the values being close to presurgical levels 6 months after surgery in patients undergoing bilateral sagittal split osteotomy for mandibular retrocession. Ueki *et al.*[16] found no changes in the pattern of the masticatory curve in class III patients who underwent sagittal and intraoral osteotomy of the mandibular ramus about 1 year after surgery.

Orthognathic surgery can also impair orofacial function due to the sensorineural

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Table 1. Patient distribution according to the surgical procedure.

Surgery	Patients		
	Males	Females	Total
Combined (Le Fort I and bilateral sagittal mandíbular)	1	3	4
Advancement of the maxilla (Le Fort I)	0	4	4
Mandibular retrocession (vertical bilateral of the ramus) & MMF*	2	3	5
Total	3	10	13

* MMF = maxillomandibular fixation.

sequelae following sagittal osteotomy of the mandibular ramus[10,21] and after the period of maxillomandibular fixation[1]. Some errors in speech articulation may persist after surgical correction[20], justifying functional rehabilitation with speech and language therapies. According to several investigators, changes in masticatory function or in its components after the correction of dentofacial deformities by orthognathic surgery are evident. The period of time for this to occur is a matter of controversy and may be related to differences in the methods of evaluation and treatment. Most studies describe orthosurgical treatment without mentioning orofacial myofunctional therapy.

The objective of the present study was to investigate the effect of interdisciplinary treatment by orthodontics, surgery and orofacial myofunctional therapy in patients with class III dentofacial deformity on the EMG activity of masticatory muscles 3 years after surgical correction, compared with a control group.

Materials and methods

The study was approved by the Research Ethics Committee of the University Hospital, Faculty of Medicine of Ribeirão Preto, University of São Paulo (HCFMRP-USP) and the patients gave written informed consent to participate in the study.

The study was conducted on 13 patients with class III corrected dentofacial deformity characterized by mandibular prognathism and/or maxillary deficiency. The patients were considered as two groups: P1 (before surgery) and P3 (3 years to 3 years and 8 months after surgery). Three patients were male aged 21–25 years (mean 22 years) and 10 were female aged 22–42 years (mean 27 years). The surgical procedures and the gender distribution are presented in Table 1.

The control group (CG) consisted of 15 volunteers with natural dentition, with no alterations of facial morphology or dental occlusion and no signs or symptoms of temporomandibular joint dysfunction. Eleven were female, aged 21–29 years (mean 24 years) and 4 were male aged 19–25 years (mean 21 years).

All patients underwent orthodontic treatment before and after surgery and orofacial myofunctional therapy follow-up according to the routine of the service of Head and Neck Surgery of the Integrated Center of Studies of Facial Deformities of HCFMRP-USP[14].

Presurgical orthodontic treatment was performed in order to align, level and decompensate the teeth, often increasing skeletal discrepancy. The teeth were positioned in an ideal manner on their osseous bases without taking into consideration the inter-arch relation. After orthognathic surgery, occlusal adjustments were made to obtain the largest possible number of dental contacts during a bite. Presurgical orthodontic treatment lasted on average 12.4 months and postsurgical treatment lasted 14 months.

Orofacial myofunctional evaluation was carried out before surgery, with investigation of the predominant mode of respiratory function (oral, nasal or oronasal). Alterations were observed in the oral phase of deglutition, in mastication and speech, and in the tonic and postural aspects of lips and tongue. The authors worked only with tongue muscles in cases in which important muscle changes were observed in addition to the use of nasal respiration. After evaluation, the patients received instructions and clarification regarding the surgery, the proposed treatment and the care needed during the postoperative period. After surgery, the patients initially had a smooth diet with a gradual return to a solid diet. Patients who reported pain or discomfort in the temporomandibular joint after surgery were instructed to maintain a soft diet and simultaneous bilateral mastication. All patients were instructed to perform mandibular movements with emphasis on the gradual recovery of these movements. Exercises were used to strengthen and improve the posture of lips and tongue. Corrective work was performed on deglutition, mastication and speech when alterations were observed in these aspects. The patients were instructed to apply lukewarm compresses and massage starting 2 weeks after surgery to reduce facial edema and to relax the mandibular levator muscles and improve mandibular movements. Postoperative oromyofunctional therapy lasted on average 11 months.

The period of maxillomandibular fixation was 3 weeks for all patients who had undergone vertical osteotomy of the mandibular ramus.

The participants were evaluated for bilateral EMG activity of the temporal (T) and masseter (M) muscles during right mastication (RMa) and left mastication (LMa) of mint-flavored Trident® chewing gum (Warner-Lambert, Adams Division, Bauru, SP, Brazil) and for bite force using a Neuropack 8, MEM 4200K model computerized electroneuromyograph (Nihon Kohden Corporation, Shinjuku-ku, Tokyo, Japan). The motor unit action

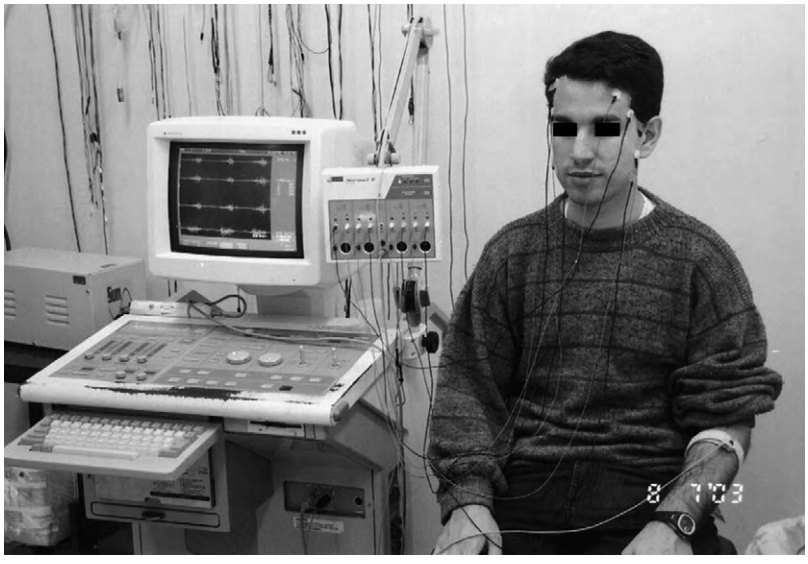

Fig. 1. Equipment for EMG evaluation and positioning of the surface electrodes.

Table 2. Median bilateral values of the amplitude interval (AI) of EMG activity (in μV) of the temporal (T) and masseter (M) muscles in mastication (MaR and MaL) and biting for groups CG, P1 and P3.

	MaR				MaL				Biting			
	T		M		T		M		T		M	
	ζ	B	ζ	B	ζ	B	ζ	B	L	R	L	R
GC	2240	1820	1490	870	2300	2840	1600	680	2760	3200	1600	1760
P3	2320	1640	1220	740	1800	2360	1280	800	2260	2240	1320	1660
P1	700	640	440	240	640	660	440	260	1052	1100	648	730

Table 3. Medial bilateral values of root mean square (RMS) of EMG activity (in μV) of the temporal (T) and masseter (M) muscles in mastication (MaR and MaL) and biting for groups CG, P1 and P3.

	MaR				MaL				Biting			
	T		M		T		M		T		M	
	ζ	B	ζ	B	ζ	B	ζ	B	L	R	L	R
GC	1474	743	580	174	922	1436	215	592	861	1449	251	602
P3	393	314	307	157	480	433	249	240	385	395	247	345
P1	336	251	151	39	262	357	72	124	321	435	107	202

potentials of the muscles under study were recorded with silver-chloride surface electrodes immersed in conductive gel and attached to the skin with micropore tape. Fig. 1 illustrates the device and the positioning of the electrodes. The procedures were carried out in the Laboratory of Neurophysiology of the Department of Neurology, Psychiatry and Medical Psychology of FMRP-USP. In the masticatory situation, the sides of work were considered (ζ) and the side of the mouth where the chewing gum was held, and the balance side (B) was considered to be the one contralateral to ζ.

The authors analyzed in each muscle, in the three situations, the values (in μV) of the amplitude interval (AI) of EMG activity and of the root mean square (RMS), which also represents the amplitude of the EMG signal. The methodology used has been described in a previous study[14].

The data were tabulated and analyzed statistically using the Wilcoxon test to determine differences between P1 and P3 (dependent samples) and by the Mann–Whitney test to determine differences between P3 and CG (independent samples) regarding the EMG activity of the M and T muscles in the mastication and biting situations. For the purpose of analysis, the mean EMG activity values were calculated using the median. All statistical tests were carried out using the statistical software Graph Pad InStat version 3.0 for Windows 95, with the level of significance set at $P < 0.05$.

Results

The EMG activity of the T and M muscles differed significantly between the P1 and P3 groups in both situations (mastication and biting), with higher values in P3, whereas no significant difference ($P > 0.05$) was detected between P3 and CG (Table 2).

In the RMS analysis, when EMG activity was compared between P1 and P3, there was a significant difference ($P < 0.05$) for the M muscle in the three situations, with higher values for P3. For T, this difference was noted only for the left side in LMa and biting.

Comparison of CG and P3 revealed a significant difference in EMG activity for both muscles in the different situations, except for the M muscle during right RMa (right side, of balance), LMa (left side, of work) and biting (left side). The median values are listed in Table 3.

Discussion

Analysis of EMG, AI and RMS, revealed some difference in response between AI and RMS, although both represent the amplitude of the EMG signal. This may be explained by the regions selected for analysis on the EMG tracing, which were different, with those selected for AI analysis consisting of two small parts of the tracings used for RMS analysis.

When the EMG activity of masticatory muscles was compared between P1 and P3, higher values were usually detected for P3. This difference was not simply noted for the T muscle in the RMS analysis but 3 years after correction of the class III dentofacial deformity, greater amplitude of the EMG signal was also noted in the M muscle. The correction of the facial skeleton and of dental occlusion increases the occlusal contacts[5–8,17] providing better conditions for muscle contraction, especially in the M muscle. The main function of this muscle is the trituration of food particles, with a partial difference from the T muscle, whose main function is to provide mandibular stability during mastication.

In a previous study, the authors observed significant changes in the absolute activity values of the T and M muscles within 6–9 months after surgery[14].

Most of the studies surveyed use EMG activity in combination with bite force, a different procedure from that used by the authors. In the studies surveyed, no significant changes were detected 3 years after surgery in the EMG activity of the masticatory muscles per unit of bite force in patients with vertical maxillary excess submitted to maxillary intrusion[24], or in retrognathic patients submitted to combined maxillary intrusion and mandibular advancement surgery[25]. A study by Nakata *et al*.[7] did not demonstrate a significant change in the EMG activity of the T and M muscles in class III patients before and up to 7 months after surgery for mandibular advancement (bilateral sagittal split ramus osteotomy).

There was a clear improvement in the EMG signal of the T and M muscles in the AI analysis, with the EMG values of the patients being identical to those of CG individuals. In the RMS analysis there was a difference for both muscles in the various situations, with proximity to the EMG values being observed only in the M muscle. Trawitzki *et al*.[14] concluded that there was an improvement in the EMG activity of these muscles by AI analysis, but the values were still lower than those of the CG.

The present patients received pre- and postsurgical speech therapy monitoring, with emphasis on the recovery of mandibular mobility and of stomatognathic function, especially mastication. The sensorineural disorders usually present[10,21] are also emphasized in orofacial myofunctional rehabilitation.

Van Lierde *et al*.[20] studied the impact of surgery for sagittal bilateral mandibular advancement on speech articulation, resonance and other vocal characteristics. The authors observed the persistence of certain articulatory errors, with no major impact on resonance or on the voice, and suggested that the surgeon and the speech therapist should be alert to articulatory errors after surgical correction.

The present study revealed that there was an improvement in the EMG activity of the masticatory muscles in patients with class III dentofacial deformity with the treatment proposed, mainly observed in the M muscle, with EMG values being equal to CG values in one analysis. Greater instability was observed in the T muscle.

References

1. Behbehani F, Al-Attar A, Al-Hamad N. Perceived effectiveness and side effects of intermaxillary fixation for diet control. Int J Oral Maxillofac Surg 2006: **35**: 618–623.
2. Eckardt L, Harzer W, Schneevoigt R. Comparative study of excitation patterns in the masseter muscle before and after orthognathic surgery. J Cranio Maxillofac Surg 1997: **25**: 344–352.
3. Ellis E, Throckmorton G, Sinn DP. Bite forces before and after surgical correction of mandibular prognathism. J Oral Maxillofac Surg 1996: **54**: 176–181.
4. Harada K, Kikuchi T, Morishima S, Sato M, Ohkura K, Omura K. Changes in bite force and dentoskeletal morphology in prognathic patients after orthognathic surgery. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2003: **95**: 649–654.
5. Iwase M, Ohashi M, Tachibana H, Toyoshima T, Nagumo M. Bite force, occlusal contact area and masticatory efficiency before and after orthognathic surgical correction of mandibular prognathism. Int J Oral Maxillofac Surg 2006: **35**: 1102–1107.
6. Iwase M, Sugimori M, Kurachi Y, Nagumo N. Changes in bite force and occlusal contacts in patients treated for mandibular prognathism by orthognathic surgery. J Oral Maxillofac Surg 1998: **56**: 850–855.
7. Nakata Y, Ueda Hm. Kato M, Tabe H, Shikata-Wakisaka N, Matsumoto E, Koh M, Tanaka E, Tanne K. Changes in stomatognathic function induced by orthognathic surgery in patients with mandibular prognathism. J Oral Maxillofac Surg 2007: **65**: 444–451.
8. Ohkura K, Harada K, Morishima S, Enomoto S. Changes in bite force and occlusal contact area after orthognathic surgery for correction of mandibular prognathism. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2001: **91**: 141–145.
9. Raberin M. Muscular equilibrium and orthognathic surgery. A preliminary electromyographic study. Orthod Fr 2000: **71**: 37–48.
10. Takazakura D, Ueki K, Nakagawa K, Marukawa K, Shimada M, Shamiul A, Yamamoto E. A comparison of postoperative hypoesthesia between two types of sagittal split ramus osteotomy and intraoral vertical ramus osteotomy, using the trigeminal somatosensory-evoked potential method. Int J Oral Maxillofac Surg 2007: **36**: 11–14.
11. Throckmorton GS, Buschang PH, Ellis III E. Improvement of maximum occlusal forces after orthognathic surgery. J Oral Maxillofac Surg 1996: **54**: 1080–1086.
12. Throckmorton GS, Ellis III E. The relationship between surgical changes in dentofacial morphology and changes in maximum bite force. J Oral Maxillofac Surg 2001: **59**: 620–627.
13. Throckmorton Gs. Ellis III E, Buschang PH. Morphologic and biomechanical correlates with maximum bite forces in orthognathic surgery patients. J Oral Maxillofac Surg 2000: **58**: 515–524.
14. Trawitzki LVV, Dantas RO, Mello-Filho FV, Marques W. Effect of treatment of dentofacial deformities on the electromyographic activity of masticatory muscles. Int J Oral Maxillofac Surg 2006: **35**: 170–173.
15. Trawitzki LVV, Dantas RO, Mello-Filho FV, Elias-Júnior J. Effect of treatment of dentofacial deformity on masseter muscle thickness. Arch Oral Biol 2006: **51**: 1086–1092.
16. Ueki K, Marukawa K, Shimada M, Nakagawa K, Yamamoto E, Niizawa S. Changes in the chewing path of patients in skeletal class III with and without asymmetry before and after orthognathic surgery. J Oral Maxillofac Surg 2005: **63**: 442–448.
17. Ueki K, Marukawa K, Shimada M, Nakagawa K, Yamamoto E. Changes in occlusal force after mandibular ramus osteotomy with and without Le Fort I osteotomy. Int J Oral Maxillofac Surg 2007: **36**: 301–304.
18. Van Den Braber W, Van Der Glas H, Van Der Bilt A, Bosman F. Masticatory function in retrognathic patients, before and after mandibular advancement surgery. J Oral Maxillofac Surg 2004: **62**: 549–554.
19. Van Den Braber W, Van Der Bilt A, Van Der Glas H, Rosenberg T, Koole R. The influence of mandibular advancement surgery on oral function in retrognathic patients: a 5-year follow-up study. J Oral Maxillofac Surg 2006: **64**: 1237–1240.
20. Van Lierde KM, Schepers S, Timmermans L, Verhoye I, Van Cauwenberge P. The impact of mandibular advancement on articulation, resonance and voice characteristics in Flemish speaking adults: a pilot study. Int J Oral Maxillofac Surg 2006: **35**: 137–144.
21. Yamashita Y, Misuashi K, Shigematsu M, Goto M. Masticatory function and neurosensory disturbance after mandibular correction by bilateral sagittal split ramus osteotomy: a comparison between miniplate and bicortical screw rigid internal fixation. Int J Oral Maxillofac Surg 2007: **36**: 118–122.
22. Yang XW, Dong YJ, Long X, Zhang Gz. Kao CT. The evaluation of jaw function subsequent to bilateral sagittal split osteotomy. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2005: **100**: 10–16.
23. Youssef RE, Throckmorton GS, Ellis III E, Sinn DP. Comparison of habitual masticatory cycles and muscle activity before and after orthognathic surgery. J Oral Maxillofac Surg 1997: **55**: 699–707.
24. Zarrinkelk HM, Throckmorton GS, Ellis III E, Sinn DP. Functional and morphologic alterations secondary to superior repositioning of the maxilla. J Oral Maxillofac Surg 1995: **53**: 1258–1267.
25. Zarrinkelk HM, Throckmorton GS, Ellis III E, Sinn DP. Functional and morphologic changes after combined maxillary intrusion and mandibular advancement surgery. J Oral Maxillofac Surg 1996: **54**: 828–837.

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