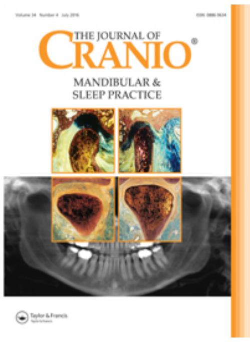

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Natural mediotrusive contact: does it affect the masticatory and neck EMG activity during tooth grinding?

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Occlusion

Natural mediotrusive contact: does it affect the masticatory and neck EMG activity during tooth grinding?

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Objectives: There is scarce knowledge regarding the influence of a natural mediotrusive contact on mandibular and cervical muscular activity. The purpose of this study was to analyze the EMG activity of the anterior temporalis (AT) and sternocleidomastoid (SCM) muscles during awake grinding in healthy subjects with or without a natural mediotrusive occlusal contact.

Method: Fifteen subjects with natural mediotrusive occlusal contact (Group 1) and 15 subjects without natural mediotrusive occlusal contact (Group 2) participated. Bilateral surface EMG activity of AT and SCM muscles was recorded during unilateral eccentric or concentric tooth grinding tasks. EMG activity was normalized against the activity recorded during maximal voluntary clenching in intercuspal position (IP) for AT muscles and during maximal intentional isometric head-neck rotation to each side, for SCM muscles.

Results: EMG activity of AT and SCM muscles showed no statistical difference between groups. EMG activity of AT muscle was higher in the working side (WS) than in the non-WS (NWS) in Group 1 during concentric grinding (0.492 vs 0.331, $p=0.047$), whereas no difference was observed in Group 2. EMG activity of SCM was similar between working and NWSs in both groups and tasks. Asymmetry indexes (AIs) were not significantly different between groups.

Discussion: These findings in healthy subjects support the assumption that during awake tooth grinding, central nerve control predominates over peripheral inputs, and reinforce the idea of a functional link between the motor-neuron pools that control jaw and neck muscles.

Keywords: Electromyography, Masticatory muscles, Neck muscles, Jaw movement, Dental occlusion, Tooth grinding, Natural mediotrusive occlusal contact

Introduction

Tooth grinding is an activity of major concern for dentists due to its many clinical implications: destruction of tooth structure,[1] damage and/or fracture of dental rehabilitation, headache, exacerbation of temporomandibular disorders, and/or induction of temporalis muscle tension and grinding sounds that may also interfere with the sleep of family or life partners[2] and with awake activity of the individual.

Classically, the side toward which the mandible moves is called laterotrusive or working side (WS), while the other side is called mediotrusive or non-working side (NWS).[3]

According to the glossary of prosthodontic terms,[4] NWS occlusal contacts are defined as contacts of the teeth on the side opposite to the side toward which the mandible moves in articulation. Mediotrusive interferences on the NWS, either natural or artificial, could represent an undesirable contact. It has been

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suggested that mediotrusive contacts are differently perceived by the central nervous system and therefore should be avoided in developing an optimum functional occlusion.[5] This theory agrees with the concept of mutually protected occlusion proposed by Schuyler[6] in the fifties. Since mediotrusive contacts can modify activation and coordination of jaw muscles,[7,8] some authors have attributed a potential risk to occlusal interferences and recommended their elimination.[9–11] Other authors, however, propose that this kind of contact does not cause major problems,[12,13] or could be a more protective than harmful element for the stomatognathic system.[14]

As occlusal stability is relevant to muscular performance, several investigators have inserted artificial interferences and investigated its impact on EMG activity during maximal voluntary clenching, finding changes in EMG pattern, and asymmetry index (AI).[15,16] However, little is known about the influence of a natural mediotrusive occlusal contact on EMG activity of jaw and neck muscles during tooth grinding.

Several studies have been performed in healthy subjects with natural dentition in order to assess the influence of eccentric and concentric grinding on EMG activity of the cranio-cervical-mandibular muscles,[17–19] although, none of the subjects had a mediotrusive occlusal contact in the NWS. To the authors' knowledge, studies about the influence of a natural mediotrusive occlusal contact on the EMG activity of jaw and neck muscles have not been performed during tooth grinding.

In this work, the authors chose to record the activity of the anterior temporalis (AT) muscle because it is a mandibular postural muscle that allows wide movements and great range of adjustment for maintaining the stability of the mandible and controlling jaw movements in the excursive function.[20–22] This muscle presents a higher number of muscular spindles than the masseter muscle, related with the fine proprioceptive control of the mandible.[23] In addition, the sternocleidomastoid (SCM) muscle was recorded because it functions as a chief of balancing muscles of the head,[24] and also plays an important role during the different functions of the cranio-cervical-mandibular system.[25–27] Connections between neck motoneurons and trigeminal afferents should allow critical trigeminal modulation of head-neck movements in specific tasks, which support the concept of a functional trigeminal-cervical coupling during jaw activities.[28] Therefore, it is important to know if the presence of a natural mediotrusive occlusal contact influences AT and/or SCM muscle activity.

Asymmetrical malocclusion could produce an altered neuromuscular coordination, with abnormal muscular patterns in the masticatory muscles.[29] Therefore, it is important to explore the influence of unilateral mediotrusive contact in the muscular asymmetry using the AI.

The hypothesis of the present study is that subjects with or without a natural mediotrusive occlusal contact differ neither in EMG activity nor in AI. Therefore, the aim of the present work was to evaluate the EMG activity and AI of AT and SCM muscles in healthy subjects with or without a natural mediotrusive occlusal contact during eccentric and concentric tooth grinding.

Materials and Methods

Subjects

This study included 30 healthy subjects. Group 1 consisted of 15 subjects (eight males and seven females, mean age: 20.4 ± 1.3 years), who presented a unilateral mediotrusive molar occlusal contact during laterotrusive jaw displacement. Group 2 consisted of 15 subjects (five males and ten females, mean age: 20.1 ± 1.2 years) without mediotrusive molar occlusal contact.

All participants had complete natural dentition (excluding third molars), protrusive incisive guidance, overjet and overbite ranging from 2 to 4 mm, Angle Class I molar relationship; and did not present unilateral or bilateral crossbite, prior orthodontic treatment, history or actual presence of orofacial pain, temporomandibular or cervical disorders, history of spinal, cervical or dental trauma or fractured teeth, or large restorations, which involved the incisal edge of one or more cusps. None of the subjects were on medication that could influence muscle activity and none reported systemic diseases or showed clinically apparent facial asymmetry. None of the subjects had a self-reported habit or diagnosis of bruxism, presented facial pain, muscular hypertrophy, or coincident opposite tooth attrition signs.[30]

Participants were recruited among students from the Faculty of Dentistry and the Faculty of Medicine of the University of Chile.

Mediotrusive occlusal contact was defined as an occlusal contact between support cusps of the natural second molars on the NWS during a slightly forced lateral excursive jaw displacement, which did not interfere with the occlusal contact during laterotrusive guidance movement on the WS. This occlusal contact was identified by a 50-μm thick polyester strip (Hawe Striproll® 687, KerrHawe SA, Switzerland) within the first millimeters of the lateral excursion,[31] and verified by the resistance to remove the strip during this movement. The authors considered the contact between the second molars, since it is the most prevalent contact on the NWS during lateral excursions.[32] During clinical examination, subjects were asked to keep the intensity and direction of the laterotrusive movement in order to homogenize the displacement. Agreement of two expert examiners was needed for subject selection. Consistency in the clinical diagnosis across the examiners was high, and when there was no agreement, the subject was excluded.

All participants were volunteers and gave their informed written consent. The study was approved by the Ethics Committee of the Faculty of Dentistry, University of Chile (no. 2012/07). The experimental procedures were conducted in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki).

Surface electromyography

EMG activity of right and left AT and SCM muscles was recorded using disposable RG-63B adhesive hydrogel bipolar surface electrodes (interelectrode distance 19 ± 1 mm; BioFLEX: BioResearch, Inc., Brown Deer, Milwaukee, WI, USA). The skin area was cleaned with alcohol to reduce skin impedance. The lower electrode was placed on the AT muscle 1 cm above the zygomatic arch and 1.5 cm behind the orbital border. The electrodes were placed parallel to the main direction of muscle fibers.[19] On the SCM muscles, the electrodes were placed on the anterior border (middle portion), 1 cm above and below the motor point.[17] A large surface (about 15 cm^2) ground electrode was attached to the forehead.

EMG activity was amplified (Model 7P5B preamplifier, Grass Instrument Co., Quincy, MA, USA), filtered (10 Hz high pass and 2 kHz low pass), with a common mode rejection ratio (CMRR) higher than 100 dB. The output was filtered again (notch frequency of 50 Hz), full-wave rectified and then integrated (time constant of 0.33 seconds), and recorded online using all channels (four channels) of a computerized instrument dedicated to acquisition and processing of EMG signals. EMG signal was acquired at a sample rate of 200 Hz (50 Hz each channel) with a 12 bits A/D converter (MAX191) connected to the computer through an RS-232 port. The system was calibrated before each record.

Experimental procedures

Bilateral EMG activity was recorded while the subjects were sitting with their eyes open looking straight ahead and the head in the postural position. Each subject underwent three EMG recordings of AT and SCM muscles during the following tasks: (A) eccentric grinding from intercuspal position (IP) to the WS lateral edge-to-edge contact position; (B) concentric grinding from WS lateral edge-to-edge contact position to IP.

The authors considered WS as the most frequently chewing side selected by each subject. If the subject had no preferred side, they had to chew a piece of apple to visually determine the WS. Group 1 only included subjects with a mediotrusive occlusal contact on the opposite side (NWS). To standardize and reproduce the same edge-to-edge laterotrusive contact position, grinding tasks were explained to each subject by the same examiner. Prior to recording, all individuals practiced each task using a mirror, until they were able to repeat each task correctly at least five times, consecutively. Subjects were instructed to maintain the intensity and direction of the jaw displacement and to grind as hard as they could while performing the task movement. After each trial, the subjects were asked if they were able to successfully maintain the intensity during each grinding task. The initial and final jaw positions were visually checked during EMG recordings by the same examiner.

In order to standardize EMG activity during grinding tasks, activity of AT and SCM muscles was recorded during 5 seconds of maximal voluntary clenching in IP and maximal intentional head-neck rotation to each side, respectively. Also, for SCM normalization, the subject was instructed to avoid shoulder movement during the recording, while his/her head was blocked by one of the researchers.[33]

During both tasks, no trial lasted more than 10 seconds, a rest period of 1 minute between each record was allowed, and a 3-minutes resting period between different tasks was included in order to avoid muscular fatigue.[19] Each record was measured every 0.1 second and later averaged with purpose-designed software. The mean value of the three trials at each task for each subject and each muscle was normalized according to the following formula:

Normalized Muscle Activity (NMA) ratio = EMG recorded during each grinding task/EMG recorded during standardization task.

In order to quantify asymmetrical muscle activity, the partial and total AI were calculated for each subject and muscle from the average AT and SCM potentials recorded during each task. The index was calculated based on Naeije et al.[34]

Partial AI = (WS muscle – NWS muscle)/(WS muscle + NWS muscle)%,

Total AI = (WS SCM + WS AT – NWS SCM – NWS AT)/(WS SCM + WS AT + NWS SCM + NWS AT)%.

The AI may vary between −100 and +100%. Negative numbers show the predominance of the NWS muscle, while a positive number indicates WS muscle preponderance. A value equal to 0 reflects similar muscular activity between NWS and WS muscles.

Statistical analysis

Estimated sample size for two-sample comparison of means with statistical power of 80% was used.

The ANOVA test for repeated measures obtained from different subjects in three different days was used to test EMG measurement reproducibility (three trials per day). Task-to-task variability was calculated by a coefficient of variability for each grinding task. Shapiro–Wilk test was applied to determine the normality of the sample. EMG activity data presented a non-normal distribution; therefore, the Mann-Whitney *U*-test was used to compare EMG activity between groups and the Wilcoxon signed rank-sum test was used to compare between sides. For AI, data presented normal distribution; thus, the Student's *t*-test for independent samples was used to compare groups. A p-value <0.05 was considered as statistically significant. The SPSS version 19 software (SPSS, IBM, Chicago, IL, USA) was used for statistical calculations.

Results

Reproducibility results of EMG recordings showed no significant differences ($p>0.05$). Task-to-task variability calculated by a coefficient of variability for AT muscles during eccentric and concentric grinding was 21.5 and 27%, respectively; for SCM muscles during eccentric and concentric grinding, coefficients were 20.5 and 21.4%, respectively.

Figures 1 and 2 show EMG activity recorded in AT and SCM muscles, respectively. Table 1 shows no significant differences in EMG activity of AT muscles between Groups 1 and 2 on both sides during eccentric or concentric grinding ($p>0.05$). Moreover, no significant differences in EMG activity of SCM muscles were found between Groups 1 and 2 on both sides and tasks ($p>0.05$).

EMG activity of AT muscles was significantly higher in the WS than in the NWS in Group 1 during concentric grinding ($p<0.05$), whereas no difference was observed in Group 2. EMG activity of SCM muscles showed no differences when comparing groups or sides, as shown in Table 1 ($p>0.05$).

Table 2 compares AI between Groups 1 and 2 during both grinding tasks. No significant difference was observed in the partial and total AI during eccentric and concentric tasks ($p>0.05$)

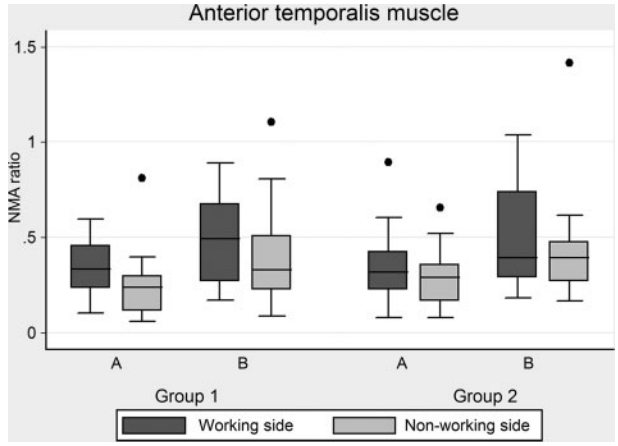

Figure 1 Box plot graph showing median and IQ range of anterior temporalis (AT) EMG activity in subjects with a mediotrusive contact (Group 1) and without mediotrusive contact (Group 2) on working and NWS, recorded during eccentric grinding (A) and concentric grinding (B). Normalized Muscular Activity (NMA) ratio = EMG recorded during grinding/EMG recorded during maximal voluntary clenching in intercuspal position (IP).

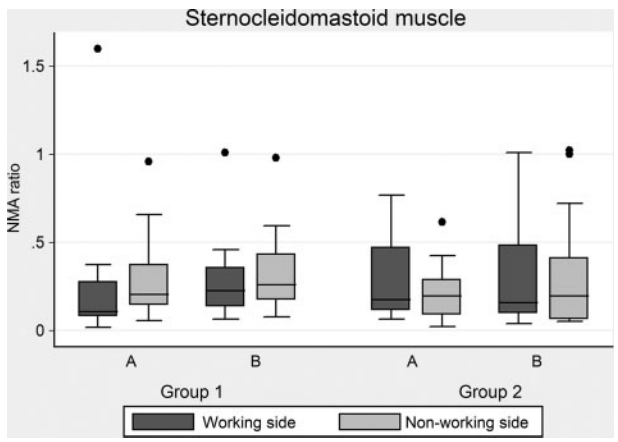

Figure 2 Box plot graph showing median and IQ range of sternocleidomastoid (SCM) EMG activity in subjects with a mediotrusive contact (Group 1) and without mediotrusive contact (Group 2) on working and NWS, recorded during eccentric grinding (A) and concentric grinding (B). Normalized Muscular Activity (NMA) ratio = EMG recorded during grinding/EMG recorded during maximal intentional isometric head-neck rotation to each corresponding side.

Discussion

Evidence about the jaw and cervical muscular activity during a parafunctional test is very scarce, by which it is relevant to improve the knowledge about the EMG pattern of AT and SCM muscles during grinding tasks in the presence or absence of a natural molar mediotrusive occlusal contact.

The major finding of this study is that the presence of a natural mediotrusive occlusal contact does not cause an alteration of the EMG patterns and

Table 1 Comparison of normalized EMG activity between Group 1 and Group 2 and between working and NWS recorded during eccentric and concentric grinding

			Group 1		Group 2		
Muscle	Task	Side	Median	IQR	Median	IQR	*P*-value‡
AT	A	WS	0.333	0.2203	0.317	0.198	0.852
AT	A	NWS	0.240	0.1808	0.291	0.192	0.237
P-value†			0.078		0.233		
AT	B	WS	0.492	0.4038	0.180	0.448	0.740
AT	B	NWS	0.331	0.2840	0.394	0.208	0.481
P-value†			0.047*		0.570		
SCM	A	WS	0.107	0.1917	0.173	0.357	0.206
SCM	A	NWS	0.202	0.2292	0.193	0.198	0.548
P-value†			0.100		0.776		
SCM	B	WS	0.226	0.2207	0.155	0.386	0.604
SCM	B	NWS	0.258	0.2590	0.195	0.349	0.419
P-value†			0.140		0.691		

Group 1: with mediotrusive occlusal contact; Group 2: without mediotrusive occlusal contact; AT: anterior temporalis; SCM: sternocleidomastoid; A: eccentric grinding from intercuspal position (IP) to the WS lateral edge-to-edge contact position; B: concentric grinding from WS lateral edge-to-edge contact position to IP; WS: working side; NWS: non-working side; IQR: interquartile range. ‡ Mann–Whitney *U*-test. † Wilcoxon signed rank-sum test. * Significant difference at $p < 0.05$.

Table 2 Comparison of normalized asymmetry index (AI) (partial and total) between Group 1 and Group 2 recorded during eccentric and concentric grinding

		Group 1		Group 2				
Task	AI	Mean	SD	Mean	SD	Mean difference	95% CI	*P*-value¥
A	AT	20.681	34.308	9.611	28.266	11.071	−34.581 to 12.440	0.343
A	SCM	−19.783	27.811	5.090	51.657	−24.874	−6.585 to 56.333	0.115
B	AT	12.339	17.708	4.484	20.767	7.855	−22.289 to 6.580	0.274
B	SCM	−8.793	32.652	−0.964	47.669	−7.829	−22.731 to 38.388	0.604
A	Total	4.475	25.037	7.407	32.911	−2.932	−18.939 to 24.803	0.786
B	Total	2.846	20.496	−1.373	25.698	4.219	−21.604 to 13.166	0.623

Group 1: with mediotrusive occlusal contact; Group 2: without mediotrusive occlusal contact; A: eccentric grinding from intercuspal position (IP) to the working side (WS) lateral edge-to-edge contact position; B: concentric grinding from WS lateral edge-to-edge contact position to IP; AT: anterior temporalis; SCM: sternocleidomastoid; CI: confidence interval. ¥ Student's *t*-test for independent samples.

muscular symmetry in AT and SCM muscles during eccentric or concentric tooth grinding.

As can be seen by the large SDs compared to the means, the data showed a considerable variability, which reflects the fact that although the entrance criteria of the sample were strict and all selected subjects fulfilled the stated requirements, inter-subject variability was large and should be taken into account. From a statistical point of view, this fact was taken into account by selecting non-parametric tests to analyze the authors' data.

Subjects of Group 2 (controls) presented similar EMG activity in AT muscles during the grinding tasks between WS and NWS. This result disagrees with the authors' previous study in healthy subjects with different laterotrusive schemes (canine guidance or group function) but without natural mediotrusive contact, where higher EMG activity on WS than on NWS during eccentric and concentric grinding tasks were recorded.[35] It is difficult to explain this discrepancy. It could be speculated that this difference may be due to the presence of individuals with different Angle's molar relationship in the authors' previous work. Moreno et al.[36] found that subjects with Angle class III EMG activity of AT muscle showed a tendency to be more activated than classes I and II, especially in maximum effort tests, even though they were not statistically different. Harper et al.[37] showed that subjects with class II presented lower values than class I subjects during maximal effort in maximum intercuspation. Furthermore, Gadotti et al.[38] indicated that the muscle activity pattern was different in subjects with class II occlusion compared with those with class I occlusion. However, these results cannot be directly extrapolated to the present study because these investigations have not been performed during tooth grinding.

In the present study, subjects of Group 1 (with natural mediotrusive occlusal contact) showed lower EMG activity in the AT muscle of the NWS compared with the WS during concentric grinding. In the authors' opinion, since the jaw is returning to IP guided by the stability given by the mediotrusive occlusal contact, lower effort is required in the AT muscle of the NWS.

For the SCM muscle, the same EMG activity pattern was observed when comparing WS and NWS in both groups, during eccentric or concentric grinding. This result agrees with another study performed in healthy subjects during grinding, but without mediotrusive contact.[17]

The NMA ratio utilized in the authors' research is an adaptation of the IP ratio proposed by Mizutani et al.,[7] which normalizes the EMG activity. This formula has been used by other authors too.[39,40] The authors have adapted the formula because it could only be applied when the maximal muscular activity was obtained during clenching in IP, which occurs only in some jaw muscles as masseter and temporalis. However, it is not applicable, i.e. for cervical muscles. Normalized muscle activity ratio can be used for normalization of other muscles since the denominator of the ratio has been changed by the EMG recorded during the chosen standardization task (maximal muscular activity during isometric contraction). This approach has also been used by other authors.[41,42]

Partial or total AIs of the EMG activity showed no significant differences for AT and SCM muscles. Ferrario et al.[15] showed an immediate change in EMG pattern of SCM muscles after the insertion of an artificial occlusal interference. This discrepancy could be explained by: (a) different task used in that study (maximum voluntary clenching); (b) experimental interference was placed in different positions (maxillary canines and maxillary first molars); and (c) the subjects did not have a period of adaptation to the artificial interference, which could dramatically enhance peripheral inputs, impacting their muscular balance.

From a general point of view, the EMG results for this study could not be contrasted because this is the first study in which the influence of a natural molar mediotrusive contact on EMG activity of AT and SCM muscles has been assessed.

The findings of this study can be explained by two reasons at least: (a) the predominance of central nerve control over peripheral inputs,[43] initiated by the presence of the mediotrusive occlusal contact on the motor-neuron pools that control AT and SCM muscles, and (b) the subjects studied presenting a natural mediotrusive occlusal contact were well-adapted, since they did not evidence signs or symptoms associated with this occlusal feature. According to the results of this study, it is possible to speculate that the mediotrusive contact may not be an initiator of TMD. However, it is important to point out that this finding cannot be extrapolated to patients with signs and symptoms of TMD and/or myofascial pain. If during a rehabilitation treatment, such as a crown, an artificial mediotrusive contact is eventually produced, a dramatic initial enhancement of peripheral inputs could be expected, leading to an impact in the muscular balance. In the long term, however, the effect of the artificial mediotrusive contact may depend on the adaptation capability of the subject.

The present study has some limitations, such as: (a) it is not possible to determine if the mediotrusive contact initially changed the EMG pattern and adapted afterward; and (b) it is not possible to know the effect of the mediotrusive contact on other jaw muscles (masseter, suprahyoid). Therefore, further studies are required.

In accordance with the results of this study and within the above limitations, the authors accept the hypothesis because EMG of AT and SCM muscles and AI were similar between both groups.

This new knowledge could provide a better understanding of EMG patterns during eccentric and concentric grinding. The fact that no difference between subjects with or without mediotrusive occlusal contact was found supports the clinical concept of not intervening with individuals presenting mediotrusive occlusal contact, unless they show clinical signs or symptoms like tooth mobility, muscular or joint pain.

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Disclaimer Statements

Contributors All authors contributed to conception, design, data acquisition, analysis of the results, drafted and critically revised the manuscript. All authors gave final approval and agree to be accountable for all aspects of the work.

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