Influence of vision on masticatory muscles function: surface electromyographic evaluation

Domenico Ciavarella, DDS, PhD[1]
Antonio Palazzo, MD[1]
Alfredo De Lillo, DDS[1]
Lucio Lo Russo, DDS, PhD[1]
Sergio Paduano, DDS[3]
Luigi Laino, DDS, PhD[1]
Claudio Chimenti, DDS[2]
Federica Frezza, DDS[1]
Lorenzo Lo Muzio, DDS,PhD[1]

[1] Department of Clinical and Experimental Medicine, Faculty of Medicine, School of Dentistry, University of Foggia, Italy
[2] Department of Surgical Sciences, Faculty of Medicine, School of Dentistry, University of L'Aquila, Italy
[3] Department of the Health, University "Magna Graecia" Catanzaro, Italy

Corresponding author:
Domenico Ciavarella
Department of Clinical and Experimental Medicine,
Faculty of Medicine, School of Dentistry,
University of Foggia
Via Rovelli
71100 Foggia, Italy
Phone: +39 347 6131225
Fax: +39 0881 588080
E-mail: drdomenicociavarella2@yahoo.it

Summary

The role of the ocular disorders (OD) in pathogenesis of MMp is still a controversial issue. Ocular arc reflexes (OAR) may involve changes in head and neck posture and generate modifications of contraction resulting in muscle contraction and finally weakness. sEMG tests were performed on 28 patients (13 with masticatory muscles pain and myopia/15 healthy) in rest position with eyes open and eyes closed. Patients group control (healthy patients) showed no significance difference in sEMG record in open/close test. In non healthy patients there were great differences between the sEMG recordings with eyes closed and open. Temporalis and masseters showed a statistical difference of means activation in two tests (temporalis p = 0.0010; masseters = 0.0006). Great difference there was in means muscles activation between open eyes healthy test and non healthy. No difference in close eyes test was evaluated in temporalis and masseters close test in the two groups. The exact causes of MMp are still unknown. The role how ocular disorders (OD) may play an important role in pathogenesis of MMp is still a controversial issue. Ocular arc reflexes (OAR) may involve changes in head and neck posture and generate modifications of contraction resulting in muscle contraction and finally weakness.

Key words: surface electromyography, masticatory muscles pain, ocular disorders.

Introduction

Masticatory muscles (MM) function is influenced by many factors such as postural problems, traumas, psycho-physiological issues and occlusal alterations. Masticatory muscles pain (MMp) is a condition encountred in temporo-mandibular joint disorder (TMD) and in head/neck facial pain. Its pathogenesis is still unclear (Fig. 1) (1,2). Several studies have described how the level of electromyographic activity (EMG) in the pericranial muscle is higher in patients with MMp than in healthy controls in rest position (3-6). The interaction between muscle pain and muscle activity at rest is still unclear because the EMG activity in muscle pain patients has been shown to be higher as compared to control subjects (7,8). The maximal voluntary contraction (MVC) in painful muscles is decreased in patients with temporomandibular disorder (7,8).
Other symptoms related to MMp are often acoustic alterations, vertigo, nausea, salivary disturbance,

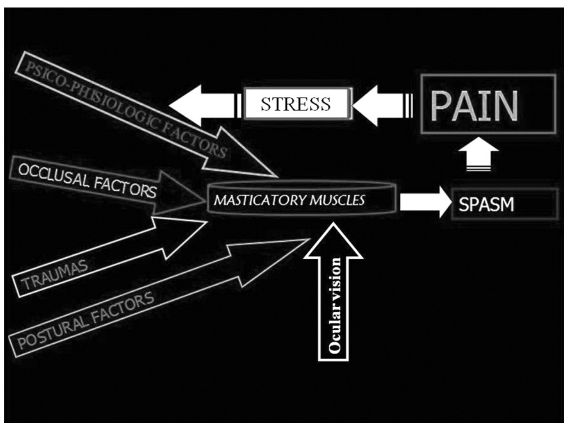

Figure 1. Possible pathogenesis of MMs.

disfagy and sometimes language alterations (9). The muscular stress is often treated with an oral appliance such as resin splint which helps reduce clenching (10-12).

The role how ocular disorders (OD) may play an important role in pathogenesis of MMp is still a controversal issue. Ocular arc reflexes (OAR) may involve changes in head and neck posture and generate modifications of contraction resulting in muscle contraction and finally weakness. The aim of this study is to evaluate the influence of OD in MM contractions, in patients with masticatory muscles pain and in healthy subjects, using surface Electromyography (sEMG).

Materials and methods

In this study, sEMG tests were performed on 28 patients (10 males and 18 females, ages 16 to 48) at School of Dentistry, University of Foggia. The participants and their parents provided written informed consent to be involved in the study. The EMG activity at rest and clench in the temporal and masseter muscles was recorded in two groups of patients with different conditions: myopic patients and masticatory muscles pain; asymptomatic subjects was used as a control. On each patient the RDC questionnaire was submitted (13).

Patients' criteria selection was as follows: Angle's Class I Molar (i.e. normal intermaxillary dental relationships), good symmetry of dental arches, no refractive errors, patients' anamnesis of temporomandibular disease (TMD) or facial pain history absence, absence of neuromuscular pathology, and no history of neuromuscular pathology, absence of neuropathic or myofascial pain, absence of any anterior or posterior/lateral cross-bite; no signs or symptoms of TMD (according to the RDC questionnaire) (13). Subjects taking drugs other than nonsteroid inflammatory drugs, paracetamol or minor opioid analgesics were excluded, as well as subjects presenting with systemic pathologies such as diabetes, and subjects suffering from generalised diffuse muscle and/or articular pain. The non-healthy group (13 patients; mean age 26,5 ± 6.9) suffering from either masticatory muscles pain (MMp) and myopia was enrolled in the study. Examinations were performed using a standardized form in which the following were listed: history of the diseases, palpation at rest, in maximal voluntary contraction and during mandibular motions of the masticatory and neck muscles, palpation of temporo-mandibular joint (TMJ), assessment of spontaneous and triggered pain using a visual analogue scale (VAS), mandibular motions recorded by an electrognathograph as suggested by Okeson (14).

Surface electromyography evaluation

The tests, performed by means of Biopack electromyography. This diagnostic test provided information on the functional status of the craniomandibular neuromuscular system and was useful in determining the proper cranio-mandibular relationship.

To position the electrodes, subjects were requested to close their mouths and clench (Fig. 2) (15,16). To reduce electrode impedance, the skin was carefully cleaned prior to electrode positioning, and recordings were performed 5-6 min later, allowing the conductive paste to adequately moisten the skin surface (17).

The analogue sEMG signal was amplified, digitised, and digitally filtered. The instrument was directly interfaced with a computer, which presented the data graphically. The signals were averaged over 25 ms, with muscle activity of the four tested muscles espressed in microvolts (µV).

The sEMG test was performed on each patient in resting (i.e. no voluntary muscle contraction and no dental contact) conditions and in different ocular states (i.e. eyes open and eyes closed). In particular, the sEMG test was performed in patients sitting, with their ocular plane parallel to the floor, after measuring their body temperature, and with a room temperature of 26° C. No other interferences were present in the room.

An eight channel surface Electromyograph was used on 4 groups of muscles: temporalis and masseters (masticatory muscles) and the digastrics and sternocleidmastoids (neck muscles). On sEMG test muscle contractions were represented on 5 window displays and were calculated in microvolts (µV). On view displays it is possible to see the activity level of each monitored muscle. Each column of numbers represents the average muscle activity (µV) throughout a marked region and the time for the muscle to exceed the activity level. This is measured in milliseconds.

Figure 2. Patient with surface electromyography electrodes.

Electromyography gives the operator the effective RMS (Root Mean Squared) value. RMS is calculated as the square root of the medium power in a date time interval ($X_{RMS} = \sqrt{1/T \, {}^{t}{}_{0}\int x^2 (t) \, dt}$). The Averaged EMG display shows a rectified average of the muscle signals which are contained within the zoom cursor. The height of the graph ("mountain peaks") represents the activity of the muscle averaged every 25 milliseconds. The numbers below represent the average firing strength of each muscle (µV). All tests were performed for 10 seconds duration.

Statistical analysis

A statistical analysis of data with open and close eyes in healthy and non healthy were done. Data were evaluated on statistical "GraphPad" software performing a Paired t-test. Statistical significance was set at 0.05.

Results

Control group showed no significant difference in sEMG records in open/close tests. Temporalis activation (right and left mean) in two tests had the same range of activation. The medians do not differ significantly (P-Value = 0.3976) .

Masseters activation (right and left mean) in healthy subjects, in open/close tests had no significant change in activation (open 3.200 µV; close 2.600 µV). Values of 2.0/3.0 µV when recorded with the mandible at rest are generally accepted as indicating muscle posturing. The medians do not differ significantly (P-Value = 0.3274) (Tab. 1).

In patients with muscles suffering (non-healthy) there were differences between the sEMG recordings with close eyes and open. MM increased their work by vision. Temporalis showed great difference of means activation in two tests. In open eyes test mean of activation was 23.85 µV. This value was greater than mean in close eyes 3.538 µV. The medians differ significantly (P-Value < 0.0001) (Tab. 1).

Masseters changed their activity in close eyes test in respect to open eyes test. Non-healthy subjects showed a mean of activation in open eyes (24.46 µV) greater than close eyes test (4.923 µV). The medians differ significantly (P-Value < 0.0001).

Authors evaluated open eyes means of each muscle between healthy and non-healthy subjects. There was a great difference in masseters means between open eyes healthy test and non-healthy test. Healthy showed masseters mean of activation of 3.200 µV while non-healthy subjects 24.46 µV. The medians differ significantly (P-Value < 0.0001).

In close eyes test of masseters non-healthy subjects presented no difference with healthy subjects (mean non-healthy 4,923 µV, healthy 2,600 µV). The medians do not differ significantly (p=0.1987).

In open eyes temporalis presented a substantial difference of activation as well (healthy 4.067 µV, non-healthy 23.85 µV). The medians differ significantly (P-Value < 0.0001).

In close eyes test there was no difference between the two groups of patients. No statistical difference was evaluated (p=0,7605) (Tab. 2).

Authors observed a significant variation in switching from eyes closed to eyes open in all non-healthy patients.

An Electromyographic test in open and close eyes and in rest jaw position was conducted. During the test an error occurred because some patients closed their eyes. Authors observed how 4 subjects during physiologic open/close eyes produced an electromyographic image that was unusually. Every open/close movement induced a great increase of electromyographic trace. Authors did not include this data in statistical analysis because only a small sample presented this phenomena.

Table 1. Results of sEMG test in healthy and non-healthy subjects.

		Mean	SEM	Median	Min	Max	95 % CI	*p-Value* (pairing means Test)
Temporalis activation (µV) healthy	open close	4.067 3.567	0.82 0.7485	2.000 2.000	1.000 1.000	24.000 21.000	2.374-5.759 2.036-5.097	0.3976
Masseter activation (µV) healthy	open close	3.200 2.600	2.511 2.298	2.000 2.000	1.000 0.000	12.000 11.000	2.263-4.137 1.742-3.458	0.3274
Temporalis activation (µV) non healthy	open close	23.85 3.538	6.807 0.7590	10.00 2.000	1.000 0.0	128.0 17.00	9.823-37.869 1.975-5.102	<0.0001
Masseter activation (µV) non healthy	open close	24.46 4.923	5.708 1.105	15.00 2.000	2.000 0.0	100.0 21.00	12.703-36.22 2.647-7.199	<0.0001

SEM: Standard error of means; CI: Confidence Interval; Significance level: p < 0.05

Table 2. Results of sEMG open/close test between healthy and non-healthy subjects.

		Mean	SEM	Median	Min	Max	95 % CI	*p-Value* (pairing means Test)
Temporalis activation (μV) open	**Healthy**	4.067	0.82	2.000	1.000	24.000	2.374-5.759	<0,0001
	Non healthy	23.85	6.807	10.00	1.000	128.0	9.823-37.869	
Temporalis activation (μV) close	**Healthy**	3.567	0.7485	2.000	1.000	21.000	2.036-5.097	0,7605
	Non healthy	3.538	0.7590	2.000	0.0	17.00	1.975-5.102	
Masseter activation (μV) open	**Healthy**	3.200	2.511	2.000	1.000	12.000	2.263-4.137	<0,0001
	Non healthy	24.46	5.708	15.00	2.000	100.0	12.71-36.22	
Masseter activation (μV) close	**Healthy**	2.600	2.298	2.000	0.000	11.000	1.742-3.458	0,1987
	Non healthy	4.923	1.105	2.000	0.0	21.00	2.647-7.199	

SEM: Standard error of means; CI: Confidence Interval; Significance level: $p < 0.05$

Discussion

The purpose of the authors was to evaluate if ocular disorders (OD) may influence MM activity and produce masticatory muscles pain (MMp). The MMp pathogenesis is still unclear. Its association with OD is an actually item of discussion in literature research. The association of upper activation of the muscles in rest position and the OD was observed (18). It was evaluated a modification of EMG activity at rest with closed eyes in patients with cranio-cervical disfunction (19) and in patients with OD (20). No significant difference of EMG over the anterior temporalis area at mandible rest position comparing eyes closed with eyes open condition in young healthy people with normocclusion and without visual defects (21).

Authors evaluated MM contraction in healthy and non healthy (i.e. patients suffering of facial pain) subjects by use of sEMG. In the present paper authors observed no difference in healthy patients without OD in both conditions open/close eyes and in patients with ocular disorders as myopia the modifications in open eyes are statistically significative when paired in close condition both for temporalis and masseters rest evaluation. The activation of the masticatory muscles in open eyes was greater in patients with OD than healthy subjects; no difference was observed in close eyes test in two evaluated groups.

It is well known that ocular vision (OV) has an important role in controlling body equilibrium and movements. Vestibulo-ocular reflex and ocular reflex through substantia reticularis influences masticatory and postural muscles. In recent years, some authors have tried to discover if OV plays a role in MMp pathogenesis. Neuro-physiologicical sources show how there is a strong connection between the various parts of the nervous system for some types of involuntary reflexes. Control of conscious and subconscious movements and some functions are modified by neurologic sensitive afferent reflexes (22).

OV may influence many types of muscular activity by activating neurologic sensitive reflexes. It is well known that when the ocular globes stir, all ocular muscles are stimulated. At the same time there is a neurologic reflex that induces all the neck muscles to change position for a better view of the object in interest. Some fibres coming from the macula do not reach the visual cortex of the brain but directly influence postural mechanisms of the body (23,24).

Anatomical researches show how the Optic Nerve starts from the retinal photoreceptors and stretches to corpus genicolatum laterale and then continues to parts 17/18/19 of Brodmann's area of lobus occipitalis (25). Some optic nerve fibres don't follow the same route through corpus genicolatum laterale but instead

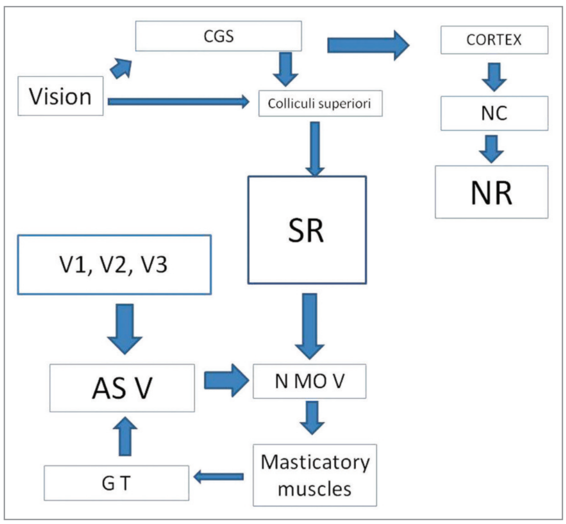

Figure 3. Possible neurologic connection. Corpus genicolatum lateralis CGL; nucleus centralis (NC); nucleus rubrum (NR); substantia reticularis (SR); nucleus motorius nervi trigemini (N mo V); ganglius trigemini (GT); apparatus sensitivus nervi trigemini (ASV). [modified from Francis Hartmann, Gerard Cucchi. Le disfunzioni cranio-mandibolari (SADAM). Ed. Springer, 1997]

go to the superior colliculi via the brachium of colliculi. From the superior colliculi, fibres project to substantia reticularis and the reflex ends in nucleus motorius nervi trigemini (Fig. 3) (26). It is probable that this type of arc reflex in patients, with OD, unevaluated is overexpressed to generate a strong MM contraction that may result finally in pain.

Conclusion

sEMG evaluation showed how no modifications in open/close tests was presented in healthy subjects. Non-healthy subjects presented great modification in open/close tests. These findings were of great interest in patients with unexplainable masticatory muscles pain.
The exact causes of MMp are still unknown; peripheral myofascial mechanisms and central dysregulation of pain processing structures play a role in MMp pathogenesis but their relative weight both with the frequency of pain and among patients is still a controversial issue.

Conflicts of Interest/Role of the Funding Source

All authors disclose any financial and personal relationships with other people or organizations that could inappropriately influence (bias) their work.

References

1. Svenson J, Cowen D, Rogers A. Headache in the emergency department: importance of history in identifying secondary etiologies. J Emerg Med. 1997;15(5):617-21.
2. Silveira A, Armijo-Olivo S, Gadotti IC, Magee D. Masticatory and cervical muscle tenderness and pain sensivity in a remote area in subjects with a temporomandibular disorder and neck disability. J Oral Facial Pain Headache. 2014;28(2):128-37.
3. Schoenen J, Gerard P, De Pasqua V, Sianard-Gainko J. Multiple clinical and paraclinical analyses of chronic tension-type headache associated or unassociated with disorder of pericranial muscles. Cephalalgia. 1991;11:135-39.
4. Ashina M, Bendtsen L, Jensen R, Sakai F, Olesen J. Muscle hardness in patients with chronic tension-type headache: relation to actual headache state. Pain. 1999; 79(2-3):201-5.
5. Jensen R, Rasmussen BK. Muscular disorders in tension-type headache. Cephalalgia. 1996; 16:97-103.
6. Jensen R, Bendtsen L, Olesen J. Muscular factors are of importance in tension-type headache. Headache. 1998;38:10-17.
7. Burdette BH, Gale EN. The effects of treatment on masticatory muscle activity and mandibular posture in myofascial pain-dysfunction patients. J Dent Res. 1988;67:1126-30.
8. Raphael KG, Janal MN, Sirois DA, Dubrovsky B, Wigren PE, Klausner JJ, et al. Masticatory muscle sleep background electromyographic activity is elevated in myofascial temporomandibular disorder patients. J Oral Rehabil. 2013. 40(12):883-91.
9. Hartmann F, Cucchi G. Stress and the problem of pain in myofascial pain dysfunction syndrome (M.P.D.S.). Prog Odontoiatr. 1991;4(10):8-10.
10. Coy RE, Flocken JE, Adib F. Musculoskeletal etiology and therapy of craniomandibular pain and dysfunction. Cranio Clin Int. 1991;1(2):163-73.
11. Kidder GM, Solow RA. Precision occlusal splints and the diagnosis of occlusal problems in myogenous orofacial pain patients. Gen Dent. 2014;62(2):24-31.
12. Koralakunte PR. Prosthetic management of a masticatory muscle disorder with customized occlusal splint. J Clin Diagn Res. 2014;8(3):259-61.
13. Dworkin SF, LeResche L. Research diagnostic criteria for temporomandibular disorders: review, criteria, examinations and specifications, critique. Craniomandib Disord. 1992;6 (4): 301-55.
14. Okeson J. Oro-facial pain: guideless for assessment, diagnosis, and management. Chicago, IL: Quintessence Publishing Co, Inc. 1996.
15. Castroflorio T, Farina D, Bottin A, Piancino MG, Bracco P, Merletti R. Surface EMG of jaw elevator muscles: effect of electrode location and interelectrode distance. J Oral Rehabil. 2005;32(6):411-7.
16. De Oliveira RH, Hallak JE, Siessere S, De Sousa LG, Semprini M, De Sena MF, et al. Electromyographic analysis of masseter and temporal muscles, bite force, masticatory efficiency in medicated individuals with schizophrenia and mood disorders compared with healthy controls. J Oral Rehabil. 2014;41(6):399-408.
17. Tartaglia GM, Testori T, Pallavera A, Marelli B, Sforza C. Electromyographic analysis of masticatory and neck muscles in subjects with natural dentition, teeth-supported and implant-supporte prothesis. Clin Oral Implants Res. 2008;19:1081-1088.
18. Veiersted KB, Westgaard RH, Andersen P. Electromyographic evaluation of muscular work pattern as a predictor of trapezius myalgia. Scand J Environ Health. 1993;19:284-290.
19. Miralles R, Velenzuela S, Ramirez P, Santander H, Palazzi C, Ormeno G, et al. Visual imput effect on EMG activity of sternocleidomastoid and masseter muscles in healthy subjects and in patients with myogenic cranio-cervico-mandibular disfunction. Cranio. 1998;16(3):168-84.
20. Monaco A, Cattaneo R, Spadaro A, Giannoni M, Di Martino S, Gatto R. Visual input effect on EMG activity of masticatory and postural muscles in healthy and in myopic children. Eur J Paediatr Dent. 2006;7(1):18-22.
21. Spadaro A, Monaco A, Cattaneo R, Masci C, Gatto R. Effect on anterior temporalis surface EMG of eyes open-closed condition. European Juournal Of Paediatric Dentistry. 2010;11:210-212.
22. Pierrot-Deseilligny C. Central oculomotor circuits. Rev Neurol (Paris). 1985;141(5):349-70.
23. Horton JC. Ocular integration in the human visual cortex. Can J Ophthalmol. 2006; 41(5):584-93.
24. Tzelepi A, Lutz A, Kapoula Z. EEG activity related to preparation and suppression of eye movements in three-dimensional space. Exp Brain Res. 2004;155(4):439-49.
25. Kuhl S, Haug H, Schliesser W. Morphometry of cortical neurons. The best estimation of perikaryon volume from the projection area. Microsc Acta. 1982;86(4):315-22.
26. Lewis RF, Zee DS. Abnormal spatial localization with trigeminal-oculomotor synkinesis. Evidence for a proprioceptive effect. Brain. 1993;116 (Pt 5):1105-18.