Voluntary regulation of the contractile activity of the masseter muscle in healthy individuals vs. patients with temporomandibular disorders: a potential diagnostic test.

Luis Ignacio Fernández-Rey[1], Marcelo Kreiner[2], Alejandro Francia[3], Guillermo Zanotta[4], José Piaggio[5]

DOI: 10.22592/o2017n30a6

Abstract

This study analyzed the electrophysiological aspects of the voluntary control of the contractile activity of the masseter muscle studying a new variable, previously presented by our group. We conducted a comparative study among healthy volunteers and patients with temporomandibular disorders. We used an experimental system that included real time visual feedback to control the contractile effort of the masseter muscle. The time that each individual needed to control the trajectory of the motor activity was calculated for each electromyographic record. Coefficients of variation and standard deviations were different in the groups analyzed ($p<0.01$ and $p = 0.02$ respectively). We found a coefficient of variation greater than 0.936, which determines a 93.7% specificity. Additionally, a 60% sensitivity was verified. This new variable showed promising diagnostic potential, with high specificity. Sensitivity can be increased if more repetitions are conducted for each individual, so as to better analyze the impact of dispersion.

Keywords: mandibular function; electromyography; muscle control.

[1] Department of General and Oral Physiology. School of Dentistry, Universidad de la República. ORCID: 0000-0003-1622-823X

[2] Department of General and Oral Physiology. School of Dentistry, Universidad de la República. ORCID: 0000-0001-6463-1280

[3] Department of General and Oral Physiology. School of Dentistry, Universidad de la República. ORCID: 0000-0002-7942-9189

[4] Department of General and Oral Physiology. School of Dentistry, Universidad de la República. ORCID: 0000-0003-2696-6391

[5] Department of Biostatistics. School of Veterinary Medicine, Universidad de la República. ORCID 0000-0003-2460-2842

.

Received on: 12 Sep 2017 – Accepted on: 16 Oct 2017

This study was conducted at the Laboratory of the Department of General and Oral Physiology, School of Dentistry, Universidad de la República.

Introduction

The cranial mandibular muscles take part in the dynamics of the temporomandibular joint (TMJ), during the different functions of the stomatognathic system. The main branches involved are the medial and lateral pterygoid muscle, the masseter and anterior temporalis muscles, all of which are muscles of rapid contraction, capable of generating force. These muscles are associated to quick, repetitive movements, as well as to strong, sustained contractions(1). Understanding the physiology and the pathology of these muscles has been one of the most frequent research aims in dentistry.

Furthermore, temporomandibular disorders are known to have a high prevalence in our country. A nationwide epidemiological study showed that 55% of the population under study had at least one symptom of the disorder, and 44% were found to have at least one clinical sign of the dysfunction, which led us to conclude that these pathologies involve a series of variables which affect the health of the stomatognathic system, and the quality of life of the people who suffer them[2]. These results show the need to allocate research resources to better understand the diagnostic mechanisms as well as the therapeutic possibilities for these pathologies. Electromyography (EMG) has become the most widely used procedure to study and assess muscle physiology[2]. It assesses muscle function through the analysis of electric signals produced during the contraction of the muscle[3,4]. Because they are easily accessible to place the electrodes, superficial electromyography has been widely used to assess the electrical activity of the masseter and temporalis muscles, thus becoming a very useful tool in this field of study [4,5].

Electrophysiological records taken with surface electrodes can also be used to study some cranial mandibular reflexes. This technique is called reflexometry (RFXM), and it contributes valuable data about the physiology of the neuromuscular system[6-8].

García Moreira et al. used this technique to study the trajectory of the motor activity of the masseter muscle by studying the inhibition following reflex discharge in healthy volunteers[9], and found highly reproducible trajectories at the intraindividual level in the records analyzed.

To assess muscle strength in this kind of records, our team introduced a variable that studies the individuals' ability to control the strength generated in the masseter muscle. This voluntary contractile effort is guided by real time visual feedback[10]. Likewise, the variable may be quantified by recording the number of seconds it takes the volunteer to reach a preset contraction level, a necessary condition to trigger an automatic and standardized pneumatic stimulus.

Several studies have described particular characteristics of the muscle function in patients with TMD, compared to healthy individuals[6,11]. Some authors have concluded that patients suffering from TMD have muscle hypertonicity[12,13] and a lower resistance to masticatory muscle fatigue[14.15].

Similarly, the pain present in some temporomandibular disorders has been linked to alterations in the motor function of the mandible[13,16], for it affects the isotonic and isometric contractile activity of the masticatory muscles due to the alteration of the sensorimotor system[17,18].

Considering that so far none of the electromyographic variables assessed has shown adequate sensitivity to be used as a diagnostic tool[11], the aim of this study was to further study motor control, analyzing this new variable which reflects the individual's ability to control the trajectory of a muscle contraction in a controlled isometric effort, based on real time visual feedback. The working hypothesis was that this variable would be different in healthy and ill patients.

Materials and methods

This study was conducted with a sample of 31 volunteers (13 men and 18 women aged 31 on average), 16 of which were healthy, and the remaining 15 suffered from temporomandibular disorders (TMD).

Inclusion criteria for the control group:

- Age between 18 and 40

- Presence of at least six teeth per quadrant
- Absence of muscle and/or joint pain
- Absence of functional limitations
- Absence of disk disorders

Inclusion criteria for the TMD group:

- Age between 18 and 40
- Presence of at least six teeth per quadrant
- Muscle or joint alterations in the stomatognathic system

Exclusion criteria for both groups:

- Pregnant women
- Presence of orthodontic treatment
- Neurological disease or psychiatric alterations
- Pain other than musculoskeletal pain
- Patients taking muscle relaxers, anti-inflammatory drugs on a regular basis and who cannot stop taking them at least 48 hours prior to the electromyographic record
- Patients taking antidepressants on a regular basis or as part of a medical treatment

The patients in the TMD group were recruited as they were referred by the Temporomandibular Disorder Diagnostic and Treatment Department of the School of Dentistry (Universidad de la República). The protocol was approved by the Ethics

Committee of the School of Dentistry of Universidad de la República. All the participants signed a written consent form prior to starting the study.

The volunteers were given a general, regional, and local clinical examination to check the inclusion and exclusion criteria. Once the volunteers had been included in the study, the methodology was explained to them.

The first step was connecting the volunteers to the reflexometer, which allowed them to control the trajectory of the muscle strength in real time through visual biofeedback. Figure 1 shows the experimental setup, and simulates three muscle contraction situations, showing the standardized and preset contraction level for the automatic and computerized triggering of the stimulation system.

A third electrode was placed on the trapezius muscle for reference in every case. The signal was amplified 10,000 times on a flat passband from 0.1 to 1,000 Hz. The A/D conversion was done at 3,300 (m.p.s.) and 1/256 (8 bits).

For the visual feedback, the rectified and integrated EMG was presented as color bars in a monitor. The inhibition reflex was obtained by applying a standardized pneumatic stimulus to the chin. This was done using a reflexometer built using a microprocessor linked in parallel to a personal computer, the mechanical response (hammer) of which is controlled by visual feedback.

An individual record was created for each patient with data obtained from making six readings per muscle, which were later averaged by the processor. Each record measured the time it took each individual to control the trajectory of the strength until a series of standardized conditions were met. The preset contraction level was approximately 40% of the maximum contractile force, and it was set for all the volunteers included in the study[(9)].

The time required to trigger the stimulus in each one of the six readings was recorded in a spreadsheet created for each patient, which was later statistically analyzed.

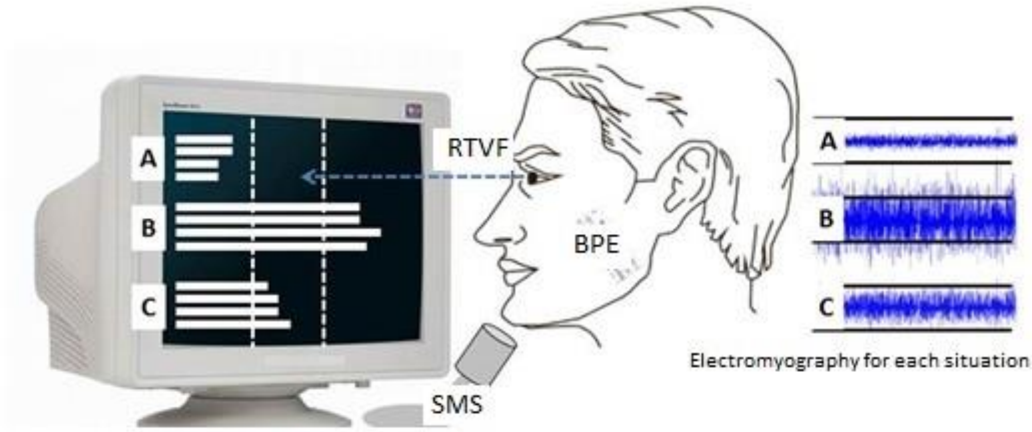

Fig. 1. ***Experimental setup and contraction levels:*** **A:** Subthreshold contraction, **B:** Suprathreshold contraction, **C:** Preset contraction necessary to trigger the stimulus, **RTVF:** Real time visual feedback, **SMS:** Standardized mechanical stimulus, BPE: Bipolar electrode

Statistical analysis

Standard deviations and coefficients of variation were calculated for all the readings. Non-parametric tests were used to compare the groups. The diagnostic potential of the test was determined by means of a discriminant analysis using ROC curves.

Ethical considerations

The protocol was approved by the Ethics Committee of the School of Dentistry of Universidad de la República. All the participants signed a written consent form prior to starting the study.

Results

The coefficients of variation and the standard deviations were different for the groups under study ($p < 0.01$ and $p = 0.02$, respectively). The coefficient of variation found was higher than 0.936, thus determining a 93.7% specificity, and a 60% sensitivity. (Figure 2). The ROC is shown in Figure 3.

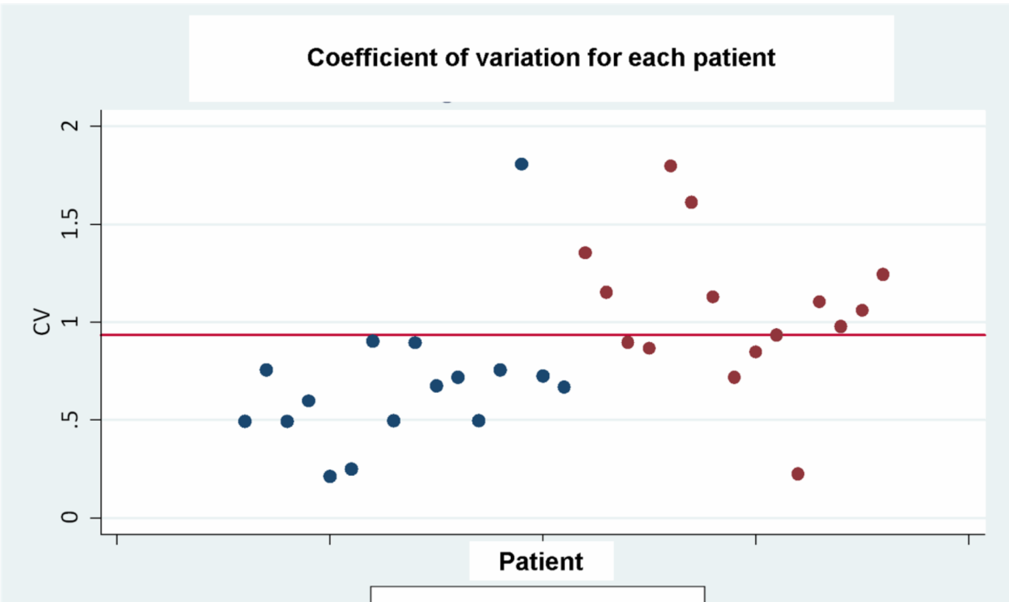

Figure 1

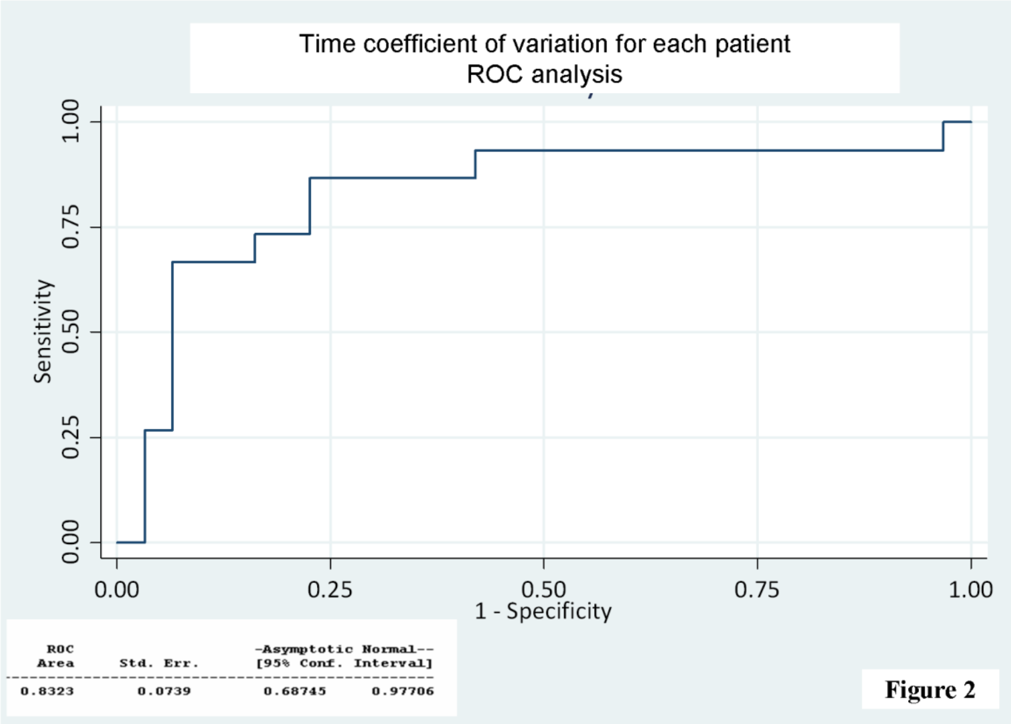

Figure 2

Discussion

The theoretical foundation to use electromyography as a diagnostic tool in cranial mandibular dysfunctions is the potential alterations of the muscle function in patients with TMD, when compared to healthy individuals[19,20].

Thus, since the creation of electromyography, researchers in dentistry have been making significant efforts to validate several electromyographic recording techniques as diagnostic tools. However, methodological difficulties related to the standardization of the technique have proven difficult to overcome, and several methods have been clinically impracticable[21]. The validity, sensitivity, and specificity of the records with the variables analyzed so far (latency, morphology, and electromyographic silent period) have been questioned based on current scientific evidence[22-26].

For this reason, this study fully analyzed a new variable with diagnostic potential presented by our study group in a previous study[(10)], proving its methodological feasibility, as well as showing some promising results. The high specificity determined in this paper shows the capability of our test to classify healthy volunteers as negative cases; i.e., the proportion of healthy individuals correctly identified. However, the sensitivity achieved (60%), namely the capability of the test to detect the condition in sick individuals, needs to be improved so that the internal validity of the test improves as well. The solution proposed to improve the sensitivity of the test is to increase the sample and the number of repetitions included in the experimental setup. Therefore, these preliminary results including dysfunctional patients promise new horizons for the application of this recording technique as a supplement to clinical assessment.

The differences found in this study could have physiological and clinical repercussions which must be confirmed in future experimental studies that overcome the weaknesses of this one.

Conclusions

This new variable looks promising in terms of its diagnostic potential, showing high specificity. It might be possible to improve its sensitivity by increasing the number of repetitions in the experimental setup in order for the dispersion to have greater impact. Future studies are needed to prove this hypothesis.

Acknowledgments

The Temporomandibular Disorder Diagnostic and Treatment Department of the School of Dentistry (Universidad de la República).

Research funded by CSIC and by the School of Dentistry, Universidad de la República.

References

1. Sciote J, Horton M, Rowlerson AM, Ferri J, Close JM, Raoul G. Human masseter muscle fiber type properties, skeletal malocclusions, and muscle growth factor expression. Journal Oral Maxillofacial Surgery. 2012; 70 (2): 440-448.
2. Riva R, Sanguinetti M, Rodríguez A, Guzzetti L, Lorenzo S, Álvarez R, Massa F. Prevalencia de trastornos témporo mandibulares y bruxismo en Uruguay. Parte I. Odontoestomatología. 2011; 13 (17): 54-71.
3. De Luca, C. The use of surface electromyography in biomechanics, Journal of Applied Biomechanics. 1997, 13 (2): 135-163.
4. Kümbüloğlu B, Saraçoğlu A, Bingöl P, Hatipoğlu A, Özcan M. Clinical study on the comparison of masticatory efficiency and jaw movement before and after temporomandibular disorder treatment. The Journal of Craniomandibular and Sleep practice. 2013; 31 (3): 190-200.
5. De FelÌcio CM, Mapelli A, Sidequersky FV, Tartaglia GM, Sforza C. Mandibular kinematics and masticatory muscles EMG in patients with short lasting TMD of mild-moderate severity. Journal of Electromiography and Kinesiology. 2013; 23 (3): 627-633.
6. García Moreira C, Angeles Medina F, Gònzalez Gòmez H, Nuño Licona A, Garcìa Ruìz J, Galicia Arias A, Rodrìguez Espinoza M. Improved automatized recording of masticatory reflexes through analysis of effort trajectory during biofeedback. Medical Progress through technology. 1994; 20 (1-2): 63-73.
7. Fernández LI, Zanotta G, Kreiner M. Estudio comparativo del complejo electromiográfico post-estímulo del músculo masetero en pacientes rehabilitados con prótesis completa bimaxilar mediante técnica piezográfica y técnica convencional. Odontoestomatología 2010; 7 (14): 45-53.
8. Kreiner M, Fernández LI, Zanotta G, Barrios JA, Radke J. Nuevo método para el registro simultáneo de reflejos inhibitorios cráneo-faciales de tres pares craneanos, utilizando retroalimentación visual a tiempo real. Cúspide 2012; 26: 14-17.
9. García Moreira C, Angeles F, et al. Trayectoria de la actividad masetérica durante un esfuerzo isométrico asistido por retroalimentación visual electromiográfica en pacientes jóvenes normales. Rev Mex Ing Biomed, 1994; 15 (2): 259-272.

10. Zanotta G, Fernández LI, Barrios J, Kreiner M. Odontoestomatología. 2013; 15 (22): 40-45.
11. Santana Mora U, Cudeiro J, MoraBermùdez MJ, Rilo Pousa B, Ferreira Pinho JC, Otero Cepada JL, Santana Penìn U. Changes in EMG activity during clenching in chronic pain patients with unilateral temporomandibular disorders. J Electromyography Kinesiology. 2009; 19 (6): 543-549.
12. Tecco S, Tetè S, D'Attilio M, Perilloet L, Festa Fal. Surface electromyographic patterns of masticatory, neck and trunk muscles in temporomandibular joint dysfunction patients undergoing anterior repositioning splint therapy. European Journal of orthodontics. 2008; 30 (6): 592-597.
13. Amorim, C; Vasconcelos, F et al. Electromyographic analysis of masseter and anterior temporalis muscle in sleep bruxers after occlusal splint wearing. Journal of Bodywork and Movement Therapies. 2012; 16 (2): 199-203.
14. Ferrario V, Sforza C, D'Addona A, Barbini E. Electromyographic activity of human masticatory muscles in normal Young people. Statistical evaluation of reference values for clinical applications. Journal of Oral rehabilitation. 1993; 20 (3): 271-280.
15. Tartaglia G, Lodetti G, Paiva G, De Felicio CM, Sforza C. Surface electromyographic assessment of patients with long lasting temporomandibular joint disorder pain. 2011; 21 (4): 659-664.
16. Peck CC, Murray GM, Gerniza TM, Tartaglia GM, Dellavia C. How does pain affect jaw muscle activity? The integrated pain adaptation model. Australian Dental Journal. 2008; 53 (3): 201-207.
17. Ferrario V, Sforza G, Tartaglia GM, Dellavia C. Immediate effect of a stabilization splint on masticatory muscle activity in temporomandibular disorder patients. Journal of Oral rehabilitation. 2002; 29 (9): 810-815.
18. Koutris M, Lobezoo F, Naeije M, Wang K, Svensson P, Arendt Nielsen L, Fariana D. Effects of intense chewing exercises on the masticatory sensory-motor system. Journal Dental Research. 2009; 88 (7): 658-662.
19. De Felicio C, Ferreira CL, Medeiros AP, Rodríguez Da Silva MA, Tartaglia GM, Sforza C. Electromyographic indices, orofacial myofunctional status and temporomandibular disorders severity. A correlation study. J Electromyographic Kinesiology. 2012; 22 (2): 266-272.
20. Santana Mora U, López Ratón M, Mora MJ, Cadarso Suárez C. Surface electromyography has a moderate discriminatory capacity for differentiating between healthy individuals and those with TMD: A diagnostic study. Journal of Electromyography and Kinesiology. 2014; 24 (3): 332-340.
21. Jensen R, Fuglsang Frederiksen A, Olesen J. Quantitative surface EMG of pericranial muscles: reproducibility and variability. Electroenceaphalogr Cli Neurophysiol 1993; 89 (1): 1-9.
22. Klasser GD, Okeson JP. The clinical usefulness of surface electromyography in the diagnosis and treatment of temporomandibular disorders. J Am Dent Assoc 2006; 137 (6): 763-771.

23. Al-Saleh MA, Armijo Olivo S, Flores Mir C, Thie NM. Electromyography in diagnosing temporomandibular disorders. J Am Dent Assoc. 2012; 143 (6): 351-362.
24. Politti F, Casellato C, Kalytczak MM; García MB, Biasotto Gonzalez DA. Characteristics of EMG frequency bands in temporomandibular disorders patients. J Electromyogr Kinesiol. 2016; 31: 119-125.
25. Choi KH, Kwon OS, Jerng UM, Lee SM, Kim LH, Jumg J. Development of electromyographic indicators for the diagnosis of temporomandibular disorders: a protocol for an assessor-blinded cross-sectional study. Integr Med Res. 2017; 6 (1): 97-104.
26. Ferreira CL, Machado BC, Borges CG, Rodríguez Da Silva MA, Sforza C, De Felicio CM. Impaired orofacial motor functions in chronic temporomandibular disorders. Journal of Electromyography and Kinesiology. 2014; 24 (4): 565-571.

Luis Ignacio Fernández: nachofernandez81@gmail.com