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Electromyographic study of activity of the masseter and anterior temporalis muscles in patients with temporomandibular joint (TMJ) dysfuction: Comparison with the clinical dysfunction index

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Abstract

Objectives: A comparison was made between the electromyographic patterns specific to patient with temporomandibular disorders and that of normal healthy patients. Study design: Electromyographic tests were carried out during rest and function of the masseter muscles and anterior temporalis muscles in a homogeneous group consisting of 95 patients for whom such pathology and its different degree of severity had been previously studied by means of a Helkimo Test. The electromyographic exploration results were compared to those of a control group consisting of 31 healthy subjects. Results: There were significant differences among patients with a different degree of clinical dysfunction, as well as between these and the control group. These differences were more important during maximum effort clenching and mastication. During maximum effort clenching, differences in masseteric activity were observed between control group and group III, between groups I and II and between groups I and III. Meanwhile, differences in temporalis activity were significant among all groups except between groups I and II. The multiple comparison analysis demonstrated the existence of significant statistical differences between healthy subjects and patients with severe TMD. However, the linear combination of these electromyographic (EMG) variables led us to elaborate four linear functions that classify all subjects into four well defined groups. Once extreme cases were eliminated, our EMG classification revealed an 80% match with that of the Helkimo Test. We thus conclude that in many cases, classification using electromyographic criteria matches that established by the Helkimo Test.

Key words: *Electromyography, temporalmandibular joint dysfunction, Helkimo test.*

Introduction

Temporomandibular disorders (TMD) are characterized by pain in masticatory muscles and temporomandibular joints, restricted mandibular movements and joint noises. As in other painful disorders, its diagnosis is fundamentally based on clinical history and exploration(1-3). Nowadays, a wide battery of tests are available to dentists to assist with the diagnosis of TMJ. Recently, electromyographic exploration has been added to this long tests list (4-6). The theory that the masticatory muscles, in dysfunctional patients, suffer from hypertonicity at rest and fatigue easily when effort is demanded is widely accepted (7-9). This has given special relevance to the monitoring of muscle activity at rest and during effort in the diagnosis of this pathology. Computer processing of the electrical signal has allowed these recordings to be susceptible to quantification and statistical analysis. However, despite many authors have already shown the reliability and validity of its use in odontology (10), some practitioners do consider that it is necessary to continue to study this diagnostic technique in depth (11). In this study, our main goal is to detect the possible existence of a specific electromyographic pattern in patients with temporomandibular joint dysfunction compared to subjects showing no signs nor symptoms of the TMJ dysfunction.

Material and Methods

We have used the most widely accepted electromyographic tests (6-8, 12) adapted to our material resources in a series of TMD patients previously diagnosed. To this end, a group of 95 patients as homogeneous as possible was selected, all of them women with ages ranging from 20 to 50 years, for whom the existence of the syndrome had been clinically noted. In this study, patients should be completely dentated admitting only the absence of one tooth in each dental arch. Patients with systemic neurological or muscular diseases were excluded to avoid pathological influence in EMG recordings.

Patients were classified following Helkimo test into 3 groups of approximately 30 subjects each, depending on their degree of clinical manifestation (2). Results obtained from their electromyographic recordings were compared to the results of a control group consisting of 31 normal healthy women presenting the same characteristics of the patients as per age, sex, and integrity of the dental arches. Furthermore, patients who may be potentially affected by any systemic condition that could seriously compromise nervous and muscular functions were not used.

In order to separate the control group from the group of TMD patients and to classify the latter according to the level of severity of their symptoms, the protocol for clinic exploration proposed by Helkimo was used with the 126 individuals integrating the sample for this study. A clinical dysfunction index was assigned to all patients allowing us to classify them into three degrees of affliction: Minor (Group I), Moderate (Group II) and Serious (Group III). The control group was formed by subjects lacking TMJ symptoms and were included as a result of the Helkimo Test within the dysfunction group 0. The group distribution was as follows:

31 subjects included in control group
33 in group I
29 in group II
33 in group III

For the electromyographic exploration of the muscles at rest position and at maximum effort, we used the electromyograph of eight channels K6-I Myotronics which allows us to calculate the average myoelectric activity in records of 15 seconds. For the mastication tests, we used an instrument Mystro Medelec of five channels and fitted with a cursor which allows us to mark any point of the record in the screen and measure the magnitude of the electromyographic peaks and the length of the masticatory cycles (Fig. 1 and 2). For the neurostim-

Fig. 1. Electromiograph mystro.

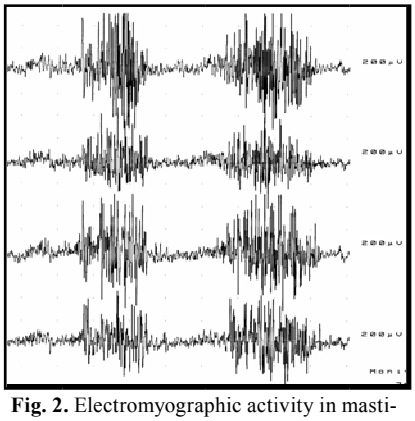

Fig. 2. Electromyographic activity in masticatory cycles.

ulation, a TENS of low frequency Myomonitor J4 was used. Surface silver/silver chloride electrodes of 10mm diameter were always used. Each patient underwent electromyographic tests at resting position and in function of the superficial masseter and anterior temporal muscles. The following protocol was used for register-taking in all cases.

Electrode placing

Silver chloridized-surface electrodes were applied onto the skin covering the muscles to be monitored. For their location, the protocol proposed by Macaluso and de Laat in 1995 was followed (13).

Preparation of the patients

The patient was asked to seat comfortably in a quiet and relaxing environment and was informed about the test so he could offer the maximum cooperation.

Test

The wires were connected. The appliance is equipped with a trial test which is necessary to verify the correct state of the electrodes and connections.

EMG rest recordings

The first recording is performed during 15 seconds. The electrical activity of the four muscles simultaneously appears reflected. This way, we obtain a reference value of the state of the muscles at rest which can be achieved by the patient by one´s own means by simply responding when being asked to relax (12,14). For this, we calibrated the screen reticle to a range of 30 μV/div and a speed of 1 sec/div.

Tens

We used the TENS according to a protocol proposed by Jankelson. To achieve the correct relaxation, a 45-60 minutes interval of neurostimulation is often needed. After this interval, we proceeded to carry out a new electromyographic recording at rest.

EMG rest recording after TENS

The objective of this recording is to obtain information about the state of muscular rest achieved by all the patients under the same relaxation conditions (15). The recording is made in the same way as for the basal rest and it allows obtaining the average range in μV on each one of the four monitored muscles (Four variables: RARM, RALM, RART, RALT).

EMG recording of maximum effort clenching

Under the same conditions, the patient is instructed to make a maximum contraction effort in maximum intercuspidation. In this case, we calibrated the screen reticle to 100 μV /div in amplitude and to 1 sec/div in speed. In order to obtain a reliable and significant result, the patient must start from a rest state and then maintain the contraction for 3 seconds. This way, it is possible to measure the average range in μV achieved by each of the monitored muscles (16).

Mastication

During the mastication test the patient must chew a piece of chewing gum for 10 minutes applying the mastication rate and effort allowed by his dysfunction (17). Tests are carried out by exclusively using the right side for chewing in first place and then the left side after a 15 minute break. In these recordings speed is calibrated at 500 msec/div and the range at 500 μV/div. This way, the peak range in μV and duration in milliseconds can be measured for each masticatory cycle and the muscle activity can be measured, defining the peak range as the maximum range registered during the same masticatory cycle (18). Moreover, the duration of the interval as the time interval between the beginning of myoelectric activity within a cycle until the beginning of the next cycle.

Variables

As a result of these four tests we obtained the next sixteen electromyographic variables. Four variables in the basal test: two for the masseter (RAMD, RAMI) and two for the temporalis (RATD, RATI).Four variables for the maximum effort clenching test: two for the masseter (MECRM, MECLM) and two for the temporalis (MECRT, MECLT). Four variables for the peak activity in masticatory cicles: two for the masseter (MPMD, MPMI) and two for the temporalis (MPTD, MPTI). Four variables for the duration of masticatory cicles: two for the masseter (MDMD, MDMI), and two for the temporalis (MDTD, MDTI).

Statistical analysis approach

The following statistical analyses were applied:

1) An analysis contrast of the variance to find out if there were significant differences between the dysfunctional groups

2) An analysis of multiple comparisons to find out which groups were different among them and which was the extent of the difference

3) A discriminant analysis that could allow us to classify the persons according to their response to the electromyographic tests and to compare this classification with the one previously established through the Helkimo Test.

Results

The statistical analyses applied to the records obtained in the electromyographic tests performed on the 126 subjects included in the sample showed the following significant results. The results obtained in the electromyographic exploration in average values in each test can be summed up as follows:

In the basal testing, the average activity of the muscles calculated separately for each group of patients fluctuated between the minimum values of 1,5 μV approximately in the masseter muscle in the dysfunction group 0, and the maximum values of nearly 3 μV showed by the temporalis muscle in the rest of dysfunctional groups.

In the basal tests after the TENS, there was a certain

trend to have an increase in the electromyographic values in the more advanced dysfunctional groups although it can be observed that the muscle relaxation caused lowering of all the average values of basal activity in all muscles. All dysfunctional cases showed a significant decrease in comparison with those obtained in the same test before applying the TENS.

In the test of maximum effort at closure, the average rates of activity were much greater. They fluctuated between 100 and 200 uV and the differences between the groups were stronger whereby observing a clear trend to the reduction of the electromyographic values in the greatest dysfunctional cases. These differences are also evident in the results obtained when we measured the peak activities in the cycles in the mastication tests. However, when we measured the duration of the mastication cycle, the groups were hardly differentiated and we could only observe a slight trend to the extension of this period in the high dysfunction degrees.

Significant results:

The ANOVA Test proved that there were significant differences between the averages of the groups in all the electromyographic tests for a significance level of 0, 05. Nevertheless, the analysis of multiple comparisons proved that such differences between all the dysfunction groups were not showed in any of the tests. In fact, both in the basal tests and in the rest tests made after TENS, the analysis of multiple comparisons proved that there were only differences between the normal healthy individuals (control group) and the greatest dysfunction degrees (group III). These differences faded even more at the rest tests after the TENS. In them, the dysfunctional individuals behaved homogeneously, almost standing out as one single group (groups I, II, III) against the healthy persons (control group).

In the test of maximum effort at closure, the number of groups which differ from each other was much greater than in the rest tests. Differences in masseteric activity resulted when comparing control group and group III, group I and II, and group I and III; meanwhile temporalis muscles differences were observed among all groups, except between group I and II.

Muscles studied in the mastication test were reduced to those ipsilateral to the preferred side of mastication, the

Table 1. Classification functions.

EMG	Classification functions			
Variables	0	I	II	III
RARM	1,5228	2,14147	2,81452	2,6142
RALM	-0,676818	-0,781423	0,561509	0,705788
RART	-0,228923	0,331318	-0,145907	-0,0425476
RALT	-0,900688	-0,276704	0,41549	0,62199
MECRM	0,00439154	0,00865649	-0,0167049	-0,0203135
MECLM	-0,0129391	-0,0226821	-0,0421131	-0,0441061
MECRT	-0,0158469	-0,00926719	0,00703442	0,00146185
MECLT	0,0880656	0,0620952	0,0609593	0,0565826
MPRM	0,0158039	0,014429	0,0159258	0,0114639
MPRT	0,0200447	0,0117007	0,01154	0,0149878
MPLM	0,00392579	0,00313494	0,00329233	0,00274128
MPLT	0,00370162	0,00509436	0,000212977	-0,0018975
MDRM	0,0139775	0,0140163	0,0244768	0,0225449
MDRT	0,0240791	0,0172201	0,00883754	0,00705439
MDLM	0,0180441	0,0161042	0,0108839	0,00731622
MDLT	-0,0176719	-0,0120261	-0,00276025	0,00439243
CONSTANT	-43,2262	-32,55	-35,42	-32,76

Table 2. Example of the application of the classification functions to the sixteen EMG variables of a new patient (R.M.A.). In this case the higher value was obtained in the second function and the patient was classified in the dysfunction group I.

EMG	Patient	Classification functions			
Variables	R.M.A.				
		0	I	II	III
RARM	1,4	1,5228	2,14147	2,81452	2,6142
RALM	1,0	-0,676818	-0,781423	0,561509	0,705788
RART	6,6	-0,228923	0,331318	-0,145907	-0,0425476
RALT	3,8	-0,900688	-0,276704	0,41549	0,62199
MECRM	239	0,00439154	0,00865649	-0,0167049	-0,0203135
MECLM	237	-0,0129391	-0,0226821	-0,0421131	-0,0441061
MECRT	240	-0,0158469	-0,00926719	0,00703442	0,00146185
MECLT	238	0,0880656	0,0620952	0,0609593	0,0565826
MPRM	820	0,0158039	0,014429	0,0159258	0,0114639
MPRT	640	0,0200447	0,0117007	0,01154	0,0149878
MPLM	900	0,00392579	0,00313494	0,00329233	0,00274128
MPLT	800	0,00370162	0,00509436	0,000212977	-0,0018975
MDRM	924	0,0139775	0,0140163	0,0244768	0,0225449
MDRT	914	0,0240791	0,0172201	0,00883754	0,00705439
MDLM	860	0,0180441	0,0161042	0,0108839	0,00731622
MDLT	822	-0,0176719	-0,0120261	-0,00276025	0,00439243
CONSTANT		-43,2262	-32,55	-35,42	-32,76
RESULT		36,632102	38,921102	33,284185	29,321105

reason being that these ones will present more signs of TMD. From 126 subjects, only 117 could perform this test completely.

Both in the case of masseter and temporalis muscles, the analysis of multiple comparisons proves the existence of significant differences in the peak activity between the group 0 and each of the other groups as well as between Helkimo groups I and III.

In the tests for measuring the duration of the mastication cycle, as it happens with the rest tests, the differences among the groups are not as pronounced as in those of maximum effort and mastication peaks, causing the result of a great overlap between pairs of groups.

Classification

Any of the variables obtained with the EMG tests can accurately differentiate on its own the four TMJ dysfunction groups. However, the lineal combination of 16 of them in a discriminating analysis allowed us to create four lineal functions which classify the 117 individuals who underwent all of the tests in four clearly differentiated groups.

In the first step, this classification matched 68.38% of the cases the classification carried out using the Helkimo Test. The accuracy obtained at this first step has significantly improved as it rejected 17 extreme patients who were mistakenly classified, due to EMG variability, inaccuracy in classifying TMD patients with Helkimo test, transcription errors…. This way, the coincidence between both classifications reached 80%. The significance of these results lies in the fact that each classification function obtained defines a dysfunctional group. The application of their coefficients to the 16 electromyographic variables of an eventual new case allows its classification with great approximation to the clinical assessment in the group showing a higher value as a consequence of the addition of their products (Table 1 and 2).

Discussion

Our results are difficult to compare with others, obtained in similar studies because of differences in the material and method used. Surface electromyography presents large variability, so standard protocols must be compulsory and samples have to be large. The studies from Ferrario in 1993 (6) respects these norms. Both of them stated the rest position in the same way, and similar results were obtained: electrical activity of masseters between 1,5 and 2 microvolts (μV), and temporalis 2 and 2,5 microvolts. As well, in our study we obtained mean value for masseter 1,73 and 2,64 for temporalis.

EMG values presents variability due to differences in: electrodes position, muscle anatomy, width of subcutaneous tissue between electrode and muscle, and facial morphology (5). These seldom variations, when huge efforts are demanded, do not have a significant influence. This is the reason why maximum effort, clenching and mastication were selected to establish differences between TMD patients groups. Differences in muscles affected with muscular alterations become more evident when maximum effort is demanded (16).

Remarkable differences were obtained between control group: 206 μV in masseter, 216 μV in temporalis muscle, against 96 μV in masseter and 103 μV in temporalis, in patients with severe TMD. Bakke et al. (5), Ferrario et al.(6), Rilo et al. obtained similar mean values:100-150 μV in TMD patients, and nearly 200 μV in healthy subjects (14).

Schumann et al.in 1998 (8) studied with similar EMG techniques 70 TMD patients and 20 healthy subjects. They measured two parameters: postural activity and mastication, they found 19,4% of classification error as result of a discriminant analysis. Our error is superior, nevertheless, Schumann only divided the individulas in two groups, with or without pathology. Our classification is more complex because our sample is divided in four groups.

Buchner et al. In 1992 (19) made an EMG exploration for the same group of muscles as the ones in this study, but the only variables studied with discriminant analysis were maximum effort clenching and the index of asymmetry of the pair studied.

In the 17 extreme eliminated cases, likewise in the other 20 cases which were wrongly classified, some of the above factors have undoubtedly occurred. However, except for some particular patients, for whom transcription errors or evident failures were detected during the Helkimo Test exploration, we cannot normally determine the cause for these classification errors. We just then proceeded to mark them and referred them to a subsequent and more exhaustive analysis that might be another reason for a new study which would allow us to find out the cause of this result discrepancy. This would give us more information which can help us, in first place, to improve our classification functions and secondly, to open a new investigation line aimed at better understanding of the limitations of electromyographic exploration (11,13) and to study in depth those TMJ dysfunction factors not provided by Helkimo's exploration which can have influence in the results of the electromyographic exploration.

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