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Surface Electromyography Findings in Unilateral Myofascial Pain Patients: Comparison of Painful vs Non Painful Sides

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Abstract

Objectives. To answer the clinical research question: in patients with myofascial pain, are there any differences in the surface electromyography (sEMG) activity of muscles of the painful and nonpainful sides that can be detected by commercially available devices?

Methods. The study sample (N = 39; 64%F, mean age 35.7 ± 15 years) consisted of patients seeking for temporomandibular disorders Temporomandibular Disorders (TMD) treatment and meeting Research Diagnostic Criteria for TMD (RDC/TMD) diagnosis of myofascial pain, with pain referred only in muscles on one side. They underwent sEMG of jaw muscles to record levels of standardized sEMG activity at rest, as well as during maximum clenching on teeth for the four investigated muscles, viz., bilateral masseter and temporalis. The existence of differences between sEMG values of muscles of the painful and nonpainful sides during the standardization test (i.e., clenching on cotton rolls) at rest and during clenching on teeth was assessed.

Results. At the study population level, differences between the sEMG values of muscles of the painful and nonpainful sides were not significant in any conditions, viz., either at rest or during clenching tasks. At the individual level, the difference between the sEMG activity of painful and nonpainful sides was very variable.

Conclusions. The above findings were not supportive of the existence of any detectable difference in sEMG activity between jaw muscles of the painful and nonpainful sides in patients with unilateral myofascial pain. Centrally mediated mechanism for pain adaptation may explain these findings, and the role of sEMG as a diagnostic tool for muscle pain needs to be carefully reconceptualized.

Key Words. Temporomandibular Disorders; Research Diagnostic Criteria for Temporomandibular Disorders; RDC/TMD; Surface Electromyography; Myofascial Pain

Introduction

The diagnosis of musculoskeletal disorders of the stomatognathic system, viz., temporomandibular disorders (TMD), is mainly based on a thorough clinical assessment, including the integration of the findings of imaging studies [1,2]. Notwithstanding that, several other instrumental approaches have been proposed over the years as valuable tools for either diagnosing or monitoring symptoms in TMD patients. Among the others, surface electromyography (sEMG) recordings have been claimed to be useful in the clinical setting [3,4] and, despite negative findings regarding their clinical usefulness suggested by several literature reviews performed in the past decades [5–7], their use persists in selected professional communities.

Several research groups are trying to get more deeply engaged in the analysis of muscle function in TMD patients. One potential explanation for the difficulties in translating research-based knowledge into clinical practice is that most investigations are performed with instruments designed for the research setting, which are perceived by the everyday practitioners as having less influence on their own practice than commercially available devices [8]. However, the risk for overdiagnosing disease by the use of those commercial devices, thus exposing patients to unnecessary treatments, has been repeatedly pointed out along with the need to better educate the clinical community on the evidence basis for their use [9–11]. In consideration of this potential problem, it was hypothesized that performing sEMG studies in TMD patients by the use of devices that are currently available for use in the clinical setting may be a suitable strategy to increase knowledge about this particular issue and to define more properly the indications, if any, for the use of commercially available devices in the TMD practice. Consequently, a series of studies demonstrated that sEMG with the so-called neuromuscular commercially available devices is not accurate to either diagnose [12,13] or monitor TMD pain symptoms [14].

Thus, a need for further studies for developing a rationale for using sEMG in the clinical setting has emerged. In particular, such study should gather as much data as possible on the sEMG features of muscle pain, which is the main reason for patients to seek TMD treatment. One possible strategy to start pursuing that objective is to measure the sEMG activity of painful muscles vs that of contralateral nonpainful muscles in patients with unilateral myofascial pain of jaw muscles. Based on this strategy, the present investigation was designed to answer the clinical research question: in patients with myofascial pain, are there any differences in the sEMG activity of muscles of the painful and nonpainful sides that can be detected by commercially available devices?

Materials and Methods

A Priori Sample Size Calculation

A priori calculation of the needed sample size to detect clinically significant differences between a painful muscle and a nonpainful muscle was based on data drawn from the literature and from previous investigations using the same devices [12], taking resting sEMG values as the main outcome parameter. A 50% difference with respect to 2.5 μV, which was suggested to be the cutoff for abnormal sEMG values by a community of expert sEMG practitioners [4], was set as the difference to detect. Expected variance was set at 3 μV, on the basis of an estimated standard deviation comprised between 1.5 μV and 2.5 μV. This meant that a sample size of about 30 subjects per group was enough to achieve an 80% statistical power (beta error set at 0.20) to detect a clinically significant difference with a 5% probability to have a false positive error (alpha error set at 0.05).

Study Sample and Design

A group of 39 consecutive patients (25 females; mean age 35.7 ± 15 years) seeking for TMD treatment at the TMD Clinic, Department of Maxillofacial Surgery, University of Padova, Italy, and meeting Research Diagnostic Criteria for TMD (RDC/TMD) axis I diagnosis of myofascial pain [15] with moderate-to-severe unilateral muscle pain lasting for at least 6 months underwent an sEMG assessment in accordance to the protocol described below. The presence of concurrent multiple diagnoses, along with myofascial pain, viz., TMD such as disc displacements or inflammatory-degenerative disorders, was allowed provided that joint pain was present only on the same side as muscle pain. All RDC/TMD assessments were made by one of two trained examiners (D.M; L.G.N.) already involved in other RDC/TMD multicenter studies [16]. All myofascial pain patients presented pain in both the masseter and temporalis muscles of the painful sides at the time of the EMG recording session, with an average VAS level of 5.3 (±2.1 SD) points on a 0–10 rating scale. Written consent to take part in the study protocol was obtained from all patients, and IRB approval was obtained from the local committee.

Surface Electromyography and Kinesiographic Recordings

All study participants underwent an electromyographic recording with a commercially available device (K7 Diagnostic System®, Myotronics Inc., Seattle, WA, USA). During all exams, the patient was sitting on a wooden high-backed chair, with the trunk perpendicular to the floor and the head upright. According to the manufacturer's protocol, the sEMG assessment was recorded by the use of bipolar surface electrodes (Duotrode®, Myotronics Inc.), bilaterally placed on the subject's skin overlying the body of masseter muscle and the anterior temporalis muscle. In according with literature suggestions, EMG recordings were standardized to reduce the potential influence of factors related with the patients' physical (e.g., sex, age, and body weight) characteristics [17,18]. Based on that, recordings of EMG activity during maximum voluntary clenching (MVC) on cotton rolls were adopted as the reference for standardization, viz., the mean EMG activity recorded (in μV) during the clenching on cotton rolls task was set at 100%. Then, after the EMG activity at rest was recorded, the patient was asked to clench the teeth maximally three times for 2 seconds, with 2-second relaxation between each clench. The values of EMG activity recorded at rest and during MVC on teeth were expressed as percentage of the activity recorded during the standardization test (μV/μV*100). All tasks were performed three times at 10-minute intervals, and the average value of the three attempts was recorded. All sEMG recordings were performed in accordance with the manufacturer's guidelines and were made by an investigator (F.C.) with expertise in the use of such device and with continued education training at in-house courses organized by the manufacturer. The examiner was blinded to the participants' status, viz., the side of the painful muscles.

For all participants, the following parameters were recorded for the four investigated muscles and considered as outcome variables for sides' comparison: MVC on cotton rolls (standardization test—unit of measure: μV); standardized sEMG values at rest and during MVC on teeth (unit of measure: μV/μV*100).

Statistical Analysis

The average values in sEMG activity were managed as continuous variables. The statistical approach was designed to answer both at the study population and at the individual patient level the clinical research questions "Are there any differences in the sEMG activity of muscles of the painful and nonpainful sides?" (primary question—population level) and "How many patients do have an higher resting sEMG activity or a reduced clenching sEMG activity in the painful side?" (secondary question—individual level). To this purpose, the following approaches were adopted:

1. As a strategy to answer the primary question at the study population level, the existence of differences between sEMG values of muscles of the painful and nonpainful sides during the three tasks (i.e., standardization test on cotton rolls, rest, and MVC on teeth) was assessed by the adoption of a *t*-test for independent samples, with the level for statistical significance set at $P < 0.05$;
2. As a strategy to answer the secondary question at the individual level, the difference in sEMG activity between muscles on the painful and nonpainful sides during the three tasks was assessed for each pair of muscles. The sign "+" was assigned if the sEMG activity was higher in the painful sides, while the sign "–" was assigned if it was higher in the nonpainful sides. Data of each single patient were presented.

All statistical procedures were performed with a dedicated software (Statistical Package for the Social Sciences, SPSS 19.0, SPSS Inc., Chicago, IL, USA).

Results

Standardization test on cotton rolls showed no differences between the sEMG activity recorded in the painful and nonpainful sides, with a mean activity of 78.8 ± 49.3 μV (range 10–257 μV) for the masseter and 75.4 ± 49.3 μV (range 15–252 μV) for the temporalis muscles of the painful side vs 86.5 ± 68.3 μV (16–311 μV) for the masseter and 71.1 ± 55.7 μV (15–255 μV) for the temporalis of the nonpainful side. Ranges of standardized sEMG data (in μV/μV*100) at rest in the masseter and the temporalis muscles were respectively within the 0.3–23.3 and 1.7–33.3 range in the painful side and within the 0.4–13.7 and 0.8–23.6 range in the nonpainful side. sEMG activity markedly increased during clenching tasks in both painful and nonpainful muscles for all the investigated muscles. Standardized sEMG activity during clenching on natural teeth in painful muscles was 9–253.8 in the masseter and 18.5–313.3 in the temporalis muscles, while in nonpainful side, it was 12.3–387.8 in the masseter and 11.1–300 in the temporalis muscles. Differences between the sEMG values of muscles of the painful and nonpainful sides were not significant in any condition, viz., either at rest or during clenching tasks (Table 1).

At the individual level, the difference between the sEMG activity of painful and nonpainful sides was very variable, with wide ranges in the standardization clenching task as well as at rest and during clenching on natural teeth. At rest, an increased sEMG activity in the painful side was shown by 22/39 (56.4%) of patients in the temporalis muscle and 19/39 (48.8%) in the masseter muscle. The percentage of patients with higher sEMG activity in the nonpainful side during clenching tasks was also very variable, with less than half patients showing higher sEMG activity in the nonpainful side (temporalis: 18/39, 46.1%; masseter: 15/39, 38.5%) during MVC on natural teeth (Table 2).

In summary, the above findings were not supportive of the existence of any detectable difference in sEMG activity between jaw muscles of the painful and nonpainful sides in patients with unilateral myofascial pain.

Discussion

For years, the field of temporomandibular disorders has seen plenty of poorly supported theories and beliefs that did not pass the filter of evidence. In particular, all diagnostic and therapeutic approaches based on the so-called vicious cycle, postulating that muscle pain is due to muscle hyperactivity and is then further aggravated by the increasing hyperactivity of painful muscles, were dismantled in favor of the pain adaptation model [19]. Such model is not an etiological one, but it described the adaptive changes occurring after the onset of pain, suggesting that an adaptation leading to

Table 1 Mean ± SD values of sEMG activity at rest and during clenching tasks

		Nonpainful	Painful	Sig.
Standardization test (MVC on cotton rolls) (in μV)	Temporalis	71.1 ± 55.7	75.4 ± 49.3	0.716
	Masseter	86.5 ± 68.3	78.8 ± 49.3	0.572
Standardized activity at rest (in μV/ μV*100)	Temporalis	7.4 ± 5.4	7.5 ± 7.1	0.897
	Masseter	4.3 ± 3.4	4.6 ± 4.6	0.712
Standardized activity during MVC on teeth (in μV/ μV*100)	Temporalis	123.1 ± 70.1	116.2 ± 69,2	0.665
	Masseter	99.3 ± 64.2	94.8 ± 47.6	0.728

Comparison of findings between painful and nonpainful sides (*t*-test).
MVC = maximum voluntary clenching; sEMG = surface electromyography.

Table 2 Difference (Δ) in sEMG activity between painful and nonpainful side during standardization test on cotton rolls, at rest and during maximum voluntary clenching (MVC) on teeth

Patien No.	Age, Sex	ΔT (Standardization Test—μV)	ΔM (Standardization Test—μV)	ΔT (Standardized Rest—μV/μV*100)	ΔM (Standardized Rest—μV/μV*100)	ΔT (Standardized MVC—μV/μV*100)	ΔM (Standardized MVC—μV/μV*100)
1	28, f	17	1	–2.7	5.1	–27.6	–32.6
2	18, f	1	18	0.3	0	73.7	22.1
3	46, f	–14	–1	2	–3.4	43.8	4.9
4	27, f	–27	–7	–1.2	–1.5	–13.8	1.9
5	30, f	29	–32	–1.1	–3.6	–10.6	7.5
6	26, f	–41	–8	–1.1	–1.4	–86.3	–5.5
7	36, m	118	24	1.2	1.5	2.1	1.9
8	33, f	–1	–12	2.8	1.1	26.3	24.3
9	23, m	10	1	1.1	1.3	3.9	19.1
10	41, m	29	–16	1.6	–0.2	16.1	5.2
11	24, f	–90	–170	–1.8	–1.9	–14.5	–11.4
12	33, f	–37	–37	0.1	–0.4	–69.9	0.6
13	26, f	65	–9	1.1	1.3	40.7	–10.9
14	24, f	–1	16	1	0.9	–2.2	31.1
15	32, f	–5	11	–1.7	–5.1	–3	133.9
16	45, m	–52	–12	–0.1	0.1	18	24.3
17	18, m	30	19	2.6	0.5	–18	–9.2
18	21, m	0	–55	0.7	–0.4	–9.1	–16.5
19	54, f	–9	11	–9.4	–3.3	–3.7	–6.6
20	43, f	22	–29	1.3	5.3	–134.5	–36.2
21	65, f	21	–4	2.6	0.4	–23.9	–46.3
22	18, f	–42	–41	–41.8	–1.4	29.6	–52.5
23	19, f	–5	40	15.1	2.8	47	–13
24	32, f	49	2	8.1	1.3	1.2	–8.3
25	54, f	23	–6	5.8	–2.3	–25.6	–25
26	61, m	7	11	5.1	–9.5	194.8	26.9
27	23, m	14	–54	–0.8	–1	14.8	18
28	25, f	1	–2	–5	–1.2	–2.8	–51.4
29	54, m	1	36	–33.9	0.5	15.4	35.7
30	45, m	7	–4	3.3	0.5	–28.6	–50.8
31	31, m	3	29	–0.9	4.8	5	12
32	70, f	–44	65	–16.2	4.3	10.7	50.6
33	23, f	11	–17	2.6	–0.9	45.3	4.5
34	18, f	89	–92	2.2	–1.1	66.4	–70.7
35	19, f	3	4	–4.2	–5.3	11.1	11.1
36	45, f	–17	–20	0.2	0.2	–2.4	4.4
37	53, m	–5	25	–0.3	–0.2	23.4	25.5
38	46, m	19	8	2	0.3	68.5	16.5
39	64, f	–3	35	–15.8	–0.2	–13.3	61.7

Findings of individual patients.
f = females; m = males; T = temporalis; M = masseter; sEMG = surface electromyography.

reduced muscle activity and range of motion, and not an increased activity, is the natural answer to pain to avoid further damage [20]. Thus, the use of the many devices that were put into commercial use to measure the activity of jaw muscles for diagnostic purposes and treatment planning needs to be reconceptualized [8,9]. With the aim to provide information that can be easily transmitted to clinicians, some recent investigations were performed with the use of commercially available devices. Such studies showed, for example, that patients with myofascial pain of jaw muscles have a similar sEMG activity at rest and a reduced sEMG activity during clenching tasks with respect to asymptomatic controls. Also, it was pointed out that the percentage of false positives, if calculated on the basis of the manufacturer's and accustomed users' claims [4], was unacceptable for all parameters [12]. These and other negative findings coming from the literature on similar instrumental devices (i.e., jaw kinesiograph and joint vibration analyzers) supported the limited usefulness of those approaches in the field of TMD diagnosis [21]. On the other hand, it must be recognized that efforts have been made by several research groups to provide a better insight into the repeatability and standardization of sEMG recordings in studying the various aspects of muscular function [17,18,22,23]. The above sEMG findings can also be viewed as an important confirmation of the pain adaptation model, achieved with easy-to-use and commercially available instruments. So, it will be interesting to more deeply examine the physiology and pathophysiology of painful jaw muscles identified by their sEMG activity, especially if one considers the very scarce literature.

The present investigation used standardization sEMG recordings according to protocols used in the research setting [17,18] and showed that when pain occurs only in muscles of one side of the face, the sEMG features of those painful muscles are similar to those of the other side. At the study population level, no significant differences were shown between muscles of the painful and nonpainful side as for sEMG activity at rest and during clenching tasks. At the individual level, a very high variability of findings was shown, with an almost even prevalence of a higher or lower sEMG activity in the painful side during the different recording conditions.

These findings are interesting because of their only partial agreement with the postulates of the pain adaptation model and are in line with recent suggestions that pain adaptations are variable at the individual level [24]. In general, they support the concept that pain is not associated with muscle hyperactivity per se, as well as the hypothesis that adaptation is centrally mediated [25]. The absence of difference in sEMG activity at rest between painful and nonpainful contralateral muscles within the same individual has been also reported in the research setting [26,27]. Results from the present investigation confirmed that commercially available devices may be able to replicate findings of research performed with instruments designed ad hoc for the research setting, and suggested that, even if sEMG measurement cannot be proposed as a stand-alone diagnostic procedure in TMD patients, clinically available devices can be used to help refine the indications and features of sEMG recordings.

As a recommendation for future research, it is suggested that clinical investigations are performed on the topic of electromyographic recordings of jaw muscles' activity. In particular, it appears that, decades after the proposal and subsequent dismantling of the vicious cycle theory, there is still a lack of knowledge about the etiology of jaw muscles pain and the identification of diagnostic markers, and that the pain adaptation model is not able to explain all findings at the individual level [24]. Keeping this in mind, regarding the argument of sEMG recordings, it seems logical to suggest that future studies should be mainly directed to define the sEMG features of jaw muscles during physiological functioning and normalize them according to all possible confounding factors (e.g., age, sex, facial morphology, and body mass index), in order to provide a set of physiological range of measures for comparison with patient populations. While it must be recognized that focused efforts to pursue such a goal have been undertaken in the research setting, findings from the present investigation also suggest that the use of commercially available devices may be an acceptable strategy to help enlarge study samples and reduce the costs of the research setting.

Conclusions

Within the limits of this investigation, which was designed to answer the clinical research question "In patients with myofascial pain, are there any differences in the sEMG activity of muscles of the painful and nonpainful sides that can be detected by commercially available devices?", it is suggested that there are no detectable differences in sEMG activity between jaw muscles of the painful and nonpainful sides within the same individual. Centrally mediated mechanism for pain etiology, maintenance, and adaptation may be involved to explain these findings, and the employ of sEMG recordings to study muscle pain needs to be reconceptualized.

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