Electromyographic Data From TMD Patients With Myofascial Pain and From Matched Control Subjects: Evidence for Statistical, Not Clinical, Significance

Alan G. Glaros, PhD
Professor
Department of Dental Public Health and Behavioral Science

Ernest G. Glass, DDS, MS, MSD
Associate Professor
Department of Oral Diagnostic Sciences

David Brockman, DDS, MS
Former Resident
Department of Orthodontics
Currently, Private Practice
Lincoln, Nebraska

University of Missouri-Kansas City
School of Dentistry
Kansas City, Missouri

Correspondence to:
Dr Alan G. Glaros
650 East 25th Street
Kansas City, Missouri 64108

This study tested the hypotheses that electromyographic (EMG) activity at rest would be significantly greater for temporomandibular disorder (TMD) patients with myofascial pain than for nonpain control subjects, and that a cutoff score based on EMG values could be established to accurately separate the two groups. Fifty-four TMD patients diagnosed with myofascial pain and 54 nonpain control subjects who were matched for age and gender were examined. Both groups participated in an EMG scanning procedure in which the left and right frontalis, temporalis, and masseter muscles were examined. Results showed that the TMD group had significantly higher EMG activity at rest for three of the six sites examined. The application of a cutoff value that produced the smallest classification error nonetheless resulted in misclassification of about one third of the TMD and nonpain individuals. These data provide little support for the use of resting EMG data obtained via a scanning procedure in accurately distinguishing facial pain patients from nonpain control subjects.
J OROFACIAL PAIN 1997;11:125–129.

key words: temporomandibular disorders, electromyography, diagnosis, myofascial, classification

Several reports have suggested that temporomandibular disorder (TMD) patients with myofascial pain are characterized by elevated facial electromyographic (EMG) activity at rest.[1] In one study, Kapel et al[2] compared 20 TMD patients with myofascial pain to 20 nonpain control subjects who were matched for age and gender. Electromyographic data were recorded from the left and right frontalis, temporalis, and masseter muscles. The results showed that the TMD patients had significantly elevated baseline values for four of the six sites examined.

Some researchers have argued that methodologic factors such as insufficiently long adaptation and baseline measurement periods[3] or unreliability of EMG readings because of body movement, electrode placement, and electronic equipment instability[4] may account for the reported differences in resting EMG values between TMD and non-TMD groups. Since resting EMG activity may also differ as a function of age and gender,[5,6] the failure to control for these two variables may contribute to inflated differences between TMD and nonpain groups. Alternatively, diagnostic heterogeneity in the TMD group may reduce the probability of finding EMG differences at baseline between TMD and non-TMD groups. This is

Portions of the data reported in this study were obtained as part of a master's thesis conducted by Dr David Brockman under the direction of Dr Alan G. Glaros.

because individuals assigned to the TMD group whose primary complaints involve disc displacement or degenerative joint problems may be less likely to show EMG differences at rest than TMD patients whose pain arises primarily from the muscles of mastication or other facial and upper body muscles (ie, individuals with a diagnosis of myofascial pain).

If differences in EMG activity between TMD and non-TMD groups are present, how useful are these data in making a diagnostic decision? To assess the utility of a diagnostic decision, research must first establish that a given diagnosis is characterized by a particular pattern of muscular activity (eg, hyperactivity) as compared with the muscular activity patterns of a nonpatient sample. Next, a cutoff score that appropriately separates the two groups should be established.[7] The accuracy of prediction based on the scores could then be used to assess their utility.

The present study compares EMG data derived from a scanning protocol from both TMD patient and nonpatient (nonpain) samples. The TMD patient sample was homogeneous with respect to diagnosis, and the age and gender of the nonpain control subjects were matched to those of the TMD patients. The hypotheses examined in this study were that EMG activity at rest would be significantly greater for TMD patients with myofascial pain than for the nonpain control subjects, and that a cutoff score which would accurately separate the two groups could be established.

Materials and Methods

Participants

Of the 108 individuals who participated in the study, half (n = 54) were TMD patients diagnosed with myofascial pain (with or without limited opening),[8] and half were nonpain control subjects, whose ages and genders matched those of the TMD patients. Criteria for diagnosis of myofascial pain included *(1)* self-report of facial pain, *(2)* tenderness to palpation in at least 3 of 10 muscle sites palpated bilaterally according to the directions provided by the research diagnostic criteria for temporomandibular disorders,[8] *(3)* no other painful condition of the head or neck as the primary diagnosis, and *(4)* no current use of muscle relaxants or intraoral appliance. Individuals receiving myofascial pain diagnoses were selected from patients seen at the University of Missouri–Kansas City Facial Pain Center, a tertiary care facility for individuals with TMD and other facial pains. Nonpain control subjects did not report facial pain; they were selected from among individuals being evaluated for orthodontic treatment. The mean age (and standard deviation [SD]) for the TMD and nonpain groups was 25.11 years (7.56) and 25.5 years (7.67), respectively. Both groups consisted of 44 women and 10 men.

Equipment

Silver–silver chloride surface post electrodes were used to collect EMG data. The electrodes were inserted into a hand-held electrode adaptor (EA-1, J & J Instruments, Poulsboro, WA). The adaptor was connected to an electromyographic module (M-501). The module filter was set for 20 to 1,000 Hz bandpass with notch filtering at 58 to 62 Hz. The bandpass setting was consistent with the recommendations of Fridlund and Cacioppo.[9] Output from the module was fed into an I-330 interface (J & J Instruments) that converted the analog signals to digital form. The operation of the I-330 interface was controlled by CRAM Scan (version 1.0) software application.

The sites examined were, in order, right frontalis, left frontalis, left temporalis, left masseter, right masseter, and right temporalis. For frontalis and masseter sites, the electrode placement recommendations of Fridlund and Cacioppo[9] were followed; for the temporalis sites, the recommendation of Kawazoe et al[10] was followed. Three placement templates were constructed, following these recommendations, for the frontalis, temporalis, and masseter sites. The templates were used to mark recording sites on the skin surface before data collection.

Procedure

Each subject was seated in a comfortable chair, and the muscle sites were cleansed with alcohol and abrasive pads. The areas to be tested were marked with a nonpermanent pen to ensure comparability across subjects and to increase reliability of electrode placement. The subjects were asked to maintain a relaxed mouth by keeping the lips together with the teeth apart. Subjects were instructed in the attainment of a natural head position.[11] They were asked to maintain this position while viewing their images in a mirror mounted at eye level, 4 feet away.

The hand-held electrodes were placed on the test sites one at a time. While the electrodes were held in place, the computer monitor was examined.

Table 1 Means and Standard Deviations of EMG Data for TMD and Nonpain Subjects

	TMD		Non pain		
Site	Mean	SD	Mean	SD	$t^{\dagger}$
Left frontalis	7.86	7.17	7.52	4.08	0.30
Right frontalis	9.59	8.36	6.94	3.68	2.13*
Left temporalis	5.71	6.08	3.72	1.80	2.31*
Right temporalis	4.54	4.18	3.56	1.80	1.58
Left masseter	3.31	2.35	2.26	0.72	3.14**
Right masseter	2.90	3.20	2.23	0.87	1.48

†For right frontalis, $df = 52$; for all others, $df = 53$.
*$P < .05$.
**$P < .01$.

When the monitor showed a stable and artifact-free EMG reading,[12] subjects were asked to press a button to initiate data collection. A series of six facial muscle sites was examined in sequence. When the first set was completed, a second set was initiated. The mean of the two readings was used in calculating group differences.

Results

Mean EMG values for the six sites for both the TMD and nonpain groups are presented in Table 1. Differences between groups were examined by *t* tests. The TMD patients showed greater EMG activity than did nonpain individuals on all sites tested, but the differences between the two groups were statistically significant for only three sites.

Cutoffs derived from EMG values that were +1.00 SD, +1.64 SD, and +2.00 SD above the means of the nonpain sample (implying cutoffs at the 84th, 95th, and 97.7th percentiles, respectively) were determined (Table 2). These cutoffs were applied to the data obtained from the TMD and nonpain samples for the three sites that showed statistically significant differences between the two groups. If *all* of the EMG values for an individual were lower than the respective cutoffs for the three sites, the individual was classified as *nonpain*; if the value for *any* site was higher than the respective cutoff, the individual was classified as *TMD*. For each subject, the classification derived from EMG data was compared to the original group assignment. The proportion of individuals correctly placed into TMD and nonpain groups is presented in Table 3. The percent correct classification for TMD patients ranged from 68.5% to 33.3% as the cutoff percentile increased from the 84th to the 97.7th percentile; for the nonpain group, percent correct classification ranged from 66.8% to 85.2% as the cutoff percentile increased.

Table 2 Cutoff Values Derived from EMG Data Obtained From Nonpain Group

Site	+1.00 SD (84th percentile)	+1.64 SD (95th percentile)	+2.00 SD (97.7th percentile)
Right frontalis	10.62	12.98	14.30
Left temporalis	5.52	6.37	7.32
Left masseter	2.98	3.44	3.70

Table 3 Percent Correct Classification of TMD and Nonpain Individuals as a Function of Cutoff Value

Cutoff percentile*	TMD	Nonpain
84th	68.5	66.8
95th	37.0	83.3
97.7th	33.3	85.2

*Cutoffs based on means and standard deviations obtained from nonpain group.

Discussion

The presence of statistically significant differences in EMG activity between the facial pain group and the matched control group is consistent with other studies.[13] For all six sites, values for the TMD group were higher than the corresponding values for the nonpain group. In only three sites, however, were the differences of sufficient magnitude to be statistically significant.

An examination of Table 1 shows that the variability of the TMD group was greater than that of the nonpain group. Several factors might account

for this greater variability. Some TMD subjects, who may unknowingly engage in parafunctional clenching,[14] could have performed this behavior at a low level during the testing sequence, despite instructions to keep their teeth apart during testing. Rugh and Drago[15] have shown that masseter activity is least when vertical jaw opening ranges between 4.5 and 12.6 mm; when the vertical opening is zero, masseter activity increases markedly. Alternatively, muscular hyperactivity may not be distributed evenly across all muscle sites tested. For example, one individual diagnosed with TMD may have elevated EMG activity in two sites, while another individual diagnosed with TMD may have elevated EMG activity in sites completely different from those of the first. Across both groups, variability was highest for the frontalis muscle, decreasing for the temporalis muscle, and decreasing again for the masseter muscle. These findings are comparable to data reported by Burdette and Gale[16] who found lower test-retest reliabilities for the temporalis than for the masseter.

The data presented in Table 3 suggest that a cutoff at the 84th percentile is the most accurate in separating TMD and nonpain groups. Not surprisingly, increasing the cutoff value improves accuracy of placement for the nonpain group while simultaneously decreasing accuracy of placement of TMD patients. However, the cutoff value that produced the smallest error misclassified about one third of the TMD and nonpain individuals alike. These data provide little support for the use of resting EMG data in accurately separating facial pain patients from nonpain control subjects, at least using the scanning procedure described here.

Because muscle palpation can be used with at least fair reliability to diagnose the myofascial pain of TMD,[17,18] and because the palpation technique can be quickly performed without instrumentation, there appear to be a priori reasons against the use of EMG scanning to diagnose TMD. However, EMG data may be valuable in enhancing the diagnostic process in TMD[7] or as a monitor of treatment progress. For example, resting EMG data could be collected at the start of treatment and used to track the effect of splint therapy or cognitive-behavioral treatments on at least this aspect of jaw muscle behavior.[19] The mechanisms that underlie various treatments for TMD are not well known,[20] and EMG data may also provide information to improve understanding of the effects of treatment.

Acknowledgments

The authors thank Patty Lavalle for her assistance.

Portions of this work were supported by a grant from the National Institute of Dental Research (DE11017) to Dr Alan G. Glaros.

References

1. Rao SM, Glaros AG. Electromyographic correlates of experimentally induced stress in diurnal bruxists and normals. J Dent Res 1979;58:1872–1878.
2. Kapel L, Glaros AG, McGlynn FD. Psychophysiological responses to stress in patients with myofascial pain-dysfunction syndrome. J Behav Med 1989;12:397–406.
3. Flor H, Birbaumer N, Schulte W, Roos R. Stress-related electromyographic responses in patients with chronic temporomandibular pain. Pain 1991;46:145–152.
4. Biedermann H-J. Comments on the reliability of muscle activity comparisons in EMG biofeedback research with back pain patients. Biofeedback Self Regul 1984;9: 451–458.
5. Carlson KE, Alston W, Feldman DJ. Electromyographic study of aging in skeletal muscles. Am J Phys Med 1964; 43:141–145.
6. Visser SL, de Rijke W. Influence of sex and age on EMG contraction pattern. Eur Neurol 1974;12:229–235.
7. Glaros AG, McGlynn FD, Kapel L. Sensitivity, specificity, and the predictive value of facial electromyographic data in diagnosing myofascial pain-dysfunction. J Craniomand Pract 1989;7:189–193.
8. Dworkin SF, LeResche L (eds). Research Diagnostic Criteria for Temporomandibular Disorders: Review, Criteria, Examinations and Specification, Critique. J Craniomand Disord Facial Oral Pain 1992;6:301–355.
9. Fridlund AJ, Cacioppo JT. Guidelines for human electromyographic research. Psychophysiology 1986;23:567–589.
10. Kawazoe Y, Kotani H, Hamada T. Relation between integrated electromyograph activity and biting force during voluntary isometric contraction in human masticatory muscles. J Dent Res 1979;58:1440–1447.
11. Moorrees CFA. Natural head position. In: Jacobson A, Caufield PW (eds). Introduction to Radiographic Cephalometry. Philadelphia: Lea & Febiger, 1985:84–89.
12. Thompson JM, Erickson RP, Offord KP. EMG muscle scanning: Stability of hand-held surface electrodes. Biofeedback Self Regul 1989;14:55–62.
13. Rugh JD, Montgomery GT. Physiological reactions of patients with TM disorders vs symptom-free controls on a physical stress task. J Craniomand Disord Facial Oral Pain 1987;1:243–250.
14. Glaros AG. Awareness of physiological responding under stress and non-stress conditions in temporomandibular disorders. Biofeedback Self Regul 1996;12:261–272.
15. Rugh JD, Drago CJ. Vertical dimension: A study of clinical rest position and jaw muscle activity. J Prosthet Dent 1981;45:670–675.
16. Burdette BH, Gale EN. Reliability of surface electromyography of the masseteric and anterior temporal areas. Arch Oral Biol 1990;35:747–751.

17. Duinkerke ASH, Luteijn F, Bouman TK, de Jong HP. Reproducibility of a palpation test for the stomatognathic system. Community Dent Oral Epidemiol 1986; 14:80–85.
18. De Wijer A, Lobbezoo-Scholte AM, Steenks MH, Bosman F. Reliability of clinical findings in temporomandibular disorders. J Orofacial Pain 1995;19:181–191.
19. Turk DC, Zaki HS, Rudy TE. Effects of intraoral appliance and biofeedback/stress management alone and in combination in treating pain and depression in patients with temporomandibular disorders. J Prosthet Dent 1993;70:158–164.
20. Glaros AG, Glass EG. Temporomandibular disorders. In: Gatchel RJ, Blanchard EB (eds). Psychophysiological Disorders: Research and Clinical Applications. Washington, DC: American Psychological Association, 1993:299–356.

Resumen

Datos Obtenidos de AEMG de Pacientes con Desorden Temporomandibular con Dolor Miofacial Junto con Correspondientes Pacientes Control: Evidencia Para Clínica, no Para Estadística Significancia

La hipótesis del presente estudio fué que la actividad electromiográfica (AEMG) en posición de descanso tiene un valor significantemente más alto en los pacientes con desorden temporomandibular (DTM) que presentan dolor miofacial que en un grupo control (sin dolor). Además, que un número que sirva de "valor marca" basado en los resultados de estudios de AEMG pudiera establecerse para que adecuadamente separara dichos grupos. Cincuenta y cuatro pacientes presentando DTM a los qué se les diagnosticó dolor miofacial y cincuenta y cuatro pacientes sin dolor correspondiendo en edad y sexo al grupo anterior; sirviendo como control fueron examinados. Ambos grupos participaron en una lectura de AEMG, en la cual, los músculos frontal, temporal y masetero de los dos lados fueron objeto de examen. Los resultados demonstraron, que el grupo con DTM presentó más AEMG en posición de descanso de manera significánte en tres de los seis lugares examinados. El nombrar un número como "valor marca," que pudiera tener una posibilidad de error lo más baja posible, para usarlo como corte en la clasificación, resultó con un margen de error de alrededor de una tercera parte. Tanto de los individuos del grupo de DTM así como del grupo control por igual. Estos resultados proveen poco apoyo para el uso de los datos de AEMG en posición de descanso, obtenidos por medio de este tipo de lectura; para apropiadamente distinguir pacientes con dolor facial de pacientes sin dolor facial como los del grupo control.

Zusammenfassung

Die EMG Daten wurden von Patienten mit Temporomandibular Störungen und Myo-Fazial Schmerzen gesammelt und mit schmerzenlosen Patienten verglichen: Dieser Bewis ist nur für Statistiks, nict für klinische Bedeutung

Dieses Studium prüfte die Annahme das die EMG Aktivität in Patienten mit Myo-Fazialen Schmerzen im Ruhezustand oedeutend grösser währen wie in Patienten mit schmerzenloser Kontrolle. Das Endresultant wurde auf Basis der EMG bestimmt, welche die beiden Gruppen separieren konnte. Vierunfünfzig TMD Patienten welche mit Myo-Fazialen Schmerzen diagnost wurden und Vierunfünfzig ohne Schmerzen im selben Alter und Geschlect wurden ebenfalls untersucht. Beide Gruppen beteiligten sich in der EMG Skänner Behandlung wo die rechte und linke Frontalies, Temporalis und Masseter Muskeln geprüft wurden. Das Resultat zeigte die TMD Gruppe mit bedeutend höherer EMG Aktivität im Ruhestand in drei aus den sechs Seiten geprüft. Die Anwendung eines Abschnittwertes der den kleinsten Klassifikationsfehler produzierte, endete in Miskalkulation von einem drittel der TMD und ohne Schmerzen Einzelpersonen. Diese daten versehen wenige Unterstüzung für die ruhenden EMG Datan durch Skänner Behandlung mit deutlichen Gesichtsschmerzen ohne Schmerzenkontrolle.