Is Quantitative Electromyography Reliable?

Francesco Cecere, DDS
Temporomandibular Joint Associate
Department of Orthodontics
University Federico II
Napoli, Italy
Guest Researcher
Department of Orthodontics

Sabine Ruf, DDS, Dr Med Dent
Assistant Professor
Department of Orthodontics

Hans Pancherz, DDS, Odont Dr
Professor and Head
Department of Orthodontics

Clinic of Dentistry
Justus-Liebig University
Giessen, Germany

Correspondence to:
Dr Sabine Ruf
Clinic of Dentistry
Justus-Liebig University
Schlangenzahl 14
D-35392 Giessen
Germany

The reliability of quantitative electromyography (EMG) of the masticatory muscles was investigated in 14 subjects without any signs or symptoms of temporomandibular disorders. Integrated EMG activity from the anterior temporalis and masseter muscles was recorded bilaterally by means of bipolar surface electrodes during chewing and biting activities. In the first experiment, the influence of electrode relocation was investigated. No influence of electrode relocation on the recorded EMG signal could be detected. In a second experiment, three sessions of EMG recordings during five different chewing and biting activities were performed in the morning (I); 1 hour later without intermediate removal of the electrodes (II); and in the afternoon, using new electrodes (III). The method errors for different time intervals (I-II and I-III errors) for each muscle and each function were calculated. Depending on the time interval between the EMG recordings, the muscles considered, and the function performed, the individual errors ranged from 5% to 63%. The method error increased significantly (P < .05 to P < .01) with the time interval between recordings. The error for the masseter (mean 27.2%) was higher than for the temporalis (mean 20.0%). The largest function error was found during maximal biting in intercuspal position (mean 23.1%). Based on the findings, quantitative electromyography of the masticatory muscles seems to have a limited value in diagnostics and in the evaluation of individual treatment results.
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In the last 20 years, quantitative electromyography (EMG) of the masticatory muscles has been widely used in the diagnosis of temporomandibular disorders (TMD) to assess muscle function and dysfunction during rest, biting, and mastication.[1–6] Furthermore, quantitative EMG recordings from the mandibular muscles have been employed to measure the effectiveness of different approaches in the treatment of TMD.[7–13]

However, most of the investigations have given little attention to the method error of the EMG recordings. There are a few studies dealing with the reliability of EMG, but the results from these are sparse and contradictory.[14–19] Since a significant method error could have a powerful effect on the outcome and interpretation of a clinical EMG recording, it is important to determine the exact dimensions of such errors.

Therefore, the purpose of the present study was to evaluate the reproducibility of quantitative EMG recordings from the masticatory muscles. These recordings were made during five assigned functional tasks. The investigation was carried out on asymptomatic adult subjects to eliminate the influence of temporomandibular pain and dysfunction on muscle contraction patterns. Particular regard was given to the time factor between recordings and to the relocation of electrodes. The study was limited to the anterior temporalis and the superficial masseter muscles because these are the muscles most frequently used in EMG investigations.

Materials and Methods

Subjects

The sample consisted of 14 staff members (seven women and seven men) of the Orthodontic Department, University of Giessen, Giessen, Germany. The mean age of the subjects was 24.9 years, ranging from 18 to 40 years. None of the subjects exhibited any signs or symptoms of dysfunction from the masticatory system as assessed by means of the *Manual Functional Analysis*.[20,21]

Instrumentation

Direct and integrated EMG recordings from the masseter and the anterior temporalis muscles were obtained bilaterally with the aid of a Mingograph T 16 (Siemens-Elema, Solna, Sweden) connected to an amplifier Type 15 C 01 (Dantec, Skovlunde, Denmark) with a band pass of 20 Hz to 10 kHz. The integration of the EMG signals was obtained by means of an analog integrator Type 31 C 17 (Dantec), which integrated the full-wave rectified EMG potentials. The EMG activity was evaluated by measuring the maximum height (mm) of the integrated signal from the baseline, and the absolute value of the integral was calculated by multiplying the height of the signal by a calibration factor (200 µV or 500 µV). Paper speed was 50 mm/second.

The EMG recordings were performed using bipolar surface electrodes (Tüshaus Tüs 40, Velen, Germany). The skin was cleansed with 70% alcohol to reduce its impedance, and the electrodes were placed according to a standardized scheme (Fig 1). All recordings were carried out by the same operator.

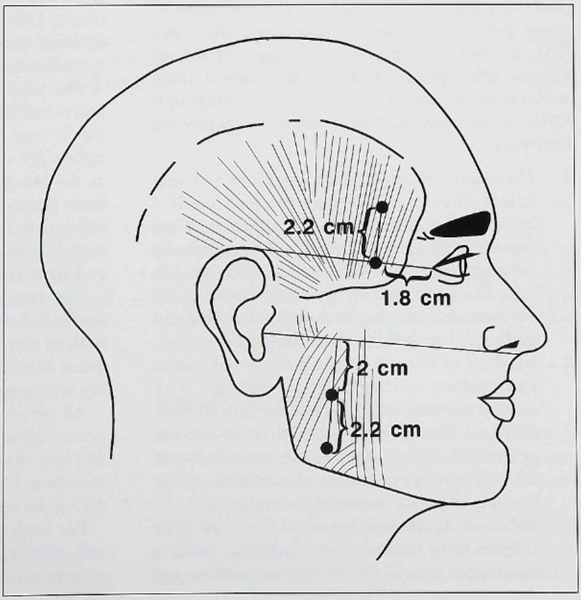

Fig 1 Electrode placement on the anterior temporalis and masseter muscles.

Experimental Design

Two different experiments were performed. In the first experiment, the effect that repositioning the electrodes might have on EMG activity was analyzed. In the second experiment, the influence that repeated recordings might have on EMG activity was examined.

Electrode Relocation. Five men were randomly selected from the entire sample of 14 subjects. The maximal integrated EMG activity was recorded bilaterally from the masseter and the anterior temporalis muscles during maximal biting in intercuspal position. The subjects sat relaxed and upright in a straight-backed chair without head support during the recording sessions. For each muscle, the mean value of five consecutive biting cycles was used for evaluation. At the end of the recording session, the electrodes on the left side were kept in place, while the electrodes on the right side were removed. On a subsequent session, 1 hour later, EMG recordings during maximal biting in intercuspal position were performed using the same left electrodes and new right ones located in the same place as for the first recording (see Fig 1).

Repeated Recordings. For each of the 14 subjects, three sessions of EMG recordings were performed on the same day. The first recording session was done in the morning (I); the second, 1 hour later, without intermediate removal of the electrodes (II); and the third, in the afternoon (7 hours after the first session) using new electrodes (III). In each recording session, the subjects sat relaxed and upright in a straight-backed chair without head support. The maximal integrated EMG activity was recorded during the following functions:

1. *Unilateral Chewing of Chewing Gum.* A sugarless chewing gum was chewed until a homogenous consistency was attained. Then the subjects were requested to chew only on the right side, and afterward, only on the left side. For each muscle, the mean value of 10 consecutive cycles for both unilateral right and unilateral left chewing was used for evaluation.
2. *Chewing of Peanuts.* The subjects were given five peanuts to chew. To not interfere with normal chewing function, no instructions were given to the subjects other than to eat the peanuts. For each muscle, the mean value of 10 consecutive cycles in the middle of the chewing sequence was used for evaluation.
3. *Maximal Biting in Intercuspal Position.* The subjects were requested to clench their teeth in intercuspal position as forcibly as possible and then to relax. For each muscle, the mean value of five consecutive biting cycles was used for evaluation.
4. *Maximal Biting on Cotton Rolls.* To eliminate dental influences on muscle activity, a cotton roll was placed between the maxillary and the mandibular dental arches on the left and the right sides. The subjects were asked to bite on the rolls as strongly as possible and then to relax. For each muscle, the mean value of five consecutive biting cycles was used for evaluation.

Data Analysis and Statistics

Electrode Relocation. The mean difference in EMG activity (= error) between the two recording sessions during maximal biting in intercuspal position was evaluated for each muscle. Then, the left side error (same electrodes for both sessions) was calculated as the mean of the left temporalis and left masseter error. The right side error (different electrodes between sessions) was calculated as the mean of the right temporalis and right masseter error. Left side and the right side errors were compared.

Repeated Recordings. The mean difference in EMG activity (= error) among the repeated recordings was evaluated for each muscle and each function in all the subjects. The I-II error and the I-III error were calculated as the mean individual variation in EMG activity for all functions between the first and second (I-II) and the first and third (I-III) recording sessions, respectively.

The muscle error (Fig 2) expressed the mean individual variation in EMG activity for each muscle. It was calculated separately for the left and right sides of the temporalis and masseter muscles as the mean of five different functions among the three recording sessions. In addition, the temporalis error (mean of the left and right temporalis errors) and the masseter error (mean of the left and right masseter errors) were assessed.

The function error (see Fig 2) expressed the mean individual variation in EMG activity for each of the five functions. It was calculated as the mean of all four muscles among the three recording sessions.

All errors were expressed in microvolts and in percentages. Each percent error was obtained by dividing the specific microvolt error by the corresponding EMG activity recorded and then multiplying the result by 100.

For each microvolt measurement, group means and standard deviations were calculated; for the percent errors, only group means were considered.

Functions		LEFT TEMPORALIS	LEFT MASSETER	RIGHT TEMPORALIS	RIGHT MASSETER
UNILATERAL	I	A1	X1	Y1	Z1
CHEWING	II	A2	X2	Y2	Z2
RIGHT SIDE	III	A3	X3	Y3	Z3
UNILATERAL	I	B1			
CHEWING	II	B2			
LEFT SIDE	III	B3			
CHEWING	I	C1			
OF FIVE	II	C2			
PEANUTS	III	C3			
MAXIMAL	I	D1			
BITING	II	D2			
ICP	III	D3			
MAXIMAL	I	E1			
BITING	II	E2			
ON ROLLS	III	E3			

FUNCTION ERROR (UNILATERAL CHEWING ON THE RIGHT SIDE) $= \frac{F1+F2+F3+F4}{4}$

$$\frac{|A3-A1|+|A3-A2|+|A2-A1|}{3} = F1$$

$$\frac{|X3-X1|+|X3-X2|+|X2-X1|}{3} = F2$$

$$\frac{|Y3-Y1|+|Y3-Y2|+|Y2-Y1|}{3} = F3$$

$$\frac{|Z3-Z1|+|Z3-Z2|+|Z2-Z1|}{3} = F4$$

MUSCLE ERROR (LEFT TEMPORALIS) $= \frac{M1+M2+M3+M4+M5}{5}$

$$\frac{|A3-A1|+|A3-A2|+|A2-A1|}{3} = M1$$

$$\frac{|B3-B1|+|B3-B2|+|B2-B1|}{3} = M2$$

$$\frac{|C3-C1|+|C3-C2|+|C2-C1|}{3} = M3$$

$$\frac{|D3-D1|+|D3-D2|+|D2-D1|}{3} = M4$$

$$\frac{|E3-E1|+|E3-E2|+|E2-E1|}{3} = M5$$

Fig 2 Method for calculation of the function errors and the muscle errors for each subject. The function error during unilateral chewing on the right side and the muscle error for the left temporalis are used as models. The values from A1 to E3 and from X1 to Z3 represent the corresponding EMG activity recorded. I = first recording session; II = second recording session; III = third recording session.

Student's paired *t* tests were performed to evaluate the differences between left side error and right side error, the I-II and the I-III errors, the muscle errors, and the function errors. Wilcoxon's signed rank tests were used to evaluate the differences between the corresponding percent errors. The levels of significance used were $P < .01$ and $P < .05$; $P \geq .05$ was designated as not significant (NS).

Results

Electrode Relocation

The left side errors (same electrodes between sessions) and the right side errors (different electrodes between sessions) are shown in Table 1. Considering the whole sample, the left side error was 48.0 µV (23.8%) and the right side error was 78.0 µV (23.4%). No statistically significant differences were found between the left side and the right side errors, either in microvolts or in percentage.

Repeated Recordings

Influence With Respect to the Time Interval Between the Recordings. The I-II errors are shown in Table 2. Considering the whole sample, the I-II errors ranged from 20.2 µV (chewing of peanuts) to 42.7 µV (maximal biting in intercuspal position), with a mean of 30.4 µV for all the functions. The corresponding percent errors ranged from 15.1% (maximal biting in intercuspal position) to 22.0% (unilateral chewing on the right side), with a mean of 17.6% for all the functions.

The I-III errors are shown in Table 3. Considering the whole sample, the I-III errors ranged from 27.3 μV (unilateral chewing on the left side) to 82.7 μV (maximal biting in intercuspal position), with a mean of 49.6 μV for all the functions. The corresponding percent errors ranged from 21.7% (chewing of peanuts) to 28.8% (maximal biting in intercuspal position), with a mean of 25.6% for all the functions.

The I-II and the I-III errors for the whole sample are compared in Table 4. Each I-III error was significantly larger than the corresponding I-II error during all the functions recorded ($P < .05$ or $P < .01$).

Influence With Respect to the Different Muscles Analyzed. The muscle errors are shown in Table 5. Considering the whole sample, the muscle errors ranged from 32.3 μV (left temporalis) to 52.7 μV (right masseter), with a mean of 42.9 μV for all the muscles. The corresponding percent errors ranged from 19.2% (left temporalis) to 28.0% (right masseter), with a mean of 23.5% for all the muscles. No statistically significant difference was found between the left and right side of either the temporalis or the masseter muscles.

The temporalis errors and the masseter errors are shown in Table 5. Considering the whole sample, the masseter error was significantly larger than the temporalis error, both in microvolts (51.9 μV and 34.2 μV, respectively; $P < .05$) and in percentage of activity (27.2% and 20.0%, respectively; $P < .01$). The mean error for all muscles (mean of temporalis and masseter error) amounted to 42.9 μV or 23.5%.

Influence With Respect to the Different Functions Performed. The function errors are shown in Table 6. Considering the whole sample,

Table 1 Left Side Errors (Same Electrodes Between Sessions) and Right Side Errors (Different Electrodes Between Sessions) During Maximal Biting in Intercuspal Position in Five Subjects*

	Left side		Right side	
Subject	μV	%	μV	%
1	45	21	45	22
2	60	25	95	27
3	50	20	150	24
4	35	28	20	14
5	50	25	80	30
Mean	48.0	23.8	78.0	23.4
SD	9.1	—	49.8	—

*Errors were calculated as the mean of the left temporalis and left masseter errors and the mean of the right temporalis and right masseter errors, respectively.

Table 2 Errors I-II (Mean Difference Between Recording Sessions I and II) During Chewing and Biting Activities in 14 Subjects*

	Chewing						Maximal biting			
	Right		Left		Peanuts		ICP		Rolls	
Subject	μV	%	μV	%	μV	%	μV	%	μV	%
1	7	6	34	21	36	21	20	5	40	11
2	8	6	14	15	13	14	46	18	27	14
3	18	6	53	20	33	22	35	8	60	15
4	20	18	14	13	16	22	25	19	43	32
5	37	23	33	22	18	21	16	7	24	9
6	18	24	14	20	26	18	58	20	68	23
7	11	28	6	11	9	14	9	7	7	8
8	57	38	45	33	19	10	55	12	40	9
9	8	12	15	22	5	5	20	5	85	25
10	6	5	15	16	13	8	28	13	35	8
11	35	18	30	17	29	12	88	23	40	12
12	31	37	8	10	36	24	60	20	40	15
13	28	38	5	8	6	9	118	44	78	28
14	51	49	33	51	24	21	20	11	8	5
Mean	23.9	22.0	22.7	19.9	20.2	15.7	42.7	15.1	42.5	15.2
SD	16.5	–	15.1	–	10.6	–	30.9	–	23.4	–

*Right = unilateral chewing on the right side; Left = unilateral chewing on the left side; Peanuts = chewing of peanuts; ICP = maximal biting in intercuspal position; Rolls = maximal biting on cotton rolls.

the function errors ranged from 27.8 μV (chewing of peanuts) to 66.7 μV (maximal biting in intercuspal position), with a mean of 43.0 μV for all the functions. The corresponding percent errors ranged from 21.5% (chewing of peanuts) to 24.8% (unilateral chewing on the right side), with a mean of 23.1% for all the functions.

Discussion

The current controversies about the value of EMG in diagnosis and treatment of TMD include several issues: reliability of the recording method; interpretation of the recordings; and relevance of the recorded phenomenon to the TMD. Of all of these, high reproducibility should be the main requirement for even considering the use of quantitative electromyography in diagnostics and in the assessment of treatment results. However, when recordings were repeated in the present asymptomatic sample, considerable individual variation was found.

In general, electromyographic method errors are expressed in microvolts. However, this might be misleading because the microvolt measurements represent an absolute value not related to the individual activity level of a certain subject. For exam-

Table 3 Errors I-III (Mean Difference Between Recording Sessions I and III) During Chewing and Biting Activities in 14 Subjects*

	Chewing						Maximal biting			
	Right		Left		Peanuts		ICP		Rolls	
Subject	μV	%	μV	%	μV	%	μV	%	μV	%
1	32	29	42	30	27	18	95	30	168	57
2	13	11	22	22	27	23	52	27	43	22
3	38	15	66	27	43	23	88	21	83	21
4	28	23	23	20	25	27	26	17	36	22
5	39	22	36	22	9	10	34	16	32	13
6	25	31	19	24	41	24	95	32	113	34
7	5	11	9	15	8	11	14	14	4	5
8	59	39	32	13	22	11	115	23	110	23
9	17	27	17	19	16	18	113	32	100	32
10	14	13	19	21	33	22	188	63	65	15
11	61	42	50	38	61	32	133	48	173	49
12	50	46	13	15	38	23	70	22	85	31
13	31	43	6	12	23	33	100	38	80	35
14	18	21	29	50	31	29	35	21	21	15
Mean	30.0	27.0	27.3	23.4	28.8	21.7	82.7	28.8	79.5	26.7
SD	17.2	–	16.7	–	14.1	–	47.9	–	51.1	–

*Right = unilateral chewing on the right side; Left = unilateral chewing on the left side; Peanuts = chewing of peanuts; ICP = maximal biting in intercuspal position; Rolls = maximal biting on cotton rolls.

Table 4 Comparison Between the I-II and I-III Errors (Mean of 14 Subjects) by Means of Student's Paired *t* Tests and Wilcoxon's Signed Rank Tests*

	Chewing			Maximal biting	
	Right	Left	Peanuts	ICP	Rolls
I-II error	23.9 μV	22.7 μV	20.2 μV	42.7 μV	42.5 μV
I-III error	30.0 μV	27.3 μV	28.8 μV	82.7 μV	79.5 μV
t test	*P* < .05	*P* < .05	*P* < .05	*P* < .01	*P* < .05
I-II error	22.0%	19.9%	15.7%	15.1%	15.2%
I-III error	27.0%	23.4%	21.7%	28.8%	26.7%
Rank test	*P* < .05	*P* < .05	*P* < .05	*P* < .01	*P* < .05

*Right = unilateral chewing on the right side; Left = unilateral chewing on the left side; Peanuts = chewing of peanuts; ICP = maximal biting in intercuspal position; Rolls = maximal biting on cotton rolls.

Table 5 Muscle Errors (Mean of Recording Sessions I, II, and III) for the Left and Right Temporalis and the Left and Right Masseter Muscles During Chewing and Biting Activities in 14 Subjects

Subject	Left temporalis		Right temporalis		Left + right temporalis		Left masseter		Right masseter		Left + right masseter	
	μV	%	μV	%	μV	%	μV	%	μV	%	μV	%
1	17	13	57	23	37	18	114	35	32	22	73	28
2	35	27	28	18	31	22	41	28	20	15	31	22
3	39	14	37	17	38	16	91	29	56	14	74	21
4	16	11	64	37	40	24	13	13	31	56	22	35
5	27	15	26	11	27	13	28	18	34	23	31	20
6	61	37	41	19	51	28	44	32	45	22	45	27
7	12	9	9	14	10	11	8	17	4	13	6	15
8	34	20	33	22	34	21	50	9	117	35	84	22
9	34	16	47	17	40	17	50	33	14	16	32	25
10	32	26	23	23	28	24	63	21	65	20	64	20
11	84	33	69	30	76	32	83	44	126	57	105	51
12	24	14	32	20	28	17	32	22	98	36	65	29
13	16	11	32	29	24	20	59	49	60	33	60	41
14	22	23	9	10	16	17	32	20	37	31	35	26
Mean	32.3	19.2	36.2	20.7	34.2	20.0	50.5	26.4	52.7	28.0	51.9	27.2
SD	19.5	–	18.2	–	15.9	–	29.7	–	37.5	–	27.4	–

Table 6 Function Errors (Mean of Recording Sessions I, II and III) During Chewing and Biting Activities in 14 Subjects*

Subject	Chewing						Maximal Biting			
	Right		Left		Peanuts		ICP		Rolls	
	μV	%	μV	%	μV	%	μV	%	μV	%
1	23	20	43	21	37	23	76	22	95	31
2	13	12	24	24	26	24	49	24	44	22
3	33	13	60	23	38	22	70	17	79	20
4	27	24	24	22	27	33	33	23	45	29
5	40	24	35	22	16	19	27	12	26	10
6	24	29	19	25	39	21	65	22	94	29
7	7	19	7	13	9	14	10	10	7	8
8	47	29	49	25	17	9	93	19	86	19
9	11	17	18	19	14	15	60	17	82	25
10	13	12	20	22	25	17	128	47	43	10
11	64	38	53	36	60	29	147	45	130	48
12	36	38	30	36	42	27	61	19	63	23
13	22	34	6	12	16	26	90	32	75	27
14	35	39	24	40	24	22	26	15	16	11
Mean	28.2	24.8	29.4	24.2	27.8	21.5	66.7	23.1	63.2	22.2
SD	15.7	–	16.5	–	13.9	–	38.7	–	34.6	–

*Right = unilateral chewing on the right side; Left = unilateral chewing on the left side; Peanuts = chewing of peanuts; ICP = maximal biting in intercuspal position; Rolls = maximal biting on cotton rolls.

ple, a 60-μV variance in EMG activity between two recording sessions would be a remarkable change in a subject whose maximal EMG activity for a certain function is 200 μV; for a subject with a maximal EMG activity level of 800 μV, the same variance of 60 μV would represent only a minor difference. Therefore, the percent errors are more meaningful than the corresponding errors in microvolts because these values are strictly related to the individual amount of EMG activity and should generally be considered when dealing with electromyography.

Electrode Relocation

Previous studies have stressed the importance of proper electrode relocation for the reproducibility of EMG measurements.[16–19,22] Variations of only a few millimeters in electrode placement can alter the amplitude of the EMG signal remarkably.[23]

When comparing the left side error (EMG recordings without removal of the electrodes during the time interval of 1 hour between the sessions) and the right side error (EMG recordings with relocation of the electrodes between the sessions) in the present study, no statistically significant differences were found. This finding suggests that electrode relocation itself might have little or no influence on the EMG activity when recordings are accomplished in a standardized manner. It would have been desirable to repeat the relocation experiment using a larger time interval, such as 7 hours, between the recordings, but the adhesive of the electrodes was not adequate for such an experiment.

Error With Respect to the Time Interval Between the Recordings

When comparing the I-II error (EMG recordings after a 1-hour interval without intermediate removal of the electrodes) and the I-III error (EMG recordings after a 7-hour interval with different electrodes), the latter was significantly larger during all the functions recorded. This result can most likely be explained by the longer time interval between the I-III EMG recordings, since electrode relocation seemed to have no influence. The first recording session (I) was performed in the morning, before the subjects began their working activities. The third recording session (III), on the other hand, was at the end of a stressful working day. Thus, the extended I-III time interval may have resulted in changes of the psychologic conditions and in physiologic variations of muscular activity or skin impedance within the subjects. This is in agreement with the findings of other authors,[24–27] who reported a significant variation in the EMG activity of the masticatory muscles under stressful situations.

Error With Respect to the Different Muscles Analyzed

Considering the muscle error, the poorer reproducibility of the EMG activity from the masseter muscle in comparison to the anterior temporalis muscle may have been the result of the fact that the masseter muscle is the principal muscle used in biting and chewing, and the anterior temporalis muscle functions mainly as a postural muscle of the mandible. In the present study, no postural recordings were performed; the five functions analyzed were restricted to chewing and biting performances. This would be in concordance with an EMG study performed by Burdette and Gale,[18] who investigated the reliability of resting EMG recordings from the masseter and the anterior temporalis muscles. A poorer reproducibility of the EMG activity from the anterior temporalis muscle was found in their study.

Furthermore, the activity of muscles close to the masseter muscle, such as the medial pterygoid muscle, the buccinator muscle, the greater and lesser zygomatic muscles, the orbicular muscle of the mouth, the risorius muscle, and the platysma muscle,[28] may affect the EMG signal from the masseter muscle. The influence of adjacent muscles on the recorded EMG activity may possibly be of special importance in the electromyographic diagnosis of myogenous TMD, since in such cases, adjacent muscles are strongly recruited for pain expressions during the functional tasks.

Error With Respect to the Different Functions Performed

The large function error (mean 23%) may have different explanations. Concerning the chewing recordings, changes in speed or direction of mandibular movements[29] may cause different motor units to discharge, thus changing the electromyograph of the masticatory muscles. With regard to maximal biting, tooth displacement during successive clenching[30] may stimulate the periodontal mechanoceptors,[31] producing a feedback effect on the elevator muscles of the mandible[32] and thus altering the normal patterns of muscular activity.

Fatigue during maximal biting may be another variable influencing the electrical activity of the masticatory muscles. The recruitment of higher threshold motor units, a decrease in firing rate,[33] and a slowing of the conduction velocity of muscle fiber[34] may affect the electromyograph of fatigued muscles and the reproducibility of EMG recordings during consecutive biting.

Changes in head and body position have been reported to alter the occlusal contacts and the mandibular pathway of closure,[35,36] affecting muscle contraction patterns,[37] and thus, the reliability of EMG measurements during chewing and biting.[16] In the present study, each subject's head was not kept in a fixed position during the three recording sessions, which allowed natural muscle function. Therefore, any possible postural changes of the head or the body may have contributed to the large function errors found.

It might be argued that the reliability of electromyography cannot be assessed without a bite force measurement to standardize the EMG signal level through constant performance of the functional tasks. However, in clinical practice, electromyography is generally used in absence of devices standardizing the EMG signal level. Therefore, the present findings certainly apply for clinical electromyography.

Conclusions

Quantitative EMG recordings from the anterior temporalis and masseter muscles result in a large method error for repeated recordings. The individual errors ranged from 5% to 63%, depending on the time interval between the recordings, the muscles considered, and the functions performed. The method error increased significantly ($P < .05$ to $P < .01$, depending on the function) with the time interval between recordings. The error for the masseter muscle (mean 27.2%) was higher than for the temporalis muscle (mean 20.0%). The largest function error was found during maximal biting in intercuspal position (mean 23.1%).

Because of its poor reproducibility, quantitative electromyography of the masticatory muscles seems to have limited value as a diagnostic tool and in the assessment of individual treatment outcomes. This would be true for all fields in dentistry, and especially in the study of TMD, because muscle pain and dysfunction might affect the accuracy of EMG recordings even more.

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Resumen

Es la Electromiografía Quantitativa Confiable?

La confiabilidad de la electromiografía quantitativa (EMG) del los musculos mandibulares fué analizada bajo diferentes funciones de masticación en 14 individuos sin evidencia de patología de la articulacion temporomandibular. La actividad electromiográfica fué registrada bilateralmente en los músculos temporal y masetero por medio de electrodos bipolares superficiales. En la primer parte del experimento se investigó la influencia de la relocación de los electrodos sobre la actividad electromiográfica. Una influencia de la relocación de los electrodos sobre el signal electromyográfico no fué detectable. En la segunda parte del experimento los 14 individuos fueron registrados tres veces durante cinco diferentes funciones masticatorias: (I) en la mañana; (II) una hora trás la primera registración sin reemplazo intermedio de los electrodos; y (III) en la tarde usando nuevos electrodos. El error metódico fué calculado para diferentes interalos de tiempo, para cada musculo y cada función. Dependiendo del intervalo de tiempo entre las registraciones, el músculo considerado y la función masticatoria evaluada el error individual varió entre el 5% y el 63%. El error metódico aumentó significativamente con el intervalo de tiempo entre las registraciones ($P < .05$ hasta $P < .01$). El error muscular fué más grande para el músculo masetero (27.2%) que para el músculo temporal anterior (20.0%). Las mordidas máximas en intercuspidación habitual mostraron el mayor error funcional. A conclusión, la electromiografía quantitativa, por causa de su gran error metódico, debe ser usada con precaución tanto para propósitos diagnósticos como para la evaluación de resultados de tratamiento.

Zusammenfassung

Ist die quantitative Elektromyographie zuverlässig?

Die Zuverlässigkeit der quantitativen Elektromyographie (EMG) der Kaumuskulatur während verschiedener Kau- und Beißfunktionen wurde an 14 Probanden untersucht. Keiner der Probanden zeigte Symptome einer craniomandibulären Dysfunktion. Die integrierte EMG Aktivität des M. temporalis anterior und des M. masseter wurde beidseitig mittels bipolarer Oberflächenelektroden registriert. Im ersten Untersuchungsabschnitt wurde der Einfluß der Elektrodenreplazierung auf die EMG Aktivität untersucht. Ein Einfluß der Elektrodenreplazierung auf die registrierte EMG Aktivität war nicht nachweisbar. Im zweiten Untersuchungsabschnitt wurden drei Registrierungen während fünf verschiedener Kau- und Beißfunktionen durchgeführt: (I) Registrierung am Morgen, (II) Registrierung eine Stunde nach "I" ohne zwischenzeitliche Entfernung der Elektroden und (III) Registrierungen am Nachmittag mit neu plazierten Elektroden. Der Methodenfehler wurde für verschiedene Zeitintervalle, für jeden Muskel und jede Funktion Berechnet. In Abhängigkeit von dem ausgewerteten Zeitintervall zwischen den Registrierungen, dem untersuchten Muskel und der untersuchten Funktion schwankte der individuelle Methodenfehler zwischen 5% und 63%. Mit dem Zeitintervall zwischen den Registrierungen stieg auch der Methodenfehler signifikant ($P < .05$ bis $P < .01$). Der Muskelfehler für den M. masseter (MW = 27.2%) war größer als für den M. temporalis (MW = 20.0%). Der höchste Funktionsfehler wurde während maximalen Beißens in habitueller Intercuspidation festgestellt. Schlußfolgernd kann festgestellt werden, daß die quantitative Elektromyographie mit einem großen Methodenfehler behaftet ist und daher für diagnostische Zwecke und zur Beurteilung von Behandlungsergebnissen nur zurückhaltend eingesetzt werden sollte.