Activity of Anterior Temporalis and Masseter Muscles During Deliberate Unilateral Mastication

The reproducibility of electromyographic parameters descriptive of deliberate unilateral chewing (activity, timing, curve symmetry) was investigated in normal asymptomatic volunteers. The best time for the initiation of muscle activity was also examined, with the future aim of staging TMJ internal derangements. The results suggest that activity is the most reliable variable, indicating that it may be helpful in describing muscle incoordination. When time was used in conjunction with another variable, overall reproducibility decreased.

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Comparisons of deliberate and habitual mastication have concluded that no one is strictly unilateral with regard to preference for bolus placement within the masticatory sequence.[1–3] It has also been suggested that simple averaging of the data based on time-amplitude alone would be inappropriate for assessing habitual mastication because of the use of different working sides within a particular masticatory sequence.[4]

Deliberate unilateral mastication has been reported to be an acceptable model for studying the influence of specific occlusal relationships on masticatory muscle activity and associated jaw movement.[5] The onset, amplitude, and duration of the masticatory cycle between subjects has been reported to be wide and to be partially related to occlusal morphology.[5,6] Subjects with more even occlusal contacts demonstrate less variation.[7] An increase in the number of working side contacts increases ipsilateral muscle activity, and the addition of nonworking contacts increases contralateral muscle activity.[6] Occlusal adjustment moves the electromyographic (EMG) peaks closer to the onset of intercuspation and makes them more coincident.[8,9] The coordination of muscle actions is generally similar between subjects, and mandibular movement is dictated by the neuromuscular controls of the masticatory muscles into the intercuspal position.[10] The anterior and posterior temporalis muscles and superficial and deep masseter muscles initiate activity around the time of first tooth contact (2 to 3 mm from maximum intercuspation). In subjects with good occulsion, activity peaks 20 to 30 ms before the onset of the intercuspal positioning and declines rapidly by the middle of intercuspation. At the onset of intercuspation, the contralateral masseter muscle is activated before the deep masseter and anterior temporalis muscles.[11]

Temporomandibular joint (TMJ) pain and dysfunction have been characterized by muscle pain, joint pain, limitation of mouth opening, distorted mandibular movement patterns,[12,13] reduced masticatory forces,[14–17] longer contraction time of the temporalis and masseter muscles, and stronger intermediary activity between strokes.[18-20] Modification of masticatory patterns may be dependent on the severity of the dysfunction.[21] A reduction in masticatory activity may be partially influenced by occlusal interferences.[6,22]

Coordination and timing of muscles during mastication in fully dentate subjects has been evaluated, and in general the ipsilateral anterior temporalis muscle is activated before the contralateral temporal, whereas masseter activity starts on the contralateral side and shows greatest strength on the ipsilateral side.[5,8,23,24] The duration of elevator activity is inversely proportional to the stability of the functional occlusion and intercuspal position.[6,19]

The purpose of this study was to investigate the activity of the masseter and anterior temporalis muscles during deliberate unilateral mastication in an asymptomatic group of subjects to determine reproducibility of signal. The asymptomatic subjects showed no TMJ internal derangement as indicated by magnetic resonance imaging.

A first goal was to determine the best starting time for the initiation of muscle activity, with the future aim of staging TMJ internal derangements.[25] The second goal was to evaluate EMG features (activity, timing, curve symmetry) for reproducibility.

Materials and Methods

Four volunteer subjects were recorded three times in five separate sessions to study the reproducibility or reliability of the investigated EMG parameters. All participants were men aged 29 to 47 years, with an average of 37.5 years. All had either no preference or right-sided preference during mastication.

The subjects were selected after successfully completing the following evaluations.

1. A TMJ subjective questionnaire documenting the absence of jaw pain, ear pain, pain on function, headache, and the presence of locking.
2. Clinical TMJ and dental examination as described by Roberts[26] for signs or symptoms of temporomandibular disorders (TMD) or internal derangement (impaired range of motion, deviation on opening, muscle palpation, and joint sounds). All participants had acceptable range of mandibular movements[27] (maximal opening of 40 mm or more, and lateral excursions of 10 mm or more).
3. Cephalometric analysis was performed only to incorporate individuals with an acceptable average mesocephalic facial pattern and profile, a Class I molar relationship, overjet of not more than 3 mm, overbite of not more than 40%, and no major mandibular shift from centric relation to centric occlusion.
4. A magnetic resonance scan to evaluate the TMJs for the presence or absence of disc displacement.

Hardware and Software

The EMG and jaw-tracking apparatus was a 12-channel system with a system band width from 40 to 1,000 Hz (±3 dB) and a gain of 5,000. Its input range is 0 to 1,400 μV (peak to peak) without clipping. Recordings were made on four channels of simultaneous EMG signal and four channels for graphic jaw tracking with a sampling rate of 240 to 1,200 samples/second/channel and a total A-to-D conversion time of 1.5 μs/channel and 9,600 samples/s. Sample collection was accomplished with an IBM PC-compatible computer with a 20-megabyte hard drive, dual floppy drives, 640-kb RAM, turbo processor, Hercules high-resolution monochrome graphics board, and graphics monitor.

Bipolar, reusable, 5-mm surface electromyographic silver/silver chloride disc electrodes, separate adhesive pads, and separate conducting gel were used for signal collection (Med Associates, East Fairfield, VT).

Electrode Position and Placement

The skin overlying the right and left anterior temporalis and masseter muscles as well as the right side of the neck was used as a ground and was cleaned with alcohol to reduce skin impedance and to enhance signal conductivity. To locate the areas for electrode placement the subject was requested to clench the jaws so that the most prominent part of the major muscle mass of the anterior temporalis could be located superior and posterior to the lateral part of the orbital rim. Its location was marked with a felt pen. The superficial masseter muscle was palpated and marked. The long axis of each muscle was located by palpation while the subject clenched, and electrodes were placed 22 mm apart (from electrode center to electrode center). To ensure replication of the electrode position, a customized measurement template was constructed by tracing a line along the canthus-tragus plane as a reference. A perpendicular was drawn from the marked center of the major muscle mass of each investigated muscle to the canthus-tragus line. The vertical and horizon-

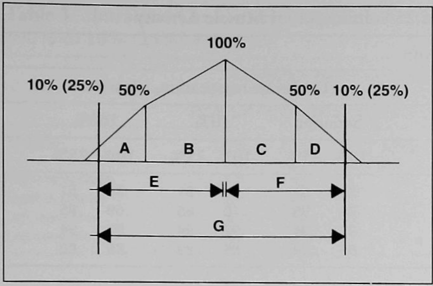

Fig 1 Diagram representing the averaged data from one muscle for the 10-second mastication period. The peak activity is identified (100%) and the corresponding 10% (25%) and 50% of peak activities for the ascending and descending curve are calculated. Times and areas (A–G) are then simultaneously calculated for each period.

tal distances obtained from the intersections were measured and recorded for later reference.

Recording procedure

The subjects sat relaxed and upright in a straight-backed chair without head support and were instructed to look at the monitor, which was placed at eye level. The patients were requested to make no head or body movements during the performance of the requested tasks other than the mandibular movements. Care-free sugarless chewing gum (Lifesavers Co, Winston-Salem, NC) was chewed until a homogenous consistency was attained. The subject was requested to deliberately chew only on one side; 18 to 21 masticatory strokes were recorded over 10 seconds. Swallowing or shifting the gum to the other side of the mouth was not allowed during the study period. The task was performed and recorded successively three times on the right side and three times on the left, with 3 minutes' rest between each recording.

The recorded signals were amplified, filtered, and sampled by the analog-to-digital converter and stored on disc. The program uses a 32-point moving average for data sampling. Output data files were analyzed with another 286-compatible computer by using a customized software program written by one of the authors (WCM). This program was designed to analyze each masticatory stroke throughout the 10-second recording period and to produce mean values. Masticatory activities that did not appear to be well-defined unilateral strokes could be eliminated.

The individual stroke was established by identifying the highest generated muscle activities as a peak. This was accomplished by utilizing the mathematical procedure of the moving window criteria.[28] Data were analyzed twice, once using 10% of maximal activity and again using 25% of maximal activity as the starting point (Fig 1). Each maximal peak represented the 100% activity (maximal activity) of the individual masticatory stroke. From these, the ascending and descending 50% and 25% (10%) activities were established simultaneously (Fig 1). The area of the masticatory stroke activity was identified by utilizing Simpson's rule, in which the area is approximated by parabolas.[29] All EMG signals have a degree of random noise. A peak is only of interest if it rises above the noise. Consequently, until the peak reaches a certain level we cannot be sure that it is not noise. Previous papers[24] have selected a 10% change in baseline for the initiation of the masticatory movement. However, signals associated with some peaks are often weak, so the authors also raised the noise level to 25%. Because random noise is not reproducible, a poorly chosen cut-off can seriously affect results.

Data Analysis

With the practical initiation and termination points of a masticatory stroke set at the 25% (10%) level, the analyzed data consisted of the following parameters.

1. The average activity (μV) at the 100%, 50%, and 25% (10%) peaks for each muscle.
2. The average skewness, which represents the degree of symmetry of the integrated curve generated by each muscle.[29]
3. The average kurtosis, which is the peakedness of the integrated curve generated by each muscle.[29]
4. The average time required to reach the ascending and descending levels of activity generated by each muscle: the time to reach 50% ascending level, 100% peak, 50% descending level, and 25% (10%) descending level, by using the ascending 25% (10%) level as the time of onset of the event.
5. The average segmented area of the ascending and descending levels: the area between the ascending 25% (10%) level to the ascending 50% level; the ascending 50% level to the

Table 1 Intraclass Correlation Coefficients for 10% and 25% Initiation of Muscle Activity

	Mean activity											
	Deliberate mastication, right side						Deliberate mastication, left side					
	Initiation		50%		100%		Initiation		50%		100%	
Muscle	10%	25%	10%	25%	10%	25%	10%	25%	10%	25%	10%	25%
Right temporalis	.90	.91	.90	.92	.89	.92	.30	.51	.30	.51	.30	.51
Right masseter	.94	.95	.94	.95	.94	.95	.70	.85	.70	.85	.69	.85
Left masseter	.74	.78	.74	.78	.74	.94	.92	.94	.92	.94	.92	.94
Left temporalis	.88	.83	.88	.83	.88	.89	.85	.89	.85	.89	.85	.89

Table 2 Intraclass Correlation Coefficients for Skewness and Kurtosis at 10% and 25% Initiation of Activity

	Deliberate mastication, right side				Deliberate mastication, left side			
	Skewness		Kurtosis		Skewness		Kurtosis	
Muscle	10%	25%	10%	25%	10%	25%	10%	25%
Right temporalis	.63	.51	.69	.73	.64	.30	.38	.39
Right masseter	.69	.80	.69	.87	.64	.55	.78	.89
Left masseter	.36	.52	.62	.77	.77	.62	.63	.82
Left temporalis	.85	.90	.78	.74	.55	.57	.68	.79

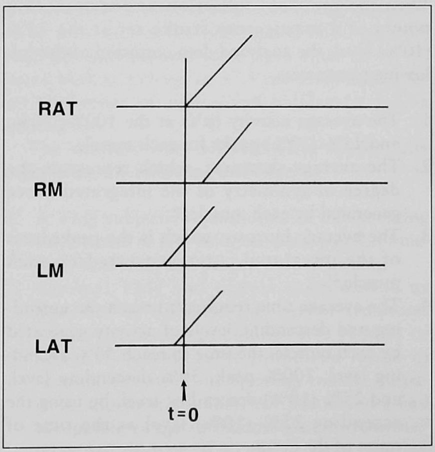

Fig 2 Diagram representing the time displacements from the initiation of activity (10% or 25%) of the right anterior temporal muscle for deliberate right-side mastication. For left-side mastication the left anterior temporal muscle would be used as the initiation of activity.

100% peak; the 100% peak; the 100% peak to the descending 50% level; the 50% descending level to the 25% (10%) descending level; and the total area from 10% (25%) to 10% (25%)

6. The time displacements for ascending and descending 25% (10%), 50%, and 100% levels, by using the ascending 25% (10%) level of the ipsilateral (masticating-side) anterior temporalis muscle as the onset of the masticatory stroke (Fig 2).
7. The activation order, expressed as the percentage of times an individual muscle activates first from initiation to completion of muscle activity.

Statistics

The reliability of each average parameter was evaluated statistically by using the intraclass correlation coefficient. Masticatory strokes from the 10% ascending to 10% descending levels were compared to those of 25% ascending to 25% descend-

Table 3 Intraclass Correlation Coefficients for the Time Required to Go From 10% (25%) to 100% and 100% to 10% (25%) Activity

	Deliberate right-side mastication				Deliberate left-side mastication			
	10% (25%) to 100%		100% to 10% (25%)		10% (25%) to 100%		100% to 10% (25%)	
Muscle	10%	25%	10%	25%	10%	25%	10%	25%
Right temporalis	.17	.59	.23	.62	–.11	.18	.17	.41
Right masseter	.64	.78	.32	.69	.67	.85	.68	.87
Left masseter	.59	.68	.54	.67	.12	.15	.31	.67
Left temporalis	.39	.38	.25	.19	–.06	.33	.25	.25

ing levels to evaluate the best starting level for the initiation for all variables studied.

The acceptable reliability value used in this study was .70 or greater. Such categorization was devised and utilized to describe the reliability results of this study, because a review of the literature produced neither similar categorization nor a meaningful value (cutoff) for what is an acceptable value of the intraclass correlation coefficient for EMG activities.

Results

The reliability of activity (at 10%, 50%, and 100% levels) by using the 10% ascending to the 10% descending level and the 25% ascending level to the 25% descending level (Table 1) demonstrates a slight improvement with the 25% values. The contralateral anterior temporalis muscle with right-sided mastication demonstrated a slight decrease, and the contralateral temporalis on the left side remained poor.

Comparing reliability of skewness from the 25% ascending level to the 25% descending level (Table 2) to the 10% ascending level to the 10% descending level reveals some improvement in the reliability values at 25% during right-side mastication for the ipsilateral masseter, the contralateral temporalis, and the contralateral masseter. However, there was a decrease in the reliability value of the ipsilateral temporalis. For the left side, the reliability values for the four muscles decreased or showed no major improvement.

Values for kurtosis when the masticatory stroke was compared from the 25% ascending level to the 25% descending level to the 10% ascending level to the 10% descending level (Table 2) demonstrated a general improvement on the right and left sides. Values for the contralateral anterior temporalis did not change with mastication on the left side.

The reliability of the time for the 25% ascending to 100% peak values compared to the 10% ascending to 100% peak values (Table 3) revealed that right-side mastication showed a general improvement in the reliability values with the exception of the contralateral temporal. Improvements occurred on left-sided chewing but overall results for both sides were poor.

Comparing time values for the masticatory stroke from the 100% to the 25% descending levels to the 100% to 10% descending levels shows that the right side demonstrated overall improvement as compared to the left (see Table 3). The overall values were poor.

When comparing the reliability of the area from the 25% ascending to the 100% peak values to the values from 10% ascending to the 100% peak, mastication on the right side showed general improvement in values of the ipsilateral temporalis muscle but a decrease in values for the remaining muscles. For left-side mastication, the contralateral masseter showed the most improvement in values while the remaining muscle activity was poor.

The reliability of the area from the 100% to the 25% descending levels compared to the 100% to the 10% descending levels for right-side mastication showed a general improvement with the exception of the ipsilateral masseter and contralateral temporal. For left-side mastication, the contralateral masseter showed the most improvement in values, while the remaining muscle activity was poor.

Values for displacement from 10% (25%) ascending with the onset of the ipsilateral temporalis as the initiation of the masticatory event are seen in Table 4. Comparing the 25% ascending

Table 4 Intraclass Correlation Coefficients for the Average Time Displacement at 10% (25%) for Each Muscle

	Deliberate right-side mastication Displacements*		Deliberate left-side mastication Displacements†	
Muscle	10%	25%	10%	25%
Right temporalis	—	—	.54	.55
Right masseter	.80	.71	.81	.82
Left masseter	.78	.79	.12	−.13
Left temporalis	.59	.70	—	—

*Time 0 is 10% (25%) of the right temporal muscle activity.
†Time 0 is 10% (25%) of the left temporal muscle activity.

Table 5 Firing Order for Right- and Left-side Mastication*

	Deliberate right-side mastication					Deliberate left-side mastication				
Muscle	10%	50%	Max	50%	10%	10%	50%	Max	50%	10%
Right temporalis	15	40	30	15	0	5	0	0	15	10
Right masseter	5	0	5	0	0	0	15	60	60	90
Left masseter	75	60	60	85	95	5	5	0	0	0
Left temporalis	5	0	5	5	5	90	80	40	25	0

*At 10% ascending, 50% ascending, maximal, 50% descending, and 10% descending activity; values represent percent of times muscle activates first.

Table 6 Firing Order for Right- and Left-side Mastication*

	Deliberate right-side mastication					Deliberate left-side mastication				
Muscle	25%	50%	Max	50%	25%	25%	50%	Max	50%	25%
Right temporalis	25	40	35	15	5	0	0	0	10	20
Right masseter	5	0	5	0	0	5	5	45	55	65
Left masseter	70	60	60	85	90	0	10	0	0	0
Left temporalis	0	0	0	0	5	95	85	55	35	15

*At 25% ascending, 50% ascending, maximal, 50% descending, and 25% descending activity; values represent percent of times muscle activates first.

values to the 10% ascending values with right-side mastication there was a general overall improvement with the exception of the ipsilateral masseter muscle, but without a dramatic effect on reliability. On left-side mastication no real improvement was noted.

The activation sequence of the individual muscles can be seen in Tables 5 and 6 (see Fig 2) for right- and left-side mastication at 10% and 25% initiation. The sequence for right-sided mastication (Table 5) at the 10% initiation level showed the contralateral masseter muscle activating *first* 75% of the time, followed by the ipsilateral temporal muscle (15%), and masseter (5%) and contralateral masseter muscle (5%). Deliberate left-side mastication (see Table 5) at the 10% initiation level demonstrated that the ipsilateral anterior temporalis muscle activated *first* 90% of the time, followed by the contralateral temporal and ipsilateral masseter muscle (5%), and the contralateral masseter muscle (0%).

Deliberate right-side mastication at the 25% initiation level (Table 6) demonstrated that the contralateral masseter muscle activated *first* 70% of the time, followed by the ipsilateral temporal muscle (25%), masseter muscle (5%), and contralateral temporal muscle (0%). The sequence for left-side mastication (Table 6) at the 25% initiation level shows the ipsilateral temporal muscle activating *first* 95% of the time, followed by the contralateral masseter muscle (5%). The ipsilateral temporal and contralateral masseter muscles never activated first at the 25% initiation.

Discussion

The use of electromyography for the diagnosis of mandibular dysfunction has been suggested by several authors.[4–9,19] Incoordination of mandibular movement patterns in patients with TMJ pain and dysfunction and subsequent changes in EMG signals has been suggested. The chief concern when evaluating patients for diagnosis of pain and dysfunction is the lack of suitable controls for accurate comparison; only Möller[24] and Hannam[8] have made comparisons to controls. Another concern rests with reliability of measurements made within any given session or between sessions. It would also be helpful to know which EMG parameters might be more reliable.

Möller[24] has suggested that the mean voltage during chewing of an apple was higher in controls than in patients with mandibular dysfunction. The present study suggests that activity is the most reliable variable, with the exception of the right temporal muscle during deliberate left-side mastication. Reproducibility is increased when 25% activity is used as the initiation of the masticatory event (see Table 1), with the ipsilateral muscles having the strongest reliability. This may suggest that this variable could be helpful when evaluating the onset of mastication.

It has also been suggested that the mean voltage descends earlier after treatment of mandibular dysfunction. Time and activity affect the skewness of the integrated event. For right-side mastication (see Table 2) the contralateral temporal muscle is the only muscle acceptable when using 10% as the initiation, and for the 25% initiation value the ipsilateral masseter and contralateral temporal muscles have acceptable reproducibility. With left-side mastication only the ipsilateral masseter muscle at 10% initiation is fair, and at the 25% initiation level values are unacceptable. If a curve (ascending and descending) were used to distinguish asymptomatic from symptomatic patients, only two muscles (ipsilateral masseter and contralateral temporal) are useful in assessing right-sided mastication at the 25% level. For left-side mastication, the ipsilateral masseter only, at 10%, is marginally useful.

Activity is one of the more reproducible variables; skewness is a function of the time and activity. This suggests that time is too variable and affects the shape of the curve.

The kurtosis curves are more reproducible (see Table 2), probably because mastication is series of a rhythmic events that produce sudden EMG bursts. It can be speculated that in TMD patients, the curve may become platykurtic or mesokurtic. Möller[19] suggests that this may indicate prolonged muscle activity. This can only be evaluated when patients with pain and dysfunction have been compared.

In measurements for right-side mastication the descending curves are poorer than are the ascending curves, which as Möller[19] suggests, indicates that the "tail" of the curve may not be adequate to distinguish asymptomatic patients from symptomatic patients. An alternative conclusion is that normal mastication is a more random event. Pain and dysfunction may influence muscle incoordination: the masticatory strokes are probably modified because of pain or pain avoidance. The ascending and descending values are poor, with the exception of the contralateral masseter muscle (at 25% initiation) with left-side mastication. Möller[24] suggested that the masticatory event (total and EMG bursts) is longer in patients than in controls. This study indicates that in controls the reproducibility of the area parameter may be questionable.

The coordination of muscle activity during mastication is thought to be a measure of dysfunction.[19] It has been suggested that the contralateral masseter muscle initiates activity before the ipsilateral muscle, and the ipsilateral anterior temporal muscle initiates activity before the contralateral temporal muscle. Displacements (at 10% and 25% initiation; see Table 4) are reproducible for right-side mastication. This suggests that the practical initiation of the mastication on the right side at 10%, for the masseter muscles, and at 25%, for the masseter muscles and left temporal muscle, is acceptable to indicate coordination of muscle activity. The values for the left side are poor, with the exception of the contralateral masseter.

The activation order for deliberate right-side mastication (at 10% initiation) is considerably different than is deliberate left-side mastication; this indicates that the pooling of the data for the right and left sides may be inappropriate (see Table 5). The contralateral masseter muscle activates first 75% of the time for right sided mastication . The activation sequence for left side mastication (10%) most often has the ipsilateral temporal muscle (90%) activating first, with the ipsilateral masseter and contralateral temporal muscles representing the remaining 10%. The contralateral masseter muscles, for right- and left-side mastication, finish their activity first 95% and 90% of the time, respectively. These parameters may thus be useful in diagnosis of muscle incoordination.

The activation order for deliberate right-side mastication (25%) is considerably different than is that for the left side, which suggests that the pooling of the data for right and left sides may be inappropriate. Right-side mastication at 25% initiation is similar to that at 10%. Because the finishing of activity with 25% initiation is not as clean as that with the 10% cutoff, 10% may be a more appropriate value for this parameter.

Conclusion

The reproducibility of EMG parameters, which describe deliberate unilateral mastication, have been investigated in asymptomatic subjects. Some values appear to be more reproducible than are others and may have value in describing muscle incoordination. When time is used in conjunction with another variable, overall reproducibility decreases. Their value will only be known when a suitable group of TMJ pain and dysfunction patients have been compared.

References

1. Wictorin L, Hedegard B, Lundberg M. Masticatory Function. A cineradiographic study. III. Position of the bolus in individuals with full complement of natural teeth. Acta Odontol Scand 1968;26:213–222.
2. Wictorin L, Hedegard B, Lundberg M. Cineradiographic studies of bolus position during chewing. J Prosthet Dent 1971;26:235–246.
3. Möller E. Discussion of Anderson DJ paper. The incidence of tooth contacts in normal mastication and the part they play in guiding the final stage of mandibular closure. In: Anderson DJ, Matthews B (eds). Mastication. Bristol: Wright, 1976.
4. Stohler CS. A comparative electromyographic and kinesiographic study of deliberate and habitual mastication in man. Arch Oral Biol 1986;31:669–678.
5. Hannam AG, Scott JD, DeCou RE. A computer based system for the simultaneous measurement of muscle activity and jaw movement during mastication in man. Arch Oral Biol 1977;22:17–23.
6. Bakke M, Möller E, Thorsen NM. Occlusal control of temporalis and masseter activity during mastication [abstract]. J Dent Res 1982;61:257.
7. Wood WW, Gelfant H, Hannam AG. Effect of occlusal reconstruction on the reproducibility of chewing movements. J Prosthet Dent 1981;46:181.
8. Hannam AG, DeCou RE, Scott JD, Wood WW. The relationship between dental occlusion, muscle activity and associated jaw movement in man. Arch Oral Biol 1977;22:25–32.
9. Hannam AG, Wood WW, DeCou RE, Scott JD. The effect of working side occlusal interferences on muscle activity and associated jaw movements in man. Arch Oral Biol 1981;26:387–392.
10. Mintz VW. The orthopedic influence. In: Morgan DH, Hall WP, Vamuas SJ (eds). Diseases of the Temporomandibular Apparatus: A Multidisciplinary Approach. St. Louis: Mosby, 1977:198–200.
11. Wood WW. A review of masticatory muscle function. J Prosthet Dent 1987;57:222-232.
12. Griffin CJ, Malor R. An analysis of mandibular movement. Frontiers Oral Physiol 1974;1:159.
13. Stohler, CS, Ash MM Jr. Silent period on jaw elevator muscle activity during mastication. J Prosthet Dent 1984;52:729–735.
14. Marklund G, Molin C. Horizontal isometric muscle forces of the mandible. A comparative study of subjects with and without manifestations of mandibular pain dysfunction syndrome. Acta Odont Scand 1972;30:97.
15. Molin C. Vertical isometric force of the mandible. Acta Odontol Scand 1972;30:485–499.
16. Helkimo E, Karlsson GE, Carmeli Y. Bite force in patients with functional disorders of the masticatory system. J Oral Rehabil 1975;2:397–406.
17. Schuimann NP, Richter A, Glasser S, Zwiener U, Misselwitz I. The specific EMG activity of masticatory muscles in response to psychic and mental load and psychic factors in neurotics. Acta Nerv Super (Praha) 1988;30:140–143.
18. Munro RR. Electromyography of the masseter and the anterior temporalis muscles in the open-close-clench cycle in temporomandibular joint dysfunction. Monographs in Oral Science (Basel) 1975;4:117.
19. Möller E, Sheikholeslam A, Lous I. Response of elevator activity during mastication to treatment of functional disorders. Scand J Dent Res 1984;92:64.
20. Möller E, Bakke M. Occlusal harmony and disharmony: Frauds in clinical dentistry. Int Dent J 1988;88:7–18.
21. Stohler CS, Ash MM Jr. Demonstration of chewing motor disorder by recording peripheral correlates of mastication. J Oral Rehabil 1985;12:49–57.
22. Riise C, Sheikholeslam A. Influence of experimental interfering occlusal contacts on the activity of the anterior temporal and masseter muscles during mastication. J Oral Rehabil 1983;10:207–214.
23. Shepherd RN. A further report on mandibular movement. Aust Dent J 1960;5:337–346.
24. Möller E. The chewing apparatus. An electromyographic study of the action of the muscles of mastication and its correlation to facial morphology. Acta Phys Scand 1966;69(suppl):280.
25. Dolwick MF. The temporomandibular joint: Normal and abnormal anatomy. In: Helms CA, Katzberg RW, Dolwick MF (eds). Internal Derangements of the Temporomandibular Joint. San Francisco: Radiology Research and Education Foundation, 1983:1–14.
26. Roberts CA. The Correlation of Clinical Findings With the Arthrographic Diagnosis of the Temporomandibular Joint {Thesis}. Rochester, New York, Eastman Dental Center, 1988.
27. Agerberg G. Maximal mandibular movements in young men and women. Svensk Tandlak-T 1974;67:81–100.

28. Abramowitz M, Stegun IA. Applied Mathematics Series, Vol 55: Handbook of Mathematical Functions. Washington DC: National Bureau of Standards, 1964. (Reprinted, New York: Dover, 1968.)
29. Murray R, Spiegel. Theory and Problems of Statistics, ed 2. Schaum's Outline Series. New York: McGraw-Hill, 1988:110–121.

Resumen

La reproducibilidad de la actividad de los músculos temporal anterior y masetero durante la masticación unilateral deliberada

Se investigó la reproducibilidad de los parámetros electromiográficos representativos de la masticación unilateral deliberada (actividad, ritmo, simetría de la curva), en voluntarios normales y asintomáticos. También se examinó el mejor momento para la iniciación de la actividad muscular, con el propósito futuro de determinar las distintas fases de los malfuncionamientos internos de la articulación temporomandibular. Los resultados indican que la actividad es la variable mas confiable, lo cual podría explicar la falta de coordinación muscular. Cuando se utilizó el ritmo en conexión con otra variable, la reproducibilidad en general disminuyó.

Zusammenfassung

Die Wiederholungsfähigkeit der Aktion der Anterior Temporalis und des Masseter Muskel während dem bewussten Kauen

Die Wiederholungsfähigkeit von elektromyographischen Parametern, welche bewusstes, einseitiges Kauen beschreiben (Aktion, Zeitmessung, Kurven-Symmetrie), wurde an normalen, asymptomatischen Freiwilligen untersucht. Die beste Zeit für den Beginn der muskulären Aktion wurde auch geprüft in der Absicht, künftige innere Störungen im TMJ bei Phasen zu erkennen. Die Resultate schlagen vor, dass die Aktion der verlässlichste, unbeständige Faktor ist, mit der Anzeige, dass sie für die Beschreibung von muskulärer Inkoordination hilfreich ist. Wenn der Zeit Faktor im Zusammenhang mit einer anderen Variablen gebraucht wurde, die gesamte Wiederholungsfähigkeit hat abgenommen.