REFERENCES


Duration of nocturnal tooth contacts during bruxing

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The etiology of nocturnal and diurnal bruxism is undetermined. Theories as to why people grind their teeth during sleep range from intraoral factors such as mechanical displacement of the dentition during intercuspation to emotional factors. More popular theories combine mechanical and psychologic components to explain bruxism. Although these theories recognize multiple etiologic factors, occlusal factors alone are frequently considered during treatment. For example, Ramfjord maintained that bruxism can be eliminated by occlusal adjustment without considering emotional factors. Appealing as this prospect may be, there is no evidence that malocclusion or interocclusal contact between opposing teeth can initiate and maintain forceful clenching or grinding of teeth.

This lack of definitive evidence of the contribution of mechanical and psychologic factors to bruxing led to the present study. It was designed to consider (1) on a temporal basis, differences in duration of activity of the masseter muscle in bruxers compared with nonbruxers; and (2) effects of an occlusal splint on nocturnal tooth grinding in subjects with a history of bruxing.

REVIEW OF LITERATURE

Some investigators have attempted to pinpoint specific personality characteristics in tooth grinders. No consistent patterns or personality characteristics were found, and investigators reported contradictory results. Reding et al. concluded that it is impossible to identify a typical "bruxist personality." A similar conclusion has

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been reached with other behavioral disorders, and during the past two decades attempts to correlate specific personality characteristics with different psychophysiological disorders have decreased. Efforts to identify a common personality characteristic have been replaced by efforts to identify specific emotional states that may be correlated with bruxism. There is reasonably strong evidence that emotional states such as anxiety can elicit muscular tension. It remains to be demonstrated, however, that muscular tension in nocturnal bruxism is related to anxiety or other emotional states.

During waking hours in asymptomatic subjects, the teeth are usually separated and contact infrequently. In his telemetric studies, Graf found that tooth contact during a 24-hour period was 17½ minutes, which included 16.2 minutes during the waking hours and 1.3 minutes during sleep. Brewer and Hudson found that tooth contact time varied from 3 minutes to 2.5 hours during 8 hours of sleep.

Data that implicates bruxism as a contributing factor in mandibular dysfunction and myofascial pain dysfunction syndrome have appeared with some frequency. Reviewers are in general agreement that oral habits such as bruxism may play a central role in the development of (1) dysfunctional mandibular movement, (2) sounds during condylar movement, and (3) pain and tenderness in the region of the masticatory muscles.

Bruxism has been measured by a wide variety of techniques that vary from comparison of muscle pain on palpation, to questionnaires, to tooth contact duration using orthodontic bands, electromyography (EMG), and intraoral radiotransmitters. Tooth contact duration measurements using orthodontic bands as described by Trenouth were tried and abandoned in this study. False positives were found in 20% to 25% of control studies. False positives occurred when the teeth were separated by distances up to 1 mm. but saliva between the orthodontic bands registered as contact. Nocturnal EMG recordings of the masseter muscles have been reported. The relationship between biting force and masseter and temporal muscle activity has been described, and it is not possible to clench or grind the teeth without eliciting significant muscle action potentials from the masseter. The relationship between bruxism and muscle pain was demonstrated by Christensen when he asked subjects to purposely grind their teeth periodically for 30 minutes. Muscular pain peaked about 2 hours after the conclusion of the grinding exercises.

Most nocturnal EMG studies have been carried out in sleep study clinics. These centers have specially designed sleeping rooms fitted with electrophysiological monitoring equipment that includes EMG to study bruxism and other parameters of sleep.

A portable single-channel EMG recorder for unilateral recording of masseter muscle activity was described by Rugh and Solberg. Via electrodes attached to the skin surface over the muscle, this instrument amplifies and stores in an integrator the muscle action potential voltage. A readout of the activity period consists of a number that can be recorded and the device reset for the next period by the test subject. Rugh and Solberg recognized that the following difficulties were inherent in this procedure.

1. The source of the electrical signals recorded is unknown. (No discrimination is made between the signal and electrical noise).
2. A correlation between the temporal relationship and the EMG signals is not made.
3. The duration, magnitude, and frequency of nocturnal bruxism are not recorded. The same cumulative EMG signals may, for example, result from one long moderate episode of clenching or several brief vigorous clenching periods during the night.

The amplitude of the muscle action potential was not actually evaluated in this study because of the extensive margin of error induced by removing and replacing EMG electrodes. On repeated testing on the same day when electrodes were left in place, Komi and Buskirk found that the correlation coefficient for surface electrode recording was $r = 0.88$. When the electrodes were carefully reapplied on another day, the reproducibility dropped to $r = 0.69$ for surface electrodes.
If the coefficient of determination \((r')\) is converted to percent, \(r = 0.692 \times 100 = 47\%\). It then appears that 47% of the variation is found in the linear relationship between force and EMG signal on sequential testing. The remaining 53% of the variation is due to unexplained factors such as experimental error.

**MATERIAL AND METHODS**

**Selection of subjects**

Ten bruxing subjects and 10 nonbruxing controls were selected from patients at the Temporomandibular Joint Research Clinic at the University of Washington. All subjects were women 21 to 43 years of age. Criteria for bruxing included (1) history of nocturnal grinding sounds confirmed by someone sleeping nearby and (2) jaw discomfort or soreness on waking. The nonbruxing subjects were either asymptomatic or without the bruxing criteria.

A maxillary occlusal splint was constructed for each bruxing subject. Splints were 2 to 4 mm thick and contacted all opposing teeth during function. Bruxing subjects were tested for three nights before the splint was used. After placement of the splint, the subject was given 2 weeks to accommodate prior to being tested for three nights while using the splint.

**Electrophysiologic recording**

A low-power 4-channel telemetry system was used to record activity during sleep for approximately 8 hours. A channel was used for each masseter muscle EMG, one channel for electrocardiography (EKG), and one for body movement. The EMG signals were detected using standard, commercially available silver/silver chloride electrodes, two of which were attached over each masseter muscle. Heart rate was monitored by placing an electrode on each shoulder, which provided a recording of the QRS complex. All data were recorded on a Hewlett-Packard frequency modulation (FM) instrumentation tape recorder (Hewlett-Packard, Palo Alto, Calif.) at the rate of 1/6 inch/sec. At this rate, 300 feet of tape was used per hour or 2400 feet in an 8-hour data-gathering session. Body movement was monitored by a small accelerometer attached to the transmitter, which was in turn attached to a belt worn by the subject. Lightweight, flexible cables connected the electrodes to the transmitter (Fig. 1).

We transported the recording equipment to the home of the subject, the test procedure was explained, and the electrodes were connected. Before the transmitter and belt were removed from the subject after the test, the test equipment was recalibrated.

**FM transmitter**

The FM transmitter generates a low-power radio frequency carrier wave of 180 MHz. The multiplexed signal is used to vary (or modulate) the carrier frequency by a small amount, hence the term frequency modulation. The transmitter worn by the test subject was never more than 50 feet from the receiver (signal range 150 feet). The signals on the four data channels of the transmitter were first amplified with the frequency range limited to values appropriate to the type of signal by signal conditioners. The four signals were then passed to the multiplexor, which encoded the four signals onto one data line used to modulate the transmitter. The encoding scheme used is called pulse width modulation (PWM) (Fig. 2).

The receiver is similar to a standard FM radio. It detects the telemetry signal and extracts the multiplexed data signal from it. The data signals are then recorded on a four-channel instrumentation tape recorder, which runs at tape speed of 1/6 inch/sec, and gives a recording time up to 8% hours on 2400 feet of tape.

**Data analysis**

To evaluate the record gathering for artifacts, the data recorded by the FM tape recorder were read out for visual study in a time-compressed, analog form. The data consisted primarily of long periods of inactivity broken by brief periods of activity on each data channel. The 2400 feet of tape was reduced to a 6-foot strip chart record, which was divided into 48 equal divisions of 1/2 inch each. The 1/2-inch division is equivalent to 50 feet of the 2400 feet of raw data. This compression permits identification and review of desired areas of the long tape. The duration of EMG activity was measured manually and converted to time in seconds. Movement artifact and electrical noise was deleted.
RESULTS

When compared with nonbruxers, bruxers rhythmically clench their teeth more frequently 15 to 45 minutes after retiring and before waking. The bruxers had a mean duration of 11.4 minutes with a range of 3.3 to 16.1 minutes and a standard error of the mean of 2.1 minutes. Nonbruxers had a mean duration of 3.1 minutes, a range of 1.2 to 4.8, and a standard error of 0.9 minutes. The difference between control subjects and bruxers was statistically significant (p < .01). The duration of bruxing in the bruxers who used splints was not significantly different from the subjects who did not use the splints (p > .20). All subjects reported more comfort while using the splint.

Bruxing and clenching could be differentiated in this study. When the electrodes were applied bilaterally and the subject clenched, there was simultaneous bilateral muscle contraction. When the subject bruxed, the muscle contractions were produced unilaterally and sequentially: first the masseter muscle on one side, then the masseter muscle on the contralateral side. There was approximately 1 second between muscle contractions on the same side, and the duration of a muscle contraction on either side had a mean of 1.1 second (standard deviation = .21).

All bruxing was accompanied by a sudden, statistically significant (p < .01) increase in heart rate. At the termination of bruxing, an equally rapid return to the prebruxing heart rate was noted. The increase in heart rate had a mean of 18 and a range of 2 to 30 beats/min. Body movement occurred infrequently, usually 5 to 10 minutes before bruxing. In this sample of bruxers and nonbruxers, body movement and bruxing never occurred simultaneously.

DISCUSSION

Several factors may account for the differences in the findings in this study and studies in which it was found that occlusal splints did reduce masseter muscle action potential.

1. The duration rather than the amplitude of the EMG signal was measured.

2. When surface electrodes for EMG data acquisition are used, the experimental artifact that is inherent in the quantification of the isometric EMG force tension relationship must be taken into account. Moritani and deVries stated that during isometric contraction, a linear relationship exists near the middle of the operating force range, but the low and high force range curve is usually parabolic.

3. Budtz-Jorgensen and McNamara found that vertical displacement of the mandible by occlusal splints was followed by continuous hyperactivity of the jaw muscles of monkeys, as demonstrated by EMG recordings.

4. Gentz found that he was unable to eliminate bruxing with the use of splints in four patients. This is confirmed by the common clinical finding that patients may grind and fracture night guard splints.

5. Christensen showed that the maximal voluntary clenching of teeth can induce jaw muscle fatigue and pain in 20 to 60 seconds. This highly unpleasant sensation can be endured for about 120 seconds. Clenching could easily account for muscle soreness on awakening, because it was of 20- to 40-seconds duration. This activity commonly occurred 45 minutes before awakening. It is curious that bruxing activity does not awaken the subject.

CONCLUSIONS

1. Occlusal splints worn at night did not significantly reduce bruxing-clenching activity in bruxing subjects.

2. Bruxing and clenching use temporally different masseter muscle activity. Clenchers contract both sides simultaneously; bruxers contract each side sequentially.

3. Bruxers-clenchers contract the masseter muscles approximately four times longer than control subjects.

4. All bruxing and nonbruxing subjects demonstrated some nocturnal bruxing activity, although there was great variance.

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