The Initial Effects of Occlusal Splint Vertical Thickness on the Nocturnal EMG Activities of Masticatory Muscles in Subjects with a Bruxism Habit

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Purpose: The objective of this study was to investigate the initial effects of the vertical thickness of occlusal splints on the electromyographic (EMG) activities (integrated EMG values) of temporal and masseter muscles during sleep in subjects with a nocturnal bruxism habit using a portable EMG recorder. ***Materials and Methods:*** The subjects consisted of 12 volunteers (4 men and 8 women, average age of 25.3 years). All subjects had never worn splints before and had a habit of nocturnal bruxism. Two types of splint were made for every subject: a splint with a 3-mm vertical thickness at the central incisors (S3) and a splint with a 6-mm vertical thickness (S6). The muscle activities of the left anterior temporal muscles and masseter muscles were recorded without occlusal splints (NS), with the S3 splint, and with the S6 splint by a portable EMG recorder. The integrated EMG values were calculated to examine muscle activities under the 3 different conditions. ***Results:*** The integrated EMG values of masseter and temporal muscles decreased following insertion of the S3 splint but were not significantly affected by the S6 splint. Six subjects in masseter EMG and 7 subjects in temporal EMG got worse with the S6 splint compared to NS. ***Conclusions:*** When the occlusal splints were used as a bruxism countermeasure, it was suggested from the analysis of muscle activities during sleep at night that the S3 splint was superior to the S6 splint. *Int J Prosthodont 2008;21:116–120.*

Nocturnal grinding and clenching are destructive to the teeth, periodontal tissue, masticatory muscles, temporomandibular joints, etc.[1–3] The use of a stabilization type of occlusal splint is one of the commonly accepted treatments for bruxism.[4,5] Manns et al[6] and Christensen[7] reported that the vertical thickness of occlusal splints should be set up beyond the mandibular rest position; however, Ramfjord and Ash[8] reported that it should be as thin as possible. Other studies have made no mention of the optimal vertical thickness of occlusal splints.[9,10] The vertical thickness of occlusal splints is an important consideration in the treatment of patients and may directly influence the clinical effect. Nevertheless, this optimal thickness remains unclear.

Electromyographic (EMG) study of masticatory muscle activities during sleep is a direct and useful method to quantitatively and objectively evaluate the effects of occlusal splints on bruxism.[9–15] It has been reported by some researchers that the insertion of occlusal splints has direct effects on masticatory muscle activities during sleep recorded by means of portable EMG recorders[9–13] and polysomnography.[14,15] However, the effects of vertical thickness of splints on masticatory muscle activities during sleep have not been evaluated. It was hypothesized that masticatory muscle activities during sleep would be altered by the different vertical thicknesses of occlusal splints.

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The purpose of this study was to evaluate the initial effects of the vertical thickness of occlusal splints on the activities of masticatory muscles during sleep in subjects with a habit of nocturnal bruxism.

Materials and Methods

Subjects

The subjects, who had never worn splints before, consisted of 12 volunteers (4 men and 8 women, average age of 25.3 years). All subjects were without severe or moderate symptoms of temporomandibular disorders (TMD) (ie, painful mouth opening, muscle and joint pressure pain, and limitation of mouth opening). The subjects were assessed by a questionnaire and clinical examination according to the Research Diagnostic Criteria for TMD.[16] None of the subjects had tooth defects, excluding the presence or absence of third molars. All subjects had normal occlusion (ie, nearly Class 1 molar relations). The interocclusal space without occlusal splints ranged from 1.4 to 2.4 mm (mean: 1.7 mm, SD: 0.37 mm). All subjects had a habit of nocturnal bruxism (grinding and/or clenching), assessed by a questionnaire and clinical examination. Inclusion criteria included a complaint of grinding or clenching during sleep in combination with at least 1 of the following conditions: abnormal wear of the teeth, sounds associated with bruxism, jaw muscle discomfort.[17]

Each subject gave informed consent prior to the start of the study. Each patient could, at any time, stop his or her participation in the study for any reason. The study was approved by the Ethical Committee at Hiroshima University.

Occlusal Splint

The stabilization type of maxillary occlusal splint was used in this study because it has been shown to reduce muscle hyperactivity[4] and is considered safe even when used for long periods. This type of occlusal splint has a flat occlusal surface with occlusal contacts in centric relation for all of the opposing teeth, with uniform anterior and canine guidance. Each splint was fabricated on stone casts mounted on a Hanau semiadjustable articulator (Arcon H2, Hanau) using a facebow transfer with the mandibular cast mounted in centric relation.

The authors decided on a minimum splint thickness of 3 mm to prevent perforation of the surface of the splint during use and adjustment. Splints with thicknesses of 3, 6, 9, and 12 mm were made for the pilot study, and the 6-mm splint was applied clinically as the maximum thickness considering the level of comfort after subjects had used the splints. Two types of splint, with vertical dimensions of 3 mm (S3) and 6 mm (S6), were made for every subject. Because these thicknesses exceeded the amount of interocclusal space in all subjects, the experimental condition was considered standardized.

The vertical dimension of occlusion was increased by 3 and 6 mm when measuring at the central incisors on the semiadjustable articulator. The material used for the occlusal splints was clear heat-curing acrylic resin (Acron MC, GC). The splints were set into each subject's mouth and adjusted so that the required interocclusal relationship could be achieved. Two weeks before the experiment, the subject used the splints during sleep at night and, if necessary, readjusted in a similar fashion.

Experimental Procedure

Muscle activities were recorded without an occlusal splint as a control (NS), with the S3 splint, and with the S6 splint. The order of occlusal splint conditions varied among the subjects. First, muscle activities were recorded without occlusal splints. The occlusal splint conditions were arranged in order of the S3 splint followed by the S6 splint for half of the subjects and in order of the S6 splint followed by the S3 splint for the other half using a block randomization design. It may be reasonable to have the subjects wear the EMG recording device first to obtain baseline data. Therefore, measurements of muscle activities were performed once under each condition, ie, 3 measurements of muscle activities during sleep at night were performed for every subject. An interval of 6 days or more was used between each measurement to minimize the influence of the previous round of measurements on the next round. Before the S3 or S6 splints were set and muscle activities were measured, the subjects were asked to sleep for 2 nights wearing the given splint (Fig 1).

EMG Recording

Nocturnal muscle activity was recorded with a portable EMG recorder (Muscle Tester ME3000P, Mega Electronics). The wires connecting the electrodes to the preamplifier were kept short to minimize pickup of electrical noise.[9]

Muscle activities were recorded from the left anterior temporal muscles and the left masseter muscles. Bipolar silver–silver chloride electrodes (Blue sensor, type-N-00S, Medicotest A/S) were used, and ground electrodes were attached to the neck area. The electrodes and preamplifier were fixed to skin surfaces with a viscosity cloth stretch bandage to prevent exfoliation during measurements (Fig 2). EMG data were recorded with a sampling frequency of 1 kHz. The averaged values of rectified EMG data for every second were stored in the recording device. The analyzed

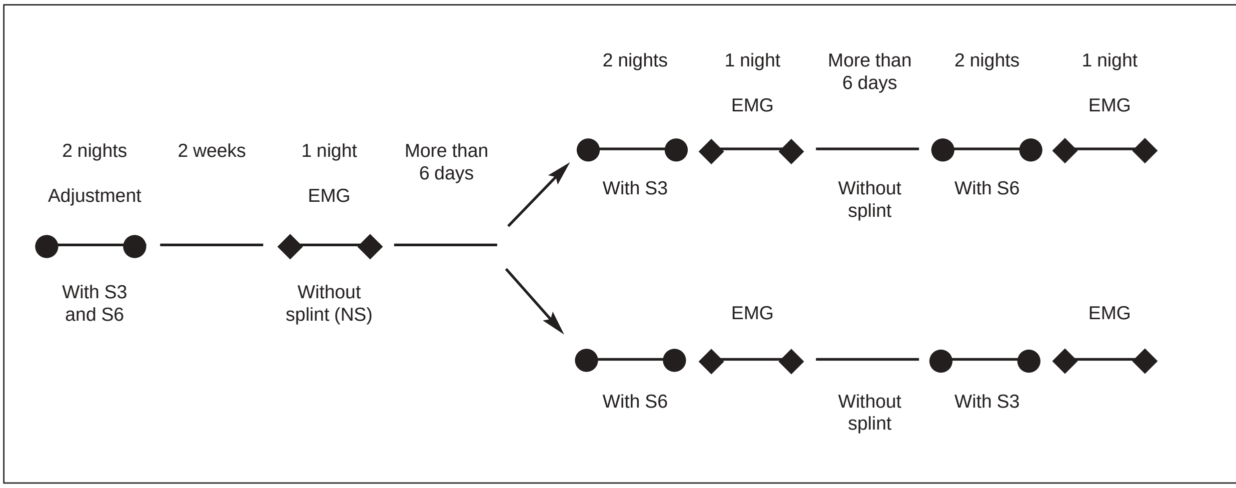
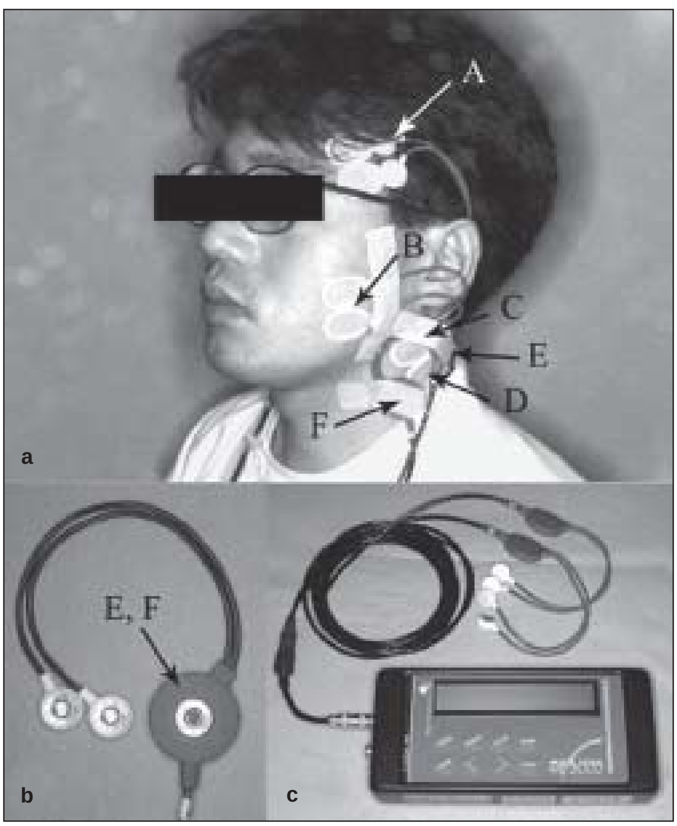


Fig 1 The study design. NS = without splint; S3 = splint with 3-mm vertical thickness; S6 = splint with 6-mm vertical thickness.

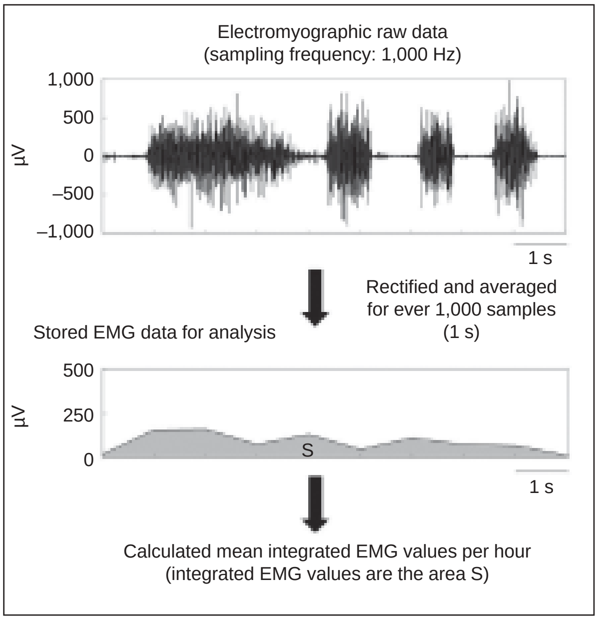


Figs 2a to 2c The EMG surface electrodes **(a)**, EMG preamplifier and wires **(b)**, and portable EMG recorder system **(c)**. A = bipolar silver–silver chloride electrodes for the temporal muscle; B = bipolar silver–silver chloride electrodes for the masseter muscle; C = ground electrode for the temporal muscle; D = ground electrode for the masseter muscle; E = preamplifier for the temporal muscle; F = preamplifier for the masseter muscle.

period of sleep each night comprised the moment starting 30 minutes after each subject went to bed until the moment they got up.

Data Analysis

After recording the average values of rectified EMG data, the integrated EMG values of each analyzed period were measured, and the integrated EMG values per hour were used for analysis (Fig 3). The integrated EMG values were calculated to examine muscle activities during sleep at night under 3 different conditions: without occlusal splint (NS), with the S3 splint, and with the S6 splint. The data for each subject were analyzed after all the measurements were finished. Therefore, neither the examiner nor the subject was aware of the effects of the splint on the muscle activities during the recording period.



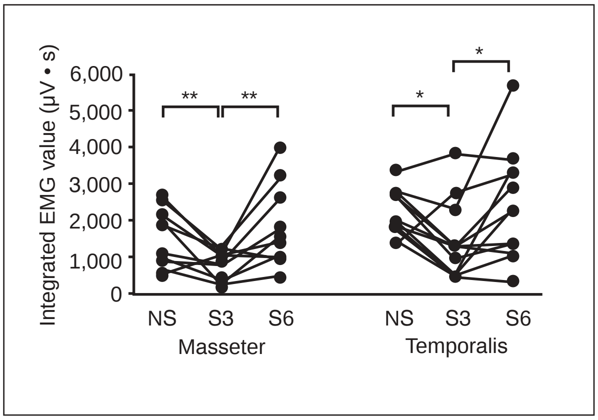


Fig 3 *(left)* Procedures for the determination of integrated EMG values (S).

Fig 4 *(above)* Comparison of the integrated EMG values between the 3 splint conditions. The values given are for every 1 hour. Asterisks indicate a significant effect (Wilcoxon signed rank test; $*P < .05$, $**P < .01$).

Statistical Analysis

Wilcoxon signed rank tests were performed to determine the difference between the muscle activities under the 3 conditions. Statistical significance was set at .05.

Results

The S3 splint decreased the activities of the left masseter and temporal muscles compared to NS, and S6 insertion increased the EMG activities of the left masseter and temporal muscles compared to S3. There was no significant difference between NS and S6 in masseter and temporal EMG activitiy. Six subjects in masseter EMG and 7 subjects in temporal EMG got worse with S6 compared to NS (Fig 4).

Discussion

The initial effects of the vertical thickness of occlusal splints on the nocturnal EMG activities of the temporal and masseter muscles in subjects with a bruxism habit were investigated using a portable EMG recorder. The integrated EMG values were significantly decreased by the S3 splint but not by the S6 splint compared to the control (NS).

Other studies reported that nocturnal masticatory muscle activities were significantly reduced by wearing occlusal splints. The present results of the S3 splint agree with these studies. In some studies, vertical thickness for occlusal splints was 1 or 2 mm in the posterior region,[12,13] which is similar to the S3 splint used in this study, and was 1 or 2 mm in the anterior region,[15] which could include different thicknesses depending on the overbite of the patients studied. In other studies, vertical thickness was not mentioned.[9–11,14] It has been suggested that the vertical dimension of occlusal splints affects masticatory muscle activities[4,6,7]; however, few studies have investigated this suggestion.

The effect of increasing the occlusal vertical dimension on the mandibular postural rest position was reported by Martin and Seev.[18] They suggested that the interocclusal space should be reestablished and adapted to increase the vertical dimension of occlusion after 1 month. In the present study, the subjects used occlusal splints only during sleep at night and for a short period. Therefore the subjects could not adapt to an increased vertical dimension. Wearing the S6 splint, which exceeded the interocclusal space more than the S3 splint, may have increased the frequency of contact between the mandibular teeth and the splint's surface. For these reasons, the EMG values got worse in some subjects.

When splint adjustments were performed, facets formed by bruxism during sleep were observed on the surface of the splints in all subjects. The facets left on the splints showed that the subjects were experiencing bruxism at that time, serving as further evidence that the subjects in this report had a habit of bruxism.[19]

The methods used to record bruxism are varied,[12,20–22] and an accepted, universal methodology has not yet been established.[23] Therefore, the stated purpose of this study was not to evaluate bruxism, but to evaluate muscle activities during sleep at night to study the influence of splint insertion on muscle activities in subjects with a bruxism habit. Facial pain can be experimentally induced by long-lasting or low-intensity clenching.[24] In this study, the whole EMG signal was recorded to study muscle load, as was done in most of the previous EMG sleep studies.[25]

The reproducibility of the EMG readings on different days was examined by a pilot study. Using the same method of attaching electrodes and the same EMG recorder used in this study, subjects were asked to perform maximal clenching at the intercuspal position, and EMG recordings were taken. These experiments were performed on 2 different days, and the same parameters as in this study were calculated. The coefficient of correlation of the integral values for the different assay dates was very high ($r = 0.9108$ to 0.9665) and there was no significant difference between the data for the different muscle activities. Therefore, the reproducibility of the EMG was thought to be very high.

It has been suggested that patients should wear splints continuously because muscle activities return to high levels if the patients stop using the splints, although activities decrease during night sleep through insertion after only a short time.[11,12] The period of splint insertion is long in many cases, and the effects of splints on muscle activities vary according to the period of splint insertion.[9] Therefore, further research is needed regarding the ideal duration of splint insertion.

Conclusions

It is desirable that muscle activities be decreased by occlusal splints. The abnormal force created by bruxism is destructive to teeth, periodontal tissue, masticatory muscles, and temporomandibular joints and causes muscle fatigue. Because the S3 splint decreases muscle activities, these destructive forces may be weakened and the muscle fatigue prevented. Therefore, the S3 splint was considered clinically useful. The S6 splint did not decrease muscle activities. Thus, within the limitations of this study, the S3 splint is superior to the S6 splint in its ability to reduce the EMG muscle activity of bruxism.

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