Perioral and dental perception of mechanical stimulus among subjects with and without awareness of bruxism

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We studied whether perioral and dental sensitivity to mechanical stimulation is changed in subjects with awareness of bruxism. Tactile detection threshold in the vermilion border of the lower lip and in the upper incisor was determined using calibrated monofilaments (von Frey hairs) and spatial resolution threshold of the lip was determined using a grating orientation task. The tactile detection threshold and the spatial resolution threshold in the perioral region were not significantly different between bruxers ($n = 7$) and asymptomatic control subjects ($n = 13$). Neither was the detection threshold for mechanical stimulation of the tooth different between bruxers ($n = 6$) and asymptomatic controls ($n = 6$). It is concluded that the tactile sensitivity of perioral region or the tooth is not significantly changed in subjects with awareness of bruxism. ☐ *bruxism; perioral skin; spatial acuity; tactile threshold; tooth*

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In sleep bruxism, rhythmic masseter contractions causing nocturnal teeth grinding and clenching typically occur during transition from delta sleep to lighter sleep (1–3). The mechanisms underlying bruxism are not well known, but recently we showed that bruxers have enhanced biting responses to submaximal loads (4). One explanation could be a disturbance in afferent input from the perioral and oral region, i.e., an inappropriate somatic signal evoked by a submaximal biting load might cause a disturbance in the somatomotor control of biting in bruxers, leading to an enhanced motor response. In the present study we determined whether bruxism is associated with sensory changes in the perioral or oral area which might cause abnormal somatomotor control of biting. For this purpose, we determined the tactile threshold in the perioral skin and the tooth, and the spatial resolution threshold in the perioral region in subjects with and without awareness of bruxism.

Materials and method

Subjects

In the first session of the study the tactile detection threshold and the spatial discrimination threshold in the perioral region were determined in the following group of bruxers and controls. The group of bruxers consisted of 7 subjects (6 M, 1 F; mean age 29.3 ± 2.6 years; ±SD). The control group consisted of 13 subjects (9 M, 4 F; mean age 30.4 ± 5.0 years). In the second session of the study the tactile detection threshold in the tooth was determined in 6 bruxers (4 M, 2 F; mean age 28.8 ± 10.0 years) and in 6 control subjects (4 M, 2 F, mean age 22.0 ± 7.8 years). The subjects in the first session were different from those in the second. All subjects had their natural dentition and symmetrical contacts between maxillary and mandibular teeth without malocclusion. The horizontal and vertical overlap of maxillary incisors was in the range 1–3 mm. The bruxers of this study were not experiencing spontaneous pain at the time of testing sessions. The study protocol was accepted by the Institutional Ethics Committee of the University of Turku. Informed consent was obtained from the subjects before the start of the experiments.

The bruxers reported episodes of teeth-grinding or teeth-clenching one to two nights or more per week. The diagnosis of sleep-related bruxism was clinically evaluated by a dentist using the minimal criteria of the International Classification of Sleep Disorders (2). The results of a recent polysomnographic study indicate that clinical criteria alone correctly predict the diagnosis in 83% of bruxers and in 81% of asymptomatic controls (1).

Sensory testing

A series of calibrated monofilaments (Stoelting, Wood Dale, IL) was used to assess tactile detection thresholds on the midportion of the vermilion border of the lower lip. Testing was performed on the right side of the face. The monofilaments used produced the following forces: 8, 15, 36 and 80 mg. Each monofilament was presented in descending order 5–10 times at intervals of 3–5 s. At each

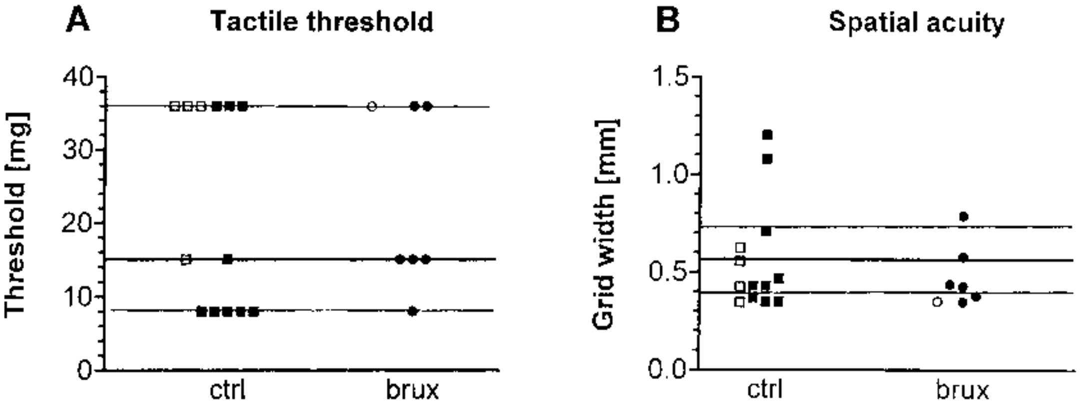

Fig. 1. A. Individual tactile detection thresholds in the vermilion border of the lower lip determined with monofilaments. The thick horizontal line indicates the median threshold over all control subjects, and the thinner lines the 25th and 75th percentiles of it. B. Threshold groove widths for discrimination of grating orientation in the vermilion border of the lower lip. The thick horizontal line shows the mean threshold over all control subjects, and the thinner horizontal lines the 95% confidence limits of the mean threshold. In both graphs, filled symbols indicate males and open ones females (■ ctrl males; □ ctrl females; ● brux males; ○ brux females).

presentation, the stimulus was applied to the lip for a duration of 1 s. The subject's task was to report immediately whether he/she felt a tactile sensation or not. The lowest stimulus force detected at a probability of ≥ 0.75 was considered the tactile detection threshold. Determination of the tactile detection threshold in the upper incisor was performed in a similar way using monofilaments producing the following forces: 0.745, 0.976, 2.35, 4.19, 4.64, 5.16 g. The monofilaments were applied at a 90° angle towards the labial midsection of the first incisor (d.11), crown surface, i.e. the stimuli were applied in a horizontal (lingual) direction. Because the stimuli were applied by hand, it was not possible to control the exact velocity of stimulus application. However, the same experimenter performed all stimulus presentations and tried to use the same velocity in all measurements. The monofilament was slowly positioned against the tooth, and after contact was observed between the tooth and the monofilament, the force was increased within about 0.5 s to the maximum (until the monofilament bend). Tapping of teeth was avoided, since in preliminary experiments it was found that tapping produced an auditory cue.

A series of rounded, circular (25-mm diameter) plastic blocks with square-wave gratings (JVP-Domes, Stoelting, Wood Dale, IL) was used to assess the spatial resolution threshold in the vermilion border of the lower lip (5–7). The test site was on the midportion of the lower lip and always on the right side. The blocks had grooves and bars of equal width. The widths of gratings used in this study were: 0.35, 0.5, 0.75, 1.0, 1.2 and 1.5 mm. Each trial consisted of applying a single stimulus in one of two orthogonal orientations (vertical or horizontal). The order of presenting different orientations was random. Subjects reported the orientation of the grating by pointing in the direction of the grooves and bars. Each width of grating was presented 5–10 times. The subjects' correct responses were plotted in psychometric function curves, i.e. the probability of correctly detecting the orientation of grating was plotted as a function of the width of the grating. The width of grating was determined from these psychometric function curves, the orientation of which was correctly detected at a probability of 0.75. This probability is commonly used as the criterion for threshold (5–7) and was considered the spatial resolution threshold of the subject. However, since in some previous studies the criterion for threshold has been set at the probability level of 0.82 (8), spatial resolution threshold was also determined at the probability level of 0.82 from the same psychometric function curves. It should be noted that the spatial resolution threshold corresponds with the two-point discrimination threshold, and is thus inversely correlated with the magnitude of the cortical representation of the skin area studied. Importantly, the spatial resolution threshold determined with the grating orientation method has proved to be more reliable and reproducible than that determined with the two-point discrimination method (5).

Statistics

Statistical evaluation of the data was performed using a parametric *t*-test (spatial resolution thresholds) or a non-parametric Mann-Whitney U-test (detection thresholds to monofilament stimulation). $P < 0.05$ (two-tailed) was considered to represent a significant difference.

Results

The median tactile detection threshold in the lower lip was 15 mg (range 8–36 mg, $n = 7$) in bruxers and 36 mg (range

8–36 mg, *n* = 13) in controls. Tactile detection thresholds were not significantly different between the bruxers and the control subjects (Fig. 1A). When the threshold criterion for correctly detecting the grating orientation was set to a probability level of 0.75, the mean spatial resolution threshold of the lower lip was 0.47 ± 0.16 mm (±SD, *n* = 7) in bruxers and 0.57 ± 0.29 mm in controls (*n* = 13). Spatial acuity was not significantly different between the bruxers and the controls (Fig. 1B). A change in the threshold criterion from the correct detection probability of 0.75 to 0.82 produced a significant increase in the mean threshold for spatial acuity from 0.57 ± 0.29 mm to 0.67 ± 0.25 mm in controls ($P < 0.01$). The median tactile detection threshold to monofilaments applied to the upper incisor was 4.19 g (range 2.35–4.64 g, *n* = 6) in bruxers and 4.19 g (range 0.976–4.64 g, *n* = 6) in controls. The tactile detection thresholds in the tooth were not significantly different between the bruxers and the controls (Fig. 2).

Discussion

The results of the present study indicate that tactile detection thresholds in the perioral region, as well as in the tooth, were in the same range in subjects with awareness of bruxism and asymptomatic controls. Interestingly, for both experimental groups the tactile detection thresholds in the lip were in the same range as the lowest activation thresholds for mechanoreceptive fibers innervating the human lip (9). This finding suggests that in the lip as well as in the finger tip (10) the threshold sensation may be evoked by single action potentials in mechanoreceptive fibers, whereas in less sensitive skin areas (e.g. hairy skin of the limbs) a considerable amount of central summation is needed for eliciting a tactile sensation (10). The detection of mechanical stimuli applied to the tooth could be based on activation of periodontal mechanoreceptors, intradental mechanoreceptive fibers, or both (11, 12). At a wide range of stimulus velocities the force threshold of most sensitive periodontal mechanoreceptive fibers stimuli appears to be in the range of tooth detection thresholds, whereas very high stimulus velocities (tapping) are needed to activate intradental mechanoreceptive fibers at the forces producing liminal mechanical sensation in the tooth (11, 12). Since in the current study tapping was not used, in order to avoid tapping-induced auditory signals, it is proposed that the tactile detection thresholds in the tooth were more likely due to activation of periodontal than intradental mechanoreceptors. Periodontal mechanoreceptors are considered to play an important role in sensorimotor control of biting force (13).

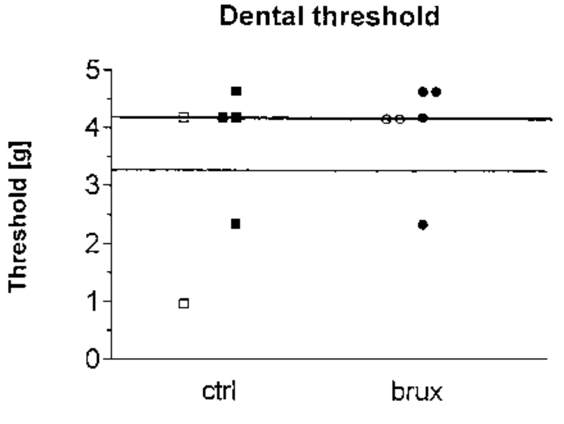

Fig. 2. Individual dental detection thresholds to mechanical stimulation in control subjects and bruxers. The thick horizontal line indicates the median threshold and the thin horizontal line the 25th percentile of it for control subjects. The 75th percentile overlaps with the median threshold. Filled symbols = males, open symbols = females (■ ctrl males; □ ctrl females; ● brux males; ○ brux females).

The spatial resolution threshold in the lip of subjects with symptoms of bruxism was in the same range as in control subjects of this study and also in the same range as previously reported in two earlier studies in healthy subjects (6, 7). In one previous study the spatial resolution thresholds in the lip of healthy subjects were higher (8); in that same study the spatial resolution threshold in the most sensitive part of the lip, the medial vermilion border of the lower lip, was 0.83 mm, whereas in other previous studies it has varied between 0.48 and 0.55 mm (6, 7). However, in the study reporting higher thresholds (8) the criterion for threshold was set at the correct detection probability of 0.82, whereas in other studies (6, 7) a lower probability of 0.75 was used as a criterion for threshold. The current results indicate that a change in criterion from the correct detection probability of 0.75 to 0.82 significantly increases the spatial resolution threshold from 0.57 to 0.67 mm. Thus, at least part of the difference in spatial resolution thresholds between these previous studies can be explained by a difference in the criterion used for determining the threshold. According to previous studies, wider gaps and bars are required for grating orientation discrimination in other skin areas (5). Earlier studies have shown that mechanoreceptors in the lip have small receptive fields (9) and a high innervation density (14). This may explain the high spatial acuity in the lip. Additionally, surround inhibition at central levels is likely to contribute to spatial discrimination. Interestingly, it has been shown earlier that in the finger tip (a skin area of the hand with a high spatial acuity) surround inhibition is stronger than in the hairy skin of the hand (a skin area with a lower spatial acuity) (15). In analogy, it might be speculated that surround inhibition for tactile input from the lip (a skin area with high spatial acuity) is strong—a phenomenon which would contribute to high spatial discrimination ability of the lip.

Our working hypothesis was that a change in processing of afferent signals might provide an explanation for our recent finding indicating that bruxers use inappropriately high forces to control submaximal biting loads (4). However, the present findings do not support this hypothesis, since mechanosensitivity in perioral skin or tooth was not significantly different between bruxers and asymptomatic controls.

Previous studies have shown that increased afferent input leads to an increase in the cortical representation of the skin area from which the afferent input originates (16). Spatial acuity is considered to be inversely related to the enlargement of cortical representation (17). Since bruxers have increased motor activity in the masseter muscles and, consequently, an increased afferent input from the oral and perioral area, it might be speculated that bruxers have changes in the cortical representation of perioral tissues. This might be reflected in the test of spatial acuity. However, as suggested by a test of tactile spatial resolution, this was not the case. There is evidence indicating that attention to the increased afferent input may be required for the enlargement of cortical representation (16). In bruxers, teeth grinding and jaw clenching typically occur while the subjects are sleeping. Moreover, the increased afferent input due to increased masseter activity has no information content to which the subject is likely to focus his attention even when awake. For these reasons, it is understandable that in spite of an increased afferent input caused by teeth grinding the cortical representation of perioral and oral tissues was not subject to plastic changes in bruxers.

Interestingly, one previous study has shown that the threshold for detecting electrical stimulation in the face is not significantly changed in temporomandibular disorders (18). However, two recent studies have reported a slightly increased vibrotactile detection threshold (19) and a decreased capacity for vibrotactile frequency discrimination (20) in painful temporomandibular disorders but not in non-painful subjects. These findings raise the possibility that also in bruxers the perception of perioral and oral mechanical stimulation might be modified if they are experiencing pain at the time of testing, unlike bruxers of the present study who did not have spontaneous pain during testing sessions.

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