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Sleep bruxism in individuals with and without attrition-type tooth wear: An exploratory matched case-control electromyographic study

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ABSTRACT

Objectives: To examine if there is a difference in possible sleep bruxism activity (SB) in subjects with or without attrition-type tooth wear.
Methods: Sixteen individuals with pronounced attritional-type tooth wear were compared with sex and aged matched controls without tooth wear by means of measurement of electromyographic (EMG) activity during a minimum of four consecutive nights of sleep. Mean age and range for the study- and control- group was 23.7 years (range 19.9–28.5) and 23.6 years (range 20.3–27.9), respectively. There were 11 females and five males in each of the two groups. The attrition group presented incisal/occlusal attrition wear into dentin and matching wear facets between opposing anterior teeth. The controls had negligible signs of incisal/occlusal wear and a minimal number of matching wear facets.
Results: The prevalence of both self-reported and partner-reported SB was significantly more common in the attrition group compared to the controls ($P = 0.04$ and $P = 0.007$, respectively). Self-reported morning facial pain was similarly more common in the attrition group ($P = 0.014$). Maximum opening capacity, number of muscles painful to palpation, salivary flow rate and buffering capacity were not significantly different between the groups. Interestingly, none of the measures of jaw muscle EMG activity during sleep, as recorded by the portable EMG equipment, differed significantly between the attrition group and the matched controls ($P > 0.05$).
Conclusions: The results from this exploratory study suggest that there is no difference in EMG activity between subjects with and without attrition-type tooth wear. Further research is needed in order to substantiate these preliminary findings.

1. Introduction

Bruxism can be defined as a repetitive jaw-muscle activity characterized by clenching or grinding of the teeth and/or by bracing or thrusting of the mandible. Bruxism has two distinct circadian manifestations: it can occur during sleep (indicated as SB) or during wakefulness (indicated as awake bruxism: AB) [1]. Sleep bruxism (SB) is considered a normal functional habit that under certain circumstances may have serious consequences, as for example tooth wear, deterioration of dental restorations or orofacial pain [2]. In the current literature, the prevalence of reported SB varies considerably but manifest bruxism is estimated to about 10% in the population [3]. Clinical signs or subjective symptoms of SB are neither always present, nor evident, and no specific factors seem to be responsible for its etiology [4,5].

Due to the complex etiology of SB, diagnosis requires the usage of several measures and tools. This may include history taking, examination for clinical signs and an electromyographic recording (EMG) of the masticatory muscle activity of the sleeping patient. Polysomnography (PSG), including audio and video monitoring, is considered a gold standard as a diagnostic tool in SB but can be complicated at the practical level since several night recordings ideally should be made in order to detect its fluctuations [1,4,6]. Therefore, portable EMG equipments have been developed to be used in SB assessment [7–9] but their validity in relation to PSG

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may still be questionable [10]. One of these portable equipment on the market (Grindcare Measure®, Medotech A/S, Copenhagen, Denmark) has been used in the present study as an indicator of SB diagnosis [11–13].

Attrition type of tooth wear featuring matched, sharp and clearly demarcated wear facets between opposing teeth, have anecdotally been believed by many dental professionals to be associated with SB. Such a presumption may lead to different flaws in treatment planning and in restorative and other treatments prescribed for the specific patient. SB alone may not be the sole cause of such faceting and is more likely the result of a combination of different wear-promoting causative factors [14,15].

It should be emphasized that the clinical diagnosis of SB is associated with considerable diagnostic uncertainty, which has prompted the suggestion of a grading system [1]. This diagnostic grading system takes into account the methods and their validity to determine the presence of SB. Three levels have been proposed: "possible", "probable" and "definitive". "Possible" AB or SB is based on "self-reports" using the history or questionnaires. "Probable" AB or SB will be the same as for "possible" plus the outcome from the clinical examination, e.g. tooth wear or hypertrophic jaw muscles. "Definitive" will be the same as "probable" plus evidence from a PSG study following the gold standards for SB while for AB it was proposed to use the criteria for "probable" plus ecological momentary assessment of EMG.

The objective of this study was to assess EMG activity in individuals with attrition-type tooth wear compared to an age- and sex-matched control group having none or minimal such wear. The hypothesis was that there is no difference in SB activity, evaluated by portable home ambulatory EMG equipment, in subjects with or without attrition-type tooth wear.

2. Material and methods

2.1. Sample size estimation and selection of participants

The sample size was based on the EMG activity and calculated with risk of type I and type II errors of 5% and 20% respectively and an estimate of the inter-individual variation of EMG measures set to 40% [16] and a minimal relevant difference to detect between the paired observations of 40% [11]. The EMG parameter "bites per hour" was the primary outcome and the other EMG parameters were secondary outcomes. Thus, the sample size comprised 16 participants in each group and all recruited from dental and dental hygienist students at the Department of Clinical Dentistry.

One hundred and eighty seven students were initially screened for tentative inclusion in the study by two of the investigators (CJ, PAH). Sixty-eight students were selected for a more extensive examination. In this examination, three additional examiners experienced in tooth wear examinations (AJ, AKJ, MB) participated in medical history-taking and clinical examination. All tentative participants were interviewed about dietary habits (current and previous), general and oral health, awareness of tooth grinding or tooth-clenching, headache/facial pain, muscles and dryness of the mouth. Supplementary intraoral examination regarding tooth wear/dental erosion and abrasion was conducted and intraoral photos were taken. Based on this, and in a closed discussion, the five examiners evaluated photos and the collected information for the final selection of participants, which comprised 16 participants for the attrition group and 16 sex and aged matched controls with none/minimal wear.

Final inclusion criteria for both groups included informed consent, good general health and a complete or almost complete dentition. The attrition group exhibited a severity of incisal/occlusal attrition of grade two or higher (wear into dentin, Table 1) and matching wear facets between opposing anterior teeth and matching contact relationship between opposing teeth in horizontal tooth-guided movements. The controls showed no obvious signs of incisal/occlusal wear (maximum grade 1, Table 1) [17] and a minimal number of matching wear facets and non-matching contact relationship between opposing teeth in horizontal tooth-guided movements. Typical cases representing the degree of wear in the attrition and control groups are shown in Figs. 1 and 2.

For both groups the following exclusion criteria were applied: Suspicions that the trial participant cannot or will not follow the trial procedures, pacemaker, cochlear implant, documented or suspected local irritation caused by electrode gel. Participants with clinical features of erosive or abrasive wear affecting any of the incisal, occlusal, buccal, palatal (lingual) or proximal surfaces were excluded (Table 2) [18]. In this regard, the participants were examined by the five operators for specific changes of the anatomical landmarks at typical predilection sites for dental erosion, i.e. palatal and buccal surfaces of teeth 13–23 and cuppings on the mesiobuccal cusp of the first mandibular molar [19]. Exclusion also applied if there was a suspicion of hypo-salivation, a high-risk erosive diet or general diseases known to be associated with tooth wear.

2.2. Clinical examination

The Research Diagnostic Criteria for Temporomandibular disorders (RDC-TMD) questionnaire, translated into Norwegian, and the RDC-TMD clinical examination form were used for all participants in both groups [20]. Partner-reported bruxism was assessed by the question "has someone you live with told that you grind your teeth". Assessments of occlusal and incisal wear were made on a tooth-by-tooth basis using ordinal scales (Table 1) by one of the investigators (CJ) after a period of examiner training and calibration.

Resting saliva was collected for 15 min and paraffin-stimulated saliva for 5 min and pH and a buffer capacity measurement were carried out (ColorpHast®, EMD Millipore, Billerica, MA, United States and Dentobuff® Strip, Orion Diagnostica, I-02101 Espoo, Finland). Saliva collection and analyses were performed according to the guidelines at the Department of Dentistry and manufacturers' instructions.

Table 1
Ordinal scale used for grading severity of occlusal/incisal wear without reference to a presupposed cause [17].

Grade	Criteria
0	No visible facets in enamel. Occlusal/incisal morphology intact
1	Marked wear facets in enamel. Occlusal/incisal morphology altered
2	Wear into dentin. Dentin exposed occlusally/incisally and/or adjacent tooth surface. Occlusal/incisal morphology changed in shape with height reduction of tooth
3	Extensive wear into dentin. Larger dentin area (>2 mm^2) exposed occlusally/incisally and/or adjacent tooth surface. Occlusal/incisal morphology totally lost locally or generally. Substantial loss of crown height
4	Wear into secondary dentin (verified by photographs).

Fig. 1. Typical examples of individuals in the attrition group. (A) 21 year old man with marked attritional wear facets matching between opposing teeth in lateral excursion. (B) 26 year old woman with an almost perfect match between maxillary and mandibular incisors during protrusive movement. Note also the sharply demarcated wear facets extending into dentin on lower incisor teeth.

2.3. EMG measurement

GrindCare Measure is a portable, single-channel EMG device for the measurement of SB. It has a build-in algorithm setting with a threshold and can record SB events in relation to EMG activity. It is battery operated and the device has been developed in accordance with applicable patient safety rules. The EMG activity of the anterior temporal muscle (unilaterally) is recorded. The patient is able to use the device in his/her own home during sleep. The GrindCare Measure was calibrated according the manufacturer's instructions and each participant was carefully taught how to manage the device. Written instruction were also given. A minimum of four night's error-free recordings was required for the participants in both study groups.

The data from GrindCare Measure recordings was transferred to a PC using the software Grindcare Manager (Medotech A/S, DK) and include the following parameters. *Grinds:* EMG activity with duration of more than 0.1 s with amplitude higher than 20% of the maximum EMG level during setup. Each grind is defined to last for one second. *Bursts:* EMG activity with duration of more than 0.25 s, with amplitude three times larger than the background level. A phasic burst is defined by EMG activity of 0.25 s to two seconds duration. A tonic burst is defined as EMG activity lasting more than two seconds. Only bursts that are part of an episode are counted.

Fig. 2. Typical examples of individuals in the control group. (A) 24 year old woman with minimal degree of wear facets and non-matching anterior teeth in lateral excursion, canine guidance only. (B) 25 year old man with similar features.

Table 2
Ordinal scale used for grading severity of dental erosion on buccal and lingual surfaces of maxillary anterior teeth [18].

Grade	Criteria
0	No visible changes, developmental structures remain, macro-morphology intact
1	Smoothened enamel, developmental structures have totally or partially vanished. Enamel surface is shiny, matt, irregular, "melted", rounded or flat, macro-morphology generally intact
2	Enamel surface as described in grade 1. Macro-morphology clearly changed, facetting or concavity formation within the enamel, no dentinal exposure
3	Enamel surface as described in grades 1 and 2. Macro-morphology greatly changed (close to dentinal exposure of large surfaces) or dentin surface exposed by $\leq$1/3
4	Enamel surface as described in grades 1, 2 and 3. Dentin surface exposed by >1/3 or pulp visible through the dentin.

Note: Approximal erosion and presence of "shoulder" should be recorded.

Episodes: Three different types of episodes can be defined: Phasic, tonic or mixed. A phasic episode is defined by at least three phasic bursts separated by two inter-burst intervals (at least 3 s each). A tonic episode is defined as one or more tonic bursts also separated by two inter-burst intervals. A mixed episode is a combination of phasic and tonic bursts. *Intensity:* Intensity is the total area under the EMG curve, for all bursts being part of an episode, summed up over one night, measured in mV $\times$ s (seconds). The intensity is a

measure of the entire workload of the muscle overnight. *Duration:* Duration is the average duration of every burst of an episode, recorded during the whole night, measured in seconds.

The study was submitted to the local/regional committee for Medical and Health Research Ethics (REK-vest) and approved (ref. nr.: 2012/388 A).

2.4. Statistical methods

The following variables from the EMG measurement/Grind Care Manager were used for both the descriptive and inferential analysis: treatment time, total bites, bites per hour, total bursts, bursts per hour, average burst duration, total episodes, episodes per hour. The processed EMG data were averaged for each of the parameters and during all nights (minimum four nights) for each patient. Differences between groups were tested by means of Wilcoxon Signed Ranks Test. The level of statistical significance was set at $P < 0.05$.

3. Results

A total of 187 dental students and dental hygienist students were screened (133 females, 54 males) in order to select the final 32 participants. Mean age, range and SD for the study and control group was 23.7 years (range 19.9–28.5, SD 2.5) and 23.6 years (range 20.3–27.9, SD 2.1), respectively. There were 11 females and five males in each of the two groups. The (mean) age difference between the matched pairs was 7.6 months (range: 17–29 months). Two pairs had equal age, eight were older and six were younger in the control group compared to their counterparts in the attrition group.

The prevalence of self-reported and partner-reported SB were significantly higher in the attrition group compared to controls ($P = 0.004$ and $P = 0.007$, respectively) (Fig. 3). If combined, 11 out of 16 individuals in the attrition group presented self- or partner reported sleep bruxism compared to none in the control group. Self-reported morning facial pain was similarly more common in the attrition group ($P = 0.014$) (Fig. 3). The distribution of wear scores (graded according to Table 1) are shown in Fig. 4. The majority of participants in the attrition group had grade 1 and 2 score while in the control group it was grade 0 and 1. The wear scores between the groups differed significantly ($P = 0.001$). Maximum opening capacity, number of muscles painful to palpation, salivary flow rate and buffering capacity (in both resting and stimulated saliva) were not significantly different between the groups. EMG parameters according to GrindCare measurements are shown in Table 3. None of the variables differed significantly between the attrition and control group ($P > 0.05$).

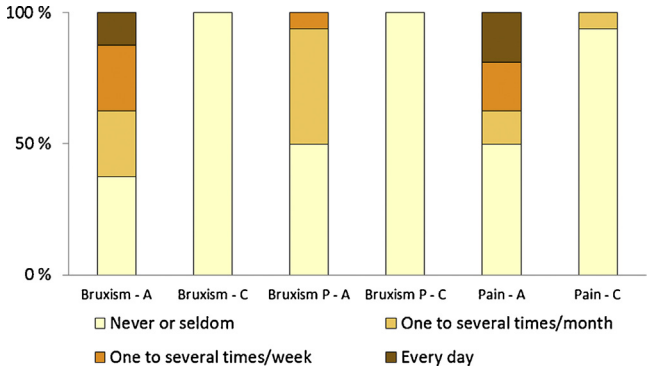

Fig. 3. Frequency distribution of self-reported SB (Bruxism), SB reported by partner (Bruxism P) and pain in the morning (Pain M) in the attrition- (A; $n = 16$) and control- (C; $n = 16$) group.

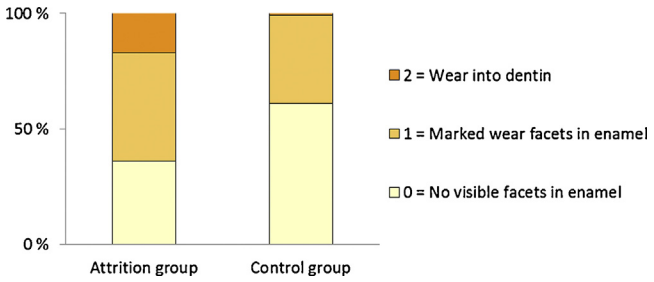

Fig. 4. Wear scores on all teeth ($n = 448$/group) in the attrition and control group.

4. Discussion

According to the proposed criteria for sleep bruxism, the attrition group in this study did not fulfill the criteria for neither possible, probable nor definitive bruxism [1]. "Possible" includes self-report of bruxism but only 11 of the 16 participants in the attrition group answered affirmative to the question of night time grinding. "Probable" should in addition to self-report, comprise a positive finding in the "inspection part of a clinical examination" e.g. tooth wear, which all the participants in the attrition group fulfilled. Consequently, the attrition group in this study falls somewhere in between the two definitions. In this paper we have used the term "possible sleep bruxism" based on EMG findings and thus in a broader context compared to the suggested definition.

According to the inclusion and exclusion criteria, it was not difficult to select healthy participants, with (almost) complete dentition attending the dental school. In all classes, the majority of students are females which was reflected in the distribution of trial participants (22 females, 10 males). A more even gender distribution would have been preferable but as the study and control groups were matched in gender and age, the uneven distribution is deemed acceptable. It has also to be emphasized that this student population, who all attending a dental school, is probably "biased" in terms of self-report compared to a community-based population. In this respect, they are more informed than an ordinary layperson would be when responding to several of the items included in the questionnaire examination.

Tooth wear including matching wear facets is by many dentists considered a prerequisite for the clinical diagnosis of SB [5,14]. However, a comorbidity of tooth wear caused by dental erosion should most likely have complicated the picture as this condition may accentuate the development of wear facets [15]. Therefore, each individual in the attrition and control group was carefully screened for possible erosive influences by a meticulous clinical examination and recording of medical and present/past dietary history. Individuals with clinical signs of dental erosion or reported findings in terms of dietary habits or diseases possibly related to erosive wear were thus excluded. In order to be included in the attrition group a minimum of grade 2 on anterior teeth (wear extending into dentin) on anterior teeth was required (Table 1). This is a relatively mild degree of wear but detecting more severe (attritional) wear among young individuals, especially if erosive influence has to be excluded, is difficult and especially so on posterior teeth. It was also ensured that the wear facets were matching in between the opposing teeth, thus indicating that attrition was the main causative factor. A high number of students had to be screened in order to find individuals fulfilling the inclusion criteria for the attrition group but we could relatively easy find those who fulfilled the criteria to be included in the control group. Gender matching of the study and control group was easy because of the relatively high number of tentative controls. Age matching presented somewhat more of a challenge. There was a relatively large initial selection of controls so each individual in

Table 3
EMG variables in the attrition group ($n = 16$) and control group ($n = 16$).

	Attrition group				Control group		
	Median	Range	IQR	*P*	Median	Range	IQR
Treatment time[a]	7.2	5.6–8.2	1.3	0.76	7.2	4.6–8.9	1.1
Total bites	107.2	31.3–212.0	94.2	0.72	124.0	11.3–473.5	85.2
Bites per hour	13.4	4.6–25.8	12.7	0.96	16.7	1.6–56.4	10.5
Total bursts	137.2	57.8–313.3	156.1	0.20	118.0	23.7–438.8	132.7
Bursts per hour	19.3	8.3–39.6	18.3	0.18	15.5	3.4–47.9	13.8
Average burst duration	1.4	0.8–2.6	0.6	0.50	1.4	1.0–3.0	0.4
Total episodes	37.9	12.6–69.5	24.4	0.12	30.6	7.0–84.2	18.8
Episodes per hour	5.2	1.5–8.3	3.0	0.12	4.2	1.1–9.3	2.2

IQR = Interquartile range.
[a] Number of nights.

the attrition group could be paired with two or more controls. The final selection of matching control was based on closest age, minimum erosion/negative dietary factors and minimal tooth wear/matching opposing wear facets. Although the average age difference was relatively small (7.6 months) there was a considerable greater range (17–29 months). However, this age discrepancy between the matched pairs is unlikely to affect the differences between the variables reported on in this study (EMG activity, clinical and salivary parameters and self-reported SB/pain). Study casts and clinical photos together with a clinical assessment will provide an appropriate baseline reference point for the assessment of the severity of tooth wear, for reviews see references [21–23]. Although we did not use study cast analyses in this study, it is felt that this was compensated for by the relatively high number of examiners/researcher involved in the clinical examination who all were experienced in tooth wear studies.

The golden standard for diagnosing SB is polysomnography (PSG) with audio-video recordings [6]. PSG is however complicated, costly and time consuming, and is therefore difficult to use for several nights in order to detect fluctuations in SB intensity and frequency. Portable equipment (e.g. GrindCare) as used in the present study for SB diagnosis based on EMG measurements has been developed during recent years claiming in some aspects a corresponding accuracy to that of PSG [24–26]. A tentative exception could however be the Bruxoff device which has shown a reasonably good diagnostic accuracy [10] and a single channel EMG may serve as good proxy [24].

Ambulatory EMG devices will contain false-positive results because artefacts from movements, scratching skin, swallowing and such events may influence the EMG recording (unless taken out based on visual inspection during the EMG recording). This probably leads to an overestimation of the EMG activity in comparison to that recorded with PSG but maximum EMG activity may not be affected [12]. On the other hand, ambulatory EMG is able to record many nights and may therefore provide a better insight into the natural fluctuating of the EMG level, which probably is true for SB as well. Other factors that may have influenced the EMG recordings are the set-up procedure and that the placement of the EMG electrode may have differed between repeated recordings [16]. In this study, all participants were carefully instructed and trained in the use of the ambulatory EMG device prior to the registrations. In addition, they were all dental/dental hygienist students and showed great interest to the study, which made them promptly try to manage technical problems (e.g., lost electrodes) and compliance issues. The average usage of the EMG device was seven nights (minimum four nights) which is considered to be a good compliance.

The majority of studies reporting on the association between bruxism and tooth wear are based on self-report and often reflects the opinion of the patient's dentist and several reports have stated that diagnosis of SB based on self-report is unreliable [5,27,28]. As a consequence, the many studies reporting on a positive correlation between severity of wear and self-reported bruxism are subjected to bias. An exemption to the foregoing was seen in a study by Seligman et al. [28] where it was found that awareness of bruxism had no correlation to wear scores and that the severity of wear should not be used as a diagnostic feature of bruxism [29], a finding which was confirmed in a later study [30]. A similar finding was reported in a large epidemiological study, where the contribution of self-reported bruxism to the presence of tooth wear was not more than 3% [31]. By measuring SB activity by an intra-splint bruxing detection system in 30 year olds in Japan, the severity of tooth wear was not associated by bruxism activity [32]. In another study it was concluded that erosive wear, and not attritional, was the likely cause of tooth tissue loss despite that the patients had a clinical diagnosis of bruxism [33]. In longitudinal studies of tooth wear, other factors than bruxism have been found to be associated to the progression of the wear [17,34].

In one report, moderate to severe sleep bruxers (scored by PSG) showed little tooth wear and those with little muscular activity showed more tooth wear [4]. Another study where SB was recorded over two consecutive nights with PSG, the presence of tooth wear could to some extent discriminate bruxers from non-bruxers. Its diagnostic value was deemed as modest because the severity of SB could not be detected. It was therefore stated that caution should be applied when using tooth wear as an indicator of SB [35]. In a recent study, and based on a one-night video-PSG recording, individuals with tooth attrition showed significantly higher number of rhythmic masticatory muscle episodes. However, the sample size was small with no controls and it was unclear how attrition was diagnosed in relation to other wear conducive factors [36].

Consequently, the presence of tooth wear should not be used for diagnosis of SB at least not in this age group with relatively mild attritional-type of wear. In this study, ongoing/active EMG activity was recorded and it cannot be ruled out that previous periods of SB and possible more severe activity in the attrition group could be responsible for the observed tooth wear. The results cannot be applied to other population groups or to cases suffering from more severe wear, which may have different and additional wear-conducive factors working concurrently. Based on the results from this study and from other reports, it seems likely that SB is an overestimated causative factor in tooth wear and that other contributions, and especially from that of dental erosion, may be far more important [5,14,15].

Another finding in our study was that the attrition group reported significantly more SB than the controls despite that the groups' EMG activity did not differ. This further supports the above discussion about the unreliability of self-reported SB. The attrition group did however report significantly more morning pain than the controls. It is difficult to find any plausible explanation to this finding and the relationship is most likely not causal but rather coincidental. In this regard, it has been convincingly stated in a

recent systematic review that "Anterior tooth wear was not found to be a major risk factor for TMD" [37]. In addition, it has been strongly stated that "the common belief that SB is a sufficient explanation for myofascial TMD should be abandoned" [38].

5. Conclusions

Individuals with attrition-type tooth wear did not have greater EMG activity during sleep than matched controls. This suggests that the clinician cannot use the presence of tooth wear as a direct indication of active sleep bruxism. More research is however needed in order to substantiate these preliminary findings. The hypothesis that there is no difference in SB activity as evaluated by portable home ambulatory EMG equipment, in subjects with or without attrition-type tooth wear was supported.

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