Bruxism in Children: Effect on Sleep Architecture and Daytime Cognitive Performance and Behavior

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Study Objectives: Sleep bruxism is an involuntary mandibular movement with tooth grinding during sleep. The prevalence of sleep bruxism in children is high and may lead to frequent arousals with altered daytime functioning. We investigated the sleep architecture, the incidence of gastroesophageal reflux, and the daytime cognitive behavioral functioning in a group of children with sleep bruxism.

Design-Patients: This prospective pilot study included 10 children. Polysomnographic data with pH-probe analysis was compared with 10 age- and sex-matched controls. Each patient completed a dental evaluation, a nighttime polysomnogram, and cognitive behavioral tests (Kaufman Brief Intelligence Test and Achenbach Child Behavior Checklist).

Results: Eight of 10 children had clinically significant bruxism and the 2 remaining patients had recent teeth exfoliation. There was no difference on sleep architecture between patients and controls, except for a higher arousal index for the bruxism group (36.7 vs 20.7, $p < .007$). Sleep bruxism occurred more frequently in stage 2 and rapid eye movement sleep, with arousals in 66% of the cases. There was no relationship of bruxism to gastroesophageal reflux or intelligence. However, 40% of the patients had elevated scores on the Achenbach Child Behavior Checklist, indicating significant attention and behavior problems, and there were moderate correlations between the arousal index and several of the behavior-problem scales from the Achenbach Child Behavior Checklist (0.5 to 0.6).

Conclusions: The data suggest that children with bruxism have a higher arousal index, which may be associated with an increased incidence of attention-behavior problems. Future studies investigating pediatric sleep bruxism will need to focus on behavior issues that may be prevalent in this population.

Keywords: Sleep, bruxism, children, behavioral, cognitive

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INTRODUCTION

SLEEP BRUXISM IS AN INVOLUNTARY MANDIBULAR MOVEMENT WITH TOOTH GRINDING OR CLENCHING OCCURRING DURING SLEEP THAT CAN LEAD TO several dental, oral, and facial complications.[1] According to the American Academy of Sleep Medicine, the diagnosis of sleep bruxism is based on the report of tooth grinding or clenching in combination with at least 1 of the following signs: abnormal tooth wear, sounds associated with bruxism, and jaw muscle discomfort.[2,3] Sleep bruxism is reported in up to 20% of children younger than 11 years of age.[1] This is probably an underestimate and may indicate only clinically significant bruxism. The prevalence decreases with age.

Polysomnography studies in adults have investigated the sleep architecture in patients with bruxism. Whereas most adult studies have found no difference in the percentage of different sleep stages in patients with bruxism as compared with controls,[3-5] others have reported a shorter rapid eye movement (REM) latency, a decreased percentage of REM sleep, and an increase in the number of sleep transitions.[6] Adult studies have shown that sleep bruxism occurs mainly during stages 1 and 2 of non-REM sleep and REM sleep and to a lesser degree in stage 3 and 4 of non-REM sleep.[1,5,7] In adults, episodes of sleep bruxism are frequently accompanied with brief arousals.[1,5] In addition, a recent study in adults has linked bruxism with gastroesophageal reflux disease (GERD).[8,9] Frequent arousals in children related to obstructive sleep apnea have been correlated with problems in behavior regulation, attention, and executive functioning.[10] To our knowledge, however, there has been no study to evaluate the sleep architecture, incidence of arousals, relationship to GERD, or daytime cognitive and behavior functions in children with bruxism.

The objectives of this study are to investigate the sleep architecture of children with bruxism, to evaluate the presence of GERD as a cause of bruxism, and to assess the daytime behavior and cognitive impact of bruxism.

METHODS

This prospective study was approved by the Institutional Review Board of Drexel University School of Medicine at St. Christopher's Hospital for Children. Children between 5 to 18 years of age referred to the sleep or dental clinic for complaints of grinding sounds during sleep (bruxism) and abnormal tooth wear were offered the opportunity to enter the study. Ten patients with bruxism were recruited. Inclusion criteria included frequent tooth grinding with bruxism sounds occurring at least 3 nights per week for the last 6 months, as reported by the caretakers, and at least 1 of the following clinical criteria: observation of tooth wear or shiny spots on restorations, report of morning masticatory muscle fatigue or pain, or masseteric muscle hypertrophy upon digital palpation. Dental wear was evaluated based on the criteria by Johansson (Figure 1).[11] Teeth were scored by groups, and group scores were added in each patient to form a composite. Patients

Disclosure Statement

This is not an industry supported study. Drs. Herrera, Valencia, Grant, Metroka, Chialastri, and Kothare have indicated no financial conflicts of interest.

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Figure 1—Dental wear was evaluated based on the criteria by Johansson (Form).[11]

Form—DENTAL EVALUATION

Name:____________________________________

Age:_______ years

Date of examination:_____________

1. Tooth wear evaluation (Johansson)[11]:

	Maxillar				Mandibular			
Severity of wear	**Molar**	**Premolar**	**Canine**	**Incisors**	**Molar**	**Premolar**	**Canine**	**Incisors**

0. No visible facets in the enamel. Occlusal/incisal morphology intact.
1. Marked wear facets in the enamel. Occlusal/incisal morphology altered.
2. Wear in to the dentine. The dentine exposed occlusally/incisally or adjacent tooth surface. Occlusal/incisal morphology changed in shape with height reduction of the crown.
3. Extensive wear in to the dentine. Larger dentine area (>2mm^2) exposed occlusally/incisally or adjacent tooth surface. Occlusal/incisal morphology totally lost locally or generally. Substantial loss of crown height.
4. Wear in to secondary dentine.

2. Tooth hypermobility	YES	NO
3. Tooth fractures secondary to bruxism	YES	NO
4. Pulpal involvement	YES	NO
5. Morning fatigue or pain of masticatory muscles	YES	NO
6. Pain to palpation to masseter/temporal muscles	YES	NO
7. Masseter hypertrophy	YES	NO
8. Patient/parent reports click when opening TMJ or is positive at exam	YES	NO

were excluded from the study if they had a history of obstructive sleep apnea, periodic leg movements, gross malocclusion, mental retardation, autism, cerebral palsy, epilepsy, presence of dental prosthesis, or were under the effect of a medication that could affect sleep activity such as benzodiazepines. Teeth exfoliation was defined as the process of elimination of primary teeth associated with the eruptive process of the permanent successor.

Each patient completed a brief neurocognitive battery that included the Kaufman Brief Intelligence Test and (K-BIT)[12] and the Achenbach Child Behavior Checklist (CBCL).[13] The K-BIT is an individually administered standardized psychometric test measure that provides an estimate of a child's verbal and nonverbal cognitive skills, which are then used to compile a composite intellectual score. The K-BIT is reported with a mean score of 100 as normal and a standard deviation of ± 15.

The CBCL is a self-administered, parent-report measure used to assess parental perceptions of a child's competencies and behavioral and emotional functioning. We have included the results from general externalizing and internalizing composite scales used to screen for problem behaviors, and individual DSM-Oriented (Diagnostic Statistical Manual) problem behavior scales. The results are given as T scores, with scores of 65 and below considered to be in the normal or expected range in comparison with same-age peers. T scores above 65 are considered to be in the borderline to clinically significant range, as these scores occurred in less than 10% of the normative sample population of same-age peers. CBCL questionnaires were administered to all participating families during their clinic visit, and families were permitted to return questionnaires by mail or finish them by phone if there was insufficient time to complete them during their visit.

A multichannel digital polysomnogram (PSG) was performed according to the American Academy of Sleep Medicine guidelines.[14,15] It included 8 channels for standard electroencephalography, 2 for electrooculogram, chin electromyography (EMG), chest and abdomen belts, nasal thermistor and pressure transducer, anterior tibialis EMG and 2 channels for left and right EMG

Table 1—Sleep Variables of Children with Bruxism and Age- and Sex-Matched Controls

Sleep Characteristic	Patients	Controls	p Value
Sleep stage, %			
1	2.5 ± 1.2	2.7 ± 1.6	NS
2	45.2 ± 9.9	44.7 ± 9.9	NS
3	4.9 ± 1.7	4.8 ± 2	NS
4	17.3 ± 5.7	19.7 ± 4.9	NS
REM	16.6 ± 3.8	17.7 ± 9	NS
Sleep latency, min	26.9 ± 25.6	15.7 ± 14.8	NS
REM latency, min	171.7 ± 81	134.5 ± 49	NS
Sleep efficiency, %	82.2 ± 13	86.8 ± 9	NS
Total sleep time, min	377 ± 62	378 ± 86	NS
AHI, no./h	0.27 ± 0.28	0.15 ± 0.22	NS
PLM index, no./h	0.01 ± 0.03	0.02 ± 0.06	NS
Arousal index, no./h	36.7 ± 15	20.7 ± 6	.007

Data are presented as mean ± SD. REM refers to rapid eye movement sleep; AHI, apnea hypopnea index; PLM, periodic leg movement.

masseter activity, electrocardiogram, pulse oximetry, and $PetCO_2$ (value and wave form). Patients also had a pH-probe testing done for evaluation of GERD as part of the PSG. Microphone and video recording were also obtained to assess and validate EMG-scored bruxism episodes. Prior to the PSG, the level of masticatory muscle contraction was recorded as explained by Lavigne et al:[3] 3 levels of voluntary contractions at maximum (100%), moderate (50%), and light (20%) were evaluated at maximum intercuspal occlusion. Other movements were also recorded for differential diagnosis at the time of the scoring: lateral and protrusive jaw movements, swallowing, and coughing.

For analysis, only masticatory EMG potentials of at least 20% of the maximum voluntary contraction during sleep were scored as bruxism.[3] EMG events were divided in to 3 different types:[3] tonic (sustained muscle contraction), phasic (rhythmic muscle contraction), and mixed (both sustained and rhythmic). A phasic episode corresponded with at least 3 EMG bursts of 0.25 to 2 seconds in duration separated by 2 interburst intervals. A tonic episode corresponded to an EMG burst lasting more than 2 seconds.[3]

PSG recordings were reviewed and scored with the Rechtschaffen and Kales Criteria[16] by a certified sleep technologist who was blinded to the patient's group. Sleep bruxism and associated arousals were rescored by 2 independent investigators (SK, IV). Arousals were scored using specific criteria.[17] For scoring, apnea was defined as a complete cessation of airflow and hypopnea as a 50% reduction of airflow, both lasting at least 2 respiratory cycles. Obstructive sleep apnea was defined as an apnea-hypopnea index of 1.5 or more per hour.[18]

The 10 patients in this study each completed their dental evaluation, short cognitive and behavioral test battery, and PSG. Ten age- and sex-matched controls who had no history of bruxism and normal PSGs were obtained from the sleep database. Their data were used to compare sleep staging and arousal index with the 10 patients with bruxism recruited for this study.

The statistical significance was determined with 2-tailed t tests using SPSS statistical software (SPSS, Inc., Chicago, IL). Two-tailed Pearson correlations were also obtained between the cognitive and behavior variables, sleep-related variables, bruxism variables, and dental composite scores. Due to the nonlinear correlation between the KBIT scores and the CBCL, nonlinear regression analyses were performed between them. A p value < .05 was set as the statistically significant level.

Table 2—Bruxism Polysomnography Characteristics in 10 Children with Sleep Bruxism

Characteristic	
Bruxism episodes, no.	36 ± 25.7
Time of bruxism, sec	136.8 ± 98.6
Duration of mean episode, sec	4 ± 1.6
Bruxism Index, no./h	6 ± 5
Bruxism Arousal Index, no./h	3 ± 2
Episodes of bruxism, based on type, %	
Phasic	40.7 ± 30.1
Tonic	20.8 ± 20
Mixed	38.5 ± 27.1
Occurrence during sleep stage, %	
1	11.7 ± 16.2
2	46.3 ± 26.4
3	3.2 ±4.7
4	12.5 ±11
REM	26.3 ± 20.8
Episodes associated with sleep phenomena, %	
Arousals	66.7 ± 28.5
PLM	10.5 ± 15.4
Light snoring	9.3 ± 16.3

Data are presented as mean ± SD. REM refers to rapid eye movement sleep; PLM, periodic leg movements.

RESULTS

There were 10 patients (5 boys and 5 girls) enrolled in the study, ranging between 5 and 15 years of age (Mean ± SD: 9.2 ± 3.2).

Dental Variables

The average Johansson composite score was 8.6 (range 2-18, SD = 5.7). Two patients, 9 years and older, had a score of 2. All other 8 patients had a score of 6 or higher, which is a sign of moderate bruxism. There was a moderate (r = .53) correlation between the composite dental scores and the number of bruxism episodes during the sleep studies that did not reach statistical significance (p = .1).

Six children had exfoliated their primary teeth, making the dental assessment of bruxism more difficult. Three patients had tooth fractures secondary to bruxism. Nine patients complained of morning fatigue or pain of masticatory muscles, whereas 8 patients had masseter hypertrophy. Only 1 patient had a click on the temporomandibular joint. No patient had tooth hypermobility at exam.

Sleep Variables

Patients had a mean total sleep time of 377 minutes, with a mean sleep latency of 27 minutes and a mean sleep efficiency of 82%. The mean REM latency was 172 minutes. The arousal index was significantly elevated in the bruxism group compared with controls (mean 36.7 vs 20.7 per hour, p < .007), indicating a higher number of brief arousals during sleep for the children with bruxism. There was no statistical difference between the other sleep variables for this small group of patients and their age- and

Table 3—Cognitive and Behavior Results in 10 Children with Sleep Bruxism

	Patients	NNS
K-BIT		
K-BIT Composite IQ score	93.1 ± 13.1	100 ± 15
Vocabulary	90.9 ± 17.2	100 ± 15
Matrices	95.7 ± 9.7	100 ± 15
CBCL		
Internalizing problems	60.6 ± 11.3	50 ± 10
Externalizing problems	58.4 ± 13.2	50 ± 10
Total problems	60.1 ± 13.1	50 ± 10
Affective problems	59.2 ± 8.8	50 ± 10
Anxiety problems	58.3 ± 8.4	50 ± 10
Somatic problems	66.2 ± 12.5	50 ± 10
ADHD problems	61.4 ± 8.4	50 ± 10
ODD problems	60.3 ± 10	50 ± 10
Conduct problems	59.6 ± 10.3	50 ± 10

Data are presented as mean scores ± SD. K-BIT refers to the Kaufman Brief Intelligence Test; CBCL; Achenbach Child Behavior Checklist; SD: ADHD, attention-deficit/hyperactivity disorder; ODD, oppositional defiant, NNS, national normative sample.

sex-matched controls, as shown in Table 1, but it was noted that sleep and REM latencies were prolonged in our pediatric bruxism group (sleep latency mean: 27 vs 16 minutes, and REM latency mean: 172 vs 135 minutes).

Data gathered from the pH probe showed that the pH dropped below 4 for 10% of the total sleep time in 1 patient and 18% of the total sleep time in another. The times at which these 2 patients had GERD did not correlate with bruxism episodes. The other 8 patients did not have GERD.

Bruxism Variables

Patients had a mean of 36 episodes of bruxism during their PSGs. The mean total duration of EMG bruxism activity was 137 seconds per patient during the entire night. Patients had a mean bruxism index (number of bruxism episodes per hour) of 6 ± 5. The mean duration of the EMG bruxism episodes was 4 seconds, but they tended to occur in clusters throughout the night. The majority of the bruxism episodes were phasic (41%) and mixed (38%). Sleep bruxism occurred predominantly in stages 2 of non-REM sleep (46.3%) and REM sleep (26%). The mean bruxism arousal index (the number of arousals per hour due to bruxism) was 3, as scored by American Academy of Sleep Medicine criteria.[16] Sixty-six percent of bruxism episodes had associated arousals. Other bruxism variables are shown on Table 2. Control-group patients did not have episodes of bruxism during their PSGs, as defined in this research study.

Cognitive and Behavior Variables

The K-BIT was completed by all 10 children with bruxism included in this study. On the K-BIT, the group obtained an average composite standard score of 93, with a standard deviation of 13. Intellectual test scores ranged from 75 to 118. Eighty percent (8 of 10) of the children had an IQ of 85 or above, which is within normal range. The remaining 2 children had IQ scores of 81 and 75. There were no children in this sample with mental retardation. There was no correlation between the K-BIT variables and the bruxism variables obtained during the sleep study, nor were there significant correlations with any of the PSG sleep variables.

The CBCL was completed by all 10 families of the bruxism patients. CBCL results are expressed as T scores, with scores less than 65 falling within the normal range and above 65 within the clinically significant range. The averaged group results of the completed CBCL report measures were elevated and in the clinically significant range on the Somatic Problems scale (66.2 ± 12.5). Results were within the normal range for all other composite and individual problem scales (Table 3). However, although the group mean was within the normal range, in this small sample of children with bruxism, 40% (4 of 10) of the children had elevated scores, in the borderline to clinically significant range (T = 66 to 74), on both the CBCL Total Problems scale and the DSM-oriented Attention Problems scale. Elevated scores (T scores ranging from 66 to 97) were also obtained for 30% (3 of 10) of the children on each of the remaining CBCL DSM-oriented problems scales (scales used to assess Affective problems, Anxiety problems, Oppositional Defiant Behavior, and Conduct Behavior).

There were moderate correlations obtained between the PSG arousal index, reflecting the number of arousals per hour in this population of children with bruxism, and several of the CBCL behavior-problem scales, including the Internalizing Problems ($r = .5$), Externalizing Problems ($r = .55$), Somatic Problems ($r = .52$), Oppositional Defiant Behavior ($r = .6$), and Conduct Problems ($r = .6$) scales. Although there was a trend, the p values for these correlations (0.07 to 0.1) did not reach statistical significance. The correlations remained at a comparable level between these behavior and sleep variables, even when intelligence (KBIT) was statistically controlled.

There was a nonlinear, U-shaped scatter-plot distribution found between the KBIT intellectual scores and CBCL behavior variables. As such, nonlinear regression analyses were employed, and a quadratics model of nonlinear curve estimation was used, which revealed strong correlations between the KBIT Composite IQ scores and the CBCL behavior problem scales. Specifically, the KBIT score correlated strongly with the Internalizing Problems ($r = .76$, $p = .047$, analysis of variance), and the Externalizing Problems scale ($r = .74$, $p = .06$, analysis of variance) scores. The most significant of the individual subscales were the Somatic Problems scale ($r = .85$, $p = .01$, analysis of variance) and Conduct Problems ($r = .76$, $p = .04$, analysis of variance).

DISCUSSION

To our knowledge this is the first prospective PSG study in children with sleep bruxism. The clinical assessment of bruxism was difficult due to the different exfoliative stages in our patients. Eight of our 10 patients had significant signs of bruxism. Two patients who were 9 years or older had fewer signs of bruxism, with low scores presumed to reflect recent teeth exfoliation and insufficient time for the recently erupted teeth to display effects of bruxism. The moderate, but not statistically significant, correlation found in our study between the dental scores and the amount of bruxism could be explained on this basis. Studies that aim to correlate the amount of bruxism during PSG and the clinical severity of bruxism should subclassify patients according to their exfoliative stage.

We found a statistically significant difference in the arousal index in our children with bruxism who were compared with age- and sex matched controls, reflecting a much higher number of arousals in the children with bruxism. Although the groups did not differ statistically, our children with bruxism also showed prolonged sleep latency and REM latency, compared with controls, which differs from the results of a small study of 5 adults who displayed decreased REM latencies.[6] We found no differences between our groups in the percentage of time spent in different stages of sleep or their sleep efficiency. These data are consistent with those from most of adult studies.[3-5]

We found that, in children, the episodes of bruxism during sleep occur primarily during stages 2 of non-REM sleep and during REM sleep. This finding is similar to results in adults.[1,5,7] Our 10 patients had light snoring associated with bruxism in only 9% of the bruxism episodes. As expected, however, a significantly high percentage of bruxism episodes were associated with arousals (66.7%) as defined by previous criteria.[17] In a study of adults with bruxism, controls demonstrated approximately 13 episodes of bruxism per night, with a mean bruxism index of 1.7 per hour, as compared with 39 episodes in patients with symptomatic bruxism, with a mean bruxism index of 5.4 per hour.[3] Our pediatric patients had a total number of 36 bruxism episodes per night, with a mean bruxism index of 6 per hour, suggesting that our group represents children with symptomatic bruxism.

Results from normative behavior rating scales completed by the parents of the children of this study revealed an increase incidence of physical somatic problems in this group of patients, which is consistent with results from studies of adults with bruxism.[19] Our study revealed a moderate positive correlation between the number of arousals during sleep, as indicated by the PSG arousal index score, and the incidence of attention, somatic, and behavior problems, as measured by the CBCL. The lack of statistical significance despite moderate to strong correlations between these behavior and sleep variables is presumed to reflect the limited power resulting from the very small sample size. In this study, children with bruxism had significantly higher arousal index scores than did age-matched controls, and 40% of the children had reports of clinically significant attention or behavior problems. It is unknown whether sleep bruxism is the cause of increased arousals and attention or behavior problems or if children with behavior and attention difficulties exhibit altered sleep, along with bruxism. It is known that sleep fragmentation secondary to sleep-disordered breathing in children can lead to behavior, attention, and executive-function problems[10]; therefore, it is not surprising to find a similar behavior pattern in our series of patients with bruxism who display fragmented sleep due to frequent arousals during sleep.

There was a strong nonlinear U-shape correlation between the KBIT intellect scores and the CBCL behavior results, indicating that children with intelligence scores on the lower and higher ends had more behavior difficulties.

Previous studies in adults have suggested that GERD is associated with bruxism episodes, having more mandibular movements at the time of low pH on the esophagus.[8,9] Neither of our 2 patients who had low pH values had low pH during their bruxism episodes. In this pediatric population, we did not find the relation of GERD and bruxism that has been reported in adult patients.[8,9]

In summary, our findings show no difference on sleep staging in children with sleep bruxism, compared with controls without bruxism. The distribution of bruxism episodes during different stages of sleep was similar to that identified in adults with bruxism, but there was no correlation between bruxism episodes and GERD in this patient population. Of primary interest, there was a significantly higher number of arousals in sleep in our children with bruxism, and increased arousals were correlated with parent reports of somatic or physical complaints and externalizing and internalizing behavior and attention problems in this small group of children.

Although a PSG evaluation may not be essential for the evaluation of most children with sleep bruxism, it is important to screen children for bruxism in the general pediatric office because these children appear to be at higher risk for having somatic complaints or problems, as well as behavior and attention problems. The etiology of these difficulties is uncertain and may need to be further evaluated. In addition to validating the findings of this pilot study, we believe that future studies should focus on daytime behavior and cognitive performance in children with bruxism and should investigate ways to assess and treat those difficulties.

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