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Original Article

Evaluation of jaw bone density and morphology in bruxers using panoramic radiography

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KEYWORDS
Bruxism;
Panoramic radiography;
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Abstract *Background/purpose:* Bruxism affects the stomatognathic system and causes tissue damage by the excessive jaw movements. The purpose of this study was to evaluate the effects of sleep bruxism on jaw bone density, mineralisation and morphology by comparing bruxers and non-bruxers.
Materials and methods: 60 bruxers and 60 non-bruxers (control) patients were included in the analysis. Cortical width at the gonion (GI), at the mental foramen (MI), at the antegonion (AI), the panoramic mandibular index (PMI), the mandibular cortical index (MCI) and antegonial notch depth (AND) were measured bilaterally on 120 panoramic radiographs. The measurements were evaluated for repeatability, correlation with age, gender and correlation between the variables.
Results: A significant association was observed between cortical shape (MCI) and bruxism status ($p = 0.012$). The MI was significantly different between the bruxers and non-bruxers ($p = 0.006$). There was a significant but weak correlation between the MI value and age in bruxers and the control ($p = 0.003$, $p = 0.04$). The AI was not associated with bruxism status and did not vary by age or gender ($p > 0.05$). The AND was higher in bruxers than non-bruxers ($p = 0.001$). Male bruxers had a significantly higher AND value than female bruxers ($p = 0.001$). The GI was higher in male bruxers ($p = 0.001$).
Conclusion: Defects in the endosteal margin of the cortex and cortical thickening in the mental region were detected in bruxer patients. Furthermore, AND was increased in bruxers. Tiny bone peaks accompanied the cortical thickening seen in the gonial region. Male bruxer patients had higher GI and AND values than female bruxers.

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Introduction

Bruxism is a condition characterised by persistent jaw clenching and grinding of the teeth, during sleep or while awake.[1] "Sleep bruxism" (9.3–15.9%) and "awake bruxism" (22.1–31%) are widespread in the general adult population.[2–4]

Bruxism is associated with various factors,[5,6] but its aetiology is not well understood. Occlusion,[6] sleep disorders, and sympathetic or parasympathetic nervous system activation,[7] have all been associated with bruxism.

Bruxism affects the stomatognathic system; the excessive jaw movements may cause microtrauma, orofacial pain, or tooth fractures. Bone loss around implants,[8] and changes in bone resorption in the condylar region,[9] have been reported in bruxism, which is ultimately attributed to excessive occlusal force on the jaw bone. Tissue damage occurs with bone loss.[10] It has been reported that decreasing muscle contractions via botulinum toxin injection or tooth loss may cause bone loss in the mandibular condyle and alveolar process.[11,12] However, bone mineralization varies according to the bite force.[13] Muscle activity is essential for mechanotransduction and bone homeostasis.[14]

Radiographic assessments of bone mineral density and bone height are important in dental treatment planning for bruxism patients, to prevent the harmful effects of bone mineralisation and remodelling. Bone density and quality can be measured on panoramic radiographs; indices include the mandibular cortical index (MCI), mental index (MI), antegonial index (AI), gonial index (GI) and panoramic mandibular index (PMI).[15–18] To the best of our knowledge, no study has evaluated the effects of bruxism on these radiomorphometric indices.

More comprehensive radiographic data on bruxism patients, including bone changes, could aid disease diagnosis. This study aimed to evaluate the effects of sleep bruxism on jaw bone density, mineralisation and morphology by comparing bruxers and non-bruxers.

Material and methods

This study was approved by the Gaziantep University Ethical Committee (code: 2020/139). Data were obtained from patients who were referred to a private dental clinic in Gaziantep (Turkey) with bruxism.

Patient selection

In total, 120 patients (age range: 24–52 years; mean age, 35.1 ± 10 years) were included in the study. The exclusion criteria were as follows: missing teeth (except the third molar), systemic or metabolic disease, bone-altering diseases (e.g. hyperparathyroidism, hypoparathyroidism or osteodystrophy), smoking, drug or alcohol use, previous orthodontic treatment, and presence of cysts, or neoplasms. Thirteen of 75 bruxism patients had periodontal disease, whereas 9 of 75 patients in the control group were determined to be unhealthy and thus excluded from the radiomorphometric analysis. A power analysis revealed that the required sample size was 120, for a power of 75% and effect size of 0.3. Ultimately, 60 bruxers and 60 non-bruxers (control) were included in the analysis.

A self-report anamnesis questionnaire was completed by the patients to obtain the bruxism history. Patients fulfilling one or more of the clinical criteria for bruxism were included in the bruxers group. The questionnaire asked about jaw clenching and teeth grinding during the day and night, fatigue and pain in the temporal-masseter muscles, and report of grinding or clenching teeth by a sleeping partner.[19,20]

Radiographic measurements

The MCI, MI, PMI, AI, AND and GI were obtained for qualitative and quantitative assessment of bone.[15–18] In the MCI, the inferior mandibular cortex is classified as follows: C1, the endosteal margin of the cortex is even and sharp on both sides (normal cortex); C2, the endosteal margin has semilunar defects (lacunar resorption) and/or endosteal cortical residues are present on one or both sides; C3, heavy endosteal cortical residues and porosity are present in the cortical layer (Fig. 1).

The MI, a measure of cortical width, is calculated at the mental foramen region according to Ledgerton et al.,[16] as follows: after identifying the mental foremen, a line perpendicular to the tangent of the lower border of the mandible is measured. The mean bilateral cortical width is determined. The PMI is determined by dividing the width of the mandibular cortex by the distance between the superior (PMIs) or inferior (PMIi) border of the mental foramen and the inferior mandibular cortex.[21] The PMIi was determined in the present investigation.

The AI provides a measure of cortical thickness at the site defined by a line extending from the anterior border of the ascending ramus down to the lower border of the mandible.[17]

Antegonial notch depth (AND) was used to evaluate morphological changes in bruxers, and is given by the distance along a perpendicular line from the deepest point of the mandibular inferior border notch concavity to a tangent through the inferior border of the mandible.

The GI corresponds to the cortical thickness at the gonial angle,[22] measured at the bisection of the angle between the tangent to the posterior border of the ramus and another line tangent to the lower border of the mandible (Fig. 2).

Imaging and analyses

All panoramic images were acquired using a 2D Veraviewpocs digital panoramic X-ray device (J. Morita Manufacturing Corp., Kyoto, Japan). The tube voltage was varied according to patient size, between 65 and 75 kVp (5 mA, 15 s exposure time). Linear measurements were taken using Image J software (ver. 1.42; NIH, Bethesda, MD, USA) under 25 × magnification. An oral radiologist took the measurements at 2-week intervals and interobserver reliability was evaluated. An orthodontist also took measurements and the intraobserver reliability was evaluated.

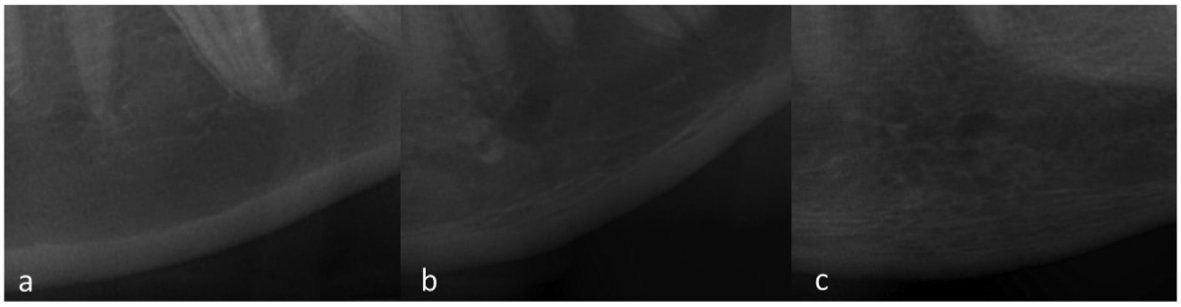

Figure 1 MCI classifications a) C1; endosteal margin of the cortex is even and sharp on both sides (normal cortex); b) C2; endosteal margin has semilunar defects (lacunar resorption) and/or endosteal cortical residues are present on one or both sides; c) C3; heavy endosteal cortical residues and porosity are present in the cortical layer.

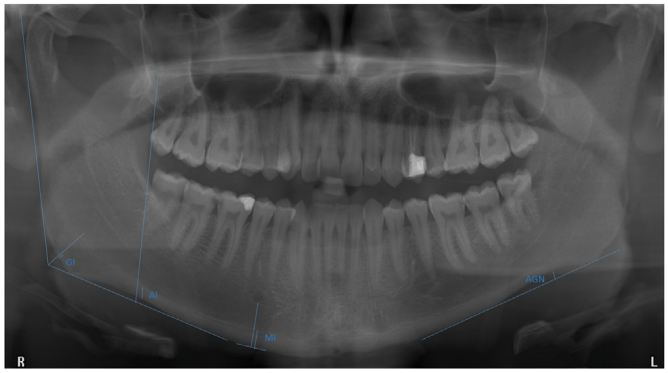

Figure 2 Measurement of the distances of interest in this study.

All data were analysed using SPSS software (ver. 17.0; SPSS Inc., Chicago, IL, USA). The chi-square test was used to analyse categorical variables. Spearman's correlation coefficient was used to analyse the correlations between age and other variables of interest. The radiomorphometric variables, AND, and rate of periodontal disease were compared between the bruxers and non-bruxers. The Mann—Whitney *U* test was used to compare the bruxers and non-bruxers in terms of the MI, PMI, AND, AI, and GI. The intraclass correlation coefficient (ICC) was used as a measure of the intra- and interobserver reliability for the MI, PMI, AND, AI and GI. Weighted kappa statistics were used to determine the reliability of the MCI. Descriptive statistics were also calculated. A p-value < 0.05 was considered significant.

Results

The values for interobserver agreement were 0.80, 0.81, 0.79, 0.73, 0.84 and 0.78 for the MCI, MI, PMI, AI, AND and GI, respectively. The ICC was 0.82 for the first observer and 0.78 for the second observer. Periodontal diseases were more prevalent in bruxers compared to non-bruxers ($p = 0.001$).

A significant association was observed between cortical shape (MCI) and bruxism status ($p = 0.012$). In total, 21 bruxers had the C1 shape, 33 had the C2 shape and 6 had the C3 shape. Of the non-bruxers, 33 had the C1 shape and

Table 1 Distribution of cortical shapes according to Klemetti index regarding the presence of bruxism.

	MCI		Male %	Female %	Total %	P
Bruxers	C1	index	23.8	76.2	100	0.012[a]
		gender	19.2	48.5	35.6	
	C2	index	56.3	43.8	100	
		gender	69.2	42.4	54.2	
	C3	index	50.0	50.0	100	
		gender	11.5	9.1	10.2	
Total		index	44.1	55.9	100	
		gender	100	100	100	
Control	C1	index	33.3	66.7	100	
		gender	44.0	62.9	55.0	
	C2	index	51.9	48.1	100	
		gender	56.0	37.1	45.0	
	C3	index	0.0	0.0	0.00	
		gender	0.0	0.0	0.00	
Total		index	41.7	58.3	100	
		gender	100	100	100	

MCI; mandibular cortical index, C1; endosteal margin of the cortex is even and sharp on both sides (normal cortex); C2; endosteal margin has semilunar defects (lacunar resorption) and/or endosteal cortical residues are present on one or both sides; C3; heavy endosteal cortical residues and porosity are present in the cortical layer.

[a] Indicates statically significant difference between bruxers and control.

27 had the C2 shape (Table 1). Gender and age were not associated with the MCI in either group ($p > 0.05$).

Morphological changes (tiny "bone peaks") in the cortex of the mandibular gonial region (Fig. 3) were detected in 31.7% ($n = 19$) of patients with bruxism and 5% ($n = 3$) of the non-bruxers. The presence of bone peaks was associated with bruxism status ($p = 0.001$) and AND ($p = 0.001$).

Descriptive statistics for the MCI, MI, AI, GI, PMI, and AND are shown in Table 2. The MI was significantly different between the bruxers and non-bruxers ($p = 0.006$). There was a significant ($p = 0.003$) but weak correlation (Spearman Rho, $r = 0.348$) between the MI value and age in bruxers and the control. Gender was not associated with the MI in either group ($p > 0.05$). The PMI was not different between the bruxers and non-bruxers ($p > 0.05$) and did not vary by gender or age (Table 3).

In the whole cohort, no correlation was detected between the PMI and MCI ($p = 0.68$). The AI was not associated with bruxism status ($p = 0.4$) and did not vary by age or gender. The AND was higher in bruxers than non-bruxers ($p = 0.001$). Male bruxers had a significantly higher AND value than female bruxers ($p = 0.005$) (Table 2). Notch depth was not related to age ($p > 0.05$). The GI was higher in male bruxers. In non-bruxers, the GI did not vary by gender or age.

Discussion

The primary aim of this investigation was to evaluate the effects of excessive bite force on mandible bone mineral density and quality by comparing bruxers and non-bruxers. A higher rate of periodontal disease was observed in the patients with bruxism. While periodontal damage does not occur due to bruxism, excess mechanical force can stress the periodontal tissues and make them more susceptible to gingivitis-periodontitis.[23] In this study, to determine the effects of bruxism on bone mineral density and shape, the measurements were performed only in periodontally and medically healthy patients.

This is the first study to report on the relationship between radiomorphometric measurements and bruxism status. However, occlusal overload, which may influence bone quality, should also be evaluated. Furthermore, the suitability of panoramic radiographs for diagnosing bruxism remains unclear.

Bruxism status was associated with cortical shape, the MI, AND and GI. Semilunar defects, cortical residues and porosity in the endosteal cortex of the mandible were more prevalent in bruxers.

The role of excess occlusal force on osseointegration and bone remodelling is controversial.[11,13,24] Jofre et al. reported that marginal bone loss around implants was not associated with the maximum bite force.[24] However, excess mechanical stress led to bone resorption in another study.[25]

Another study investigated the effects of bruxism on fractal dimension, which was found to be significantly reduced in the condylar region of patients with bruxism.[9] Discrepant results among studies may be due to differences in methodologies and bite forces. An animal study investigated whether the bite force was associated with bone destruction. In a dog model, osteointegration occurred with a bite force <2 kg/mm 2, while bone damage and absorption was observed when the force exceeded 12 kg/mm 2.[13] A reduced bite force following injection of masticatory muscles with botulinum toxin was associated with bone loss in the mandibular condyle and alveolar process.[11] Thus, results differ by bite force and the region exposed to mechanical stress.

In the present study, cortical thickening in the mental and gonial regions of the mandible was observed in bruxers. Tiny bone peaks were detected in the cortex of the mandibular gonial region in bruxers at a significantly higher rate than in non-bruxers. Bone thickening is a secondary response to microfracture caused by excessive bite force.[26] Previous studies on long bones reported periosteum and periosteal bone apposition due to vascularization and tension caused by muscles, which in turn resulted in local cortical thickening.[27]

The masseter muscle insertion is at the gonial angle; the excessive bite force in bruxers could explain the higher GI and tiny bone peaks seen in that group. Cortical thickening in the mental region may occur in response to endosteal bone damage caused by premolar teeth in bruxers.

We found no correlation between age and any other variable, nor between cortical shape and the PMI, unlike Gulsahi et al. They evaluated radiomorphometric parameters in a Turkish population and reported an increase of C3 with age, and a higher PMI in C1 and C2 groups.[28] However, patients with osteoporosis or other medical conditions were not excluded from their study, so the proportion of C3 cases may have been higher. Moreover, some medical conditions would likely have affected the outcomes.

In the present investigation, AI was not correlated with bruxism status, age or gender. However, AND was greater in

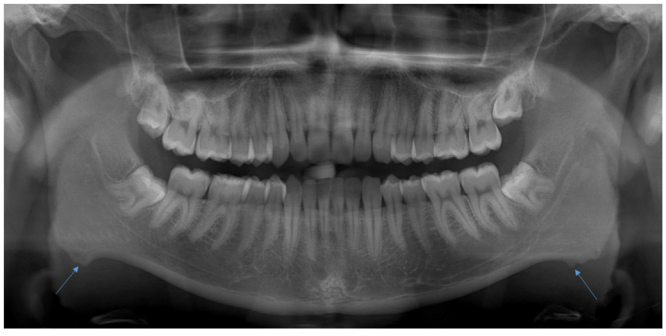

Figure 3 Morphological changes in the form of tiny "bone peaks" in the cortex of the mandibular gonial region.

Table 2 Descriptive statistics of MI, PMI, AI, AND, GI measurements in bruxers and controls.

			Mean	SD	Minimum	Maximum	P
MI	Bruxers	Female	3.15	0.76	1.5	4.43	0.006*
		Male	3.5	0.77	2.25	5.25	
	Control	Female	2.7	0.5	1.3	3.9	
		Male	3.15	0.4	2.4	3.9	
PMI	Bruxers	Female	0.33	0.08	0.19	0.46	0.94
		Male	0.33	0.1	0.22	0.56	
	Control	Female	0.32	0.07	0.22	0.51	
		Male	0.33	0.05	0.25	0.51	
AI	Bruxers	Female	2.78	0.67	1.35	4.0	0.4
		Male	2.61	0.71	1.4	4.2	
	Control	Female	2.34	0.62	1.2	3.9	
		Male	2.8	0.60	1.2	3.7	
AND	Bruxers	Female	0.87	1.06	0	4.28	0.001*
		Male	2.4	0.85	0.9	3.83	
	Control	Female	0.9	0.54	0	1.8	
		Male	0.68	0.69	0	2.33	
GI	Bruxers	Female	0.74	0.21	0.45	1.27	0.001*
		Male	1.33	0.41	0.53	2.1	
	Control	Female	0.75	0.3	0.45	1.65	
		Male	0.77	0.3	0.48	1.65	

Cortical width at the mental foramen (MI), the panoramic mandibular index (PMI), antegonial index (AI), antegonial notch depth (AND), at the gonion (GI).
'*' Indicates signficant difference.

male bruxers. This finding disagrees with Baydas et al.,[29] who found no significant effect of gender on AND. The present results agree with a study that reported a greater AND in males, and found no effect of age on AND.[30] However, they also reported that AND was higher in edentulous patients, who are thought to have lower bite strength.[30]

The observation that both excessive and reduced biting force can have destructive effects may explain the diversity of results among studies.[11,13] Differences in the reported effects of gender may be due to differences in sample characteristics and methodologies.

Table 3 Correlation MCI, MI, PMI, AI, AND, GI variables with age and gender.

		P	
		Age	Gender
MCI	Bruxer	0.32	0.06
	Contol	0.1	0.14
MI	Bruxer	0.003[a]	0.09
	Contol	0.04[a]	0.01
PMI	Bruxer	0.83	0.16
	Contol	0.76	0.23
AI	Bruxer	0.72	0.68
	Contol	0.85	0.77
AND	Bruxer	0.25	0.001[a]
	Contol	0.65	0.05
GI	Bruxer	0.44	0.001[a]
	Contol	0.35	0.06

Cortical width at the mandibular cortical index (MCI), at the mental foramen (MI), at the panoramic mandibular index (PMI), antegonial index (AI), antegonial notch depth (AND) the gonion (GI).
[a] Indicates signficant difference.

This investigation provided morphometric data on bruxer patients, which could facilitate radiologic diagnosis of the condition; however, some limitations should be considered. Firstly, as bite force was not measured, the correlation between thickening and force could not be calculated. In addition, our study included patients varying widely in age; studies with more homogenous populations, and higher power, may be beneficial.

Within the limitations of this study, defects in the endosteal margin of the cortex and cortical thickening in the mental region were detected in bruxer patients. Furthermore, AND was increased in bruxers. Tiny bone peaks accompanied the cortical thickening seen in the gonial region. Male bruxer patients had higher GI and AND values than female bruxers.

Further studies of bony changes in bruxers, including more patients, could improve understanding of the diagnostic utility of panoramic radiography for bruxism.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jds.2020.09.008.

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