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ORIGINAL ARTICLE

Impact of bruxism on the mandibular angle and condylar structures: a panoramic radiographic assessment

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Abstract

Objectives The aim of this study is to comparatively evaluate morphologic changes in the mandibular angle and condylar region, assess the mandibular cortical index (MCI), and analyze the relationships between these parameters in bruxers and non-bruxers using panoramic radiographs.

Methods A total of 182 patients (364 mandibular condyle and angle), 91 bruxers and 91 non-bruxers (controls), aged between 18 and 35, were participated in this study. Three hundred sixty four mandibular angles were classified as G0, G1, G2, G3 in terms of bone apposition and direction change. In addition, osseous changes in the mandibular condyle were determined and the endoestal edge of the basal cortex was evaluated according to the MCI classification. Parameters were analyzed using the Pearson's Chi-Square test and Fisher's Exact test. A p value < 0.05 was considered significant.

Result MCI class C1, G0 class, and normal condyle type were found to be significantly more common in the non-bruxist group than in the bruxist group ($p < 0.001$, $p = 0.025$, $p = 0.006$, respectively). It was determined that deformity and MCI-C2 class were more common in the bruxist group ($p = 0.006$, $p < 0.001$). Morphologic changes in the endosteal margin of the cortex and in the condylar region were observed more frequently in bruxist individuals.

Conclusion For a general overview of the probable presence of bruxism, osseous changes in the mandibular condyle, and MCI can be used as auxiliary diagnostic markers.

Keywords Bone changes · Bruxism · Mandible · Panoramic radiography

Introduction

In an international consensus in 2018, sleep and awake bruxism were defined as masticatory muscle activities that happen during sleep (characterized as phasic or tonic) and wakefulness (identified by repetitive or constant tooth contact and/or by pushing or supporting of the mandible), respectively.

Also in this consensus, it was emphasized that bruxism is not a disorder in healthy persons but a behavior with different etiological factors. This behavior may be harmless when associated with clinical results. It might be a risk factor when it causes negative clinical results such as excessive mechanical tooth wear, masticatory muscle pain, temporomandibular joint (TMJ) pain, and also it might be a protective factor when it prevents the collapse of the upper airway or reduces the risk of chemical tooth wear caused by gastroesophageal reflux by increasing the amount of saliva secretion [1].

In the explanatory note published by Manfredini et al. [2] in 2023, this issue was clarified by stating that bruxism should not be considered a disease in both healthy and unhealthy persons.

Bruxism is graded as: 'possible' when it is based on self-report (questionnaires, oral history); 'probable' when it is based on self-report plus clinical inspection; and 'definite' when it is based on self-report, clinical inspection plus instrumental approaches such as electromyography and polysomnography [3]. Studies have reported that the epidemiology of bruxism is not very clear due to different methodological approaches for the evaluation of bruxism [4, 5].

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Bone is a dynamic structure that undergoes lifelong remodeling to maintain function, morphology, and blood calcium balance [6]. Wolf's Law (1870) posits that the size and activity of skeletal muscles influence the morphology of the bone structures where these muscles originate and insert [7]. A similar relationship is thought to exist between bone shape and muscle function within the maxillofacial complex [8]. Türp et al. [9] determined that there is an additional growth (apposition) in the bone tissue in the mandibular angle region in bruxism cases. This apposition was categorized based on its severity (G0, G1, G2, G3) on radiographic evaluation of the basal cortex in the mandibular angle. There are studies in the literature evaluating the mandibular cortical index (MCI), a parameter by which the porous appearance of the mandibular cortex is classified [10], and bone peaks at the mandibular angles, in bruxers and non-bruxers on panoramic radiography [9, 11, 12]. In addition, the relationship between the severity of the degrees of these two parameters was also assessed [13]. To our knowledge, no study comparatively evaluates the osseous changes in the mandibular angle and condyle region, MCI, and the relationships between these parameters in bruxist and non-bruxist individuals. The null hypotheses of the study were that the morphology of the mandibular angle and condylar region, and MCI were not different between bruxist and non-bruxist individuals (1) and that there would be no significant relationship between these parameters (2). Detection of radiologic changes thought to be related to bruxism may direct clinicians to perform a more comprehensive examination in individuals who are unaware of their bruxism. Thus, adverse outcomes that may occur due to bruxism, such as temporomandibular problems [14] and implant failure [15], can be prevented with early diagnosis and treatment of bruxism.

The aim of this study is to comparatively evaluate morphologic changes in the mandibular angle and condylar region, assess the mandibular cortical index (MCI), and analyze the relationships between these parameters in bruxers and non-bruxers using panoramic radiographs.

Materials and methods

Patient selection

This retrospective, cross-sectional and observational study was conducted in accordance with the principles of the Declaration of Helsinki. Approval for the study was obtained from Kahramanmaras Sutcu Imam. University Medical Research Ethics Committee (number: 2023/89, No: 07). Determination of the sample size was made using the G*Power 3.1.9.2 program. The standardized effect size was obtained as 0.3596 from a similar study [13] at a 95% confidence level ($\alpha = 0.05$), and the minimum sample was calculated as 120 with a theoretical power of 0.95.

Participants were selected from patients aged between 18 and 35 who applied to the Department of Oral and Maxillofacial Radiology of Kahramanmaras Sutcu Imam University Faculty of Dentistry for various reasons. The study included panoramic radiographs clearly showing the areas to be evaluated. The study group consisted of 91 bruxist individuals (61 women, 30 men; median age: 23 years, mean age: 24,85 ± 5 years) the control group consisted of 91 non-bruxist individuals (60 women, 31 men; median age: 22 years, mean age: 23,54 ± 4 years). Bruxism was assessed by anamnesis and clinical examination (made by AA) of the patient [1, 16]. The following criteria were used in the evaluation of bruxism:

- Presence of teeth grinding and/or clenching at least three nights a week for the previous 6 months in the patient
- Abnormal wear of the teeth during clinical examination, hypertrophy of the masseter muscles when the patient is asked to clench the teeth voluntarily, and the presence of symptoms such as discomfort, pain and fatigue in the jaw muscles, particularly in the morning.

The following criteria were used to exclude participants: systemic disease, metabolic disease that affects bone, neurologic, and psychiatric diseases, missing (except the third molar) or restored teeth, drug and alcohol addiction, history of orthodontic treatment, presence of cysts/neoplasms in the maxillofacial region, temporomandibular joint (TMJ) disease. The study did not include radiographs with incomplete visualization of the mandibular angles or TMJs.

Evaluation of radiographs

All panoramic radiographs were obtained using KaVo OP 3D (PaloDEx Group Oy, Tuusula, Finland; 66 kVp, 7.1 mA and 14 s) digital panoramic X-ray device. The patient's sagittal plane was positioned in the middle of the device and perpendicular to the floor, while the Frankfurt plane was aligned parallel to the ground. All assessments were performed independently by two specialists in oral and maxillofacial radiology with 8 (AA) and 6 (EMA) years of experience in oral radiology. Before analysis, calibration and training were conducted among two researchers to standardize and ensure consistency in classification. To determine intraobserver reliability, each observer re-examined 30% of the randomly selected data 2 weeks after the first assessment.

Türp et al. [9] classified the morphologic appearance of the basal cortex according to its curvature and the presence or absence of bone apposition. In our study, the mandibular angle region was evaluated according to this classification.

G0: Convex contour of the basal cortex without bone apposition and change of direction.

G1: Change of direction in the convex contour of the basal cortex without bone apposition.

G2: Diffuse bone apposition with nonuniform surface with change of direction in the convex contour of the basal cortex.

G3: Focal bone apposition at one or more places with change of direction in the convex contour of the basal cortex (Fig. 1).

MCI was assessed according to the categorization of Klemitti et al. [17].

C1: The endosteum of the mandibular cortex is smooth and even.

C2: Endosteal margin of the cortex has semilunar irregularity and stratification (one–three parts) on one or both sides.

C3: The endosteum of the mandibular cortex has dense endosteal cortex remnants and is porous (Fig. 2).

Condylar osseous changes were evaluated as normal (no bone change), flattening, sclerosis, osteophytes, erosion, deformity, subcortical cysts and surface irregularities.

Flattening: A flattened bony contour turning from the convexity.

Osteophytes: New bone formation at the periphery of the articular surfaces of the condyle.

Sclerosis: Increased bone density in the subchondral area.

Erosion: Loss of continuity at the condyle articular surface.

Deformity: Contraction of the condyle contour.

Subcortical cysts: A round, radiolucent area with irregular borders beneath the joint surface.

Surface irregularities: Irregularity of the condyle articular surface [18–20] (Fig. 3).

Fig. 1 Bone apposition at the mandibular angle and grade classification: G0: Convex contour of the basal cortex without bone apposition and change of direction; G1: Change of direction in the convex contour of the basal cortex without bone apposition; G2: Diffuse bone apposition with nonuniform surface with change of direction in the convex contour of the basal cortex; G3: Focal bone apposition at one or more places with change of direction in the convex contour of the basal cortex

Statistical analysis

Analyses were performed using the IBM SPSS 27 program. In this study, descriptive statistics (numbers and percentages) of the data were given. In testing the relationship between categorical variables, the Pearson's Chi-Square test was used when the sample size assumption (expected value > 5) was met, and the Fisher's Exact test was used when the sample size assumption was not met. The Intraclass Correlation Coefficient (ICC) and Kappa statistics were used to assess the consistency of the repeated measurements. A p value < 0.05 was considered significant.

Results

In total, 182 patients (364 mandibular condyles and angles), 91 bruxers and 91 non-bruxers (control) were included in the study. The intra- and inter-observer reliability coefficient

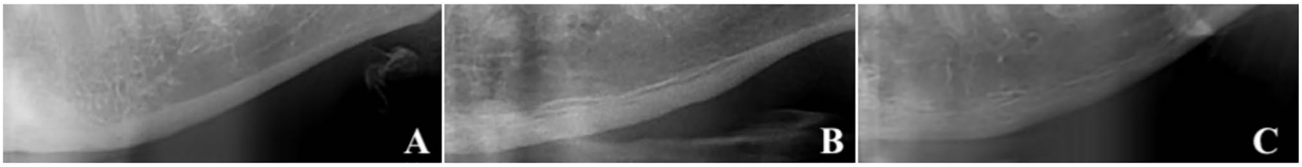

Fig. 2 MCI classifications **A** C1; the endosteum of the mandibular cortex is smooth and even; **B** C2; endosteal margin of the cortex has semilunar irregularity and stratification (one–three parts) on one or both sides; **C** C3; the endosteum of the mandibular cortex has dense endosteal cortex remnants and is porous

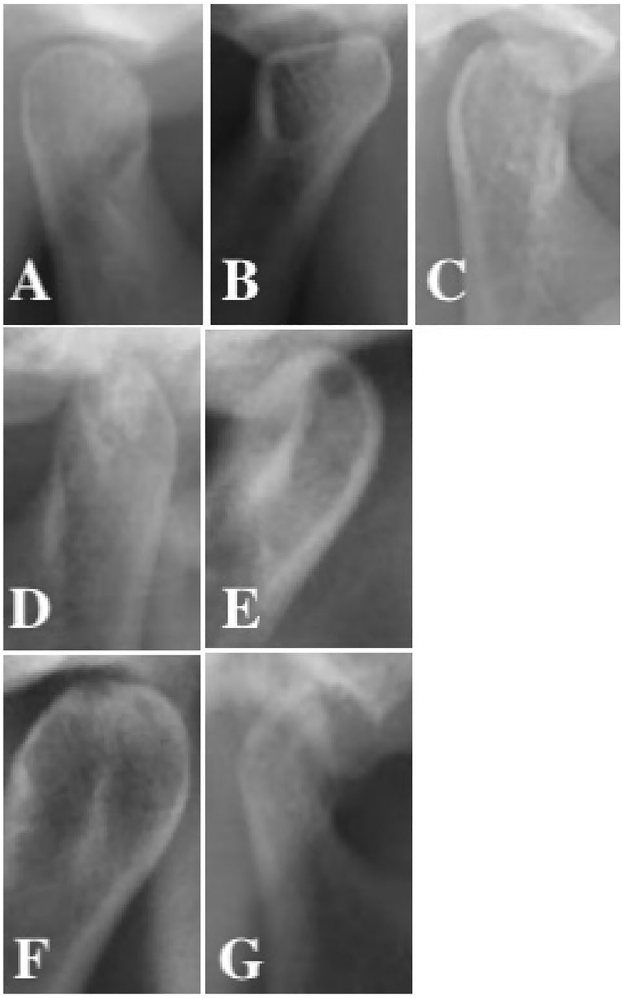

Fig. 3 Bone changes in the condyles **A** normal, **B** flattening, **C** erosion, **D** sclerosis, **E** subcortical cyst, **F** surface irregularities, **G** deformity

for all assessments (κ: 0.85–0.89, respectively) was almost excellent.

The distribution of gender, MCI, degree of bone apposition at the mandibular angle and bone changes at the mandibular condyle according to the study groups (bruksist and non-bruksist groups) is given in Table 1. Pearson's Chi-Square and Fisher’s Exact tests were applied to examine the relationships between them. Statistically significant differences were determined between the bruxist and non-bruxist patients in terms of the degree of bone apposition at the mandibular angle, MCI, and bone changes at the mandibular condyle ($p = 0.025$, $p < 0.001$, $p = 0.006$, respectively). No significant relationship was found between gender and study groups ($p = 0.824$). MCI class C1, G0 class, and normal condyle type were found to be significantly more common in the non-bruxist group than in the bruxist group. It was determined that deformity and MCI-C2 class were more common in the bruxist group. Osteophyte was not detected in any patient.

The relation between MCI and the degree of bone apposition in the mandibular angle region according to groups is evaluated in Table 2. Fisher’s Exact test was applied to examine the relationships between them. A significant difference was found between the bruxers and the control group ($p < 0{,}001$). In bruxist G0 and bruxist G2 individuals, the rate of MCI class being C2 was higher than C1. In bruxist G3 individuals, the rate of MCI class being C3 was higher than C1 and C2. In non-bruxist G0 and non-bruxist G1 individuals, the rate of MCI class being C2 was lower than C1.

In Table 3, the relationship between MCI and changes in the condylar bone according to groups was evaluated using Fisher’s Exact test. As a result of the analysis, a statistically significant relationship was found between MCI and condyle types in the study groups ($p < 0.001$). In the non-bruxist group, the rate of MCI class being C1 was higher than C2 in the flattening condyle type.

The evaluation of the relationship between gender and the degree of bone apposition at the mandibular angle according to groups is presented in Table 4, and Fisher’s Exact tests were performed to examine the relationships between them. A significant relationship was found between gender and the degree of bone apposition at the mandibular angle ($p < 0.001$). In addition, the mandibular angle degrees in bruxist and non-bruxist individuals showed significant differences according to gender ($p < 0.001$). G0 was significantly higher in females, and G2 and G3 were significantly higher in males. The number of bruxist G3 individuals and non-bruxist G2 individuals was higher in males, while the number of non-bruxist G0 individuals was higher in females.

Table 1 Evaluation of the relationship between bruxism and gender, MCI, degree of bone apposition at the mandibular angle, and bone changes in the mandibular condyle

		Bruxers			Non-bruxers			Test statistics	*p* value
		n	%	*G%*	*n*	%	*G%*		
Gender	Female	122	50.4	67.0	120	49.6	65.9	0.049	0.824‡
	Male	60	49.2	33.0	62	50.8	34.1		
MCI	C1	125a	44.2	68.7	158b	55.8	86.8	18.141	**< 0.001***
	C2	54a	69.2	29.7	24b	30.8	13.2		
	C3	3a	100.0	1.6	0a	0.0	0.0		
Grades	G0	52a	40.9	28.6	75b	59.1	41.2	9.089	**0.025***
	G1	89a	54.6	48.9	74a	45.4	40.7		
	G2	35a	52.2	19.2	32a	47.8	17.6		
	G3	6a	85.7	3.3	1a	14.3	0.5		
Condyles	Normal	123a	44.7	67.6	152b	55.3	83.5	15.831	**0.006***
	Flattening	38a	61.3	20.9	24a	38.7	13.2		
	Erosion	2a	100.0	1.1	0a	0.0	0.0		
	Sclerosis	2a	66.7	1.1	1a	33.3	0.5		
	Surface irregularities	4a	80.0	2.2	1a	20.0	0.5		
	Deformity	8a	88.9	4.4	1b	11.1	0.5		
	Subcortical cyst	5a	62.5	2.7	3a	37.5	1.6		

%: Row percentage

G%: Column percentage for the groups, and lowercase letters indicate the differences between the column percentages

[*] Fisher's Exact test

[‡] Pearson's Chi-Square test

p values < 0.05 were considered statistically significant

The values written in bold are statistically significant *p* values (*p*0.05)

Table 2 Evaluation of the relationship between MCI types and mandibular angle bone apposition degrees according to groups

Groups	Grades	C1			C2			C3			Test statistics	*p* value
		n	%	MCI%	*n*	%	MCI%	*n*	%	MCI%		
Bruxers	G0	33a	63.5	11.7	18b	34.6	23.1	1a.b	1.9	33.3	43.843	**< 0.001***
	G1	70a	78.7	24.7	18a	20.2	23.1	1a	1.1	33.3		
	G2	20a	57.1	7.1	15b	42.9	19.2	0a.b	0.0	0.0		
	G3	2a	33.3	0.7	3b	50.0	3.8	1b	16.7	33.3		
Non-bruxers	G0	70a	93.3	24.7	5b	6.7	6.4	0b	0.0	0.0		
	G1	63a	85.1	22.3	11a	14.9	14.1	0b	0.0	0.0		
	G2	24a	75.0	8.5	8a	25.0	10.3	0a	0.0	0.0		
	G3	1a	100.0	0.4	0a	0.0	0.0	0a	0.0	0.0		

%: Row percentage

MCI%: Column percentage for MCI and lowercase letters indicate the differences between the column percentages

[*] Fisher's Exact test

p values < 0.05 were considered statistically significant

The values written in bold are statistically significant *p* values (*p*0.05).

Evaluation of the relationship between mandibular angle grades and bone changes at the condyle according to groups was given in Table 5. Fisher's Exact test was applied to examine the relationships between them. The condyle types of the bruxist and non-bruxist groups showed a significant difference according to mandibular angle grades ($p = 0.043$). When the subcortical cyst was seen in the bruxist group, the rate of class being G3 was higher than G0, G1, and G2.

Table 3 Evaluation of the relationship between MCI types and bone changes at the condyle according to groups

Groups	Condyles	C1			C2			C3			Test statistics	*p* value
		n	%	MCI%	*n*	%	MCI%	*n*	%	MCI%		
Bruxers	Normal	87a	70.7	30.7	34a	27.6	43.6	2a	1.6	66.7	46.993	**< 0.001***
	Flattening	24a	63.2	8.5	13a	34.2	16.7	1a	2.6	33.3		
	Erosion	1a	50.0	0.4	1a	50.0	1.3	0a	0.0	0.0		
	Sclerosis	1a	50.0	0.4	1a	50.0	1.3	0a	0.0	0.0		
	Surface irregularities	4a	100.0	1.4	0a	0.0	0.0	0a	0.0	0.0		
	Deformity	6a	75.0	2.1	2a	25.0	2.6	0a	0.0	0.0		
	Subcortical cyst	2a	40.0	0.7	3a	60.0	3.8	0a	0.0	0.0		
Non-bruxers	Flattening	130a	85.5	45.9	22b	14.5	28.2	0a	0.0	0.0		
	Erosion	22a	91.7	7.8	2a	8.3	2.6	0a	0.0	0.0		
	Sclerosis	1a	100.0	0.4	0a	0.0	0.0	0a	0.0	0.0		
	Surface irregularities	1a	100.0	0.4	0a	0.0	0.0	0a	0.0	0.0		
	Deformity	1a	100.0	0.4	0a	0.0	0.0	0a	0.0	0.0		
	Subcortical cyst	3a	100.0	1.1	0a	0.0	0.0	0a	0.0	0.0		

%: Row percentage

MCI%: Column percentage for MCI and lowercase letters indicate the differences between the column percentages

*Fisher's Exact test

p values < 0.05 were considered statistically significant

The values written in bold are statistically significant *p* values (*p*0.05).

Table 4 Evaluation of the relationship between gender and degree of bone apposition at the mandibular angle according to groups

Groups	Grades	Female			Male			Test statistics	*p* value
		n	%	*g*%	*n*	%	*g*%		
Bruxers + Non-bruxers	G0	94a	74.0	38.8	33b	26.0	27.0	27.840	**< 0.001***
	G1	116a	71.2	47.9	47a	28.8	38.5		
	G2	32a	47.8	13.2	35b	52.2	28.7		
	G3	0a	0.0	0.0	7b	100.0	5.7		
Bruxers	G0	36a	69.2	14.9	16a	30.8	13.1	32.015	**< 0.001***
	G1	66a	74.2	27.3	23a	25.8	18.9		
	G2	20a	57.1	8.3	15a	42.9	12.3		
	G3	0a	0.0	0.0	6b	100.0	4.9		
Non-bruxers	G0	58a	77.3	24.0	17b	22.7	13.9		
	G1	50a	67.6	20.7	24a	32.4	19.7		
	G2	12a	37.5	5.0	20b	62.5	16.4		
	G3	0a	0.0	0.0	1a	100.0	0.8		

%: Row percentage

g%: Column percentage for gender and lowercase letters indicate differences between column percentages

*Fisher's Exact test

p values < 0.05 were considered statistically significant

The values written in bold are statistically significant *p* values (*p*0.05)

Discussion

Detection of radiological changes thought to be related to bruxism may direct clinicians to perform a more comprehensive examination in individuals who are unaware of their bruxism. Thus, adverse outcomes that may occur due to bruxism, such as temporomandibular joint problems [14] and implant failure [15], can be prevented with early diagnosis and treatment of bruxism. The present study aims to comparatively evaluate morphologic changes in the mandibular angle and condylar region, assess the MCI, and analyze the relationships between these parameters in bruxers and non-bruxers using panoramic radiographs.

Table 5 Evaluation of the relationship between mandibular angle grades and bone changes at the condyle according to groups

Groups	Condyles	G0			G1			G2			G3			Test statistics	*p* value
		n	%	*g.%*	*n*	%	*g.%*	*n*	%	*g.%*	*n*	%	*g.%*		
Bruxers	Normal	35a	28.5	27.6	61a	49.6	37.4	22a	17.9	32.8	5a	4.1	71.4	51.059	**0.043***
	Flattening	12a	31.6	9.4	22a	57.9	13.5	4a	10.5	6.0	0a	0.0	0.0		
	Erosion	0a	0.0	0.0	1a	50.0	0.6	1a	50.0	1.5	0a	0.0	0.0		
	Sclerosis	1a	50.0	0.8	0a	0.0	0.0	1a	50.0	1.5	0a	0.0	0.0		
	Surface irregularities	1a	25.0	0.8	1a	25.0	0.6	2a	50.0	3.0	0a	0.0	0.0		
	Deformity	2a	25.0	1.6	3a	37.5	1.8	3a	37.5	4.5	0a	0.0	0.0		
	Subcortical cyst	1a	20.0	0.8	1a	20.0	0.6	2a	40.0	3.0	1b	20.0	14.3		
Non-bruxers	Flattening	64a	42.1	50.4	64a	42.1	39.3	23a	15.1	34.3	1a	0.7	14.3		
	Erosion	9a	37.5	7.1	8a	33.3	4.9	7a	29.2	10.4	0a	0.0	0.0		
	Sclerosis	0a	0.0	0.0	0a	0.0	0.0	1a	100.0	1.5	0a	0.0	0.0		
	Surface irregularities	0a	0.0	0.0	1a	100.0	0.6	0a	0.0	0.0	0a	0.0	0.0		
	Deformity	0a	0.0	0.0	1a	100.0	0.6	0a	0.0	0.0	0a	0.0	0.0		
	Subcortical cyst	2a	66.7	1.6	0a	0.0	0.0	1a	33.3	1.5	0a	0.0	0.0		

%: Row percentage

g.%: Column percentage for grades and lowercase letters indicate the differences between the column percentages

*Fisher's Exact test

p values < 0.05 were considered statistically significant

The values written in bold are statistically significant *p* values (*p*0.05)

According to our study's results, in bruxist G3 individuals, the rate of MCI class C3 was higher than C2 and C1. This may be because bite forces cause different bone activity in different regions [13].

Bone and muscle are closely interrelated both anatomically and functionally [21]. Bone architecture and morphology depend on the load exerted by muscles [22], and muscle-derived insulin-like growth factor 1 receptor (IGF-1R), secreted by muscle fibers near the periosteum due to muscle hypertrophy, may direct nearby osteoblasts to build new bone [23]. A study examining long bones [24] noticed that muscle tension caused local cortical thickening of the bone. Another study evaluating the craniofacial region reported that variations in the growth pattern in this region had some effect on the width and height dimensions of the mandibular angle [25].

The mandibular angle region was evaluated on panoramic radiographs of bruxist and non-bruxist individuals (control group), and bone peaks in this region were determined to be associated with bruxism [10–12, 26]. Erzurumlu et al. found that bone peaks were observed approximately three times more in the study group than in the control group [11]. While Isman et al. [10] and Casazza et al. [26] thought that excessive bite force in individuals with bruxism caused bone peaks in the mandibular angle region, which is the attachment point of the masseter muscle, Hayek et al. [12] concluded in their study that since bony changes take a long time to occur, these appositions may provide information about the presence and duration of bruxism. In their research, Trüp et al. [9] classified the morphologic changes (change of direction and bone apposition) in this region as G0, G1, G2, and G3 according to their severity. They detected that bone appositions (G2, G3) were not found in the non-bruxist group. In the present study, in line with other studies, significantly more individuals were found to have G0 class in the non-bruxist group compared to the bruxist group, and we agree with the view that the bone apposition occurring in the mandibular angle region may be due to increased masseter and medial pterygoid muscle activity in bruxist patients [9, 10, 12, 13].

While no bone apposition was detected in the control group of Türp et al. [13], patients with both grade 2 and grade 3 classifications were detected in our control group. In that study, the non-bruxist group consisted of individuals between the ages of 12–18, while in our study, it consisted of individuals between the ages of 18–35. Simonek et al. [27] reported in their study that bone apposition is related to age and that the probability of occurrence is lower in the younger age group than in the middle age group. The difference between the study of Türp et al. [13] and our study may be due to the relationship between bone apposition and age. Further studies can be conducted examining the relationship between bone apposition and age groups in patients with bruxism.

When the relationship between bruxism and gender was evaluated, some studies [28, 29] reported that bruxism was not related to gender; some reported that it was more common in females [30] and some in males [31]. In the present study, no relationship was found between bruxism and gender, and the results of studies in the literature differ. Considering the significant relationship between bruxism and psychosocial factors [32, 33], the inconsistency between the results of the studies may be due to psychosocial differences between societies.

Isman et al. [10], evaluated the density and morphology of the mandibular bone in bruxist patients in their study. They reported that porosity in the endosteal cortex of the mandible was more common in bruxist individuals. Yilmaz et al. [13] specified a significant relationship between MCI and bruxism in their studies. According to the results of this study, C2 type MCI was detected the most and C3 type the least among bruxist individuals. Onsuren et al. [34] evaluated the effect of bruxism on the mandibular bone in pediatric patients using fractal analysis and radiomorphometric measurements on panoramic radiograph images. They emphasized that there was no significant difference in terms of MCI between the study groups and that the reason why their results differed from the other two studies [10, 13] may be related to the ongoing growth and development in pediatric patients. In the present study, MCI class C1 individuals were significantly more in the non-bruxist group, while MCI class C2 individuals were significantly more in the bruxist group. As in other studies [10, 13], individuals aged 18 and over were evaluated in our study and our results were consistent with these studies. According to our results, the reason why the C2 type is higher in bruxist individuals than in non-bruxist individuals may be that the increased chewing force due to bruxism causes resorption at the endosteal margin of the cortex.

Zhang et al. [35] compared cone-beam computed tomography (CBCT) images of adult patients with definite sleep bruxism with those without bruxism and found that condylar bone changes were higher in patients with bruxism. While 55% of the condyles in the control group had normal contours, this rate was 29% in the study group, and bone changes were observed in most condyles. The changes were classified as flattening, sclerosis, erosion, flattening + sclerosis, and others, and flattening constituted the majority of the changes observed in the study group. Güler et al. [36] emphasized in their magnetic resonance imaging study that condylar bone changes were more common in reduction joints in bruxist patients. In the present study, while no osteophytes were detected in either group, the normal condyle type was found to be significantly more common in the non-bruxist group, and the deformity condyle type was found to be significantly more common in the bruxist group. It is widespread for the anatomic structure of the TMJ to be remodeled in response to the stress it is exposed to [37]. It is considered that the reason why the abnormal condition type is detected more frequently in bruxist individuals is that the excessive stress acting on the TMJ due to bruxism leads to bony changes in this condition.

While Yilmaz et al. [13], did not observe a significant relationship between the severity of mandibular angle apposition and MCI in individuals with bruxism, a significant relationship was found in our study. In this research, in the bruxist G0 individuals, the rate of C2 was found higher than C1, and in the bruxist G3 individuals, the rate of C3 was found higher than C2 and C1. In the non-bruxist G0 and non-bruxist G1 individuals, the rate of C2 is lower than the rate of C1. The difference between the studies may be due to the study populations. In the study by Yılmaz et al., the non-bruxist group consisted only of group 0 individuals. According to the result of our study, as the apposition increases at the outer margin of the mandibular cortex, resorption and porosity at the endosteal margin of the mandibular cortex also may increase, in the bruxist group. This may be because bite forces cause different bone activity in different regions [13].

In the study of Erzurumlu et al. [11], the relationship between the gender and bone peaks in the mandibular angle region was evaluated. The probability of having bone peaks was 5.5 times higher in men than in women. Yilmaz et al. [13] reported that the degree of bone apposition at the mandibular angle was significantly higher in males (G2, G3) than in females (G0, G1). In our study, similar to the study of Yılmaz et al. [13], the degree of bone apposition at the mandibular angle was significantly higher in males (G2, G3) than in females (G0). In the present study, when the relationship between the bone apposition degree in the mandibular angle and gender was evaluated according to the study groups, the G3 degree rate was higher in males in the bruxist group, and the G0 degree rate was higher in females in the non-bruxist group. Considering the data in our study, we agree with the idea that the higher masticatory muscle strength observed in men may cause an increase in the severity of apposition.

In the present study, the relationship between the mandibular condyle type and MCI was compared between bruxist and non-bruxist groups. In non-bruxist individuals, the C1 class was significantly higher than the C2 class in the flattening condyle type. According to our study, the flattening may also be observed in cases where there is no bone loss at the endosteal margin of the mandibular cortex, and TMJ is not overloaded due to increased masticatory muscle activity. In the condyle, when the bone tissue is exposed to increased mechanical loads, osteoproliferation characterized by osteosclerosis and osteophyte development or bone resorption exemplified by erosions and subchondral cyst formation may occur [38]. In degenerative diseases seen in TMJ, erosive lesions and narrowing of the joint space may reflect early changes, while sclerosis, flattening, subchondral cysts, and osteophytes may reflect late changes [39]. In our study, when the relationship between the mandibular condyle type and the degree of apposition at the mandibular angle was compared between bruxist and non-bruxist groups in the presence of subcortical cysts in bruxist individuals, the rate of G3 was significantly higher than the rate of G0, G1, and G2. According to our study, as the degree of apposition increases, the rate of subcortical cyst occurrence also increases in bruxers. Further studies evaluating the intensity and duration of forces in bruxism can be conducted to interpret whether apposition and subcortical cysts are late-stage changes of bruxism.

Various studies were conducted to determine whether radiologic changes can be used as an auxiliary diagnostic tool in the evaluation of bruxism, which has a prevalence of 22.22% worldwide [40] and is a risk factor for adverse health outcomes [1]. Some of these studies used radiomorphometric indexes determined by linear measurements on panoramic radiography images, a preferred imaging method in routine examinations. However, since it was concluded that the linear distance measured by panoramic radiography is unreliable [41], the authors preferred using classifications that evaluate macroscopically visible radiologic changes in this study.

This study provided radiologic data that could be used as additional diagnostic markers to evaluate bruxism in routine examinations involving panoramic radiographic images. However, the limitations of this study are that reference standards such as CBCT images were not used in the diagnosis of condylar bone changes, and the severity and periods of bruxism were not measured. In future studies, a reference standard such as CBCT images can be used to evaluate the diagnosis of condylar bone changes in bruxers.

Conclusion

Our study showed that deformity of the condyle and MCI class C2 were more common in the bruxist group. In bruxist G3 individuals, the rate of MCI class C3 was higher than C2 and C1. For a general overview of the probable presence of bruxism, osseous changes in the mandibular condyle, and MCI can be used as auxiliary diagnostic markers and it can be considered that the apposition at the mandibular angle may increase as resorption at the endosteal margin of the cortex increases in bruxers.

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Declarations

Conflict of interest The authors declare that they have no competing interests.

Informed consent Informed consent was obtained from all patients for being included in the study.

Ethical approval All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

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