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ORIGINAL ARTICLE

A new perspective for radiologic findings of bruxism on dental panoramic radiography

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Abstract

Objective This study aims to evaluate whether there is a relationship between the appositional classification in the mandible angle region and the mandibular cortical index (MCI) seen in bruxist individuals and to differentiate between the bruxist group without mandibular apposition and the non-bruxist group on panoramic radiographs.

Methods The mandible angle region of 209 individuals, 170 bruxists and 39 non-bruxists, were included in the study. Each mandible angle apposition was classified as G0 (No directional change, no bone apposition)—G1 (Directional change on the basal cortex. No bone apposition)—G2 (Directional change plus generalized bone apposition with inhomogeneous surface)—G3 (Directional change plus localized bone apposition at one or more sites). The MCI of each individual was recorded according to their classified apposition.

Results No statistically significant difference was found in the relationship between MCI and apposition severity in mandible angle grades in bruxist individuals ($p = 0.063$). A statistically significant difference was found between MCI and the bruxist G0/non-bruxist G0 groups ($p < 0.001$). While the MCI-C1 was higher in non-bruxist G0 individuals, the MCI-C2 was higher in bruxist G0 individuals. A statistically significant correlation was found between gender and severity of grades ($p < 0.001$).

Conclusion Although it is known that appositional changes are seen in the mandible angle region in bruxism, MCI can be used as a valuable radiologic diagnostic criterion during the evaluation of bruxist and healthy individuals in the G0 grade who have not yet radiologically demonstrated bone apposition in the mandible angle.

Keywords Bruxism · Biological adaptation · Bone remodeling · Panoramic radiography · Mandibular cortical index

Introduction

Although bruxism has different definitions in previous studies in the literature, the definition in the latest consensus has been determined as a repetitive jaw muscle activity characterized by clenching, grinding, supporting, or pushing the mandible [1]. Bruxism is associated with various factors, but its etiology is not well understood. In general, three main factors related to its etiology are stated: psychosocial factors (depression, stress, and anxiety), pathophysiological factors (increased muscle activity, disorders in the neurotransmitter system, use of serotonin reuptake inhibitors), and environmental factors (occlusion relationships) [2–5]. Bruxism is a condition characterized by persistent jaw clenching and grinding of the teeth while asleep or awake. "Asleep bruxism" (9.3–15.9%) and "awake bruxism" (22.1–31%) are common in the general adult population [6]. The recent consensus is that 'possible' asleep or awake bruxism should be based on individual's self-report, by means of questionnaires and/or the anamnestic part of a clinical examination. 'Probable' asleep or awake bruxism should be based on self-report plus the inspection part of a clinical examination. The definitive diagnosis of bruxism is made by supporting the individual's history and clinical

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examination with methods such as electromyography (applicable in medium-sized populations, but with limited availability) and polysomnography (the gold standard tool for diagnosing asleep bruxism, but a technique suited only to small samples due to high cost and limited availability) [1]. Bruxism adversely affects the stomatognathic system in general and examples of these effects are microtrauma, orofacial pain, tooth fractures, bone loss around the implant, and changes in bone resorption in the condylar region [7–9]. In studies on bruxism, the effect of bruxism on the mandibular condyle and TMJ has been evaluated in general [10–12]. Since bruxism is the result of the activation of the masticatory muscles, the places where the muscles are attached in the mandible may try to adapt to the activity of these muscles. In a recent study, Türp et al. [13] reported that bone apposition occurs as a result of parafunctional activations of the masticatory muscles in the mandible angle region, and these appositions were classified according to their severity. In this classification, it has reported in literature by grading (G0, G1, G2, G3) on radiographs based on the bone apposition in the basal cortex in the mandible angle region.

Similar to the adaptation that occurs as a result of the effect of the muscles on the bone, bone mineralization also changes according to the chewing force [14]. Muscle activity also plays an important role in mechanical transduction, and bone homeostasis [15]. Klemetti et al. [16] made a classification called Mandibular Cortical Index (MCI) based on the bone change in the mandibular cortex in panoramic radiographs. According to this classification, the porosity in the mandibular basal bone is graded. Isman [9] reported the relationship of MCI in bruxist and non-bruxist individuals in her study. In the studies of Isman [9] and Türp et al. [13], the importance of radiologic findings, as well as clinical findings and anamnesis, were mentioned for bruxism. However, the classification in Türp et al. [13]'s study cannot distinguish between G0 (No directional change, no bone apposition at mandible angles) bruxist and non-bruxist individuals through panoramic radiographic findings. Therefore, establishing a relationship between MCI and the severity of grades may be a parameter that can radiographically distinguish bruxist and non-bruxist individuals. To the authors knowledge, there is no study in the literature investigating this relationship.

This study aims to evaluate whether there is a relationship between the appositional classification in the mandible angle region and the mandibular cortical index (MCI) seen in bruxist individuals and to differentiate between the bruxist group without mandibular apposition and the non-bruxist group on panoramic radiographs. Another objective of this study is to evaluate whether panoramic radiographic findings can be diagnostic criteria in determining whether individuals are possible bruxist.

Materials and methods

Study design

This study was designed retrospectively. The authors obtained written consent from all the participants of this study. Ethical approval was obtained from the Local Ethical Board (2022/208). The study protocol complies with the principles outlined in the Declaration of Helsinki. A power analysis revealed that the required minimum sample size was 207, for a power of 95% and effect size of 0.3 [9]. In the study, panoramic radiographs of 600 bruxist individuals who were admitted to the Department of Oral and Maxillofacial Radiology, between 2019 and 2022, were evaluated by a dentomaxillofacial radiologist (EMC). As a result, according to the inclusion and exclusion criteria in Table 1, 340 mandible angle regions (170 individuals) were included in the study as the bruxist group, and 78 mandible angle regions (39 individuals) were included as the control group.

Clinical examination

To establish bruxism diagnosis, according to the criteria reported by Pintado et al. [17], the individuals were asked to respond positively to at least two of the following questions during the anamnesis:

1. Has anyone ever told you that you grind your teeth at night?
2. Does your jaw ever get tired when you wake up in the morning?
3. Do your teeth and gums hurt when you get up in the morning?
4. Do you have a headache when you wake up in the morning?
5. Have you ever noticed that you grind your teeth during the day?
6. Have you ever noticed that you are clenching your teeth during the day?

In the clinical examination performed after the individual's anamnesis, if at least one of the clinical findings such as tooth wear, linea alba prominence, and teeth marks on the tongue edge is present, the individual's probable bruxist diagnosis is revealed [1]. No temporomandibular joint (TMJ) disorder was observed in the routine TMJ examination of these individuals.

Table 1 Inclusion and exclusion criteria for groups

Inclusion criteria of bruxist group	Exclusion criteria of bruxist group	Inclusion criteria of non-bruxist group
1. Panoramic radiographs of individuals who are osteodystrophic and have no history of systemic disease affecting bone metabolism,	1. Panoramic radiographs of individuals reporting current or past use of bisphosphonate group drugs in their anamnesis,	1. Panoramic radiographs of healthy volunteers without any systemic disease,
2. Panoramic radiographs of individuals who do not have more than one missing tooth except for the third molars in the maxilla or mandible,	2. Panoramic radiographs of individuals whose presence of any pathology such as cyst/tumor in the maxillofacial region is determined on panoramic radiographs,	2. Panoramic radiographs of individuals with angle class 1 occlusion and no missing teeth other than third molars in maxilla and mandible,
3. Panoramic radiographs of individuals with a history of jaw clenching/grinding for at least 6 months,	3. Panoramic radiographs of individuals with past or current orthodontic treatment, individuals with occlusion other than angle class 1 and individuals with TMJ disease,	3. Panoramic radiographs of individuals who have not been diagnosed with bruxism and who do not have any of the bruxism criteria in their anamnesis and intraoral examination,
4. Panoramic radiographs of patients who stated that they were Bruxist in their anamnesis and individuals with intraoral symptoms consistent with this anamnesis,	4. Panoramic radiographs of individuals who have reported neurological and psychiatric, alcoholism and drug addiction diseases in their anamnesis,	4. Panoramic radiographs of individuals who do not have any restoration or prosthetic rehabilitation in their maxilla and mandible teeth
5. Panoramic radiographs of individuals aged 20–40 years with Angle class 1 occlusion	5. Panoramic radiographs of individuals with restoration in any of their teeth were excluded from the study.	5. Panoramic radiographs of individuals aged 20–40 will be included in the control group
	6. The panoramic radiographs of Bruxist individuals with an apposition intensity of two degrees and above (G0–G2, G0–G3, G1–G3) in the right-left angle region were excluded from the study	

Radiographic examination

All panoramic radiographs were taken with the same device (OP200 Instrumentarium Dental, Tuusula, Finland; 64 kV, 8 mA and 14.1 s exposure time). The manufacturer's instructions were followed while positioning the individuals, the Frankfort horizontal plane was parallel to the floor and the sagittal plane was aligned with the vertical line generated by the device. Panoramic radiographs of the patients included in the study were anonymized and bruxist individuals were divided into 4 main groups as G0-G1-G2-G3 by the other two blinded dentomaxillofacial radiologists (MHK, SY) who evaluated the radiographs, independent of each other, according to the classification of Türp et al. [13].

Grade classification

G0: Convex course of the basal cortex. No directional change, no bone apposition.

G1: Directional change from the convex course of the basal cortex. No bone apposition.

G2: Directional change plus generalized bone apposition with inhomogeneous surface.

G3: Directional change plus localized bone apposition at one or more sites (Fig. 1).

The same dentomaxillofacil radiologists were blinded for each group and the mandibular cortical index was evaluated and recorded according to the classification of Klemetti et al. [16].

MCI classification

Cl: The endosteal margin of the cortex was even and sharp on both sides.

C2: The endosteal margin showed semilunar defects (lacunar resorption) or seemed to form endosteal cortical residues (one to three layers) on one or both sides.

C3: The cortical layer formed heavy endosteal cortical residues and was clearly porous (Fig. 2).

Non-bruxist individuals were classified as G0. The MCI of the patients in this group was determined and recorded.

Images were recorded on a Dell Precision T5400 workstation (Dell, Round Rock, TX, USA) with a 19-inch 1920 × 1080 resolution monitor (Dell E190S, China) in a semi-dark room.

Statistical analysis

Statistical analysis was performed using SPSS software (IBM Statistical Package for Social Sciences, version 23.0; SPSS Inc., Chicago, Illinois, USA). Continuous variables were summarized as mean ± standard deviation. Categorical

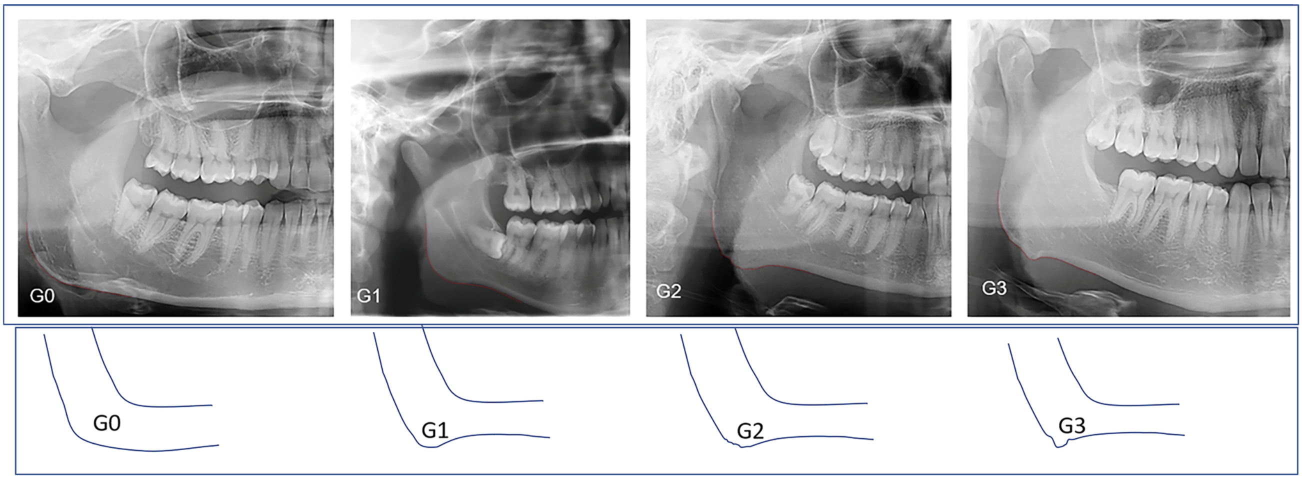

Fig. 1 Bone apposition at the mandible angle and grade classification on cropped panoramic radiography. (G0: Convex course of the basal cortex. No directional change, no bone apposition. G1: Directional change from the convex course of the basal cortex. No bone apposition. G2: Directional change plus generalized bone apposition with inhomogeneous surface. G3: Directional change plus localized bone apposition at one or more sites)

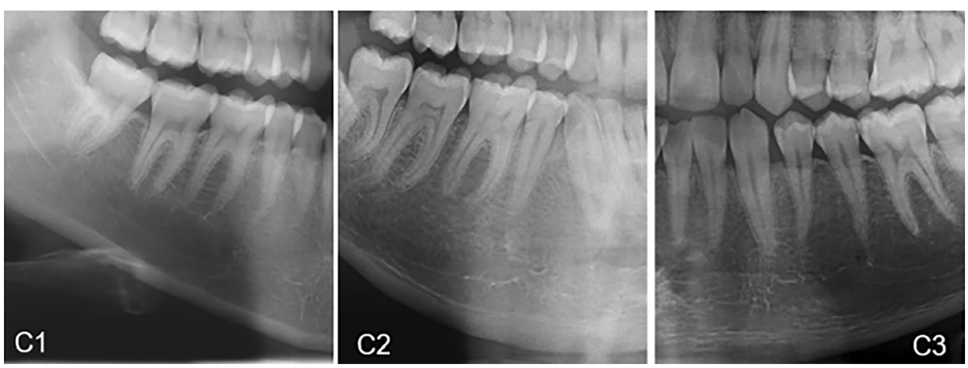

Fig. 2 Mandibular Cortical Index classification (C1, C2, C3) on cropped panoramic radiography. (Cl: The endosteal margin of the cortex was even and sharp on both sides. C2: The endosteal margin showed semilunar defects (lacunar resorption) or seemed to form endosteal cortical residues (one to three layers) on one or both sides. C3: The cortical layer formed heavy endosteal cortical residues and was clearly porous)

variables were shown as frequencies and percentages. In grade and index classification, interobserver Cohen's kappa coefficient with a confidence interval of 95% (95% CI) was determined. The authors used the scale defined by Landis and Koch [18] characterized values < 0 as indicating no agreement and 0–0.20 as slight, 0.21–0.40 as fair, 0.41–0.60 as moderate, 0.61–0.80 as substantial, and 0.81–1 as almost perfect agreement [18]. Relation between categorical variables were determined by the chi-square test. The significance level was set at 0.05.

Results

In the study, 340 samples, from 170 bruxist individuals (75 male and 95 female) were included in the bruxist group. In the non-bruxist group, there were 78 samples from 39 non-bruxist individuals (23 female and 16 male). The mean age of the male included in the study was 28.4 ± 4.29; the mean age of the female was 27.7 ± 4.09 (Table 2). The kappa coefficient used for interobserver

Table 2 Descriptive data

	Bruxist Group		Non-Bruxist Group		Total	Age
Grades	*N*	%	*N*	%	*N*	Year ± std
G0	158	46.5	78	100	236	27.51 ± 5.08
G1	73	21.5			73	28.71 ± 2.02
G2	67	19.7			67	28.59 ± 2.77
G3	42	12.3			42	28.64 ± 2.80
Total	340	100	78	100	418	
MCI						
C1	90	26.5	54	69.2	144	26.54 ± 3.61
C2	231	68	24	30.8	255	28.81 ± 4.30
C3	19	5.5	0	0	19	28.26 ± 3.95
Total	340	100	78	100	418	
Gender						
Female	190	55.9	46	59	236	27.7 ± 4.09
Male	150	44.1	32	41	182	28.4 ± 4.29
Total	340	100	78	100	418	

G0: Convex course of the basal cortex. No directional change, no bone apposition

G1: Directional change from the convex course of the basal cortex. No bone apposition

G2: Directional change plus generalized bone apposition with inhomogeneous surface

G3: Directional change plus localized bone apposition at one or more sites

Cl: The endosteal margin of the cortex was even and sharp on both sides

C2: The endosteal margin showed semilunar defects (lacunar resorption) or seemed to form endosteal cortical residues (one to three layers) on one or both sides

C3: The cortical layer formed heavy endosteal cortical residues and was clearly porous

MCI mandibular cortical index, *std* standard deviation

reliability in grade classification was found to be 0.927 (almost perfect). In the index classification, the kappa coefficient used for interobserver reliability was found to be 0.976 (almost perfect). Considering the relationship between the severity of MCI and mandible angle apposition grades in bruxist individuals, there is no statistically significant difference between MCI and grades ($p = 0.063$). However, as the severity of apposition increased, a decrease was found in the number of individuals with sharply circumscribed cortical bone structure (C1) (Table 3). A statistically significant difference was found between MCI with bruxist and non-bruxist groups ($p < 0.001$) (Table 4). The difference between the bruxist and non-bruxist groups in grade 0 classes was statistically significant. MCI-C1 class was found to be higher in non-bruxist G0 individuals, while MCI-C2 class was found to be higher in bruxist G0 individuals. A statistically significant relationship was found between gender and severity of grades ($p < 0.001$) (Table 5). G2 and G3 appositions are more common in males, while G0 and G1 are more common in females.

Discussion

As the intensity and duration of the mechanical stimuli to which it is exposed increases, the bone may respond to this and adapt together with remodeling. There is a positive relationship between muscle strength and bone mineral density [19, 20]. While the relationship between bone and muscle is reported in this way, there are appositional changes in the bone in the mandible angle region, especially in bruxist individuals [9, 13]. Isman [9] investigated the changes caused as a result of bruxism in the mandibular bone and reported bone apposition, which the author called tiny “bone peaks” in the mandible angle region. Türp et al. [13] classified these appositional changes according to the severity of apposition (G0–G3) and graded them. The main purpose of this study is to determine and investigate whether the distinction of G0 grade can be made radiologically and whether there is a relationship between these grades and any radiomorphometric index.

Table 3 Evaluation of the relationship between mandibular cortical ındex and mandibular angle grades according to groups

Groups				Mandibular cortical index			Total	*P* value
				C1	C2	C3		
Non-bruxist	Grade G0		Count	55	23		78	0.063
			% within grade	70.5%	29.5%		100%	
	Total		Count	55	23		78	
			% within grade	70.5%	29.5%		100%	
Bruxist	Grades	G0	Count	51	101	6	158	
			% within grade	32.3%	63.9%	3.8%	100%	
		G1	Count	21	49	3	73	
			% within grade	28.8%	67.1%	4.1%	100%	
		G2	Count	12	50	5	67	
			% within grade	17.9%	74.6%	7.5%	100%	
		G3	Count	6	31	5	42	
			% within grade	14.3%	73.8%	11.9%	100%	
	Total		Count	90	231	19	340	
			% within grade	26.5%	67.9%	5.6%	100%	

G0: Convex course of the basal cortex. No directional change, no bone apposition

G1: Directional change from the convex course of the basal cortex. No bone apposition

G2: Directional change plus generalized bone apposition with inhomogeneous surface

G3: Directional change plus localized bone apposition at one or more sites

Cl: The endosteal margin of the cortex was even and sharp on both sides

C2: The endosteal margin showed semilunar defects (lacunar resorption) or seemed to form endosteal cortical residues (one to three layers) on one or both sides

C3: The cortical layer formed heavy endosteal cortical residues and was clearly porous

Table 4 Evaluation of the relationship between mandibular cortical ındex and bruxist G0 And non-bruxist G0 groups

			Groups		Total	*P* value
			Non-bruxist G0	Bruxist G0		
Mandibular Cortical Index	C1	Count	55a	51b	106	0.000*
		% within group	70.5%	32.3%	44.9%	
	C2	Count	23a	101b	124	
		% within group	29.5%	63.9%	52.5%	
	C3	Count	0a	6a	6	
		% within group	0.0%	3.8%	2.5%	
Total		Count	78	158	236	
		% within group	100%	100%	100%	

Each subscript letter denotes a subset of Group categories whose column proportions do not differ significantly from each other at the 0.05 level

Cl: The endosteal margin of the cortex was even and sharp on both sides

C2: The endosteal margin showed semilunar defects (lacunar resorption) or seemed to form endosteal cortical residues (one to three layers) on one or both sides

C3: The cortical layer formed heavy endosteal cortical residues and was clearly porous

*$p < 0.001$

Radiomorphometric indexes rely heavily on cortical bone measurements because the cortical bone is more easily visualized on radiographs than trabecular bone [21]. By calculating the ratio of cortical bone thickness to total bone thickness, regional effects of bone mass and osteoporosis can be evaluated [22, 23]. Indexes containing linear measurements are controversial due to the difficulty of standardization in panoramic radiographs. Variations in linear measurements have been reported for errors due to patient positioning [24–27]. When the studies in the literature were scanned, it was observed that the MCI, among the other radiomorphomeric indexes, was used as an

Table 5 Evaluation of the relationship between gender and mandibular angle grades

			Grades				Total	*P* value
			G0	G1	G2	G3		
Gender	Male	Count	47a	25a	45b	33b	150	0.000*
		% within grade	29.7%	34.2%	67.2%	78.6%	44.1%	
	Female	Count	111a	48a	22b	9b	190	
		% within grade	70.3%	65.8%	32.8%	21.4%	55.9%	
Total		Count	158	73	67	42	340	
		% within grade	100%	100%	100%	100%	100%	

Each subscript letter denotes a subset of Grade categories whose column proportions do not differ significantly from each other at the .05 level

G0: Convex course of the basal cortex. No directional change, no bone apposition

G1: Directional change from the convex course of the basal cortex. No bone apposition

G2: Directional change plus generalized bone apposition with inhomogeneous surface

G3: Directional change plus localized bone apposition at one or more sites

*$p<0.001$

identifiable index in bruxist individuals [9, 24, 28]. When all this information was evaluated, the authors thought that the radiological distinction of bruxist G0 and non-bruxist G0 individuals could be made using the MCI index, since the changes in MCI, which is the index that is least affected by the disadvantages of panoramic radiography, are related to bruxism. In addition, the relationship between apposition severity and MCI was evaluated.

Based on analysis, a statistically significant difference was found between bruxist G0 and non-bruxist G0 individuals. While MCI-C1 class was found to be higher in non-bruxist G0 individuals, MCI-C2 class was found to be higher in bruxist G0 individuals. The reason for this is that resorption begins in the cortical bone area due to excessive chewing force and more lacunar and porous borders are seen in the mandible cortex [9, 24]. In addition, this study reports that in addition to the classification made by Türp et al. [13], bruxist and non-bruxist individuals with grade G0 can be radiologically distinguished by looking at their MCI. However, no statistically significant relationship was found between MCI and grade severity in the bruxist group. To the best of the authors' knowledge, this study is the first in the literature to classify the severity of mandibular apposition in bruxist individuals and evaluate the relationship between apposition severity and MCI. As the severity of apposition in the mandible angle region increases, it can be concluded that there is a decrease in the number of individuals whose endosteal edge is straight and sharp on both sides (C1), and therefore, there is an increase in porosity in the mandibular cortex.

Isman [9] found a significant relationship between bruxism and MCI. According to the results of this study, C2 type MCI was reported the most and C3 type the least among bruxist individuals. Bozdağ and Şener [29] found the number of MCI-C3 to be the lowest and reported that MCI-C2 was the most common in their study. Similarly, in this study, MCI-C2 was found to be the highest in the bruxist group and the least to MCI-C3. The authors think that the reason for this situation is the selected population and the rigid inclusion criteria created in the study. The authors also think that different results may be obtained in a larger population. Previous studies have reported that bite forces lead to different bone activity in different regions. Similarly, in this study, while porosity and resorption pattern were observed in the mandibular cortical bone in bruxist individuals, bone remodeling characterized by bone apposition was observed in the mandibular angulus region.

Gülşahi et al. [28], found that the prevalence of C3 increased with age, and in logistic regression analysis, the probability of C3 increased 9.17 and 79.14 times in the 50–69 age group and the over 70 age group, respectively. In the study of Bozdağ and Şener [29], unlike Gülşahi et al. [28], they found the number of MCI-C3 to be the lowest and reported that C2 was the most common. In this study, the MCI-C2 number was found to be the highest and the MCI-C3 number to be very low in bruxist individuals. The reason for this is that the age group was chosen as 20–40, which is the young adult group, similar to the study of Bozdağ and Şener [29], to determine the standardization ideally in the study. In addition, individuals who use drugs that affect bone metabolism or who have systemic diseases were excluded from this study. The authors think that Gülsahi et al. [28] found MCI-C3 in greater numbers as a result of the inclusion of patients with osteoporosis and other systemic disorders in their study.

In the study of Türp et al. [13], which is the only study in the literature in which mandibular apposition severity is classified, no evaluation is reported of the relationship between gender and apposition severity between bruxist and non-bruxist groups. In this study, a statistically significant relationship was found between gender and mandibular apposition severity. G2 and G3 appositions are more common in males, while G0 and G1 appositions are more common in females. This study is the first to reveal the relationship between gender and mandible angle apposition severity. The fact that the masticatory muscle strength of men was higher than that of women may have increased the severity of apposition [30].

In this study, besides anamnesis and intraoral findings, a standardized radiological finding was also investigated for the preliminary diagnosis of bruxism. The inability to evaluate the chewing forces and the inability to classify the time to be a bruxist are reported as limitations. It is thought that the intensity and the duration of the forces in bruxism affect the appositional or resorptional changes on the bone. For the purpose of this study, no comparison was made between non-bruxist grades (G1, G2, G3) and bruxist grades, except for the non-bruxist G0 grade. This is one of the limitations of the study.

Conclusion

Although it is known that appositional changes are seen in the mandible angle region in bruxism, MCI can be used as a valuable diagnostic criterion in the evaluation of bruxist and non-bruxist individuals in the G0 grade who have not yet radiologically demonstrated bone apposition in the mandible angle. In addition to the anamnesis and clinical examination, attention to the MCI classification of patients thought to be probable bruxists may be included in the evaluation criteria as a radiologic finding to support bruxism diagnosis. The authors suggest that studies involving chewing force and followed bruxist individuals should be conducted to investigate the effect of force and duration of exposure on appositional or resorptional changes on the bone in bruxism. In addition, non-bruxist individuals with different grades of apposition should be compared with bruxist individuals in future studies.

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Declarations

Conflict of interest All authors declare that they have no conflict of interest. This article does not contain any studies with human or animal subjects performed by the any of the authors.

Ethical approval All the procedures followed were in accordance with the ethical standards of the responsible committee institutional and national) and with the Helsinki Declaration of 1964 and later versions. Informed consent was obtained from all patients for being included in the study.

Informed consent Not applicable.

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