

Relationship Between the Mandibular Cortical Index and Periodontitis Stage/Grade: A Retrospective Radiographic Study

Mandibular Kortikal İndeks ile Periodontitis Evre/Derecesi Arasındaki İlişki: Retrospektif Radyografik Çalışma

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ABSTRACT

Background: In the literature, the relationship of the mandibular cortical index (MCI) with the stage and grade of periodontitis has not yet been investigated. This study aimed to examine the relationship between the stage and grade of periodontitis and MCI according to the current classification of periodontal disease.

Methods: A total of 199 patients (119 females, 80 males) were included in this study. The study population consisted of patients with periodontitis and controls without periodontitis. The stage and grade of the patients with periodontitis were determined according to the criteria of the "2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions". Patient records, including periodontal data and panoramic radiographs, were used for this classification. The MCI values of the patients were also recorded by evaluating the same panoramic radiograph. The Pearson chi-square test was used to compare categorical data according to groups, and multiple comparisons were undertaken with the Bonferroni-corrected Z test.

Results: The non-periodontitis (NP) group had the highest C1 type bone rate ($p<0.001$). The C3 rate of the stage III/IV group was significantly higher compared to all the remaining groups (stage I, stage II, and NP) ($p<0.001$). The C3 rate was significantly higher in the grade C group than in the grade B and NP groups ($p<0.001$).

Conclusions: The data obtained from this study suggest that there is a positive relationship between the stage and grade of periodontitis and MCI.

Keywords: Bone Density, Mandibular Cortical Index, Osteoporosis, Periodontitis

Öz

Amaç: Mandibular kortikal indeks (MKİ), mandibular kemik mineral yoğunluğunu değerlendirmek için kullanılan radyomorfometrik indekslerden biridir. Mandibular kortikal indeksinin (MKİ) periodontitisin evresi ve derecesi ile ilişkisi literatürde henüz araştırılmamıştır. Bu retrospektif çalışmada, periodontal hastalığın mevcut sınıflandırmasına göre periodontitisin evresi ve derecesi ile MKİ arasındaki ilişkinin incelenmesi amaçlanmıştır.

Gereç ve Yöntemler: Bu çalışmaya 119'u kadın, 80'i erkek olmak üzere toplam 199 hasta dahil edilmiştir. Çalışma popülasyonu periodontitisli hastalar ve periodontitis olmayan kontrol hastalarından oluşmuştur. Periodontitisli hastaların evresi ve derecesi "2017 Dünya Periodontal ve Peri-Implant Hastalıklarının Durumlarının Sınıflandırılması Çalışması" kriterlerine göre belirlenmiştir. Bu sınıflandırma için klinik periodontal verileri ve panoramik radyografileri içeren hasta kayıtları kullanılmıştır. Aynı panoramik radyografi değerlendirilerek hastaların MKİ değerleri de kaydedilmiştir. İstatistiksel analizde kategorik verilerin gruplara göre karşılaştırılmasında Pearson ki-kare testi kullanılırken, çoklu karşılaştırmalar ise Bonferroni düzeltilmeli Z testi ile yapılmıştır.

Bulgular: Periodontitis olmayan (NP) grup en yüksek C1 tipi kemik oranına sahip olarak belirlenmiştir ($p<0.001$). Evre III/IV grubunun C3 oranı diğer tüm gruplara (evre I, evre 2 ve NP) göre anlamlı derecede yüksek bulunmuştur ($p<0.001$). C3 oranı C derece grubunda B ve NP gruplarına göre anlamlı derecede yüksektir ($p<0.001$).

Sonuçlar: Bu çalışmadan elde edilen veriler periodontitisin evresi ve derecesi ile MKİ arasında pozitif bir ilişki olduğunu göstermektedir.

Anahtar Kelimeler: Kemik Yoğunluğu, Mandibular Kortikal İndeks, Osteoporoz, Periodontitis

INTRODUCTION

Periodontitis, a very common inflammatory disease caused by specific microorganisms, is characterized by the progressive loss of connective tissue and alveolar bone around the teeth.¹ Today, periodontitis is classified according to the disease's severity and rate of progression.² According to the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions, the severity of periodontitis is expressed as a stage and the rate of progression as a grade.² The stage of periodontitis is evaluated in four categories, namely stage I, II, III, and IV, and the grade of the disease is divided into the three categories of A, B, and C.

Proinflammatory cytokines secreted in periodontal disease have a strong interaction with osteoclast cells. It is considered that increased osteoclastic activity in periodontal inflammation may also affect skeletal bone metabolism with the spread of cytokines.³ Osteoporotic changes, which are characterized by reduced mineral content, especially in the jawbone part of the skeleton, may be associated with periodontitis.^{4,5}

In studies investigating the relationship between osteoporotic changes in the mandibular bone and periodontitis, mandibular bone mineral den-

sity in the mandibular bone and periodontitis, mandibular bone mineral density (BMD) has been evaluated with densitometric techniques or radiomorphometric indices using panoramic radiographs. Various imaging techniques, such as dual energy X-ray absorptiometry (DXA), quantitative computed tomography, quantitative ultrasound, digital X-ray radiogrammetry, and radiographic absorptiometry, are utilized for the evaluation of BMD.⁶ The measurement of BMD with DXA is accepted as the gold standard in the diagnosis of osteoporosis.⁷ Panoramic films, which have become one of the routine diagnostic tools in dental clinics, have also attracted the attention of researchers as a method that is easily accessible and provides information on bone density. Some radiomorphometric indices have been developed to determine mandibular BMD using panoramic X-ray films.

The mandibular cortical index (MCI), one of the radiomorphometric indices used to evaluate mandibular BMD, was defined by Klemetti et al.⁸ Although most researchers have employed the MCI to evaluate mandibular BMD in patients with osteoporosis, there are also studies in which this index has been used in patients with chronic periodontitis.⁸⁻¹²

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To the best of our knowledge, this is the first study to investigate the relationship of MCI with stage and grade in the final classification of periodontal disease. This study aimed to examine this relationship and compare the results between patients with periodontitis and periodontally healthy controls.

MATERIAL AND METHODS

This retrospective study was approved by the Clinical Research Ethics Committee of Erzincan Binali Yıldırım University Faculty of Medicine, with the decision number 2023-01/3, dated January 5, 2023. The study included examining the patients' examination records and panoramic radiographs for periodontal diagnosis. Sample selection was performed using the records of the patients who presented to the Department of Periodontology of Erzincan Binali Yıldırım University Faculty of Dentistry. Patient records between October and December 2022 were examined. The following inclusion criteria were sought: sufficient periodontal examination information for disease classification (pocket depth, attachment loss, bleeding on probing, and periodontal tooth loss), identification of no systemic disease, no antibiotic use within the last three months, no periodontal treatment within the last six months, panoramic radiography of sufficient diagnostic quality, and an age range of 18-70 years. A sample size of 199 patients was achieved by randomly selecting the patient records that met the inclusion criteria.

All dental panoramic radiographs were obtained using the Planmeca ProOne (PLANMECA OY©, Helsinki, Finland) device at 68 kVp, 7 mA, and an exposure time of 9.5 seconds. The records were examined, and the patients' age, gender, MCI, and periodontal disease classification were noted. The periodontal classification of the patients was made by following the guidelines of the 2017 World Classification of Periodontal and Peri-Implant Diseases and Conditions using clinical examination records and panoramic radiographs.² According to these guidelines, the classification of periodontitis was based on the stage and grade system. Stages (I, II, III, and IV) were used to classify the severity and complexity of periodontitis, and grades (A, B, and C) were used to estimate the probability of case progression. Patients without radiographic bone loss and clinical attachment loss were evaluated in the non-periodontitis (NP) group. This group consisted of patients with a normal periodontium and healthy gingiva or gingivitis.

To define the four stages, the radiographic examination of the alveolar bone with the interdental clinical attachment loss of the most affected tooth was considered. In the presence of certain complexity factors, the stage was shifted to a higher level. The grade of periodontitis was determined based on the ratio of the percentage of "root length affected by bone loss / total root length", calculated with the measurements of the most affected tooth on the radiographs and the ages of the patients. The enamel-cementum boundary was taken as a reference in the measurements performed to determine the percentage of root affected by bone loss. The grade was evaluated as A if this percentage was less than 0.25, B if 0.25-1, and C if greater than 1. For example, if the percentage of the bone loss of the most affected tooth in a 45-year-old patient was 55 %, it was evaluated as grade C based on the calculation of $55 / 45 > 1$. In the presence of certain risk factors, the grade was shifted to a higher level.

Evaluation was performed separately for the stage and grade categories. In each category, four groups were formed, of which three belonged to the patients with periodontitis and one belonged to the patients without periodontitis (NP group). Accordingly, the groups of the stage category were as follows: stage I, stage II, and stage III / IV (representing severe periodontitis), and NP, and the grade category consisted of the grade A, grade B, grade C, and NP groups.

The MCI of each patient was obtained using their panoramic radiographic examinations. As defined by Klemetti et al.⁸, MCI was determined through the visual evaluation of the morphology of the lower cortical layer of the mandible, distal to the mental foramen. The MCI values are classified into the following three categories:

a) C1 (normal cortex): The endosteal border of the mandibular cortical layer is observed as a sharp and straight line on both sides. The cortical layer is clearly separated from the cancellous portion. An example of C1 is shown in Figure 1.



Figure 1. C1 type mandibular cortex

b) C2 (mildly to moderately eroded cortex): The endosteal border of the mandibular cortical layer is disrupted by semilunar defects that have developed due to lacunar resorptions. In addition, there is an appearance of two to three layers formed by endosteal cortical remnants unilaterally or bilaterally. An example of C2 is shown in Figure 2.



Figure 2. C2 type mandibular cortex

c) C3 (severely eroded cortex): The endosteal border of the mandibular cortical layer has lost its clarity, and there is cortical layer porosity. An example of C3 is shown in Figure 3.



Figure 3. C3 type mandibular cortex

The screening of the examination records of the patients and the evaluation of these records together with panoramic radiographs were undertaken by a specialist periodontologist (Ö.F.O.). Intra-observer agreement on the MCI assessment was determined using the kappa test. Two weeks after the first measurements, the MCI measurements of 50 selected patients were repeated by the same researcher.

Statistical Analysis

Data were analyzed using IBM SPSS v. 23. The Pearson chi-square test was used to compare categorical data according to groups, and multiple comparisons were undertaken with the Bonferroni-corrected Z test. The results of the analyses were presented as frequency (percentage) values for categorical data. The significance level was taken as $p < 0.050$.

RESULTS

The demographic characteristics of the patients with periodontitis (according to their stages and grades) and those without periodontitis are presented in Table 1. The records of a total of 199 patients, of whom 119 were women and 80 were men, were examined.

Table 1. Descriptive statistics of demographic characteristics by periodontitis stage and grade

	Gender				Age		
	Male		Female		n	Mean ± SD	Median (min-max)
	Frequency (n)	Percentage (%)	Fre- quency (n)	Percentage (%)			
Stage							
I	15	32.6	31	67.4	46	30.37 ± 9.91	28 (18 - 56)
II	25	43.1	33	56.9	58	40.78 ± 10.25	41 (23 - 66)
III/IV	22	44.9	27	55.1	49	48.84 ± 10.91	50 (24 - 69)
NP	18	39.1	28	60.9	46	24.22 ± 8.06	21 (18 - 58)
Grade							
A	1	33.3	2	66.7	3	55.67 ± 0.58	56 (55 - 56)
B	50	39.7	76	60.3	126	39.71 ± 12.67	40 (18 - 69)
C	11	45.8	13	54.2	24	41 ± 12.19	40 (23 - 67)
NP	18	39.1	28	60.9	46	24.22 ± 8.06	21 (18 - 58)

NP: non-periodontitis

A statistically significant difference was found in the distribution of the MCI values according to periodontitis stage ($p < 0.001$). This difference was observed in relation to the rates of all MCI categories. The results of the multiple comparisons of the MCI categories according to periodontitis stage and grade are given in Table 2.

Table 2. Comparison of MCI scores according to stage and grade of periodontitis

	Mandibular cortical index			Test statistic	p*
	C1	C2	C3		
Stage					
I	29 (63) ^a	17 (37) ^a	0 (0) ^a	103.5	<0.001
II	14 (24.1) ^a	43 (74.1) ^a	1 (1.7) ^a		
III, IV	7 (14.3) ^a	26 (53.1) ^{ab}	16 (32.7) ^a		
NP	40 (87) ^c	6 (13) ^c	0 (0) ^a		
Grade					
A	1 (33.3) ^{ab}	2 (66.7) ^{ab}	0 (0) ^{abc}	67.97	<0.001
B	44 (34.9) ^a	74 (58.7) ^a	8 (6.3) ^c		
C	5 (20.8) ^a	10 (41.7) ^a	9 (37.5) ^a		
NP	40 (87) ^a	6 (13) ^a	0 (0) ^c		

*Pearson chi-square test, a-c: No significant difference between the groups with the same letter.
NP: non-periodontitis; MCI: mandibular cortical index

According to the results of the stage category, the stage III/IV group had the lowest rate of C1 and the highest rate of C3. The rate of C3 was significantly higher in the stage III/IV group than in all the remaining stage groups (stage I, stage II, and NP) ($p < 0.001$). The rate of C1 was significantly lower in the stage III/IV group than in the stage I group and NP group ($p < 0.001$). The highest rate of C1 was found in the NP group. The NP group had the highest C1 rate. This difference was statistically significant compared to all the stage groups ($p < 0.001$). The NP group had the lowest C2 rate, which significantly differed from all the stage groups ($p < 0.001$). None of the cases in the NP group were in the C3 category. Most of the patients in the stage I group (63 %) were included in the C1 category. The C3 category was not observed in any of the patients in the stage I group. In the stage I group, the rate of C1 was significantly higher than in the stage II and stage III/IV groups ($p < 0.001$) and significantly lower than in the NP group ($p < 0.001$). The stage II group had the highest rate of C2 (74 %). C2 was the most common MCI category in this group. The rate of

C2 was significantly higher in the stage II group than in the stage I and NP groups ($p < 0.001$).

According to the results of the grade category, the rate of C3 in the grade C group was numerically higher than in the remaining grade groups. The rate of C3 was significantly higher in the grade C group than in the grade B and NP groups ($p < 0.001$). The rate of C1 in the grade C group was numerically lower than in the remaining grade groups. In the grade C group, the rate of C1 was significantly lower than in the NP group ($p < 0.001$) but did not significantly differ from the grade A and B groups ($p > 0.05$).

Of the total of 153 patients with periodontitis, 56.2% were evaluated in the C2 category, 32.7% in the C1 category, and 11.1% in the C3 category according to their MCI scores. The kappa coefficient for the MCI assessment, indicating intra-observer agreement, was 0.795.

DISCUSSION

This is the first study to examine the relationship between the stage and grade of periodontitis and MCI. In addition to patients with periodontitis, those without periodontitis were included in the study and evaluated compared to the stage and grade groups. Our findings revealed that there were significant differences in the MCI data between the groups formed according to stage and grade categories.

According to the results of our study, the highest rate of C3 was observed in the stage III/IV group ($p < 0.001$) for the stage category and the grade C group for the grade category ($p < 0.001$). The rate of C1 was found to be significantly higher in the NP group than in all the stage and grade groups ($p < 0.001$). In addition, when the stage groups were examined, the rate of C1 was significantly higher in the stage I group than in the stage II and stage III/IV groups ($p < 0.001$). The grade A group was not included in interpreting the results due to the insufficient number of patients ($n = 3$). In light of our results, we consider that there is a relationship between the stage and grade of periodontitis and MCI values. Accordingly, the increase in the stage and grade of periodontitis increases the incidence of C3, which represents more porous bones, while the absence of periodontitis or a decrease in the stage and grade of periodontitis increases the incidence of C1, which represents normal BMD.

Although there is no other study to which we can compare the results of the current study according to periodontitis stage and grade, the literature contains similar studies on the subject. According to the results of a study that found a significant relationship between chronic periodontitis and MCI, C1 was mostly detected in periodontally healthy patients, and C2 was mostly found in those with chronic periodontitis.⁹ In another study, the evaluation of MCI was undertaken by dividing the patients into three groups as dentate, partially dentate, and edentulous, without referring to the periodontal status of the patients or the reasons for tooth loss. According to the results of that study, the MCI scores of the edentulous patients were higher (C2-C3), while the highest rate of C1 was observed in the dentate group.¹³

In our study, no C3 type bone was found in the stage I periodontitis group or the NP group. Similar to our study, Öztürkmen et al. determined that the C3 category was not present in any of the periodontally healthy individuals.¹¹

Considering all the patients with periodontitis in our study, the most common MCI category was C2. In parallel with our results, in a study screening the MCI values of 49 patients with chronic periodontitis in 2020, it was found that patients with chronic periodontitis had the highest rate of C2 at 59.2%.¹⁰

MCI is a mandibular radiomorphometric index that correlates significantly with periodontitis.⁹ Moeintaghavi et al. compared the MCI, mental index (MI), and panoramic mandible index (PMI) values of chronic periodontitis and healthy individuals using panoramic radiographs.⁹ The authors found a significant relationship only between MCI and chronic periodontitis. In addition, Kolte et al. found a positive relationship between MCI and chronic periodontitis in postmenopausal female patients.¹⁴ In contrast, Mudda et al., who evaluated pre- and post-menopausal female patients, reported no correlation between chronic generalized periodontitis and MCI.¹⁵ In the current study, there was a significant relationship between periodontitis and MCI.

MCI allows for the qualitative evaluation of mandibular BMD.⁸ Techniques such as quantitative computerized tomography, ultrasound measurements, single energy X-ray absorptiometry, and DXA are available to obtain more objective and clearer results in the determination of BMD.¹² However, the use of MCI in the qualitative evaluation of mandibular BMD is more practical and easier to access than techniques that require expensive devices.¹⁶ In addition, studies have shown that panoramic radiomorphometric analyses provide significant and reliable results on bone density.^{17,18} Horner and Devlin showed that the BMD of the mandible body measured by DXA was consistent with MCI.¹⁹ Furthermore, Taguchi et al. reported that MCI could be used as a useful pre-diagnosis tool in the diagnosis of osteoporosis.²⁰ In another study, a statistically significant relationship was found between the calcaneal BMD value determined by densitometry and the BMD value determined using mandibular radiomorphometric indices.¹⁷ On the other hand, Drozdowska et al. reported that the efficacy of MCI in the diagnosis of osteopenia/osteoporosis was at a low-moderate level, and although MCI showed the mandibular BMD, it might be insufficient to indicate the skeletal state.²¹

The results of the current study are also supported by some studies evaluating the relationship between periodontitis and BMD, in which techniques different from MCI were used in the determination of BMD. In 2001, von Wövern et al. concluded that severe periodontitis seen in young adults was associated with relatively low BMD in the jaw bones.⁵ In another study in which mandibular BMD was evaluated by DXA, it was reported that the mandibular BMD of individuals with chronic periodontitis was lower than that of healthy individuals.²² According to a study by Takaishi et al., there was a significant negative correlation between mandibular BMD and periodontal attachment levels.²³ Similarly, Nackaerts et al. detected a significant negative correlation between mandibular BMD and alveolar bone height.²⁴ These results support our study and demonstrate the presence of a negative correlation between mandibular BMD and periodontal bone loss. On the other hand, Klemetti et al. found a significant positive correlation between periodontal pocket depth and mandibular BMD, which, they suggested, might be due to a defensive reaction in trabecular bone against periodontal destruction.⁴ It is also important that the 2017 workshop concluded that osteoporosis was significantly associated with a higher prevalence and severity of radiographic alveolar bone loss.²⁵

The pathological resorption process that develops due to inflammatory events in periodontitis may affect mandibular BMD.²⁶ Depending on the differences in the severity and progression rate of periodontitis, varying amounts of immune cell activation and cytokine release may cause different degrees of effect on BMD.²⁷ This suggests the hypothesis that there may be important differences between the stages and grades of different manifestations of periodontitis and their relationship with MCI. The results of our study support this hypothesis.

Another theory explaining the change in MCI scores is that the decrease in occlusal forces transmitted to the mandibular bone due to missing teeth may lead to a decrease in mandibular BMD through adaptive mechanisms.^{13,28} Based on the results of their study, Hastar et al. suggested that the C3 category, which was more common in edentulous patients, was due to the inability to transfer sufficient occlusal force to the jawbone.¹³

Some limiting factors should be considered when evaluating the results of the current study. Studies are reporting that the MCI parameter, which we also used in our study, is affected by age and gender.²⁸⁻³⁰ Therefore, the age and gender of our patients may have had an effect on the results we obtained. In addition, although MCI is a convenient method for estimating BMD, it has been reported to have poor reproducibility.¹⁹ Another limiting factor concerns the retrospective design of our study. Furthermore, due to the monocentric nature of the study, the findings may not reflect the situation in the general population. Lastly, in the current study, we focused directly on the relationship between the MCI scores and the stage and grade of periodontitis. We consider that it will be useful to conduct multicenter studies using densitometric measurement techniques to evaluate the relationship between mandibular BMD and the stage and grade of periodontitis.

CONCLUSION

In conclusion, according to the data we obtained, there was a decrease in the rate of C1 and an increase in the rate of C3 in stage III /IV and/or grade C periodontitis. We consider that the absence of periodontitis or the presence of a low stage and grade of periodontitis can explain the increased incidence of the C1 category. According to our results, there may be a positive correlation between the severity and progression rate of mandibular osteopenia and periodontitis. Thus, in patients with stage III /IV and/or grade C periodontitis, MCI can be additionally evaluated during the examination, and in the presence of a possible porous mandibular cortex, the patients can be referred for densitometric measurements for osteoporosis screening.

Ethics Approval and Consent to Participate: This retrospective study was approved by the Clinical Research Ethics Committee of Erzincan Binali Yıldırım University Faculty of Medicine, with the decision number 2023-01/3, dated January 5, 2023.

Değerlendirme / Peer-Review

İki Dış Hakem / Çift Taraflı Körleme

Etik Beyan / Ethical statement

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This retrospective study was approved by the Clinical Research Ethics Committee of Erzincan Binali Yıldırım University Faculty of Medicine, with the decision number 2023-01/3, dated January 5, 2023.

It is declared that during the preparation process of this study, scientific and ethical principles were followed and all the studies benefited are stated in the bibliography.

Benzerlik Taraması / Similarity scan

Yapıldı - ithenticate

Etik Bildirim / Ethical statement

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Yazar Katkıları / Author Contributions

Çalışmanın Tasarlanması | Design of Study: ÖFO (%65) ŞA (%35)
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Veri Analizi | Data Analysis: ÖFO (%10) ŞA (%90)
Makalenin Yazımı | Writing up: ÖFO (%60) ŞA (%40)
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