IMAGING ANALYSIS OF PERIODONTAL STATUS IN A GROUP OF PATIENTS WITH OSTEOPOROSIS

Stoica George[1], Roxana Popescu[2], Andreea Diana Ilinca[2], Daniela Pomohaci[2], Balcos Carina[2], Alexandru Nemtoi[3], Sirghe Ana[2], Haba Danisia[2]

1. PhD Student , University of Medicine and Pharmacy "Grigre T.Popa", Iași
2. University of Medicine and Pharmacy "Grigre T.Popa", Iași
3. „Ștefan cel Mare" University, Suceava, Romania

Autor corespondent: Sirghe Ana – sirghe.ana@gmail.com
All authors had the same contribution

Abstract

Osteoporosis, a systemic disorder characterized by reduced bone density and microarchitectural deterioration, significantly affects bone health, including the mandibular and periodontal structures. This study aimed to evaluate the relationship between osteoporosis and periodontal pathology using imaging techniques in patients diagnosed with osteoporosis. **Material and methods**: The retrospective, descriptive study included 63 patients diagnosed with osteoporosis and other systemic conditions. Periodontal status was assessed clinically and paraclinically using the EGOHID evaluation system, while bone density was evaluated radiographically using indices such as the Mandibular Cortical Index (MCI), Mental Index (MI), Panoramic Mandibular Index (PMI), and Mandibular Cortical Width (MCW). **Results:** Results revealed significant periodontal involvement, with 42.9% of patients exhibiting moderate chronic marginal periodontitis and 46% severe periodontitis, more pronounced in the maxillary arch than the mandibular. Radiographic evaluation demonstrated that 58.7% of patients with osteoporosis had a slightly eroded mandibular cortex (C2), while 34.9% showed severe erosion (C3). The average cortical thickness (MCW) was significantly reduced in osteoporotic patients compared to non-osteoporotic individuals, highlighting its potential as a screening indicator. **Conclusions:** Osteoporosis is strongly associated with significant periodontal alterations and mandibular cortical resorption. These findings underline the importance of integrating bone health assessments into periodontal evaluations, emphasizing the role of imaging as a non-invasive screening tool for osteoporosis.

Keywords: osteoporosis, panoramic radiography, bone density

Introduction

Osteoporosis, a systemic skeletal disorder characterized by reduced bone density and structural deterioration, poses a significant public health challenge worldwide. This condition results in porous and fragile bones, increasing the risk of fractures, particularly in weight-bearing areas such as the spine, hip, and wrist (1). Often asymptomatic until a fracture occurs, early detection and intervention are crucial for the effective management of this condition. Key assessments, such as dual-energy X-ray absorptiometry or densitometry (DXA), are essential for diagnosing osteoporosis and evaluating fracture risk (2).

The prevalence of osteoporosis varies among populations and is influenced by age, sex, race, and geographic location. According to studies in the scientific literature, the global prevalence of osteoporosis and osteopenia has been estimated at 19.7% and 40.4%, respectively, with significant variations between countries and regions (3). In the United States, the prevalence of osteoporosis among men and women aged over 50 years is reported to be 4.2% and 18.8%, respectively (4). Worldwide, osteoporosis is estimated to affect 200 million women, approximately one-tenth of women aged 60 years, one-fifth of those aged 70 years, two-fifths of those aged 80 years, and two-thirds of those aged 90 years (5). Moreover, osteoporosis is a condition that affects individuals of all races/ethnicities and both sexes, with approximately 10 million individuals aged 50 and over in the United

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States living with osteoporosis, the majority of whom are women (6).

The mandibular bone, a critical component of oral anatomy, can be affected by changes associated with systemic osteoporosis. Reduced bone density in the mandible may contribute to challenges in dental procedures such as implant placement and oral surgery. This has implications for dental practitioners, requiring consideration of bone health and potential adaptations in treatment planning for individuals with osteoporosis (7).

Identifying bone quality is essential in planning advanced treatment options, such as dental implants, and diagnosing patients with osteoporosis. For this purpose, panoramic and/or periapical radiographs are the most commonly used routine diagnostic techniques for treatment planning. The primary advantages of panoramic imaging include patient accessibility for an overall assessment of the facial bones and teeth, low radiation dose, short exposure time, and suitability for patients who cannot open their mouths or present with partially reduced, extensive edentulism, or total edentulism. Many qualitative and quantitative measurements for analyzing panoramic radiographs have been developed for this purpose, including densitometry and morphometry. The mandibular cortical index (MCI) (appearance of the lower mandibular cortical thickness), mandibular cortical width (MCW) in the mental foramen region, and panoramic mandibular index (PMI) (the ratio of mandibular cortical thickness to the distance between the inferior edge of the mental foramen and the inferior mandibular cortex) have also been used to assess bone quality and identify signs of resorption and osteoporosis on panoramic radiographs (8,9).

Osteoporosis can significantly impact periodontal health, affecting the supporting structures of the teeth. Research suggests that individuals with osteoporosis may exhibit an increased susceptibility to periodontal disease, characterized by gum inflammation and progressive destruction of the alveolar bone. Compromised bone density in osteoporosis can contribute to weakened periodontal support, potentially exacerbating periodontal conditions. Conversely, periodontal disease may contribute to systemic inflammation, potentially influencing bone metabolism and osteoporosis. This complex interplay requires a holistic approach to managing both osteoporosis and periodontal health (10). Thus, the aim of the study was to evaluate, through imaging, the association between osteoporosis and periodontal pathology in a group of patients diagnosed with osteoporosis.

Material and methods

This retrospective, descriptive study was conducted on a group of 63 patients who sought medical services at the dental office of the Adult Stomatology Outpatient Clinic, "Sf. Spiridon" Hospital in Iași, and at a private clinic, between October 2021 and May 2023. These patients were diagnosed with osteoporosis and other systemic conditions by specialized medical staff from the Endocrinology Department of "Sf. Spiridon" Hospital, who recorded the results of clinical and paraclinical examinations in the medical records.

The diagnosis of periodontal disease was established both clinically and paraclinically by a general dentistry specialist using the EGOHID evaluation system to determine the periodontal status (11).

Radiological evaluation of bone integrity was performed by a radiology specialist. For assessing bone density using panoramic radiography, a **Planmeca 3D Mid device** with a 3D sensor for panoramic radiography was employed, operating under the following parameters: **70 kV, 10 mA, 15.1 s, DAP 62.0**, and **72 kV, 12.5 mA, 15.1 s, DAP 82.4**. Data processing was performed using the **Romexis 4.4. O** reconstruction software.

The radiological indices used to determine bone density on orthopantomography included:

Mandibular Cortical Index (MCI): This is an indicator of bone quality. The shapes of the mandibular cortex on dental panoramic

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radiographs were assessed by observing the mandibles distal to the bilateral mental foramen and classifying them into one of three groups according to the method of Klemetti et al. (1994) (12): **C1**: Normal cortex – The endosteal margin of the cortex was even and sharp on both sides. **C2**: Slightly to moderately eroded cortex – The endosteal margin showed semilunar defects (lacunar resorption) or appeared to form endosteal cortical residues. **C3**: Severely eroded cortex – The cortical layer presented endosteal cortical residues and had a porous appearance (Fig. 1).

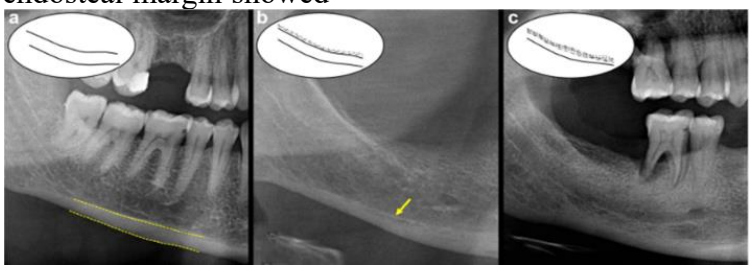

Figure 1. Mandibular Cortical Index (MCI) (Klemetti et al., 1994)

2. Mental Index (MI): The Mental Index measures the cortical width in the region of the mental foramen, as described by Ledgerton et al. (1997) (13). To determine MI: A line was drawn parallel to the long axis of the mandible and tangential to its inferior border. A perpendicular line intersecting the inferior border of the mental foramen was constructed. Along this perpendicular line, the mandibular cortical width was measured. The Mental Index was calculated as the average width of the mandibular cortex (Fig. 2).

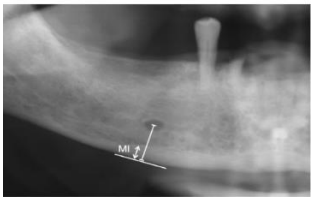

Figure 2. Mental Index (MI) (13)

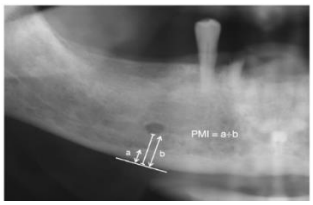

Figure 3. Panoramic mandibular index (PMI) (14)

3. Panoramic Mandibular Index (PMI): The PMI represents the ratio of mandibular cortical thickness to the distance between the inferior edge of the mental foramen and the inferior mandibular cortex (Fig. 3) (13). This index is used to evaluate structural changes in the mandible that may indicate the presence of osteoporosis. PMI is calculated based on panoramic radiographs, serving as a useful tool for screening osteoporosis in the mandible. **Normal PMI values** are generally considered to range between **0.3 and 0.4**, indicating a balanced proportion between the thickness of the mandibular cortex and the distance from the inferior margin of the mental foramen to the inferior mandibular cortex.

4. Gonial Index (GI): The GI measures the mandibular cortical thickness along the bisector of the angle formed between the tangential lines to the posterior border of the mandibular ramus and the lower border of the mandible (Fig. 4). A **normal GI value** is considered to be greater than **1.2 mm** (12). These indices provide critical insights into mandibular bone quality and are valuable tools for identifying potential osteoporosis-related changes.

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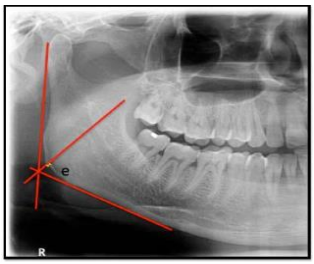

Figure 4. Indicele Gonial (GI) (12)

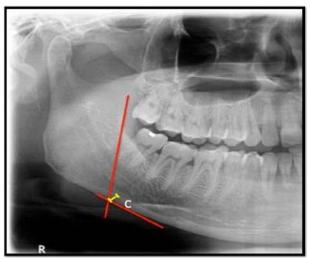

Figura 5. Indicele Antegonial (AI) (12)

6. Mandibular Cortical Width (MCW): The MCW is measured using a standardized and globally accepted method first introduced by Taguchi et al. in 1993(15) and later reaffirmed in subsequent studies by the same author.

The method involves the following steps:

1. **Drawing the line:** A line is drawn from the midpoint of each mental foramen to the inferior border of the mandible, perpendicular to the tangent at the inferior margin at that point.

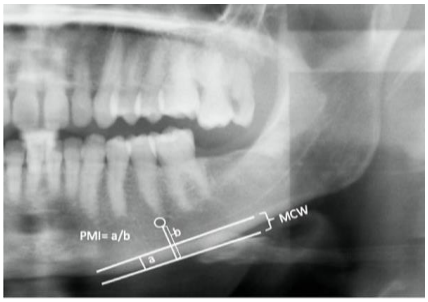

Figura 6. Lățimea corticalei mandibulare (MCW) (Taguchi,1993)

2. **Measuring cortical width:** The width of the cortical bone at the mandibular inferior border is measured along this line, from the inferior margin of the mandible to the internal edge of the cortex (Fig. 6).

These indices, including AI and MCW, provide detailed assessments of mandibular cortical integrity and are useful for detecting structural changes associated with osteoporosis.

The normal value for **Mandibular Cortical Width (MCW)** varies depending on the study criteria, population, and measurement methods used. However, a generally accepted reference value for MCW in healthy adults is approximately **3 mm or more**. A measurement below this threshold may indicate a potential decrease in bone density, often associated with osteoporosis. Regular evaluation of MCW can serve as a valuable tool for early screening and diagnosis of bone density abnormalities.

7. The visual radiographic index is a method for evaluating intraoral radiographs, used to classify the visible trabecular pattern in radiographic images. This technique was initially applied to radiographs in 1996 and involves classifying the trabeculation as follows: a) **Very sparse:** The trabecular structure is minimally dense, with larger spaces between the trabeculae. b) **Sparse:** A combination of areas with low and high trabecular density. c) **Dense:** The trabecular pattern is very dense, with small spaces between the trabeculae. The purpose of this

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classification is to determine how the trabecular structure can serve as an indicator of bone conditions, including osteoporosis, and to assess the relative risk of developing complications associated with low bone density, such as fractures (Fig. 7) (16).

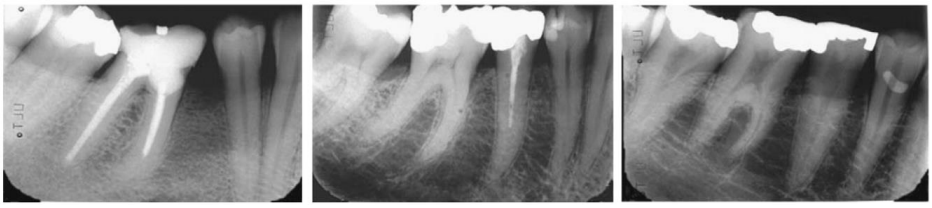

Figure 7. Reference images illustrating the trabecular pattern as follows: dense trabeculation with small intertrabecular spaces (left), mixed dense and sparse trabeculation with small intertrabecular spaces in the cervical region and larger spaces apically (center), and sparse trabeculation with large intertrabecular spaces (right) (16).

Descriptive statistical analysis was performed using SPSS for Windows 20.0 software by determining the frequencies of socio-demographic characteristics, types of systemic conditions, and oral health assessment. Pearson and Spearman tests were used to determine correlations between various variables. Statistical significance was evaluated using ANOVA and Chi-square tests, with significance set at $p<0.05$.

Results

The study group consisted of 63 subjects with a mean age of 64.49 ± 9.36 years (SD) (minimum age 44 years and maximum age 88 years). Regarding the demographic data of the study group, statistical analysis indicates that most participants were female (93.7%), 54% of the subjects came from urban areas, and 55.6% of them had a medium socio-economic level, followed by those with a low socio-economic level (39.7%) (Table 1).

Table 1. Demographic characteristics of the study group

	No	%
Age	64.49 ± 9.362 years (min.44years old, max. 88 years old)	
Gender		
Female	59	93.7
Male	4	6.3
Residence		
Urban	34	54.0
Rural	29	46.0
Socio-economic level		
High level	4	6.3
Medium level	29	46.0
Low	30	47.6

Assessment of Bone Support

The evaluation of the mandibular cortex on the right side using the Mandibular Cortical Index (MCI) shows that 58.7% of cases with osteoporosis presented a slightly eroded cortex (C2), while 34.9% of cases exhibited a severely eroded cortex (C3). The assessment of the MCI for the left side of the mandible indicates a higher number of cases with C2 and fewer cases with C3 compared to the evaluation of the right side (76.19% and 20.64%, respectively) (Table 2).

Table 2. Evaluation of the mandibular cortex using the Mandibular Cortical Index (MCI)

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		No	%
Right Hemiarc			
	C1: Normal Cortex	4	6.3
	C2: Slightly to Moderately Eroded Cortex	37	58.7
	C3: Severely Eroded Cortex	22	34.9
	Total	63	100.0
Left Hemiarch			
	C1: Normal Cortex	2	3.17
	C2: Slightly to Moderately Eroded Cortex	48	76.19
	C3: Severely Eroded Cortex	13	20.64

Table 5.41. Evaluation of the mandibular bone component using the Panoramic Mandibular Index (PMI)

	N	Range	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
Mental index (MI) partea dreapta	63	4.100	.200	4.300	1.546	.172	1.370
Mental index (MI) partea stanga	63	3.800	.100	3.700	1.221	.194	1.010
Panoramic mandibular index (PMI)	63	2.900	.100	3.000	.311	.0624	.495
Panoramic mandibular index (PMI)	63	2.100	.100	2.900	.287	.0444	.643
The Gonial Index (GI)	63	1.700	.100	1.800	.381	.0484	.384
The Antegonial Index (AI)	63	3.800	.200	4.000	1.546	.171	1.364
Mandibular cortical width (MCW)	63	3.800	.200	4.000	1.463	.160	1.276

Evaluation of the Mental Index (MI)
The cortical width measured in the area of the mental foramen on the right side of the mandible showed an average value of 1.546 ± 1.370 SD, while the average cortical value on the left side was thinner, with a value of 1.221 ± 1.010 SD (Table 3).

Evaluation of the Panoramic Mandibular Index (PMI)
This evaluation serves as a screening tool for detecting osteoporosis cases. The results support the diagnosis of osteoporosis, with values obtained for the right side of the mandible (0.311 ± 0.495 SD) and for the left side (0.287 ± 0.643 SD) (Table 3).

Evaluation of the Gonial Index (GI)
The Gonial Index (GI) measures the thickness of the mandibular cortex on the bisector of the angle between the tangent lines to the posterior edge of the mandibular ramus and the lower border of the mandible (normal value > 1.2 mm). In this study, the obtained values support the diagnosis of osteoporosis, as the value was 0.381 ± 0.384 SD, significantly lower than the standard value (Table 3).

Evaluation of the Antegonial Index (AI)
Comparing the standard value to the obtained measurements on panoramic radiographs (> 3.2 mm), the cortical thickness in the molar region supports the diagnosis of osteoporosis (1.546 ± 1.36 SD) (Table 3).

Evaluation of the Mandibular Cortical Width(MCW)
The results indicate that study participants have osteoporosis, with an average recorded value of 1.463 ± 1.276 SD, which is significantly lower than the normal value for a healthy patient (3 mm) (Table 3).

Osteoporosis can lead to complications, such as pathological

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changes in the temporomandibular joint (TMJ). The study results show that 68.3% of participants have alterations in the mandibular condyles, with 63.5% having unilateral changes and 4.8% having bilateral changes (Table 4).

Table 4. Evaluation of mandibular condyle alterations

		Nr.	%	Valid %
Valid	No Condylar Involvement	20	31.7	31.7
	Unilateral Condylar Involvement	40	63.5	63.5
	Bilateral Condylar Involvement	3	4.8	4.8
	Total	63	100.0	100.0

Table 5. Evaluation of alterations in bone trabeculation

		Nr.	%	Valid %	Cumulative %
Valid	Sparse Trabeculation	30	47.6	47.6	47.6
	Very Sparse Trabeculation	33	52.4	52.4	100.0
	Total	63	100.0	100.0	

The aspect of bone trabeculation can guide the diagnosis of osteoporosis when the trabeculation appears sparse. In our study, 47.6% of cases exhibit sparse bone trabeculation, while 52.4% exhibit very sparse trabeculation, which supports the previously established diagnosis of osteoporosis (Table 5).

Data from Table 5.48 suggests that more severe mandibular cortical erosion (from C1 to C3) correlates with a higher prevalence and severity of periodontal disease. Individuals with normal cortical bone (C1) predominantly have less severe periodontal disease, whereas those with severe cortical erosion (C3) tend to have moderate to severe periodontal disease. This finding implies that the condition of the mandibular cortical bone might serve as a predictor or an associated factor for the severity of periodontal disease in the maxillary arch. Additional statistical analysis would be required to confirm these associations and their significance.

The Pearson R coefficient has a value of 0.113, indicating a very weak positive correlation between the two continuous variables. The large asymptomatic standard error of 0.105, compared to the correlation value, suggests significant uncertainty in this estimation. The T statistic is 0.892, with a p-value of 0.376, indicating that this correlation is not statistically significant, as the p-value is far above the typical significance threshold of 0.05 (Table 6).

Table 6. Correlation Between Mandibular Cortical Index (MCI) and Periodontal Diagnosis in the Maxillary Arch

Mandibular cortical index (MCI)		Periodontal Diagnosis in the Maxillary Arch			p	r
		Superficial Marginal Periodontitis	Medium Marginal Periodontitis	Deep Marginal Periodontitis		
	C1: Normal Cortex		75.0%	25.0%	0,439	0.113
	C2: Slightly to Moderately Eroded Cortex	18.9%	45.9%	35.1%		
	C3: Severely Eroded Cortex	4.5%	54.5%	40.9%		
Total		12.7%	50.8%	36.5%		

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The results show that in the C1 group, there is a 100% prevalence of gingivitis, indicating that in this sample, patients with normal mandibular cortex have not progressed to more severe stages of periodontal disease. In the C2 and C3 groups, as cortical erosion progresses from mild/moderate to severe, the percentage of cases with gingivitis decreases, while the percentage of cases with moderate and severe periodontitis increases. This suggests a possible association between the severity of cortical erosion and the severity of periodontal disease.

The overall distribution highlights that the majority of patients have moderate to severe forms of periodontitis, suggesting that cortical erosion may be a contributing factor or a marker for the severity of periodontitis (Table 7).

Table 7. Correlation Between MCI and Periodontal Diagnosis in the Mandibular Arch

Mandibular cortical index (MCI)	Periodontal Diagnosis in the Mandibular Arch			p	r
	Superficial Marginal Periodontitis	Medium Marginal Periodontitis	Deep Marginal Periodontitis		
C1: Normal Cortex	25.0%	75.0%		0,000	0.503
C2: Slightly to Moderately Eroded Cortex	24.3%	40.5%	35.1%		
C3: Severely Eroded Cortex	4.5%	45.5%	50.0%		
Total	17.5%	44.4%	38.1%		

The Pearson R coefficient suggests a moderate positive correlation between two continuous variables. The R value of **0.503** indicates a significant relationship, while the low asymptotic standard error of **0.088** reflects a good level of precision for this estimate. The high T statistic (**4.540**) and a p-value of **0.000** demonstrate that this correlation is statistically significant, strongly suggesting that the relationship between these variables is not due to chance (Table 7).

The analysis of the association between MCI and the presence of periodontal pockets in the mandibular arch shows that as cortical erosion progresses from mild/moderate to severe, the percentage of individuals with periodontal pockets also increases. This indicates a correlation between the deterioration of cortical bone condition and the prevalence of periodontal pockets.

A significant majority (**79.4%**) of individuals, regardless of their MCI condition, have periodontal pockets, highlighting the high prevalence of periodontal issues among the sampled population. These findings emphasize the potential link between mandibular bone health and periodontal health, suggesting that more severe cortical bone erosion could be associated with a higher likelihood of developing periodontal pockets (Table 8).

Table 8. Correlation Between MCI and the Presence of Periodontal Pockets in the Mandibular Arch

Mandibular cortical index (MCI)	"Are there periodontal pockets in the mandibulary arch?"		p	r
	Yes	No		
C1: Normal Cortex		100.0%	0,000	-0.390
C2: Slightly to Moderately Eroded Cortex	81.1%	18.9%		
C3: Severely Eroded Cortex	90.9%	9.1%		
Total	79.4%	20.6%		

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Both the Pearson and Spearman correlations indicate a moderate, statistically significant negative relationship between the studied variables. This consistent finding across both measures suggests a robust association, indicating that as one variable increases, the other tends to decrease. This relationship could prove valuable for predictive modeling or inferential analysis in related studies (Table 8).

A similar trend was observed in the association between the Mandibular Cortical Index (MCI) on the right side and the presence of periodontal pockets in the maxillary arch, as indicated by the Pearson test (Table 9).

Table 9. Correlation Between MCI and the Presence of Periodontal Pockets in the Maxillary Arch

Mandibular cortical index (MCI)	"Are there periodontal pockets in the maxillary arch?"		p	r
	Da	Nu		
C1: Normal Cortex		100.0%	0,000	-0.458
C2: Slightly to Moderately Eroded Cortex	78.4%	21.6%		
C3: Severely Eroded Cortex	95.5%	4.5%		
Total	79.4%	20.6%		

Figure 8 illustrates that MI values vary significantly, indicating different levels of periodontal disease severity in the maxillary arch. This analysis provides insight into how structural changes in the mandible, as reflected by the Mental Index, are associated with varying degrees of periodontal involvement.

The observed result suggests that the frequency distribution differs significantly from what would be expected under the assumption of independence, highlighting a meaningful association between the Mental Index and periodontal diagnosis.

Figure 8. Association Between Mental Index (MI) and Periodontal Diagnosis in the Maxillary Arch

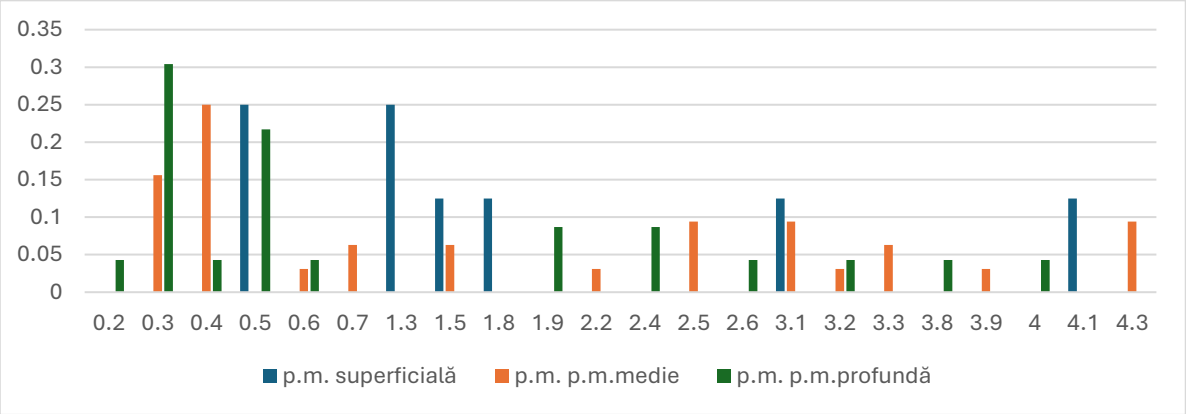

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Table 10. Pearson and Spearman Correlations for the Analysis of the Association Between Mental Index (MI) and Periodontal Diagnosis in the Maxillary Arch

		Value	Asymptotic Standard Error[a]	Approximate T[b]	Approximate Significance
Interval by Interval	Pearson's R	-.164	.111	-1.301	.198[c]
Ordinal by Ordinal	Spearman Correlation	-.229	.110	-1.837	.071[c]

The Pearson correlation indicates a weak negative relationship between the variables. A T-value of **-1.301** and a p-value of **0.198** suggest that this correlation is not statistically significant, indicating no strong association between the variables.

The Spearman correlation, which measures ordinal relationships, also shows a weak negative correlation, slightly stronger than Pearson's. The T-value of **-1.837** and p-value of **0.071**, although closer to the significance threshold of 0.05, still fail to reach this level, meaning the relationship is not strong enough to be considered statistically significant at conventional levels (Table 10).

Figure 10. Pearson and Spearman Correlations Between MI and Periodontal Diagnosis in the Mandibular Arch

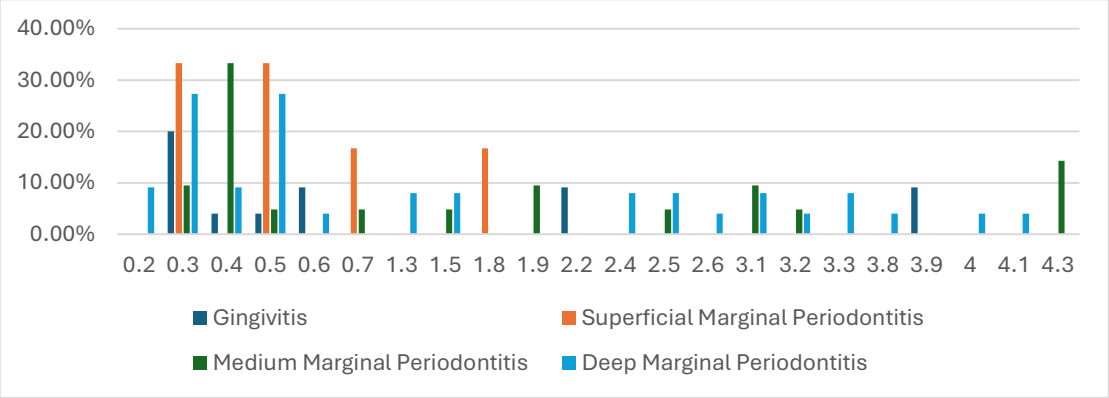

Table 11. Pearson and Spearman Correlations for the Analysis of the Association Between Mental Index (MI) and Periodontal Diagnosis in the Mandibular Arch

		Value	Asymptotic Standard Error[a]	Approximate T[b]	Approximate Significance
Interval by Interval	Pearson's R	.322	.107	2.653	.010[c]
Ordinal by Ordinal	Spearman Correlation	.296	.118	2.425	.018[c]
N of Valid Cases		63			

The analysis of MI values, ranging from **0.200** to **4.300**, highlights a broad variation in cortical thickness at the mental foramen. Notable discrepancies emerge in the proportion of patients with and without periodontal pockets at certain MI values. For instance, at **0.500**, a significantly larger proportion of patients without pockets (**30.8%**) is observed compared to those with pockets (**6.0%**).

At higher MI values, frequencies are low in both groups, indicating that larger MI measurements are less common in the studied population. This pattern may suggest that lower MI values are associated with a higher prevalence of periodontal pockets (Figure 10).

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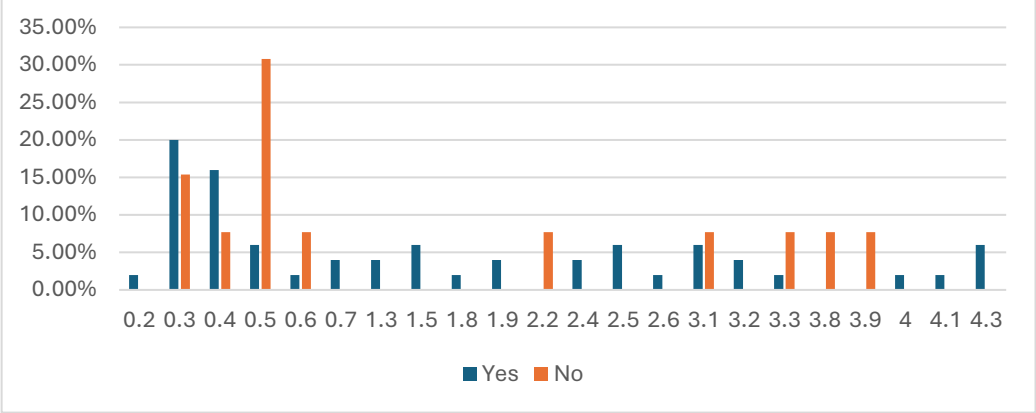
Figure 10. Association Between MI and "Are there periodontal pockets in the maxillary arch?"



The clinical implications are as follows: MI variability may provide insights into the structural condition of the mandibular bone, which could influence the presence or severity of periodontal diseases. Using MI as a diagnostic tool could aid in identifying patients at increased risk for periodontal diseases, guiding clinical decisions regarding prevention or treatment. Implications for clinical practice include the necessity of thoroughly evaluating periodontal risk factors in the context of radiographic assessment, incorporating the MI index as part of a broader screening or diagnostic protocol.

Table 12. Pearson and Spearman Correlations for the Analysis of the Association Between MI and the Presence of Periodontal Pockets in the Maxillary Arch

		Value	Asymptotic Standard Error[a]	Approximate T[b]	Approximate Significance
Interval by Interval	Pearson's R	-.006	.130	-.045	.964[c]
Ordinal by Ordinal	Spearman Correlation	.031	.123	.246	.807[c]
N of Valid Cases		63			

The Pearson correlation indicates a negligible and non-significant association between the variables, with a value close to zero and an extremely high p-value (**0.964**). This suggests that there is no linear association between the variables.

The Spearman correlation, which assesses monotonic relationships, also shows a very weak correlation between the variables, with a value close to zero and a high p-value (**0.807**). This confirms the absence of a statistically significant association (Table 12).

Discussion

Osteoporosis is a skeletal disorder characterized by low bone density and microarchitectural deterioration, leading to increased bone fragility and susceptibility to fractures. It is frequently observed in middle-aged and elderly individuals, often remaining unnoticed until fractures occur. Osteoporosis can be classified as either primary or secondary. Primary osteoporosis encompasses conditions where bone mass reduction is attributed to aging-related changes (senile types) and hormonal changes during menopause. Secondary osteoporosis refers to bone mass reduction caused by other diseases or medications (16).

In our study, subjects diagnosed with osteoporosis were selected, with a mean age of approximately 65 years. Advanced age, combined with general health issues and habitual factors, likely contributed to the impaired oral health observed among these

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patients. Oral health was deficient across all evaluated parameters.

The results demonstrate significant periodontal involvement, with **42.9%** of cases presenting moderate chronic marginal periodontitis and **46%** severe marginal periodontitis in the maxillary arch. For the mandibular arch, the same diagnoses were observed, but with lower frequencies.

The degree of periodontal involvement was assessed by the presence of periodontal lesions, such as periodontal pockets. Clinical evaluation revealed that **95%** of participants had periodontal pockets in the maxillary arch, while the mandibular arch showed slightly lower involvement at **90%**.

Both osteoporosis and periodontal diseases are bone resorptive disorders. Osteoporosis is characterized by reductions in bone mass, leading to skeletal fragility and fractures. Periodontitis is marked by alveolar bone resorption and is a major cause of tooth loss in adults. Since alveolar bone loss is a prominent feature of periodontal disease, severe osteoporosis could be suspected as an aggravating factor in periodontal destruction. It has been hypothesized that periodontal tissue breakdown may partly relate to systemic diseases, including osteoporosis. Additionally, the literature has proposed a role for osteoporosis in the onset and progression of periodontitis and tooth loss.

Bando et al. (1998)(17) reported that lower spinal bone mineral density (BMD) was positively correlated with tooth loss. In a study to determine risk factors for tooth loss in older individuals, Xie and Ainamo (1982)(18) found that tooth loss was associated with a history of bone fractures used as an indicator of osteoporosis. Increased alveolar ridge resorption and greater loss of alveolar crest height have been reported in subjects with osteoporosis and osteopenia (19-21).

Panoramic radiographs are used for the early detection of osteoporosis due to their low cost and the large number of osteoporotic patients who visit dental clinics owing to increased life expectancy. It would be economical and beneficial if these radiographs could be used for screening individuals with undiagnosed osteoporosis. Another advantage of using these radiographs is that they are often taken repeatedly with similar projection and exposure parameters, making them well-suited for comparison (15,22).

Dental radiographs, especially panoramic images, have been used to predict low bone mineral density in patients. Several mandibular cortical indices, including the Mandibular Cortical Index (MCI), Mandibular Cortical Width (MCW), and Panoramic Mandibular Index (PMI), have been developed to assess and quantify the quality of mandibular bone mass and to observe signs of resorption in panoramic radiographs to identify osteopenia. The most well-established of these is the Mental Index (MI), which measures the average width of the cortex at the inferior border below the two mental foramina. Osteopenia can be identified by thinning of the cortex at the mandibular inferior border. A thin mandibular cortex width has been shown to correlate with reduced skeletal bone mineral density. The Mandibular Cortical Index describes mandibular porosity and relates to mandibular bone mineral density. Many studies have shown this index to be a useful screening method for osteoporosis.

The Panoramic Mandibular Index is the ratio of the mandibular cortical thickness to the distance between the mental foramen and the inferior mandibular cortex (23).

It is well known that the mandibular cortical bone undergoes resorption activity in osteoporotic patients, leading to reduced thickness and a more porous inferior border, characteristics that can be identified on panoramic radiographs. Reduced skeletal bone mineral density may also alter the shape of the mandible. Studies focusing on identifying older individuals with osteoporosis, particularly postmenopausal women, have demonstrated the utility of mandibular cortical indices derived from panoramic radiographs.

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Three indices are reported in most studies: mandibular cortical shape (Mandibular Cortical Index - MCI or Klemetti Index - KI), mandibular cortical width (Mental Index - MI), and Panoramic Mandibular Index (PMI) (24-26).

Some studies have reported that women with slightly to moderately and severely eroded cortices have an increased likelihood of osteoporosis. However, others have not indicated the utility of the MCI. A recent study showed that approximately 95% of Japanese women identified by trained dentists using cortical shape findings had osteopenia or osteoporosis. Consequently, studies concluded that the sensitivity of MCI in diagnosing osteoporosis (T-score < -2.5) ranged from 35.9% to 90.9%. Differences in results are believed to be due to study heterogeneity (27-30).

The measurement of mandibular cortical width (MCW) in panoramic radiographs has been suggested as a method for predicting patients with low bone mineral density (BMD). Previous studies have demonstrated significant relationships between MCW and BMD. In the current study, cortical bone in the mental region was significantly thinner in individuals with osteoporosis, a result consistent with prior research. The present study showed that the average MCW value in patients with osteoporosis was lower than in those without osteoporosis.

Several studies have evaluated changes in mandibular cortical thickness in men. Dutra et al. (2005) observed higher MCW values in men. Findings from a study by Knezovic-Zlataric et al. (2002)(31) suggest that values begin to decline more rapidly in women compared to men. Devlin and Horner (2007) (32)reported that a cortical thickness of 3 mm is the most suitable threshold for referral to bone densitometry. White and Pharoah (2014)(33) suggested setting the threshold in the 4 mm range. Klemetti et al. (1993)(12) reported that a 4 mm threshold is optimal but insufficient as a standalone method for excellent subject classification. In the present study, a 3 mm threshold was used for cortical thickness.

Although the average mandibular cortical thickness values (normal value: ≥ 3 mm) are normal in men over 60 years, these values significantly decrease in women of the same age group.

Horner et al. (2007)(32) demonstrated that the Panoramic Mandibular Index (PMI) could be used to evaluate osteoporosis status. Average PMI values increase with age. Recent studies on PMI values, primarily conducted in women, found PMI values ranging from 0.31 to 0.38, which are higher than the average value of 0.27 found in our study. Horner et al. (2007)(32) suggested that PMI does not offer a significant advantage over MCW. However, since panoramic indices have typically been evaluated in women, data on gender differences were limited.

In the present study, the reference value for PMI was 0.30. While the average PMI value was 0.34 in men, it was 0.27 in women, suggesting that women are more frequently affected by osteoporosis. A significant difference in PMI values was observed between women and men. Additionally, the average PMI value in patients with osteoporosis was 0.27, compared to 0.32 in patients without osteoporosis.

Conclusions

The study results emphasize that the periodontal status of subjects is significantly affected, with a high prevalence of chronic marginal periodontitis, more severe in the maxilla than in the mandible. The evaluation of mandibular cortical bone suggests an association with osteoporosis and highlights its potential as a non-invasive screening method. The study underscores the need for comprehensive management of patients with osteoporosis and comorbidities to maintain optimal oral health.

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