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## **ALVEOLAR BONE CHANGES IN EARLY STAGES OF CHRONIC KIDNEY DISEASE PATIENTS WITH CHRONIC GENERALIZED PERIODONTITIS**

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With the purpose to investigate the radio-densitometric characteristics of the mandible in patients with chronic kidney disease and chronic generalized periodontitis in total 110 patients were involved. The subjects were submitted to dual-energy X-ray absorptiometry. The vertical density values also showed considerable variation, ranging from 94.3 to 123 arbitrary units. The bone density along the alveolar horizontal line (toward the focus of destruction) was  $71.6 \pm 5.12$  arbitrary units, while along the middle horizontal line, they ranged from 72 to 103.8 arbitrary units. In patients with mix form of destruction showed that in patient with mild chronic generalized periodontitis alveolar horizontal measurement was  $83.5 \pm 3.54$  arbitrary units, in those with moderate chronic generalized periodontitis –  $71.6 \pm 2.55$  arbitrary units. Vertical measurement results ranged from 39.1 to 117.3 arbitrary units. Thus, patients with chronic kidney disease and chronic generalized periodontitis exhibit significant alterations in alveolar bone mineral density, which correlate with the severity of periodontal destruction.

**Key words:** chronic kidney disease, chronic generalized periodontitis, osteoporosis.

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## **ЗМІНИ АЛЬВЕОЛЯРНОЇ КІСТКИ НА РАННІХ СТАДІЯХ ХРОНІЧНОГО ЗАХВОРЮВАННЯ НИРОК ІЗ ХРОНІЧНИМ ГЕНЕРАЛІЗОВАНИМ ПЕРІОДОНТИТОМ**

З метою дослідження денситометричних характеристик нижньої щелепи у пацієнтів із хронічною хворобою нирок та хронічним генералізованим періодонтитом, було обстежено 110 пацієнтів. Пацієнтам було проведено двоенергетичну рентгенівську денситометрію. Вертикальні значення щільності показали значну варіацію, коливаючись від 94,3 до 123 умовних одиниць. Щільність кістки вздовж альвеолярної горизонтальної лінії (у напрямку вогнища руйнування) становила  $71,6 \pm 5,12$  умовних одиниць, а вздовж середньої горизонтальної лінії – від 72 до 103,8 умовних одиниць. У пацієнтів зі змішаною формою руйнування було виявлено, що у випадку злегкою формою хронічного генералізованого періодонтиту горизонтальний розмір альвеолярного гребеня становив  $83,5 \pm 3,54$  умовних одиниць, у пацієнтів із помірною формою хронічного генералізованого періодонтиту –  $71,6 \pm 2,55$  умовних одиниць. Результати вертикального вимірювання варіювалися від 39,1 до 117,3 умовних одиниць. Таким чином, у пацієнтів із хронічною хворобою нирок та хронічним генералізованим періодонтитом спостерігаються значні зміни мінеральної щільності альвеолярної кістки, які корелюють із тяжкістю періодонтального руйнування.

**Ключові слова:** хронічна хвороба нирок, хронічний генералізований періодонтит, остеопороз.

**Funding.** This study received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors. The study was conducted at the authors' primary place of work and was funded from their income there.

Chronic kidney disease (CKD) is a global health problem, characterized by the progressive loss of renal function over time, often leading to end-stage renal disease (ESRD) and associated systemic complications. The prevalence of CKD is rising worldwide, currently affecting an estimated 9.1 % of the global population [10]. Among these complications, mineral and bone disorders are particularly significant, affecting bone metabolism and leading to structural changes in the skeletal system. Chronic kidney disease-mineral and bone disorder (CKD-MBD) is one of the most common complications in patients with CKD [4]. Jaw bones affected with CKD-MBD can have important clinical implications for the survival and osseointegration of dental implants, success of bone regeneration therapy, and increased risk of bone loss in patients with periodontitis or risk of bone fracture [3]. The alveolar bone, is highly susceptible to these

alterations, which can compromise oral health, mastication, and overall quality of life [9].

Periodontal disease, especially chronic generalized periodontitis (CGP), is prevalent in patients with CKD [7]. The pathophysiological link between CKD and periodontitis is multifactorial [1, 5]. CKD induces systemic inflammation, altered immune responses, and disturbances in calcium-phosphate metabolism, all of which can exacerbate periodontal tissue destruction [8]. Additionally, poor oral hygiene, xerostomia, and uremic toxins further increase susceptibility to periodontitis in these patients. Studies have shown that CKD patients with periodontitis often present with increased alveolar bone loss, deeper periodontal pockets, and higher rates of tooth mobility compared to individuals without renal impairment [2].

Radiographic assessment is essential for evaluating bone density and structural integrity of the alveolar bone in this population. Conventional

panoramic radiography provides qualitative information, but it lacks precision in quantifying bone density [6]. Dual-energy X-ray absorptiometry (DXA), a non-invasive imaging technique, allows for objective measurement of bone mineral density (BMD) in specific regions of the mandible, such as the alveolar ridge and mandibular body [9]. This technique has been used to detect early osteopenic changes, assess the severity of periodontal bone loss, and monitor the effects of systemic conditions on mandibular bone structure.

Given the high prevalence of both CKD and chronic generalized periodontitis, understanding the impact of renal impairment on alveolar bone density is clinically relevant. Radio-densitometric evaluation of the mandible may provide valuable insight into early bone changes, guide periodontal treatment planning, and potentially serve as a marker for systemic bone involvement in CKD. Despite its clinical significance, limited studies have systematically investigated the radio-densitometric characteristics of the mandible in CKD patients with CGP, highlighting the need for further research in this area.

**The purpose** of the study was to investigate the radio-densitometric characteristics of the mandible in patients with chronic kidney disease and chronic generalized periodontitis.

**Materials and methods.** The study was conducted between January 2024 and July 2025. A total of 179 patients diagnosed with early-stage chronic kidney disease (CKD) and receiving treatment at the Educational-Therapeutic Clinic of the Azerbaijan Medical University were enrolled in the study. Only individuals in stages 1 and 2 of CKD, whose diagnosis was confirmed by a nephrologist in accordance with the KDIGO 2024 protocol, were included. Individuals under 25 years of age, over 65 years of age, those with a glomerular filtration rate (GFR) below 60 ml/min/1.73 m<sup>2</sup>, or with other somatic diseases were excluded from the study. Dental examinations were performed on all 179 patients, and based on the findings, 110 patients were diagnosed with chronic generalized periodontitis (CGP). The diagnostic protocol included assessment of clinical attachment loss (CAL), probing pocket depth (PPD), bleeding on probing (BOP), and evaluation of radiographic bone loss. Periodontitis was defined in accordance with generally accepted clinical criteria, including the presence of interdental CAL at  $\geq 2$  non-adjacent teeth and/or buccal/oral CAL  $\geq 3$  mm with pocketing  $> 3$  mm at  $\geq 2$  teeth, after excluding non-periodontitis-related causes. The extent and severity of the disease were determined based on the distribution of affected sites and the magnitude of attachment loss.

After application of the inclusion and exclusion criteria, 110 patients were recruited for this study. To evaluate the bone mineral density in different regions of the alveolar process and the body of the jaws, radio-densitometric analysis was performed in 110 patients with chronic generalized periodontitis, including 48 patients with a mild form, 40 with a moderate form, and 22 with a severe form of the disease. The subjects were submitted to DXA performed by a Lunar 2003 X-ray bone densitometer (GE HealthCare's Lunar iDXA, General Electrics, USA).

Statistical analysis was performed using IBM SPSS Statistics (version XX.0; IBM Corp., Armonk, NY, USA). Quantitative variables were tested for normality using the Shapiro-Wilk test. Descriptive statistics were presented as mean  $\pm$  standard deviation (SD) for normally distributed data and as median (interquartile range) for non-normally distributed variables. Comparisons between groups (mild vs. moderate chronic generalized periodontitis) were conducted using the independent-samples t-test for normally distributed variables and the Mann-Whitney U test for nonparametric data. For comparisons involving more than two subgroups or measurement levels (e.g., alveolar vs. middle horizontal lines, vertical measurements), one-way analysis of variance (ANOVA) with post hoc Tukey test or the Kruskal-Wallis test was applied, as appropriate. Correlation between bone mineral density parameters and the severity of periodontal destruction was assessed using Pearson's correlation coefficient (for normally distributed data) or Spearman's rank correlation coefficient (for non-normal distributions). A p-value of  $< 0.05$  was considered statistically significant.

The study was conducted in accordance with the fundamental principles of biomedical ethics and international standards for research involving human subjects. The authors adhered to the provisions of the Declaration of Helsinki of the World Medical Association (2013 revision) and the International Ethical Guidelines for Biomedical Research Involving Human Subjects developed by the Council for International Organizations of Medical Sciences (CIOMS). All procedures were non-invasive and performed within the framework of routine clinical and diagnostic practice. The study design ensured minimal risk to participants and did not involve any interventions beyond standard medical care. Participation in the study was voluntary. All subjects were informed about the purpose and nature of the study prior to inclusion. Informed consent was obtained from each participant in written form. Confidentiality and anonymity of patient data were strictly maintained throughout all stages of the study.

**Results of the study and their discussion.** As mentioned above, a comprehensive radiological assessment was performed to evaluate the extent and pattern of alveolar bone changes in patients with chronic kidney disease and chronic generalized periodontitis. Particular attention was given to the condition of the cortical plate, the degree of bone loss, and the structural characteristics of the trabecular bone.

The analysis of radiological changes in patients with mild CGP revealed a complete absence of the cortical plate and bone loss of the alveolar process reaching one-third of the root length; the pattern of bone resorption was uneven. The analysis of the trabecular bone in the regions of different teeth revealed that horizontal bone resorption was observed in all 110 CKD patients (Table 1).

Table 1

**Radio-densitometric parameters of the Alveolar Process Bone Mineral Density in CKD patients with horizontal destruction**

Parameters	CKD+CGP (mild)	CKD+CGP (moderate)	CKD+CGP (severe)
Alveolar horizontal measurement (M±SD)	118.1±4.08	96.2±5.63	-
Middle horizontal measurement (M±SD)	134.3±8.07	129.4±5.9	54.1±3.73
Vertical measurement (M±SD)	106.2±5.59	86.1±6.04	61.8±5.27

The bone mineral density (BMD) values along the alveolar horizontal line ranged from 104.15 to 123.6 arbitrary units. The lowest density values were recorded in the central part of the alveolar horizontal line. BMD values along the middle horizontal line ranged from 120.5 to 156.0 arbitrary units. Vertically, in the interdental bone septa, the density distribution was ranged from 92.0 to 115.0 arbitrary units. In the examined cases, bone density increased progressively toward the apical base of the jaws. Mandibular bone tissue density was lower than predicted values in one or more regions of the dentoalveolar system. Densitometric histogram analysis allowed the evaluation of bone structures with varying optical densities, potentially indicating localized or generalized pathological processes, such as early-stage periodontal disease.

Orthopantomograms and radiographs of patients demonstrated radiolucency at the apices of the coronal portions of interdental alveolar septa,

suggesting the onset of osteoporosis, along with reduced differentiation of bone elements in regions adjacent to periodontal tissues. This manifested as localized or generalized decreased radiopacity, accompanied by blurring of trabecular boundaries and spaces. The primary radiographic feature in patients with mild periodontitis was osteoporosis of the interdental septa apices, observed in 42.3 % of cases, most frequently combined with early or stage I reduction in septal height by one-third of the root length.

Vertical destruction was detected in 21 patients with mild CGP. The bone mineral density (BMD) values were lowest along the alveolar horizontal line, with minimal variation. BMD values along the middle horizontal line were slightly higher; however, there was a wide range of density results, from 104 to 135 arbitrary units. The vertical density values also showed considerable variation, ranging from 94.3 to 123 arbitrary units (Table 2).

Table 2

**Radio-densitometric parameters of the Alveolar Process Bone Mineral Density in CKD patients with vertical destruction**

Parameters	CKD+CGP (mild)	CKD+CGP (moderate)	CKD+CGP (severe)
Alveolar horizontal measurement (M±SD)	71.6±5.12	57.3±3.91	-
Middle horizontal measurement (M±SD)	121.2±6.26	89.7±5.07	45.4±2.39
Vertical measurement (M±SD)	110.5±5.37	73.3±6.17	61.4±2.90

In patients with moderate chronic generalized periodontitis, a complete absence of the cortical plate was observed in the region of all teeth, along with bone tissue loss of the alveolar process amounting to one-third of the root length. Horizontal bone destruction was detected in all patients. The bone density along the alveolar horizontal line (toward the focus of destruction) was 71.6±5.12 arbitrary units, while along the middle horizontal line, they ranged from 72 to 103.8 arbitrary units. The lowest bone

mineral density values were recorded in areas adjacent to the focus of bone destruction. In patients with severe CGP, bone loss of the alveolar process extended to two-thirds of the root length, and the uneven nature of this resorption was distinctly pronounced.

In cases of mixed-type bone destruction, identified in 18 patients with mild CGP, BMD values across all regions of interest were the lowest; however, the variability of these values was minimal.

Radio-densitometric parameters of the Alveolar Process Bone Mineral Density in CKD patients with mix form of destruction showed that in patient with mild chronic generalized periodontitis alveolar horizontal measurement was  $83.5 \pm 3.54$  arbitrary units, in those with moderate chronic generalized periodontitis –  $71.6 \pm 2.55$  arbitrary units. The middle horizontal measurement showed  $121.4 \pm 4.95$  in mild form,  $97.3 \pm 4.85$  – in moderate form and  $38.6 \pm 3.38$  arbitrary units in severe form. Vertical measurement results were as follows:  $117.3 \pm 5.51$  for mild,  $108.5 \pm 4.02$  for moderate and  $39.1 \pm 2.91$  arbitrary units for severe forms.

In patients with severe CGP, bone resorption of the alveolar process reached two-thirds of the root length, with a distinctly uneven pattern of bone loss. Horizontal bone destruction was present in all patients, and BMD values along both the middle horizontal and vertical lines were markedly lower than those in patients with mild or moderate CGP, although variability between measurements was minimal. Vertical bone destruction was identified in 15 patients, with BMD along the middle horizontal line varying widely from 41.3 to 49.8 arbitrary units, while vertical density variation remained minimal. Mixed-type bone destruction was found in 9 patients, characterized by the lowest overall BMD values across all regions of interest and minimal variation.

Overall, the data indicate that as the severity of chronic generalized periodontitis increases in patients with chronic kidney disease, there is a progressive decline in mandibular bone mineral density, accompanied by a shift from localized to generalized bone destruction pattern.

The findings of this study demonstrate that patients with chronic kidney disease and chronic generalized periodontitis exhibit significant alterations in alveolar bone mineral density, which correlate with the severity of periodontal destruction. Radio-densitometric analysis revealed a progressive decline in BMD values from mild to

severe forms of CGP, accompanied by increased bone resorption and loss of cortical integrity. The transition from localized to generalized patterns of bone destruction suggests that systemic factors related to CKD – such as disturbances in calcium-phosphate metabolism, secondary hyperparathyroidism, and chronic inflammation – exacerbate alveolar bone loss.

These results highlight the interrelationship between renal dysfunction and periodontal pathology, emphasizing the importance of early diagnosis and monitoring of alveolar bone changes in CKD patients.

Hickey N, et al. (2020) also noted a link between chronic kidney disease and chronic periodontitis, which share common risk factors and both are a source of systemic inflammation, as well as a wide range of immunological and nonspecific effects that can affect the body throughout life. The authors analyzed previous studies examining the directionality of the relationship between these two diseases. However, they emphasized that there is insufficient data on how these diseases may interact at the local and systemic levels, emphasizing the relevance of research in this area [2].

Radio-densitometric evaluation, particularly using DXA, provides a valuable, non-invasive method for detecting early osteopenic changes and assessing bone metabolism disturbances in the maxillofacial region. Integrating dental and nephrological care may contribute to better management of CKD-MBD manifestations, improve periodontal outcomes, and enhance the overall quality of life in this patient population.

**Limitations.** This study has several limitations, including a relatively limited sample size and its cross-sectional design, which restricts the ability to establish causal relationships. In addition, the use of radio-densitometric measurements in arbitrary units and the absence of long-term follow-up may affect the generalizability and dynamic interpretation of the results.

## Conclusions

1. The vertical density values also showed considerable variation, ranging from 94.3 to 123 arbitrary units.
2. Horizontal bone destruction was detected in all patients. The bone density along the alveolar horizontal line (toward the focus of destruction) was  $71.6 \pm 5.12$  arbitrary units, while along the middle horizontal line, they ranged from 72 to 103.8 arbitrary units.
3. In patients with mix form of destruction showed that in patient with mild chronic generalized periodontitis alveolar horizontal measurement was  $83.5 \pm 3.54$  arbitrary units, in those with moderate chronic generalized periodontitis –  $71.6 \pm 2.55$  arbitrary units. Vertical measurement results ranged from 39.1 to 117.3 arbitrary units.

*Prospects for further research. Further large-scale, longitudinal studies are needed to clarify the pathophysiological mechanisms linking CKD and periodontal bone loss and to establish radio-densitometric parameters as potential diagnostic and prognostic markers for systemic bone involvement in CKD.*

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**Conflict of interest.** The authors have no conflicts of interest to declare.

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Article received: 10.03.2025.