THE EUROPEAN SOCIETY OF MEDICINE
Medical Research Archives, Volume 14 Issue 4

ORIGINAL RESEARCH

The Biomechanical impact of osteoporosis on the alveolar bone of the jaws

Maksym Datsenko [1]

[1] Bukovinian State Medical University, Chernivtsi, Ukraine.

OPEN ACCESS

PUBLISHED
30 April 2026

CITATION
Datsenko, M., 2026. The Biomechanical impact of osteoporosis on the alveolar bone of the jaws. Medical Research Archives, [online] 14(4).

ISSN
2375-1924

ABSTRACT

Introduction: Systemic osteoporosis is a disease of the skeletal system that occurs as a result of a slow and imperceptible loss of calcium that leads to a decrease in bone mineral density.

According to the World Health Organization (WHO), osteoporosis is the fourth most common disease after diseases of the cardiovascular system, oncology and endocrine diseases.

Despite its widespread prevalence, the biomechanical impact on the alveolar bone in the jaws and oral health has not been sufficiently studied. The aim of the study was to evaluate dental health status, mineral metabolism and bone density in patients with systemic osteoporosis.

Materials and Methods: A total of 87 patients aged 45-65 years were examined. Among them, 59 individuals had confirmed osteoporosis of varying severity, while 28 participants had no signs of bone pathology and served as a control group. Patients were categorized into three groups:

- Group 1 (n = 38) females with compromised bone mineral density (BMD);
- Group 2 (n = 21) males with BMD impairment;
- Group 3 (n = 28) – included participants of either sex without BMD abnormalities

Patients of all groups were examined using clinical, radiological, and instrumental methods.

Results: The results showed the undeniable biomechanical impact of systemic osteoporosis on the bone tissue of the alveolar processes of the jaws, as well as a deep comorbid relationship between osteoporosis and periodontal diseases.

Introduction

Systemic osteoporosis is a common metabolic disease that affects bone tissue, leading to a gradual decrease in its mineral density and disruption of its internal structure[1,2].

The World Health Organization reports that osteoporosis impacts over 200 million individuals globally, primarily affecting older adults and postmenopausal women[3,4,5,6]. Osteoporosis is the fourth most common disease in the world after diseases of the cardiovascular system, oncology, and endocrine diseases.

Osteoporosis occurs as a result of a slow and imperceptible loss of calcium with a decrease in the volume and strength of bone.

Women who have had more than three pregnancies and childbirths as well as those who have breastfed three children for a long time are more prone to osteoporosis.

Thin women are more likely to develop osteoporosis than overweight women because the fat cells convert the hormone produced by adrenal glands into estrogens in the body, lowering osteoporosis at risk[7,8,3,4,9,10,11,12,13,5].

Epidemiological studies have shown that there is no race, ethnicity, or country that is immune to osteoporosis[14,15,13].

According to the classification,[13,5] primary and secondary types of osteoporosis are distinguished. Primary osteoporosis includes postmenopausal and senile osteoporosis, which accounts for approximately 85% of all cases. Secondary osteoporosis included bone pathologies associated with other diseases (rheumatism, thyrotoxicosis etc.), as well as medication use (glucocorticoids, thyroid hormones, etc)

The bone tissue of the jaws is not much different in structure and chemical composition from other bones of the skeleton. However, in the alveolar bone, the processes of internal restructuring occur more actively than in other bones of the human body.

Normally the height of the alveolar ridge is maintained by a physiological balance of bone formation and resorption, which are regulated not only by systemic factors but also by local ones.

In accordance with the change in functional load on the jaws, remodeling modifies the structural anatomy of the bone tissue and the loaded structures, strengthening them, while in the absence of the load, the bone tissue is resorbed. (Wolff's law[16]). Often systemic and local regulatory mechanisms are opposed to each other.

In recent years, considerable attention has been paid to clarifying the relationship between metabolic bone diseases and changes in the bone tissue of the jaws[17,18,14,19]. Systematic processes occurring in the human body affect the state of the tissues of the jaws. However, the relationship between osteoporosis and oral cavity conditions remains a matter of debate.

The role of osteoporosis in the reduction of jawbone volume, pathogenesis of periodontal diseases, tooth loss, and other changes is still unclear [2].

The aim of our study is to establish the relationship between systemic osteoporosis and jaw bone tissue and the impact of this disease on oral health.

The main method for determining bone mineral density (BMD) is dual-energy X-ray absorptiometry (DXA) [20,5].

As the International Society for Clinical Densitometry (ISCD) recommends, osteoporosis is diagnosed using the T-score in the form of standard deviations (SD) from the norm:

- From +1 to – 1 SD – norm
- From -1 to -2,5 SD – osteopenia
- Less than -2,5 SD – osteoporosis.

Which is the main source of diagnostic information that allows one to access the condition of bone tissue and the degree of its mineralization.

Spiral computed tomography (SCT) can be used to set the degree of density of bone tissue according to the C.E. Misch classification.

C.E. Misch classification (1999):

- D1 – Thick, dense, compact bone with a radiological value of density > 1250 Hounsfield Units (HU).
- D2 – thick cortical layer of varying density with a small-cell spongy bone layer. (850-1250 HU) low density.
- D3 – thin, V cortical bone layer with a bid – cell spongy bone layer (350-850 HU).
- D4 – indistinct layer of cortical bone, predominantly coarse spongy bone (150-350 HU).

To determine the density of tissue in a local area of the bone, an ultrasound densitometry is also used. The advantages of this method are simplicity, the absence of X-ray impact, and the possibility of application on toothless areas of the jaws.

The study involves measuring the speed of sound (SOS) as an ultrasound wave passes along the bone. This speed depends on the density, elasticity, and structure of the bone tissue and the thickness of the cortical layer and is therefore an important parameter for determining bone strength.

Laboratory methods help to assess the balance of bone metabolism: activity of bone resorption (tartrate-resistant acid phosphatase) and bone remodeling (alkaline phosphatase)markers, as well as serum calcium and phosphorus levels and urinary hydroxyproline presence.

Clinical studies include the determination of the caries intensity index (Decayed, Filled, Missing Tooth) and the Community Periodontal Index of Treatment Needs (CPITN).

The CPITN index allows one to determine the prevalence and intensity of periodontal tissue diseases, as well as to

study the need for various types of therapeutic and preventive care for patients with periodontal pathology.

The index criteria are as follows:

- 0 points – intact periodontium
- 1 point – bleeding gums
- 2 points – supra- and subgingival calculus, periodontal pocket depth up to 3,5 mm.
- 3 points – periodontal pocket depth up to 5 mm.
- 4 points – periodontal pocket depth up to 6 mm.

Analysis of the obtained data will allow us to assess both the severity of systemic osteoporosis and its impact on the condition of the jawbone tissue and oral health.

Materials and Methods.

The study involved voluntary participation of patients who visited a private dental clinic for dental implant surgery. During preoperative preparation, their bone tissue was assessed to determine the presence of osteoporosis or osteopenia.

A total of 87 people aged 45-65 years were examined. Radiographic, instrumental and laboratory methods were used for the study.

The patients were assessed for bone resorption and remodeling markers activity (tartrate-resistant acid phosphatase (TRACP) and alkaline phosphatase (ALP)), serum calcium and phosphorus levels, and urinary hydroxyproline levels.

Dual-energy X-ray absorptiometry (DXA) was performed to assess the condition of bone tissue and diagnose systemic osteoporosis.

Among this group of patients, 59 individuals had confirmed osteoporosis of varying severity, while 28 participants had no signs of bone pathology and served as controls. Patients were categorized into three groups: Group 1 (n=38) – females with compromised BMD; Group 2(n=21) – males with BMD impairment; Group 3(n=28) – both sexes without BMD abnormalities, as can be seen in Table 1.

Table 1 Distribution of patients based on the presence of bone tissue pathology

SEX	Total number of patients	Bone pathology based on T-score N<(-2,5SD)	No systemic bone pathology
FEMALE	54 62,07%	38 70,37%	16 29,63%
MALE	33 37,93%	21 63,64%	12 36,36%
TOTAL	87 100%	59 67,82%	28 32,18%

These 87 patients underwent thorough examination of the oral cavity, in particular the condition of the teeth and periodontium.

The decayed, missing, and filled teeth index (DMFT) was used to assess the oral health status of patients in different study groups.

Then the Community Periodontal Index of Treatment Needs – (CPITN) was determined in all participants for evaluation of periodontal tissue diseases.

The structure and thickness of the mucous membrane, its color, and the presence of pathologic changes were also assessed.

To determine the type of bone tissue according to the C.E. Misch Classification and to assess the severity of osteoporosis, an additional X-ray examination was performed using a spiral computed tomography (SCT). Ultrasound densitometry was performed to assess the condition of the mandibular bone tissue.

Results.

As a result of the conducted studies, it was found that the average intensity of caries in women of the first group was 1,2 times higher than in men of the second group ($p > 0,05$) and 1,6 times higher than in people without BMD disorders in the third group ($p1 > 0,05$). (caries intensity was defined as the total number of teeth affected by caries, filled and extracted in 1 patient), as can be seen in Figure 1.

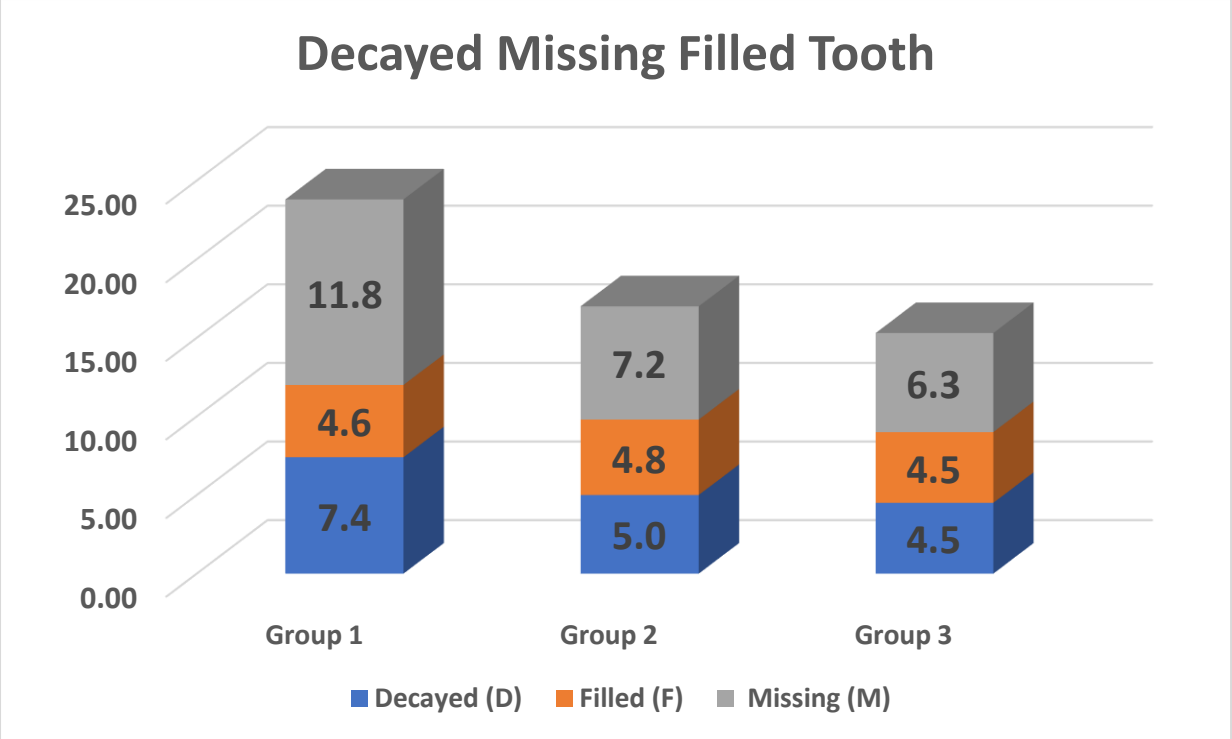

Figure 1. Composition of the DMFT index in patients of the study groups

It is noteworthy that the average number of extracted teeth per person in patients of the second and third groups does not differ much (7,2± 0,91 and 6,3 ± 0,87, respectively $p_1>0,05$), while the number of extracted teeth in patients of the first group (women with osteoporosis) was 1,6 times and 1,9 times higher than in patients of the second and third groups, respectively ($p,p_1< 0,01$).

Therefore, based on the data from this study, it can be assumed that women with osteoporosis are more likely to have more severe dental caries since this more often leads to tooth extraction.

A clinical examination of patients in all study groups revealed that in patients with impaired bone mineral density, the DMFT and CPITN indexes differ significantly from those in patients without osteoporosis. Such patients exhibited a higher intensity of caries and a worse condition of periodontal tissues.

As can be seen in Table 2, the periodontal tissues are most affected in patients with osteoporosis in the first and the second study groups, while the CPITN values in the control group were significantly lower.

Table 2. Average CPITN indicators per one examined patient in the study groups.

Code CPITN	Study groups		
	Group 1, n=38	Group 2, n=21	Group 3, n=28
0 – No inflammation	0,52±0,10	0,43±0,08	2,32±0,46•,*
1 – Gingival bleeding	1,46±0,29	1,83±0,36	0,95±0,19**
2 – supra- and subgingival calculus	2,48±0,49	2,52±0,50	0,23±0,04•,*
3 – Periodontal pocket 4-5 мм	0,56±0,11	0,93±0,18	0,25±0,05••,*
4 – Periodontal pocket 6 мм і більше	–	–	–
Total	5,02±0,25	5,71±0,28	3,75±0,19•,*
Note: •p<0,01; •• p<0,05 – significant difference compared to Group 1; *p<0,01; ** p<0,05 – significant difference compared to Group 2.			

Table 3. Quantitative distribution of patients by bone tissue type (C.E. Misch classification, 1999)

Study groups	Bone tissue type							
	D1		D2		D3		D4	
	n	%	n	%	n	%	n	%
Group 1, n=38	2	5,26± ±2,40	9	23,68± ±6,89	14	36,84± ±7,82	13	34,20± ±7,69
Group 2, n=21	6	28,57± ±9,85••	7	33,33± ±10,28	4	19,05± ±8,56	4	19,05± ±8,56
Group 3, n=28	15	53,57± ±9,42•	8	28,57± ±8,53	5	17,86± ±7,23	–	–
Note: •p<0,01; •• p<0,05 – significant difference compared to Group 1.								

In most patients of group 1 (women with systemic osteoporosis) the bone type D3 was determined in 36,84±7,82% of the examined and in 34,2 ± 7,69% of women bone type D4. It should be noted that an average BMD in men with systemic osteoporosis of group 2 was higher than in women of group 1, but significantly lower than in patients in the control group. Bone tissue of Type D3 and D4 was determined equally 19,05 ± 8,56%, respectively in the second study group.

Figure 2 illustrates this point clearly.

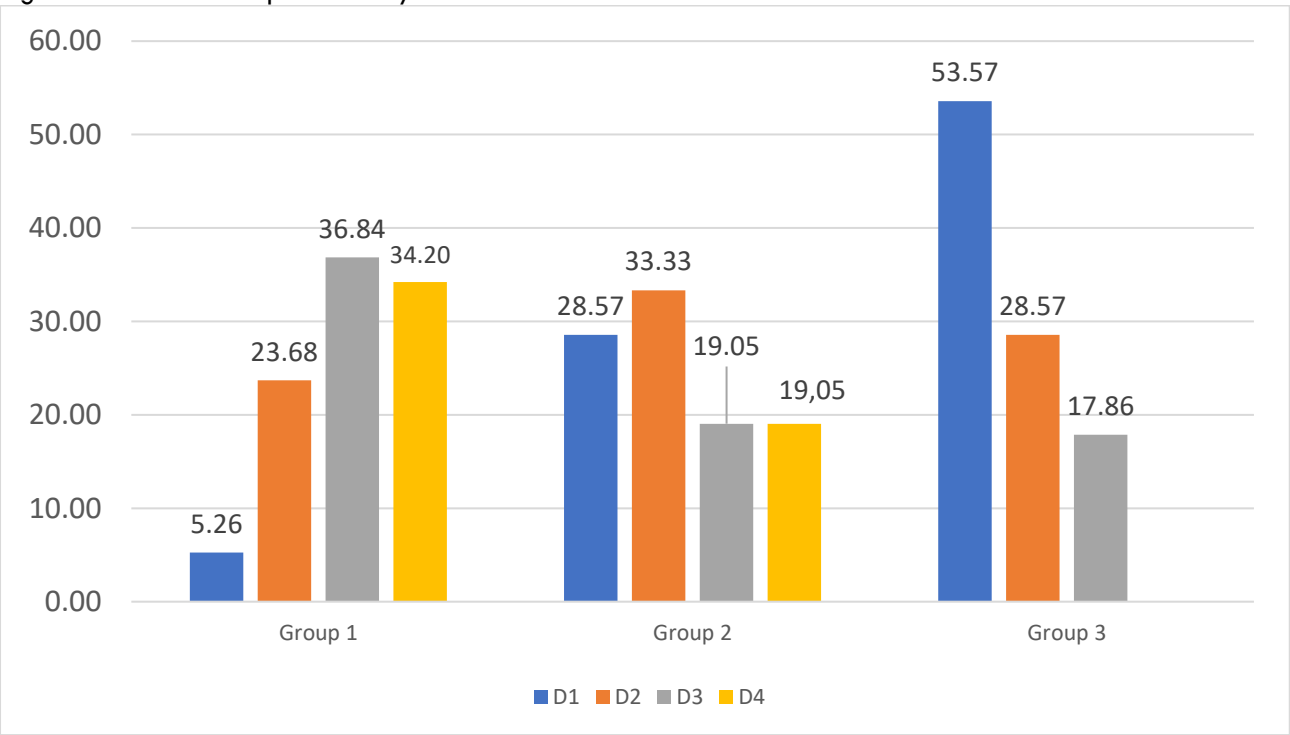

Figure 2. Differences in bone tissue types in different study groups.

Radiological studies (DXA densitometry and spiral CT) showed that in the presence of bone pathology in the peripheral skeleton, the bone structures of the jaws are also subject to deformation. In patients with osteoporosis (especially in women in the group 1) soft spongy bone of types D3 and D4 is predominant in the jawbone tissue.

Ultrasound densitometry showed a decrease in the speed of sound waves passing through the mandibular bone in patients with low bone density.

The results revealed that in women with systemic osteoporosis of group 2, SOS through the bone structure was 1,3 times lower than in individuals of group 3 (without osteoporosis), p<0,01.

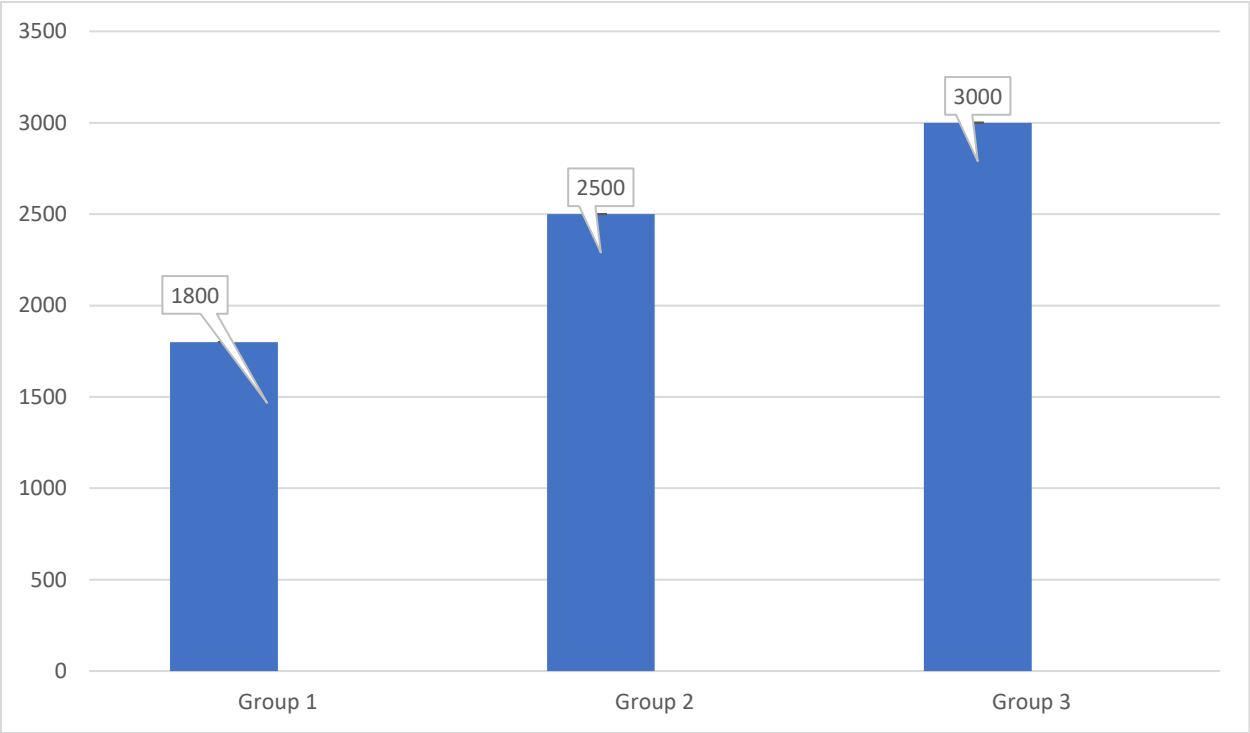

Figure 3. Ultrasound densitometry indications of the lower jaw in patients of the study groups.

It should be noted that when the results of the ultrasound densitometric study were analyzed, significant differences in the indicators were found among the groups of subjects examined.

The variation in indicators was probably due to the presence of various defects in the dentition, depending on the number of missing teeth, which led to a decrease in the degree of mineralization and SOS transmission through the bone structure[21,22,23,24,25].

Laboratory test results showed that bone remodeling markers were most imbalanced in osteoporotic females (Group 1) and to a lesser extent in males (Group 2), relative to healthy controls. In women with osteoporosis, serum calcium increased by 22,48%/ phosphorus by 37,77%, TRACP activity by 11,19%, and urinary hydroxyproline by 31,75 %, whereas ALP activity decreased threefold, p, $p1<0,01$

Thus, metabolic disorders in systemic osteoporosis negatively affect the structures of the oral cavity, which is confirmed by the worse condition of the teeth, alveolar bone tissue and periodontium.

Discussion.

Taking into account all of the above, it should be noted that there is a tendency for systemic osteoporotic influence on both the mechanical strength of jawbone tissue and biological processes in the periodontium.

As we can see from the data obtained, the number of missing teeth in patients with osteoporosis is significantly higher than in patients in the control group. This, of course, does not indicate a direct relationship between systemic osteoporosis and tooth loss, but allow us to assume that in patients with impaired BMD, complicated caries and periodontitis are prevalent, which leads to teeth extraction as the only treatment option.

As indicated by Naik, A. et al.[26], there is a relationship between systemic osteoporosis, decreased bone mass of the jaws and tooth loss. There is evidence that treatment aimed at increasing bone mineral density helps preserve teeth and slows down the loss of alveolar bone.[27,10]

But such treatment must ensure the normalization of the balance of bone metabolism[6] so that normal healing of bone tissue occurs after surgical operations in the oral cavity (tooth extraction, dental implantation, etc.).

Despite the mechanical load that the jaw bone receives and its compensatory possibilities, metabolic processes inside it are not much different from those inside the bones of the peripheral skeleton.

Although some patients with osteoporosis showed some compensatory increase in bone volume (Wolff's law[16]), in most cases, a stable correlation has been established between a decrease in the mineral density of peripheral bones and a disruption in the structure of the jawbone tissue.

Although Zeng W.et al[28] claim, that there is no correlation between systemic osteoporosis and densitometric parameters at mandibular bone quality, our research confirms that osteoporosis affects the bone tissue of all bones in the human body. As can be seen from the results of X-ray and instrumental studies, a direct relationship is determined between the general condition of bone tissue and local manifestations in the oral cavity in patients of all study groups.

However, some scientists [28,29] think that osteoporosis does not have a direct impact on periodontal tissues, but just has some common risk factors (smoking, old age, postmenopausal period), but our research clearly showed that osteoporotic changes likely affect the course and intensity of periodontal tissue diseases[30,31].

Indeed, it cannot be denied that many possible factors influence both the development of osteoporosis and periodontal diseases, so it sometimes difficult to establish a direct correlation between decreased BMD, tooth loss, reduction in alveolar bone volume, periodontitis.

Thus, there is no consensus regarding the role of osteoporosis in changes in jawbone tissue and some authors[28,29] state that the relationship between systemic osteoporosis and alveolar bone is questionable, but the results of our research allow us to disagree with this statement.

Conclusion.

It can be concluded that the biomechanical impact of systemic osteoporosis is an obvious fact, as well as the comorbid relationship between osteoporosis and periodontal diseases. It requires timely, individualized, gender-specific osteotropic therapy. The absence of such treatment can lead to irreversible changes in the jawbone tissue and to their inability to perform a supporting function for both teeth and dental implants.

Conflicts of Interest Statement.

The author has no conflicts of interest to declare.

References.

1. Fagerlund, K. Osteoclastic tartrate-resistant acid phosphatase 5b: Diagnostic use and biological significance in bone physiology (Doctoral dissertation, University of Turku). Turku University Publications.Published June,12,2009 https://www.utupub.fi/handle/10024/45167
2. Hohlweg-Majert, B., Schmelzeisen, R., & Pfeiffer, B.M. Significance of osteoporosis in craniomaxillofacial surgery. Osteoporosis International.2006; 17(9), 1367–1377. doi: 10.1007/s00198-005-1967-4
3. Zhong X, Li L, Wan W. Optimal kidney-tonifying traditional Chinese medicines for postmenopausal osteoporosis: A network meta-analysis of randomized controlled trials. J Clin Densitom. 2025;28(2):101581.
4. Zhou X, Long H, Wang JH, Huang Z, Cao L. Clinical outcomes and safety of combined calcitriol and bisphosphonates in treating postmenopausal osteoporosis: a retrospective cohort study. J Orthop Surg Res. 2025;20(1):359. Published 2025 Apr 9. doi:10.1186/s13018-025-05714-2
5. Caroline McPhee, Irene O Aninye, Lindsey Horan. Recommendations for Improving Women's Bone Health Throughout the Lifespan. J Women's Health (Larchmt).2022 Dec;31(12):1671-1676. doi:10.1089/jwh.2022.0361
6. E Michael Lewiecki, John P Bilezikian, Amanda Clark, et al. Proceedings of the 2024 Santa Fe Bone Symposium: Update on the Management of Osteoporosis and Rare Bone Diseases. Journal of Clinical Densitometry.2025;28(1):101559. doi: 10.1016/j.jocd.2024.101559
7. Coelho, P.G., Giro G., Sales-Pessoa, R., et al. Influence of estrogen deficiency on bone around implants. Journal of Oral and Maxillofacial Surgery.2011; 69(7), 1775–1780. doi: 10.1016/j.joms.2011.01.018.
8. Zhang YL, Wei X, Xie YM, Zhu LG, et.al. Evaluation of bone mass and relevance ratio of osteoporosis among middle aged and elderly population in the Beijing community. Zhongguo Gu Shang. 2020;33(10):916-21.
9. Alatalo, S. (2004). Tartrate-resistant acid phosphatase 5b: A serum marker of bone resorption [Doctoral dissertation, University of Turku]. UTUPub. 2004 https://www.utupub.fi/bitstream/handle/10024/5817/D613.pdf
10. Temmerman A, Rasmusson L, Kübler A, Thor A, Merheb J, Quirynen M. A Prospective, Controlled, Multicenter Study to Evaluate the Clinical Outcome of Implant Treatment in Women with Osteoporosis/Osteopenia: 5-Year Results. J Dent Res. 2019;98(1):84-90. doi:10.1177/0022034518798804
11. Zamani S, Kiany F, Khojastepour L, Zamani A, Emami Z. Evaluation of the association between osteoporosis and periodontitis in postmenopausal women: A clinical and radiographic study. Dent Res J (Isfahan). 2022;19:41. Published 2022 Jun 1.
12. Zou MY, Cohen RE, Ursomanno BL, Yerke LM. Use of Systemic Steroids, Hormone Replacement Therapy, or Oral Contraceptives Is Associated with Decreased Implant Survival in Women. Dent J (Basel). 2023;11(7):163. Published 2023 Jun 29. doi:10.3390/dj11070163
13. Amir Quaseem, Cristin A Mount, Karen Campos, et al. Quality Indicators for Osteoporosis in Adults: A Review of Performance Measures by the American College of Physicians. Ann Intern Med.2023 Oct;176(10):1386-1391.doi:10.7326/M23-1291.
14. Żuchowski P, Dura M, Jeka D, Wojciechowski R, Bierwagen M, Kułakowski M. Osteoporosis in axial radiographic spondyloarthritis: diagnostic limitations of bone mineral density and the need for comprehensive fracture risk assessment. Reumatologia. 2024;62(6):466-474. doi:10.5114/reum/194107
15. Zinganell A, Hegen H, Walde J, et al. Screening for osteoporosis in people with MS: A new risk score. Mult Scler Relat Disord. 2023;74:104726. doi:10.1016/j.msard.2023.104726
16. de Souza Balbinot G, Leitune VCB, da Cunha Bahlis EA, Ponzoni D, Visioli F, Collares FM. Niobium-containing bioactive glasses modulate alkaline phosphatase activity during bone repair. J Biomed Mater Res B Appl Biomater. 2023;111(6):1224-1231. doi:10.1002/jbm.b.35227
17. Zeng YH, Hao DJ. Exploration and prospect of the whole course management model of osteoporosis. Zhonghua Yi Xue Za Zhi. 2023;103(35):2737-2742. Chinese. doi: 10.3760/cma.j.cn112137-20230413-00595.
18. Zikán V. Osteoporóza u dospělých osob v klinické praxis (1) :diagnostika a diferenciální diagnostika [Osteoporosis in adults in clinical practice (1): diagnosis and differential diagnosis]. Vnitr Lek. 2023;69(E-4):4-15. doi:10.36290/vnl.2023.052
19. Riabenko T. V. Modern aspects of reparative regeneration of bone tissue and analysis of bone metabolism indicators. Ukrainian Journal of Medicine, Biology and Sport. 2020; Vol. 5, No. 3 (25). P. 89-97.
20. Steven R Cummings, David Bates, Dennis M Black. Clinical use of bone densitometry: scientific review. JAMA.2002 Oct 16;288(15):1889-97. doi:10.1001/jama.288.15.1889
21. Yamashita-Mikami, E., Tanaka, M., Sakurai, N., et al. Correlations between bone microstructure and bone markers. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology.2013; 115(5), 589–595. doi: 10.1016/j.oooo.2013.01.005
22. Zhou J, Huo X, Xue Y. Comments on Min et al.: Effects of anti- osteoporosis medications on radiological and clinical results after acute osteoporotic spinal fractures: a retrospective analysis of prospectively designed study. Osteoporos Int. 2020;31(6):1181. doi:10.1007/s00198-020-05355-7
23. Khan, A.A., Morrison, A., Kendler, D.L., et al. International recommendations for osteonecrosis management. Journal of Clinical Densitometry.2017; 20(1), 111–120. doi: 10.1016/j.jocd.2016.09.001
24. Vandenbulcke F, Renne SL, Anzillotti G, et al. "Anti-Bios": Can Local Antibiotics Affect Bone Union in Infected Bone Defects Treated with Degradable Bone Substitutes. Biomedicines.

2025;13(5):1070. Published 2025 Apr 28. doi:10.3390/biomedicines13051070
25. Zhang W, Huang P, Lin J, Zeng H. The Role of Extracellular Vesicles in Osteoporosis: A Scoping Review. Membranes (Basel). 2022;12(3):324. Published 2022 Mar 14. doi:10.3390/membranes12030324
26. Naik, A., Kale, A.A., & Rajwade, J.M. Emerging technologies for bone health assessment. Biomaterials Advances.2024; 213267. doi: 10.1016/j.biomadv.2024.213267
27. Tabrizi R, Mousavi F, Ghasemi S, Ozkan BT. Does osteoporosis increase marginal bone loss around dental implants in the posterior of the maxilla? Int .J. Oral Maxillofac Surg. 2021;50(7):964-968. doi:10.1016/j.ijom.2020.12.001
28. Zeng W, Liu W, Zhang L, et al. Trends in osteoporosis assessment, diagnosis after fragility fractures, and treatment for hospitalized patients with osteoporosis or fragility fractures between 2012 and 2021. Arch Osteoporos. 2025;20(1):8. Published 2025 Jan 8. doi:10.1007/s11657-024-01492-2
29. Zoulakis M, Axelsson KF, Litsne H, Johansson L, Lorentzon M. Real-world effectiveness of osteoporosis screening in older Swedish women (SUPERB). Bone. 2024;187:117204. doi:10.1016/j.bone.2024.117204
30. Ardakani, F.E., & Mirmohamadi, S.J. Osteoporosis and oral bone resorption. J Maxillofac Oral Surg.2009; 8(1), 19–23. doi: 10.1007/s12663-009- 0030-y
31. Heuchert, J., Kozieł, S., & Spinek, A.E. Mandibular indices as indicators of bone loss. Osteoporosis International.2024; 35(2), 323–334. doi:10.1007/s00198-023-06949-7

