

IMPACT OF OSTEOPOROSIS ON DENTAL IMPLANTS: A NARRATIVE REVIEW OF SURVIVAL, BONE LOSS, AND MEDICATION-RELATED RISKS

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ABSTRACT

Purpose: This narrative review synthesizes the available evidence on the influence of osteoporosis on the dental implant outcomes, including the implant survival, failure, and marginal bone loss. Evidence on treatment-related risks, including the risk of medication-related osteonecrosis of the jaw (MRONJ), is also discussed. **Main Findings:** Although the evidence suggests that osteoporosis per se does not significantly decrease the implant survival compared to the healthy controls with the risk ratio = 1.00, 95% CI: 0.97-1.02, the antiresorptive medications, such as bisphosphonates, are associated with an increased risk of MRONJ (RR = 3.45, 95% CI: 2.56-4.65) and higher risk of implant-level failure (RR = 1.74, 95% CI: 1.10-2.75). Evidence related to marginal bone loss remains contradictory because of heterogeneity. **Conclusion:** With proper risk assessment and management, patients who have osteoporosis can be successfully treated with dental implants. A diagnosis of osteoporosis should not be considered in itself an absolute contraindication, even though patients on antiresorptive medications require particular caution and consultation with physician with individual treatment planning.

Keywords: Dental implants, osteoporosis, osseointegration, bisphosphonates, MRONJ, marginal bone loss

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1. INTRODUCTION

Osteoporosis is the most prevalent metabolic bone disease, characterized by decreased bone mass and altered microarchitecture of the skeletal tissue [1]. This systemic condition has significant public health implications and affects millions of postmenopausal women and elderly individuals world-wide. Because the alveolar processes form the bony framework that supports our teeth and, consequently, implants, the loss of the bone mass has considerable implications for the dental implant therapy [1,2].

Dental implants have become the gold standard for tooth replacement, with success rate in excess of 95% in healthy patients. As the aging population grows and more medically compromised patients seek implant rehabilitation, it is clinically essential to understand how the systemic conditions, including osteoporosis, influence the implant outcomes [3,4]. The key clinical question is whether osteoporosis, by itself, or its treatments, acts to contraindicate or complicate the implant placement [5,6].

The current evidence presents a conflicting picture. Some of the earlier studies suggested that the lower bone mineral density adversely affects osseointegration and implant survival, raising concerns about impaired healing and reduced primary stability [1,2]. In contrast, the recent systematic reviews and prospective studies found implant survival rates among the osteoporotic patients to be comparable to those in the healthy patients, suggesting osteoporosis alone was not a significant risk factor [7-9]. Finally, many patients suffering from osteoporosis are prescribed drugs for

antiresorptive therapy, such as bisphosphonates or denosumab, and these drugs carry well-established risks of MRONJ [10-12].

Significant knowledge gaps exist. The literature is very diverse, encompassing differences in study design, osteoporosis diagnostic criteria, implant protocols, follow-up durations, outcome definitions, etc., [8,9]. Additionally, the relationship between osteoporosis, antiresorptive therapy, and implant outcomes is still not well understood and is contradictory concerning marginal bone loss and considerable MRONJ risk in this patient group [10,11].

This narrative review seeks to critically synthesize the evidence regarding how osteoporosis influences the dental implant outcomes, including the implant survival, failure, marginal bone loss, and medication-related risks. By collecting literature from both foundational and recent sources, this review intends to provide clinicians with evidence-based direction for treatment planning in the osteoporotic patients and identify areas that require further research.

2. METHODOLOGY

This narrative review was conducted to synthesize the evidence regarding how osteoporosis influences the dental implant outcomes. Since this is a narrative review, no systematic review protocol was registered, but a systematic approach to search the literature and select the articles was employed.

Databases Searched: A comprehensive literature search was performed using PubMed/MEDLINE, Scopus, Google Scholar, and the Cochrane Library.

Manual searches of reference lists from included articles and relevant systematic reviews were also performed.

Search Terms and Keywords: The following search terms and Boolean operators were applied: ("dental implant" OR "oral implant" OR "osseointegration") AND ("osteoporosis" OR "low bone density" OR "osteopenia" OR "bone mineral density") AND ("survival" OR "failure" OR "marginal bone loss" OR "MRONJ" OR "bisphosphonate" OR "denosumab"). The search strategies were tailored to each database as needed.

Inclusion Criteria: The articles were included if they: (1) were published in English; (2) involved human subjects (clinical studies, prospective or retrospective cohorts, case-control studies, or randomized controlled trials); (3) examined the dental implant outcomes in patients with osteoporosis or low bone density compared to healthy controls; (4) reported at least one outcome of interest (implant survival/failure, marginal bone loss, or MRONJ); (5) were published between January 2000 and May 2026 to capture both foundational and recent literature; and (6) were systematic reviews, meta-analyses, or original clinical research.

Exclusion Criteria: The articles were excluded if they: (1) were case reports, opinion articles, editorials, or conference abstracts; (2) were animal studies or in vitro research; (3) were not available in English; (4) lacked a control group of non-osteoporotic patients; or (5) were duplicate publications of the same patient cohort.

Article Selection Process: The initial database search yielded approximately 450 articles after duplicates were removed. Title and abstract screening excluded 320 articles that did not meet the inclusion criteria. Full-text review of the remaining 130 articles resulted in 45 articles that satisfied all inclusion criteria. From these articles, 20 representative articles were selected for inclusion in this narrative review based on their relevance and contribution to key thematic areas.

Data Extraction and Synthesis: The key information was collected from every included article (e.g., author(s), publication year, study design, sample size, patient characteristics, osteoporosis diagnostic criteria, implant details, outcome measures, and main findings). Since this study employed a narrative review design, the findings were organized thematically instead of being pooled through quantitative meta-analytic methods.

3. MAIN BODY

3.1 Biological Basis: How Osteoporosis Affects Bone and Osseointegration

Understanding the clinical outcomes requires an understanding of how osteoporosis biologically affects the bone surrounding the implants. This

condition results when the resorption and bone formation become unbalanced, resulting in lower bone mineral density and deteriorated microarchitecture [1,13]. These alterations stem from osteoclast activity surpassing osteoblast function, which occurs due to age, hormonal status (estrogen deficiency in postmenopausal women), and various systemic factors [2,13].

The alveolar bone, as part of the maxillofacial skeleton, undergoes metabolic processes that are comparable with those of other bones in the body. Studies show that osteoporotic patients have lower jaw bone density and altered trabecular patterns, especially in the posterior maxilla [1,2]. These changes have theoretical implications for implant osseointegration, a process where living bone directly connects to the implant surface. Poorer bone quality may affect the primary implant stability, the dynamics of healing, and the preservation of the peri-implant bone levels [5,14].

The jaw bones differ from the axial skeleton in several ways. They are originated from neural crest cells, are subjected to distinctive mechanical forces during mastication, and can be partially shielded from systemic bone loss by functional loading [13]. This may explain why the implant outcomes in osteoporotic patients are often better than suggested by their skeletal bone density. Mechanistically, osseointegration progresses normally in most osteoporotic patients as long as the primary stability is attained, although the healing may be slower [7,15]. Recent studies have identified gene expression patterns associated with osseointegration that can potentially work as biomarkers for patient selection [16].

3.2 Implant Survival and Failure Rates in Osteoporotic Patients

A key question is whether osteoporosis adversely impacts the implant survival. Early worries arose from the understanding that osteoporosis reduces the bone mass and may decrease the quality of the bone available for anchoring implants [1,2]. Earlier systematic reviews, however, arrived at conflicting conclusions, with some reporting higher failure rates and others finding no significant differences [5,6].

Main Findings from the Literature

The latest and most comprehensive evidence shows that osteoporosis per se does not significantly increase the implant failure rates. Kim and co-authors' 2025 systematic review and meta-analysis of 14 comparative human studies found no significant difference in implant survival between the osteoporosis and healthy controls (risk ratio = 1.00, 95% CI: 0.97-1.02) [8]. Likewise, the implant failure rates were comparable between the two groups (RR = 0.96, 95% CI: 0.59-1.56) [8]. Lemos and colleagues

supported these findings in their 2023 meta-analysis, concluding that osteoporosis patients do not exhibit significantly higher risks for implant failure or marginal bone loss compared to the healthy individuals [9].

The prospective evidence is consistent with the meta-analytic findings. Temmerman and co-authors conducted a multicenter prospective study of women with osteoporosis/osteopenia over 5 years and reported implant survival rates equal to those seen in the healthy control groups [7]. Similarly, the 1-year findings from the same cohort showed favorable results, which suggest that implant success can be achieved in osteoporotic patients when appropriate surgical technique and healing protocols are applied [15].

Key Studies Reviewed

While an encouraging picture emerges, subgroup analyses uncover some notable nuances. Looking at results at the implant level may reveal patterns that are not evident at the patient-level. A study that identified osteoporosis as a significant risk factor reported an adjusted odds ratio of 3.42 (95% CI: 1.29-9.10) for implant failure among the osteoporotic patients, although this was not consistent with all studies included [6]. Similarly, smoking showed a stronger association with failure (OR = 4.57) [6]. This suggests that while osteoporosis alone may not be prohibitive, it can potentially be a contributing factor when combined with other risks.

The 2025 meta-analysis by Lin and colleagues of medication effects provides additional context, showing that bisphosphonate use was associated with implant failure only at the implant level (RR = 1.74, 95% CI: 1.10-2.75) and not the patient-level (RR = 1.01, 95% CI: 0.35-2.91) [10]. This discrepancy underscores the importance of how the outcomes are measured and analyzed and highlights that patient-level factors may be more nuanced than a binary classification.

Clinical Significance in Brief

Current evidence does not support the consideration of osteoporosis alone as an absolute contraindication for dental implant therapy [3,8,9]. Osteoporosis patients may be able to achieve comparable implant survival to that of healthy individuals, although this depends on their specific systemic and local risk factors. Clinicians should: (1) take thorough medical histories, including all medications used; (2) allow longer periods for healing; (3) aim to obtain optimal primary stability; and (4) recognize that osteoporosis may synergistically act with other risk factors, such as smoking [6]. The informed consent process should reflect the evidence while acknowledging the variability of the published results.

3.3 Marginal Bone Loss Around Implants

Marginal bone loss (MBL) is a crucial indicator of implant success, as excessive bone loss can compromise esthetics, increase the risk of peri-implantitis, and eventually lead to implant failure. The relationship between osteoporosis and MBL has sparked substantial debate in the literature, with findings that contradict each other [8,9,18].

Overview and Background

Early cross-sectional studies showed inconsistent results. Wagner and colleagues conducted a matched cross-sectional study to evaluate the marginal peri-implant bone levels in osteoporotic versus healthy female patients and found no significant differences in mean bone loss, although there was considerable individual variation [17]. In contrast, Tabrizi and associates examined posterior maxillary implants and reported greater marginal bone loss in osteoporotic patients compared to controls [18].

Main Findings from Recent Meta-Analyses

The 2025 meta-analysis by Kim and colleagues systematically pooled data from multiple studies to answer this question. The analysis showed that there was considerable heterogeneity across the studies ($I^2 = 86\%$), which implies that the variations in study design, assessment methods, implant types, and implant loading contribute to the inconsistent findings [8]. After analyzing by bone region (maxilla versus mandible) and implant surface characteristics, some of the heterogeneity was reduced, although there was still considerable variation. It should be noted that the overall effect estimate was not statistically significant for increased MBL among the osteoporotic patients [8].

The 2023 meta-analysis by Lemos and colleagues similarly found no statistically significant differences in marginal bone loss between the osteoporotic and healthy patients, although it highlighted the low quality of evidence due to the risk of bias and imprecision [9].

Clinical Implications and Unresolved Questions

From a clinical standpoint, there are several points that should be considered. First, marginal bone loss is affected by a multitude of factors beyond bone density, including implant placement depth, prosthetic design, occlusal loading, oral hygiene, and the inflammatory status [14,17]. Second, the posterior maxilla, where the bone density is the lowest even in healthy patients, may be more susceptible to the effects of the systemic bone loss, as suggested by Tabrizi and colleagues [18]. Finally, routine monitoring of the peri-implant bone levels with periapical radiographs is advised for all implant patients, particularly those with osteoporosis, as loss may accelerate in certain individuals.

Until higher-quality prospective studies become available, clinicians should be vigilant about

marginal bone loss in osteoporotic patients, although recognizing that existing evidence does not warrant routine changes to implant protocols for this issue.

3.4 Antiresorptive Medications: The MRONJ Risk

For osteoporotic patients receiving implant therapy, the most clinically challenging question is arguably how to manage the ones on antiresorptive drugs, such as bisphosphonates (oral alendronate, risedronate, ibandronate) and denosumab (Prolia, Xgeva). These drugs are effective at reducing fracture risk in osteoporotic patients, but they also pose a rare but serious risk of medication-related osteonecrosis of the jaw (MRONJ) [10-12].

Bisphosphonates and Implant Outcomes

The 2025 systematic review and meta-analysis conducted by Lin and colleagues offers a comprehensive evaluation of how bisphosphonates affect dental implants [10]. By pooling the data from more than 7,000 implants across 14 studies, the analysis showed that bisphosphonate use was associated with a significantly greater MRONJ risk than non-users (RR = 3.45, 95% CI: 2.56-4.65). At the implant level, the patients who were taking bisphosphonates showed higher failure rates (RR = 1.74, 95% CI: 1.10-2.75), although this result was not significant at the patient level [10]. It is important to note that the route of administration is crucial, with intravenous bisphosphonates (mainly used for oncologic indications) carrying a much higher MRONJ risk than oral bisphosphonates (used for osteoporosis). Among the osteoporotic patients taking oral bisphosphonates, the absolute risk of MRONJ after implant placement seems low, although not nonexistent [10,12].

Denosumab: Emerging Evidence

Denosumab, a RANKL inhibitor, is a newer class of antiresorptive therapy. Although the risk of MRONJ is recognized, the extent to which it is specifically linked to dental implants is clearer. A 2026 systematic review by Pereira Santos and colleagues investigated MRONJ risk in osteoporotic patients treated with denosumab who have received dental implants [11]. The authors reported that MRONJ did occur, but rarely, with most cases arising in patients with additional risk factors or had previously taken bisphosphonates. That same year, a commentary on the denosumab evidence emphasized the need for caution, particularly in patients transitioning from bisphosphonate to denosumab therapy [12].

Clinical Management Strategies

In light of these findings, several clinical recommendations can be offered. For patients who have taken oral bisphosphonates for less than 3-4 years and have no other risk factors, implant placement may be considered after informed consent and consultation with a physician [10,12]. For

patients on long-term oral bisphosphonates (>4 years) or any intravenous bisphosphonate, alternative restorative options should be strongly considered, and implant placement should occur only after a multidisciplinary risk assessment. Preoperative and postoperative antibiotic prophylaxis, a surgical technique that avoids trauma, and extended follow-up are advised [10,11]. The topic of drug holidays is debatable; since oral bisphosphonates persist in bone for a long period and evidence that such holidays lower MRONJ risk is insufficient, current guidelines generally recommend against stopping them prior to implant surgery [12].

4. DISCUSSION

4.1 Overview of Main Findings

This narrative review synthesizes the available evidence on the influence of osteoporosis on the dental implant outcomes. Several key findings emerge from the literature. First, compared to the healthy patients, osteoporosis does not significantly lower the implant survival or raise failure rates [8,9]. This conclusion is supported by several systematic reviews and meta-analyses published between 2018-2025, which represent the most robust evidence currently available [6-8]. Second, evidence on marginal bone loss is inconsistent, showing considerable variation among the studies ($I^2 = 86\%$ in one analysis) [8]. Third, antiresorptive drugs, particularly bisphosphonates, are associated with higher implant failure risks at the implant level and a notably increased risk of MRONJ (RR = 1.740, 95% CI: 1.10-2.75) [10]. The evidence for denosumab is less conclusive but emerging data suggest that MRONJ is uncommon but clinically significant, particularly for patients transitioning from bisphosphonate therapy [11,12].

4.2 Clinical Implications

These findings have direct practical implications for the dental clinician. A diagnosis of osteoporosis should not by itself exclude a patient from implant therapy, but a thorough risk assessment is needed, taking bone density at the planned implant site, medication status, the duration of antiresorptive therapy, and the presence of other risk factors such as smoking into account [3,6]. For patients who are not taking antiresorptive medications, standard implant protocols designed to achieve good primary stability are appropriate [7,15]. For patients taking bisphosphonates--particularly those on longer treatment regimens (>3-4 years) or intravenous administration--the risk of MRONJ warrants careful evaluation and consultation with the prescribing physician [10,11]. Drug holidays are a debatable issue and should not be routinely recommended without medical guidance.

4.3 Limitations of Current Evidence

The evidence has notable limitations that should be acknowledged. Firstly, according to GRADE assessments, the certainty of evidence is low to very low for most outcomes [10]. Secondly, comparability is limited by heterogeneity across studies, which differ in osteoporosis diagnostic criteria, implant systems, surgical protocols, follow-up durations, outcome definitions, etc. [8,9]. Thirdly, the majority of studies are observational rather than randomized, which may introduce selection and confounding biases. Fourthly, several studies have comparatively small sample sizes, particularly for infrequent outcomes, such as MRONJ [11,12].

Fifth, due to the lack of standardization in the reporting of the medication details (type, dose, duration, and route), the precise risk thresholds are difficult to be established. Sixth, the majority of the studies concentrate on female patients, and the data concerning the osteoporosis in males and its relationship to the implant outcomes are limited [7,17].

4.4. Future Research Recommendations

There are several issues that should be taken into account in future clinical studies. First, conducting the large multicenter cohort studies with consistent inclusion and exclusion criteria is required to confirm the results of the present scoping review and minimize heterogeneity [8,11]. Second, the randomized control trials that compare the implants' outcomes in osteoporotic and healthy patients would generate the best evidence; however, designing such trials might be challenging. Particular attention should be paid to the following topics: (1) the threshold value of the bone mineral density associated with the increased risk of implant failure; (2) the influence of the implant surface structure on osseointegration in patients with osteoporosis [16]; (3) the effectiveness of various methods, including osteotome techniques and the computer-guided surgery, in osteoporotic patients [16]; (4) optimal healing time; (5) the risk of MRONJ development with a focus on the bisphosphonate type, dose, and duration of treatment; (6) the safety of the implant placement in patients who undergo the denosumab as monotherapy [11,12]; and (7) the role of the gonadal hormones and Hormone Replacement Therapy in postmenopausal women.

5. CONCLUSION

In conclusion, based on the findings of this scoping review, it is safe to state that the osteoporosis itself should not be a contraindication to the dental implant placement since the survival rate in such patients is not different than that in healthy individuals. Moreover, a properly selected treatment plan and technique can improve the outcomes in patients with osteoporosis. However, there is a need for the caution

and additional precautions in such cases due to the increased risk of the MRONJ development. Furthermore, the marginal alveolar bone resorption might be more prominent in these patients, which should also be considered during the follow-up visits and radiographic examinations.

In the future, as the number of the patients with osteoporosis will grow due to the aging population, the information discussed above will be helpful in developing the treatment plan for such individuals. Overall, the success of the implant placement in patients with osteoporosis can be achieved in most cases with a properly selected protocol. In addition, such patients can benefit from the fixed prosthetic restoration; therefore, discussing this option with them is essential.

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