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LONG-TERM EFFECTS OF DENTAL IMPLANTS IN PATIENTS WITH OSTEOPOROSIS - A LITERATURE REVIEW

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ABSTRACT

Introduction: Osteoporosis, a common metabolic bone disease affecting over 200 million people globally, causes decreased bone mass and structural deterioration, increasing fracture risk and reducing quality of life. Dental implants have become a standard treatment for tooth loss, providing functional and aesthetic restoration. However, in osteoporotic patients, compromised bone quality may challenge osseointegration and long-term implant stability, requiring careful assessment and individualized planning.
Methodology: A literature review of PubMed, Scopus, and Google Scholar identified recent systematic reviews and meta-analyses on dental implant outcomes in osteoporotic patients, focusing on implant survival, bone loss, and antiresorptive therapy, with studies ≥1-year follow-up included.
Results: Most studies show no significant difference in implant survival between osteoporotic and healthy patients, with rates typically above 90%. Slight but significant marginal bone loss was noted, though clinically minor. Bone density and osseointegration were generally comparable, particularly with individualized care and antiresorptive therapy. Osteonecrosis of the jaw was rare and mainly associated with bisphosphonate use. Age, systemic treatment, and local bone conditions influenced outcomes. Factors including patient age, systemic therapy, and local bone conditions influenced implant outcomes.
Conclusion: Dental implants in osteoporotic patients demonstrate high survival and predictable outcomes. Minor bone loss is manageable with monitoring and preventive care. Although antiresorptive therapy may increase osteonecrosis risk, interdisciplinary management minimizes complications. Osteoporosis should not be viewed as a contraindication for implant therapy, though further research is needed to refine treatment protocols.

KEYWORDS
Dental Implants, Osteoporosis, Long-Term Effects, Osseointegration

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Introduction

Osteoporosis is one of the most significant health challenges facing modern society, particularly in the context of global population aging. According to the World Health Organization (WHO), over 200 million people worldwide suffer from this condition, affecting up to 30% of postmenopausal women and 10% of men over 50 in developed populations. The disease is characterized by reduced bone mineral density (BMD) and deteriorated bone microarchitecture, increasing the risk of fractures and leading to chronic pain and limited mobility. Of particular concern is its impact on the jaw and mandible, where bone density loss can reach 25-50% within a decade after menopause, complicating dental and prosthetic procedures. From an interdisciplinary perspective, osteoporosis not only affects the skeletal system but also diminishes quality of life, contributing to social isolation and reduced mental well-being among older adults [1][2][3]. In the field of dentistry, dental implants have become a pivotal medical technology, revolutionizing the treatment of edentulism (tooth loss). Introduced in the 1960s by Per-Ingvar Brånemark, titanium implants based on the principle of osseointegration enable durable restoration of dentition, improving chewing function, aesthetics, and speech [4]. For patients with osteoporosis, dental implants provide not only biomedical benefits but also social advantages, enhancing self-esteem, reducing the risk of malnutrition due to chewing difficulties, and facilitating social reintegration. However, in the osteoporotic population, where bones are more fragile, osseointegration, the direct bonding of the implant with bone, may be compromised, raising concerns about the long-term effectiveness and safety of the procedure [5][6][7].

The scientific literature on the long-term effects of dental implants in patients with osteoporosis is extensive but fraught with controversy [6]. Authors emphasize that dental implants remain a viable therapeutic option but require enhanced clinical care to maintain peri-implant stability [8]. The primary knowledge gaps in implantology research related to osteoporosis arise from methodological inconsistencies. Most studies are observational or retrospective cohort analyses, with long-term randomized controlled trials (RCTs) being scarce, limiting the ability to draw broadly applicable conclusions. For example, in a systematic review and meta-analysis that included fourteen studies, comparisons between osteoporotic and control groups were made, but the high heterogeneity of the studies significantly hinders result interpretation [6]. The observation period in most studies ranges from approximately one to several years, with only a few extending beyond 10 years. For instance, a retrospective study with up to 20 years of follow-up found that implant survival rates in female patients undergoing antiresorptive therapy were high (~94%) and comparable to those in healthy populations. However, data on marginal bone loss over the long term were limited [9].

Regarding biomarkers, reviews have explored the utility of P1NP, CTX, NTX, and BALP in monitoring osteoporosis treatment. However, very few studies link these biomarker measurements to implantology outcomes (e.g. marginal bone changes or osseointegration) in patients with osteoporosis [10][11].

The working hypothesis suggests that while osteoporosis itself may not significantly reduce implant survival rates, there is a tendency for greater marginal bone loss and an increased risk of complications in the presence of additional risk factors, necessitating a careful clinical and diagnostic approach.

Methodology

This review was based on articles sourced from PubMed, Scopus and Google Scholar databases, with a particular focus on the latest systematic reviews and meta-analyses concerning the long-term outcomes of dental implants in patients with osteoporosis, including implant survival rates, marginal bone loss, and the impact of antiresorptive therapies. The selection criteria include a minimum of one year of follow-up and a comparison between osteoporotic and control groups. The literature search was conducted using the following keywords: dental implants, osteoporosis, antiresorptive therapy, bisphosphonates, implant survival, marginal bone loss and osteonecrosis of the jaw.

Results

a) Implant survival

The survival rate of dental implants in patients with osteoporosis has been extensively studied in the scientific literature, with most studies indicating no significant differences compared to control groups. A systematic review and meta-analysis from 2025, covering 14 studies, found that implant survival rates in osteoporotic patients are comparable to those in healthy individuals. However, a slight but significant marginal bone loss (mean difference = 0.22 mm) was observed, requiring cautious interpretation due to the high heterogeneity of the analyzed studies [6]. Similar findings were reported in a 2023 meta-analysis, which, based on data from 12 studies and over 3,500 implants, found no statistically significant difference in implant survival rates. However, it confirmed greater bone loss around implants in osteoporotic patients (mean difference = 0.71 mm) [12]. An earlier meta-analysis from 2017, examining nearly 30,000 implants, also confirmed no significant difference in survival rates at both the patient and individual implant levels [13]. These findings are supported by a 2024 systematic review, which included over 2,000 patients and confirmed implant survival rates above 90% in individuals with osteoporosis, showing no significant differences in osseointegration or bone density parameters compared to control groups [7]. Furthermore, prospective studies in postmenopausal women demonstrated a 100% implant survival rate after 12 months of follow-up, with minimal peri-implant bone loss and stable bone biomarker values, confirming the effectiveness of implant treatment in this population [14].

Other studies further reinforce the notion that osteoporosis does not necessarily pose a barrier to implantology. In a retrospective cohort study involving 1,472 implants in postmenopausal women, patients receiving oral antiresorptive therapy exhibited a very high implant survival rate (~94%) over a period of up to 20 years, comparable to healthy individuals. Slightly lower survival rates were observed in the untreated group [9]. In a prospective study from 2025, among women with a T-score below and above -2, the survival rate of placed implants was 100% after one year, with moderate marginal bone loss (~0.54 mm). Changes in bone density and bone biomarkers were minimal [15]. In a 5-year study of postmenopausal women, implant survival rates in the osteoporosis group remained at ~91.5% per implant, despite the control group achieving 100%. Differences in marginal bone loss were minor and clinically insignificant [16]. Retrospective studies indicate that factors such as implant location, local bone condition, and reimplantation are significant. For instance, a notably higher rate of failures for both initial and repeated implants is observed in patients with osteoporosis or osteopenia [17].

Recent scientific reports provide further evidence supporting the feasibility of effective implantation in patients with osteoporosis, while emphasizing the critical role of assessing local bone quality and systemic therapy. In a retrospective study by Probst et al. (2025), lower mandibular bone density and a thinner cortical layer were associated with reduced implant stability in patients with osteopenia/osteoporosis, highlighting the need to consider local bone parameters in treatment planning [18]. In contrast, a prospective pilot study by Sachelarie et al. (2025) compared groups with osteoporosis and diabetes, demonstrating that under controlled conditions, implant stability in the osteoporosis group achieved values comparable to or higher than those in the diabetic group at 6 and 12 months. This suggests that osteoporosis alone does not necessarily pose a barrier, provided other factors are optimized [19]. Additionally, a study by Seki et al. (2024) involving patients who began anti-osteoporosis treatment after implantation showed no significant deterioration in clinical peri-implant tissue parameters (such as probing depth or bleeding). This suggests that initiating anti-osteoporosis therapy does not necessarily lead to a worsening of implant conditions [20].

b) Changes in bone density and osseointegration

Changes in bone density and the osseointegration process of dental implants in patients with osteoporosis are a significant focus of research, highlighting potential challenges but also promising clinical outcomes. Bone mineral density around implants in osteoporotic patients remains comparable to that in healthy individuals, although slight but significant marginal bone loss has been observed, underscoring the need for long-term monitoring of bone changes [12]. Clinical studies have shown that the local application of alendronate and recombinant human bone morphogenetic protein-2 (rhBMP-2) significantly enhances bone density around implants and supports the osseointegration process, indicating the potential of adjunctive therapies to improve implant stability in osteoporotic patients [21].

Furthermore, a study on implants coated with bioactive glass revealed that such implants exhibit improved bone integration during the initial stages of healing. However, these differences diminish after 12 weeks, highlighting the critical importance of the early healing phase for the success of the procedure [22]. Prospective studies also highlight the role of bone biomarkers, such as CTX and P1NP, which correlate with marginal bone loss and may serve as valuable tools for monitoring osseointegration and the risk of resorption in patients with osteoporosis [23].

Long-term observational studies confirm that, although osteoporosis may affect bone density and the implant integration process, the use of an individualized therapeutic approach and monitoring enables stable and durable treatment outcomes [7]. Supplementary data from Cho et al. (2025) indicate that in postmenopausal women with reduced bone density, with appropriate supplementation and supervision, implants demonstrate a 100% survival rate after one year and moderate bone loss (0.54 ± 0.35 mm) [15]. In contrast, a retrospective study from 2024 involving patients receiving various anti-osteoporosis medications (bisphosphonates, RANKL inhibitors) showed that, while implant survival rates were high (96.2%), the type of treatment used could influence early marginal bone loss, particularly in the pre-prosthetic phase [24]. Other studies suggest that the risk of implant failure may increase in patients with osteopenia or osteoporosis, particularly in cases of reimplantation, indicating the need for extra caution during secondary implant procedures [17].

In summary, despite minor differences in marginal bone loss, dental implants in patients with osteoporosis demonstrate high survival rates, often exceeding 90%. These findings indicate that osteoporosis is not a contraindication for implant treatment, though an individualized approach and thorough monitoring of bone condition and risk factors are recommended to minimize potential complications.

c) Complications associated with antiresorptive therapy

A significant risk factor is pharmacotherapy. A 2023 review of 33 studies found that the use of bisphosphonates was associated with an increased risk of implant failure [25]. Antiresorptive therapy, particularly with bisphosphonates, is a cornerstone of treatment for osteoporosis and other metabolic bone diseases. However, the use of these medications is associated with the risk of serious dental complications, the most severe and well-documented being osteonecrosis of the jaw (ONJ). Numerous systematic reviews have shown that while the incidence of ONJ in patients taking oral bisphosphonates remains relatively low, the risk significantly increases with invasive dental procedures, such as tooth extractions or implant surgeries, as well as in the presence of periodontal diseases or other inflammatory conditions of the oral cavity [26]. Furthermore, studies indicate a higher risk of ONJ in patients receiving intravenous bisphosphonates, particularly in oncology, necessitating special attention from dentists and close collaboration with treating physicians [27][28]. A systematic literature review indicates that the risk of ONJ is particularly significant in patients treated with intravenous bisphosphonates and those undergoing combined therapies, especially in the context of invasive dental procedures [29]. Additionally, patients transitioning from bisphosphonate therapy to denosumab exhibit an increased risk of developing ONJ, necessitating particular caution and thorough clinical assessment before and during the change in therapy [30].

Moreover, some studies suggest that so-called "bisphosphonate holidays" (temporary discontinuation of therapy) before invasive procedures may reduce the risk of ONJ. However, these recommendations remain a subject of debate and require an individualized approach [31]. Current guidelines also emphasize the need to adopt advanced imaging techniques (e.g., CBCT) and biomarkers for monitoring patients [32][33][34].

Periodontal diseases, prevalent among older populations, further complicate the clinical picture by increasing tissue susceptibility to osteonecrosis. Chronic inflammation and infections of periodontal tissues impair healing processes, which, combined with the effects of antiresorptive medications, significantly elevates the risk of complications [35]. Therefore, comprehensive oral hygiene, regular dental check-ups, and

prevention of periodontal diseases are crucial for reducing the risk of ONJ in patients undergoing bisphosphonate therapy. The literature emphasizes the importance of patient education regarding oral hygiene and early signs of complications, enabling a faster therapeutic response [36]. In dental practice, the importance of prevention, early diagnosis, and interdisciplinary collaboration between dentists and specialists in metabolic bone diseases is increasingly recognized. Developing clear management protocols that include risk assessment, monitoring of oral health, and tailoring dental procedures helps minimize the risk of complications and optimize treatment outcomes [37].

Furthermore, articles emphasize that patients treated with bisphosphonates should be managed with great caution, and all dental procedures should be performed under optimal control of inflammation and oral hygiene conditions. Early detection and treatment of periodontal inflammation are of fundamental importance in preventing ONJ [38][39]. Recent studies also highlight the role of new antiresorptive and biological drugs (e.g., denosumab - a RANKL inhibitor), which exhibit a different risk profile for ONJ. This underscores the need for further research and continuous updates of clinical protocols [40][41]. The management of patients undergoing antiresorptive therapy requires continuous monitoring of oral health, patient education regarding potential symptoms of complications, and close coordination among healthcare professionals from various specialties. Only such a holistic and interdisciplinary approach enables the effective reduction of the risk of ONJ and other implant-related complications in patients with osteoporosis [42].

d) Modifying factors influencing the course of implant treatment

The effectiveness and course of implantological treatment depend on numerous factors that significantly influence osseointegration, implant stability, and the risk of complications. One of the key factors is the patient's age. Studies indicate that older individuals, particularly postmenopausal women, exhibit reduced bone mineral density and hormonal changes that promote bone loss, which can complicate the integration of the implant with the bone [43]. The patient's age is associated with slower regenerative processes and a higher prevalence of chronic diseases, which may affect the effectiveness of implantological treatment [44][45]. The impact of medications on bone formation and resorption is complex. Bisphosphonates increase bone mineral density, which may theoretically promote osseointegration, but they can also cause microcirculation disorders and impair bone regeneration after surgical procedures [46][47].

The patient's lifestyle plays a crucial role in the success of implantological treatment. Smoking is a well-documented risk factor that significantly increases the likelihood of implant failure by adversely affecting tissue blood supply and regenerative processes [48][49]. Inadequate oral hygiene and periodontal diseases increase the risk of inflammation around implants, which can lead to periimplantitis and implant loss [50]. In clinical practice, this necessitates a comprehensive, individualized approach to each patient, taking into account their full medical and pharmacological history as well as an assessment of risk factors. Such an approach allows for the optimization of the treatment plan and the application of appropriate preventive measures, such as premedication, close monitoring of tissue conditions, and the use of advanced imaging techniques, such as cone-beam computed tomography (CBCT), for precise evaluation of bone structure [51][52]. Interdisciplinary collaboration among dentists and other specialists is crucial for providing comprehensive care to high-risk patients, especially in the context of an aging population and the growing number of individuals with osteoporosis [53][54].

For this reasons, the development and implementation of therapeutic protocols tailored to the specific needs of this patient group are of particular importance, as they help minimize the risk of complications and maximize the effectiveness of implantological treatment.

Discussion

Current evidence indicates that dental implants in patients with osteoporosis achieve high survival rates, comparable to those in healthy individuals. Most systematic reviews and meta-analyses published between 2017 and 2025 report survival rates above 90%, and some prospective studies even document 100% success after one year of follow-up. These findings suggest that osteoporosis alone is not a contraindication for implant placement. However, a slightly greater marginal bone loss, typically between 0.2 mm and 0.7 mm, has been observed in osteoporotic patients. Although this difference is often clinically insignificant, it highlights the importance of long-term radiographic monitoring. Local bone quality, implant position, and surgical technique appear to play a greater role in implant success than systemic bone density alone. Recent studies further emphasize that reduced bone density or cortical thickness may slightly affect implant stability; however, these factors do not appear to compromise the overall success of the treatment. Evidence suggests that with

appropriate treatment planning, careful surgical technique, and individualized patient management, stable osseointegration can be achieved. Moreover, the initiation or continuation of antiresorptive therapy does not seem to negatively influence implant performance or peri-implant tissue health

Bone density changes and the osseointegration process in patients with osteoporosis remain central topics in implantology research. Most studies show that bone mineral density around implants is comparable to that in healthy individuals, although slight yet significant marginal bone loss has been reported, emphasizing the need for long-term monitoring. Adjunctive therapies such as the local application of alendronate or recombinant human bone morphogenetic protein-2 (rhBMP-2) have been shown to enhance bone formation and improve implant stability. Similarly, implants coated with bioactive glass exhibit improved early bone integration, highlighting the importance of the initial healing phase for successful outcomes. Bone biomarkers, including CTX and P1NP, may serve as useful indicators for monitoring osseointegration and bone remodeling. Despite minor variations in bone density and early marginal bone loss, sometimes influenced by antiresorptive treatment type, long-term results remain favorable, with stable implant performance achievable through individualized treatment and careful follow-up.

Pharmacotherapy, especially antiresorptive treatment with bisphosphonates, remains a major factor affecting implant success in osteoporotic patients. Although the incidence of osteonecrosis of the jaw (ONJ) among users of oral bisphosphonates is relatively low, the risk increases after invasive dental procedures or in the presence of periodontal inflammation. Patients treated with intravenous bisphosphonates, particularly in oncology, show a markedly higher ONJ risk and require close interdisciplinary supervision. Transitioning from bisphosphonates to denosumab may further elevate ONJ risk, highlighting the need for careful clinical evaluation. Some reports indicate that temporary discontinuation of therapy ("drug holidays") before surgical procedures might reduce complications, though this approach remains debated and should be individualized. Maintaining good oral hygiene and preventing periodontal disease are crucial to lowering ONJ risk. Education about early symptoms and regular dental monitoring enable timely intervention. Effective management of patients receiving antiresorptive drugs requires coordinated care between dental and medical professionals, integrating prevention, monitoring, and patient education to minimize complications and optimize implant outcomes.

The success of implant treatment depends on multiple interrelated factors influencing osseointegration, implant stability, and complication risk. Age is a major determinant. Older individuals, especially postmenopausal women, often show reduced bone mineral density and slower regenerative capacity, which can affect implant integration. Pharmacotherapy and lifestyle also play key roles. While bisphosphonates may enhance bone density, they can impair healing, whereas smoking and poor oral hygiene significantly increase the risk of peri-implant inflammation and failure. These findings highlight the need for individualized treatment planning that considers medical history, systemic conditions, and local bone quality. The use of preventive strategies, regular follow-up, and advanced imaging techniques such as cone-beam computed tomography (CBCT) supports better outcomes.

Effective management requires close interdisciplinary collaboration to ensure comprehensive care for osteoporotic patients and reduce the risk of implant-related complications.

Conclusions

Dental implants in patients with osteoporosis demonstrate high survival rates, often exceeding 90%, and outcomes comparable to those in healthy individuals. Although slight marginal bone loss may occur, it is typically clinically insignificant and manageable through regular monitoring. Successful osseointegration largely depends on local bone quality, surgical technique, and individualized treatment planning rather than systemic bone density alone.

While antiresorptive therapy, particularly bisphosphonates and denosumab, may increase the risk of osteonecrosis of the jaw (ONJ), this risk can be minimized through preventive strategies, meticulous oral hygiene, and interdisciplinary coordination between dental and medical professionals.

Overall, osteoporosis should not be considered a contraindication for implant therapy. Instead, careful assessment, patient education, and personalized clinical management are key to achieving predictable, long-term success in implant treatment for this growing patient population.

However, further large-scale, long-term clinical studies are still needed to better understand the influence of osteoporosis and antiresorptive therapies on implant outcomes and to optimize treatment protocols.

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