Influence of Bisphosphonates on Long-Term Dental Implant Outcomes: A Systematic Review and Meta Analysis

Rikko Hudyono[*], Louis Krisna Wardhana[**], Adisty Restu Poetri[*], Taufan Bramantoro[***]

[*]Faculty of Dentistry, Sultan Agung Islamic University – Semarang, Indonesia
[**]Prima Medistra Main Clinic – Kudus, Indonesia
[***]Faculty of Dentistry, Airlangga University – Surabaya, Indonesia

Correspondence: stefanusrikko@unissula.ac.id

Received 5 May 2026; 1st revision 3 July 2026;2nd revision 30 July 2026; Accepted 5 August 2026; Published online 20 August 2026

Keywords:

Bisphosphonate, Dental Implant, Peri-Implantitis

ABSTRACT:

Background: *The bisphosphonates are commonly used in osteoporosis management; questions have emerged regarding their influence on the implant's long-term survival. The present systematic review and meta-analysis investigated whether exposure to bisphosphonate is associated with an increased likelihood of dental implant failure.*
Methods: *Following PRISMA guidelines and registered in PROSPERO (ID: 1136620), electronic searches of ScienceDirect, EBSCOhost, PubMed, MDPI, and Google Scholar were performed up to September 2025. Observational cohort studies comparing dental implant outcomes in bisphosphonate-exposed and non-exposed patients were included. The extraction of data and appraisal of methodological quality were conducted independently by two investigators utilizing the ROBINS-I tool.*
Results: *Six studies comprising 2,196 participants and 86 implant failures were included. A significantly higher rate of implant failure was observed among individuals undergoing bisphosphonate treatment. (RR = 2.35; 95% CI, 1.24–4.44) with no heterogeneity (I^2 = 0%). Despite the elevated relative risk, implant failure remained infrequent, resulting in a small absolute risk increase. The certainty of evidence was rated as moderate.*
Conclusion: *Dental implants may still be considered for patients receiving bisphosphonates, provided that treatment decisions are based on careful patient-specific risk evaluation. Further prospective studies are needed to clarify causality and patient-level risk modifiers.*

doi: http://dx.doi.org/10.30659/odj.13.2.150-161.
2460-4119 / 2354-5992 ©2026 National Research and Innovation Agency
This is an open access article under the CC BY-SA license (https://creativecommons.org/licenses/by-sa/4.0/)
Odonto : Dental Journal accredited as **Sinta 3 Journal** (https://sinta.kemdikbud.go.id/journals/profile/3200)
How to Cite: Hudoyono, *et all*. Influence of Bisphosphonates on Long-Term Dental Implant Outcomes: A Systematic Review and Meta Analysis. Odonto: Dental Journal, v.13, n.2, p.150-161, August 2026.

INTRODUCTION

Advances in healthcare and overall living standards have significantly extended human life expectancy, leading to a substantial increase in the proportion of older adults within the population relative to past decades. The proportion of individuals aged years and above is increasing exponentially worldwide and is projected to reach approximately 16% of the global population by 2050. Data from the U.S. National Health and Nutrition Examination Survey revealed that 20.2% of adults in this age group are edentulous. Edentulism impairs chewing efficiency, resulting in alterations in dietary patterns, including decreased consumption of fibrous foods, fruits, and vegetables. Such nutritional changes may increase the likelihood of gastrointestinal complications and have detrimental effects on general health outcomes.[1]. Furthermore, edentulism is associated with the loss of alveolar bone, neural structures, sensory receptors, and musculature, which collectively impair orofacial function and negatively impact patients' psychological well-being[2]. Over recent decades, dental implants have gained widespread acceptance as an effective modality for replacing missing teeth. Technological advancements have enhanced implant performance, and titanium implants, in particular, have shown excellent biocompatibility, safety, and long-term success, resulting in favourable clinical outcomes for most patients.[3]. Epidemiological data demonstrate a growing demand for dental treatment among older adults, especially geriatric patients aged 60 years and above[4]. Although implant therapy is generally considered safe and effective, treatment failure may still occur for various reasons. Consequently, numerous developments gave been introduced to enhance osteointegration, including implant surface etching, which creates a porous surface that promotes bone attachment and growth. These modifications facilitate better osseointegration and contribute to higher implant survival and treatment success rates[5].

Population aging has contributed substantially to the rising burden of osteoporosis worldwide. With advancing age, the physiological imbalance in bone remodelling increased bone resorption relatively to bone regeneration, leading to progressive bone loss and skeletal fragility. As a result, osteoporosis has become a major health concern among older adults. In developed countries across the Asia–Pacific region, its prevalence is estimated to affect 10–30% of women aged 40 years and older and up to 10% of men[6]. Nevertheless, the true prevalence of osteoporosis—a largely silent disease—may be underestimated in population-level studies, especially in developing countries where screening programs are often limited or underutilized[7]. Previous systematic reviews have investigated the association between bisphosphonate therapy and dental implant outcomes. However, additional comparative and observational studies have become available in recent years, while advances in implant therapy accompanied with an increase of antiresorptive medications have further increased the clinical relevance of this topic. An updated systematic review and meta-analysis is therefore warranted to synthesize the current evidence and provide a more precise estimate of the association between bisphosphonate therapy and dental implant failure.

Pharmacological treatment is commonly indicated for patients at risk of osteoporotic fractures, and bisphosphonates continue to represent a cornerstone of therapy. [8]. As antiresorptive medications, these agents decrease skeletal turnover by suppressing osteoclast activity and limiting bone resorption. Their therapeutic performance may vary according to the route of administration, treatment schedule, cumulative dosage, and duration of exposure. [9] Ithough bisphosphonates are effective in preserving bone mass and lowering fracture incidence, their use has also been associated with medication-related complications, particularly osteonecrosis of the jaw, which may compromise peri-implant healing and negatively influence implant prognosis[10].

Successful dental implant therapy relies on uninterrupted biological healing, stable osseointegration, and healthy peri-implant tissues. Successful osseointegration should be supported by radiographic evidence of healthy peri-implant tissues, including the absence of peri-implant radiolucencies and the presence of adequate mesial and distal bone support around the implant[11]. The use of radiographic modalities usage before, during, and after dental implant placement is indicated to support proper implant treatment and achieve successful primary implant stability and osseointegration[12].

Primary implant stability is a critical factor for successful implant placement and subsequent osseointegration. Conversely, implant mobility following the healing period is considered indicative of failed osseointegration[11]. Therefore, implant failure represents a clincal endpoint reflecting compromised osseointegration and impaired peri-implant healing. Systemic factors and medications, including bisphosphonates, can compromise these processes and adversely affect the outcomes of implant treatment. Bisphosphonate related osteonecrosis of the jaw and implant failure have been reported in patients receiving both oral and intravenous bisphosphonates, yet their true impact remains unclear due to conflicting evidence[13].

Given the widespread use of bisphosphonates and the potential implications for implant therapy, this systematic review and meta-analysis study was conducted to comprehensively evaluate the influence of bisphosphonate treatment on implant healing, peri-implant tissue health, and the incidence of implant failure.

RESEARCH METHODS

This study was designed and reported in accordance with the PRISMA guidelines for systematic reviews and meta-analyses. To improve methodological rigor and promote transparency throughout the review process, the protocol was prospectively registered in the PROSPERO database before data synthesis was undertaken.

The review aims to answer whether dental implants patients receiving bisphosphonate therapy have an increased risk to implant failure compared to patients who are not receiving bisphosphonate therapy. The review question was formulated according to the PICO framework: Population (P), patients undergoing and/or receiving dental implant therapy; Intervention/Exposure (I), bisphosphonate therapy; Comparison (C), patients not receiving bisphosphonate therapy; and Outcome (O), long-term dental implant failure.

Comparative observational cohort studies were considered eligible for inclusion in this review. Although randomized controlled trials generally provide the highest level of clinical evidence, very few such studies have investigated this topic. Consequently, cohort studies that included a non-exposed comparison group were accepted. Case reports, case series, case–control investigations, laboratory-based experiments, and animal studies were not considered eligible.

The target population comprised of patients receiving bisphosphonate therapy in relation to dental implant treatment, regardless of whether medication exposure occurred before, during, or after implant placement. Both oral and intravenous formulations were eligible. Control participants were women undergoing implant therapy without prior bisphosphonate exposure. Studies involving individuals with a history of malignancy were excluded.

Relevant publications were identified through a comprehensive search of multiple electronic databases, including ScienceDirect, EBSCOhost, PubMed, MDPI, and Google Scholar. Searches were performed using combinations of the keywords “bisphosphonate” and “dental implant” to maximize retrieval of potentially eligible

studies. No limits were imposed on publication year, and the final database search was completed in September 2025. After duplication data removal, two investigators independently assessed titles and abstracts to determine preliminary eligibility. Articles considered potentially relevant were then reviewed in full text to confirm their suitability for inclusion. Differences in study selection decisions were resolved through discussion between reviewers until agreement was reached. In PubMed, the search string (Bisphosphonate) AND (dental implant) was used with the publication-type filters adaptive clinical trial, case reports, clinical study, clinical trial, controlled clinical trial, multicenter study, observational study, randomized controlled trial. In ScienceDirect, the search was performed in the title, abstract, and keywords fields using the search string (Bisphosphonate) AND (dental implant). Searches in MDPI and EBSCOhost were conducted using the keywords bisphosphonate dental implant without applying publication-type filter due to the limited number of records retrieved from these databases.

Data were independently extracted by two investigators using a standardized and pilot-tested extraction form. Information obtained from each study included publication details (title, authors, and year), study design, participant characteristics, bisphosphonate regimen and duration of use, number of implants placed, implant failure outcomes, follow-up duration, and the incidence of osteonecrosis of the jaw.

Risk of bias was independently evaluated by two investigators using version 2 of the Risk of Bias in Non-Randomized Studies of Interventions (ROBINS-I) instrument. Any differences in judgment were resolved through discussion until agreement was achieved. The certainty of evidence was determined qualitatively by considering methodological quality, consistency of study findings, and the level of heterogeneity identified across the included studies.

Dental implant failure was defined as the primary outcome because it represents a clinically meaningful indicator of compromised implant healing and peri-implant tissue response. The outcome measure consisted of the number of failed implants among patients exposed to bisphosphonate therapy compared with those without a history of bisphosphonate use.

Pooled risk ratios and corresponding 95% confidence intervals were calculated through meta-analysis using both fixed-effect and random-effects approaches. Between-study variability was quantified using the I^2 statistic and tau-squared (τ^2). Forest plots were generated to visualize the combined effect estimates. All statistical analyses were conducted using R software (version 4.5.2). To evaluate the stability of the findings, a sensitivity analysis was performed by restricting the meta-analysis to studies classified as having low risk of bias according to the ROBINS-I assessment.

RESULTS

The database search yielded 427 records related to the keywords “bisphosphonate” and “dental implant.” After duplicate removal and preliminary screening of titles and abstracts, 35 articles were considered potentially relevant and underwent full-text evaluation. Following detailed eligibility assessment, six studies fulfilled the inclusion criteria and were incorporated into the meta-analysis. Although six studies fulfilled the eligibility criteria, only five contributed quantitative data because one study reported zero events in both groups. Articles excluded at the full-text stage were primarily omitted because of differences in study populations or the absence of an appropriate control group.

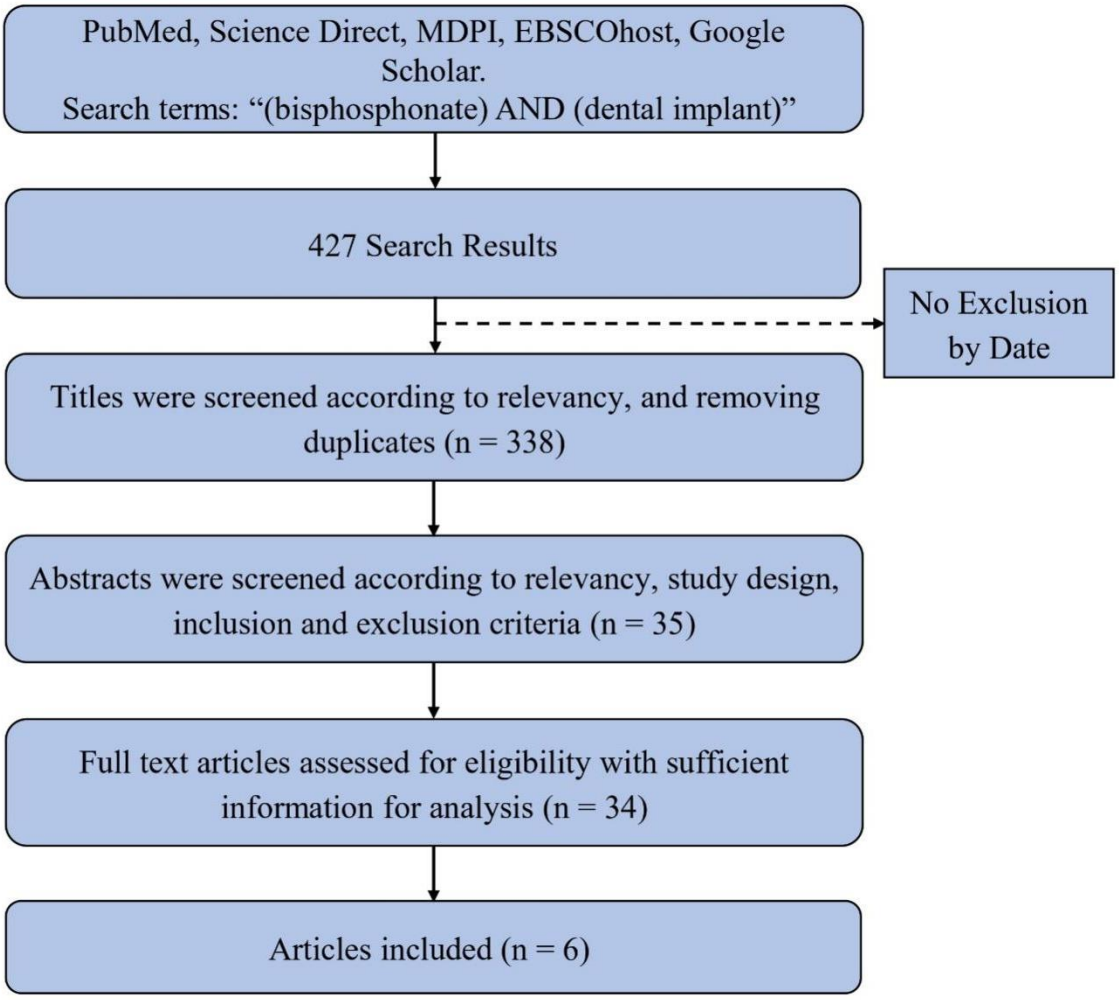

Figure 1. PRISMA Flow Diagram of Study Selection

Data were extracted from the six included studies regarding authorship and year of publication, bisphosphonate exposure, dental implant placement, study population, comparator group, and reported outcomes, including osteonecrosis of the jaw and implant success or failure rates. The results of the data extraction are presented in the table in Supplementary 1, including study characteristics included in the meta-analysis. One included study reported zero events in both groups and therefore did not contribute to the pooled relative risk estimate. This handling is consistent with the statistical approach implemented in the metabin function of the R meta package.

Table 1 summarizes the quality appraisal of the studies included in this review, which was performed using the ROBINS-I version 2 tool. Most studies exhibited satisfactory methodological quality, with four studies categorized as low risk and two as moderate risk of bias. No evidence suggested the presence of serious or critical bias in any study. Nevertheless, interpretation of the findings should consider the inherent limitations of observational research, particularly the potential effect of unaccounted confounding factors.

Author & Year	D1	D2	D3	D4	D5	D6	Overall
Jeffcoat, 2007[14]	-	+	+	+	+	+	-
Kim et al., 2020[15]	+	+	+	+	+	+	+
Siebert, et al. 2015[16]	+	+	+	+	+	+	+
Kasai, et al. 2009[17]	+	+	+	+	+	+	+
Koka et al. 2010[18]	+	+	+	+	+	+	+
Zahid, et al. 2011[19]	-	+	+	+	+	-	-

+ : Low risk of bias
- : Moderate risk of bias
X : Serious Risk of bias
Domains:
D1: Bias due to confounding
D2: Bias in classification of intervention
D3: Bias in selection of participants into the study
D4: Bias due to missing data
D5: Bias in measurement of the outcome
D6: Bias in selection of reported results

Table 1. *ROBINS-I Asessment Result*

Multiple factors influence the success of dental implant therapy, making complete control of all potential confounders challenging in observational studies. Adequate management of key confounding variables was evident in the four studies that demonstrated the highest methodological quality.

In the study by Jeffcoat et al. (2007), a moderate risk of bias was identified in Domain 1 (confounding), as smoking was the only confounding factor controlled. Although the presence of one smoker in each group was unlikely to meaningfully affect the outcomes, other relevant confounders—such as pre-existing marginal bone loss, diabetes mellitus, and alcohol consumption—were not accounted for. A similar limitation was observed in the study by Zahid et al.

A moderate risk of bias in Domain 6 (selection of the reported result) was also identified in the study by Zahid et al. due to incomplete outcome reporting. Specifically, the success rate of the control group was not explicitly reported and was instead presented as a combined success rate for both the bisphosphonate and control groups. Although the control group success rate could be calculated and extracted for the meta-analysis, this was considered a reporting irregularity.

The risk-of-bias evaluation suggested that the body of evidence was generally robust, as most studies were associated with minimal methodological concerns, while the remaining studies showed only moderate limitations based on ROBINS-I criteria.

Although six studies with comparison groups were eligible for inclusion, the study by Siebert et al. did not contribute to the meta-analysis because no implant failures occurred in either study arm. Following study selection, five investigations contributed data to the pooled analysis, yielding a combined sample of 2,196 participants and 86 documented implant failures across both study arms.

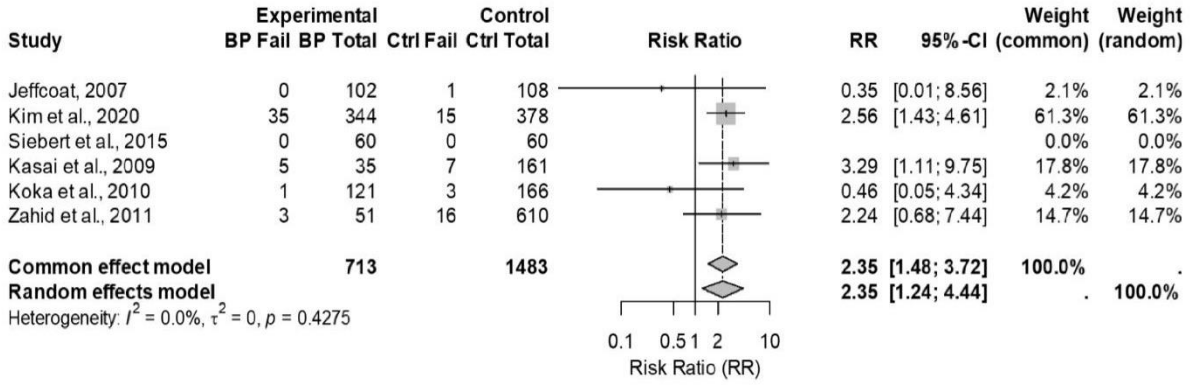

Figure 2. Forest plot showing the pooled relative risk of dental implant failure in patients exposed to bisphosphonates compared with non-exposed patients.

The pooled analysis demonstrated a significantly higher risk of dental implant failure among patients exposed to bisphosphonate therapy compared with non-exposed controls (risk ratio [RR] = 2.35; 95% confidence interval [CI], 1.24–4.44). The findings were consistent across both common-effect and random-effects models. Variation in effect estimates across studies was negligible, as indicated by the absence of detectable heterogeneity (I^2 = 0%, τ^2 = 0, p = 0.43).

To evaluate the robustness of the findings, the sensitivity analysis was conducted exclusively on four studies with minimal risk of bias. However, one study by Siebert et al did not contribute to the meta-analysis due to no implant failure in both groups of the study. The pooled risk ratio remained elevated and consistent with the primary analysis, although statistical significance was attenuated in the random-effects model, likely reflecting reduced statistical power due to the smaller number of included studies.

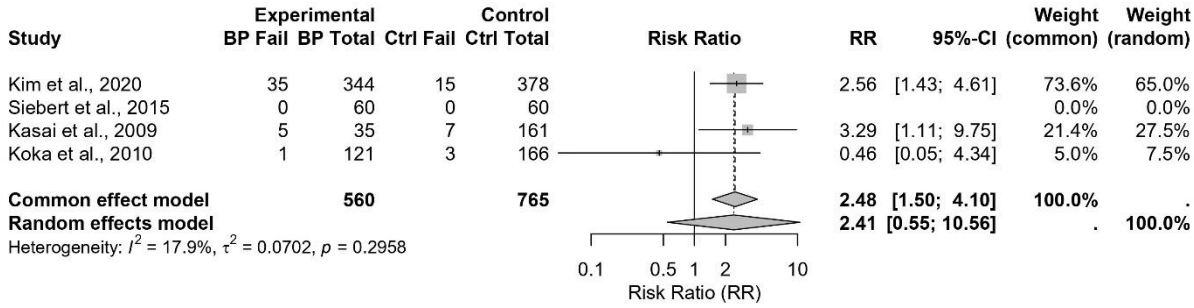

Figure 3. Result of the meta-analysis only including low risk of bias studies as sensitivity analysis presented in forest plot.

Outcomes	Illustrative comparative risks (95% CI)	Relative effect (95% CI)	No. of participants (studies)	Certainty of evidence (GRADE)	Comments
Dental implant failure	**Control:** 28 per 1,000 **Bisphosphonate group:** 66 per 1,000 (35–126)	RR 2.35 (1.24–4.44)	2,196 participants (6 observational studies)	Low	Bisphosphonate use may increase the risk of dental implant failure

Table 2. GRADE Summary of Findings

The certainty of evidence was rated as low due to the observational nature of the included studies and concerns regarding imprecision caused by the limited number of studies and events. The GRADE Evidence

Profile table can be found at Supplementary 2. The certainty was not downgraded for inconsistency or indirectness because heterogeneity was low and the evidence directly addressed the research question. Publication bias was not assessed due to the limited number of included studies; therefore, no judgment regarding this domain was made.

DISCUSSION

Although implant failure was the primary outcome assessed in this review, it should be interpreted as a clinical manifestation of impaired osseointegration and peri-implant healing that would result in the outcome of dental implant therapy. Implant failure reflects biological disturbances occurring during the healing phase of implant therapy or subsequent peri-implant maintenance. These processes may be adversely influenced by alterations in bone remodelling associated with bisphosphonate therapy[13]. Accordingly, this meta-analysis offers indirect but clinically meaningful evidence regarding the impact of bisphosphonate therapy on implant and peri-implant healing, and hence dental implant outcomes as an end result.

A higher incidence of implant failure was observed among individuals treated with bisphosphonates, suggesting a potential association between bisphosphonate exposure and compromised implant outcomes. Compared with patients who were not exposed to bisphosphonates, those receiving bisphosphonate treatment had a pooled relative risk (RR) of 2.35 for implant failure, indicating a more than twofold increase in risk. Although this association was statistically significant, dental implant failure is a relatively uncommon outcome, with baseline failure rates typically reported between 2% and 4% in multiple studies[20–22]. Consequently, despite the relatively high relative risk, the absolute increase in implant failures is modest, limiting the potential clinical impact at the individual patient level. This distinction between relative and absolute risk is important and may help explain why several primary studies included in this review did not detect statistically significant differences.

In accordance with PRISMA recommendations, pooled estimates should be interpreted in the context of study design and methodological limitations. In this meta-analysis, statistical heterogeneity was negligible ($I^2 = 0\%$), and the pooled risk ratio remained consistent across both common-effect and random-effects models, indicating a stable direction and magnitude of effect among the included studies. The absence of heterogeneity and the consistency of effect estimates support confidence in the observed association. However, the number of comparative studies contributing to the pooled estimate was limited, and all were observational in design, which constrains causal inference despite adequate sample.

Restricting the analysis to methodologically stronger studies yielded findings similar to those of the main analysis, suggesting that the reported association was not materially influenced by study quality. However, the loss of statistical significance in the random effects model reflects reduced precision, rather than a reversal of effect direction. This is likely due to smaller number of included studies. These findings highlight the impact of limited sample size on statistical power.

The observed association is biologically plausible. Bisphosphonates exert their therapeutic effects by inhibiting osteoclastic activity, thereby suppressing bone remodeling and turnover. While this mechanism is beneficial for reducing osteoporotic fractures, it may impair microdamage repair and delay or compromise implant osseointegration. Experimental evidence further suggests that bisphosphonates may have anti-angiogenic effects, potentially reducing local vascularization and impairing bone healing. These effects are likely

influenced by drug potency, route of administration, cumulative dose, and duration of therapy.[23]. Because these factors were reported inconsistently across studies, their impact could not be assessed in subgroup analyses.

The findings of this review indicate that bisphosphonate therapy, particularly oral administration, should not automatically preclude patients from receiving dental implants. Instead, implant therapy may be considered following careful patient evaluation, individualized risk assessment, and appropriate treatment planning. Although an elevated relative risk was observed, the clinical impact should be interpreted in the context of the low absolute incidence of implant failure. Particular consideration should be given to patients receiving intravenous bisphosphonates, who may be more vulnerable to adverse outcomes, including BRONJ and implant loss. Implant success is multifactorial and may depend on several variables beyond bisphosphonate exposure alone, including systemic health status, treatment duration, bone characteristics, local surgical conditions, and implant-related factors. Individualized risk assessment should therefore be performed prior to surgery to minimize the likelihood of implant failure. Clear risk communication and informed consent are especially important for patients receiving long-term bisphosphonate therapy.

Evidence regarding intravenous bisphosphonate therapy remains limited and inconsistent. Two studies, by Kim et al. and Siebert et al., report conflicting outcomes among patients receiving intravenous bisphosphonates. In the study by Kim et al., two intravenous bisphosphonate subgroups were analyzed: patients receiving intravenous Ibandronate (3 mg/3 ml every 3 months) had a failure rate of 21.1% (8/38), while those receiving intravenous Zoledronate (4 mg/5 ml yearly) had a failure rate of 21.2% (7/33).[15]. In contrast, Siebert et al. observed no implant failures in patients receiving intravenous zoledronic acid therapy (5 mg once yearly), suggesting favorable implant outcomes within this cohort [16]. The available evidence regarding intravenous bisphosphonate therapy remains limited because only a small number of comparative studies with relatively modest sample sizes have been conducted. Consequently, the current data do not permit firm conclusions about a causal relationship between intravenous bisphosphonate exposure and adverse implant outcomes. In their review, Lee et al. reported that the likelihood of developing bisphosphonate-related osteonecrosis of the jaw (BRONJ) appears to be greater among patients receiving intravenous formulations than among those treated with oral bisphosphonates.[23] BRONJ-related implant loss was observed in only a single study included in the present review. Kim et al. documented 11 implant removals among 344 implants placed in patients receiving bisphosphonates, indicating that approximately 3.2% of implants were affected by this complication.[15]. Other studies did not report any occurrences of osteonecrosis of the jaw. Importantly, implant failure and BRONJ are related but distinct outcomes; the occurrence of implant failure does not imply the presence of BRONJ.

Guidelines exist for the management of dental patients receiving oral bisphosphonate therapy. Clinical guidance from the National Health Service (NHS) emphasizes preventive strategies, including maintenance of oral hygiene, atraumatic surgical techniques, mitigation of risk factors such as smoking, and careful monitoring of postoperative healing. Prophylactic antibiotic therapy may also be justified to further reduce the risk of osteonecrosis, with particular concern for bisphosphonate-related osteonecrosis of the jaw (BRONJ)[24].

This observation is consistent with the recommendations of the American Dental Association (ADA), which underscore the importance of comprehensive pre-treatment oral evaluation. In addition, maintaining adequate oral hygiene and receiving regular dental care are considered key preventive measures for reducing the risk of oral complications and improving long-term treatment outcomes[25].

Importantly, causality cannot be inferred from the available evidence. Despite the consistency of the pooled effect, the predominance of retrospective cohort study designs introduces susceptibility to confounding and bias. Factors such as osteoporosis severity, smoking status, and systemic health were not fully controlled across studies and may have influenced the observed outcomes. Future research should focus on carefully designed prospective cohort studies with robust strategies to minimize the influence of confounding factors and strengthen causal inference.

Although bisphosphonate exposure is associated with a higher risk of dental implant failure compared to non-exposed patients, the absolute risk increase is modest and unlikely to be clinically prohibitive for most individuals. Current evidence supports a cautious, individualized approach rather than routine avoidance of implant therapy in patients receiving bisphosphonate treatment. From a clinical standpoint, the use of oral bisphosphonates should not be considered an absolute contraindication to dental implant therapy. Comprehensive patient evaluation, individualized risk assessment, meticulous treatment planning, and appropriate informed consent are essential to maximize treatment success. Particular attention should be given to patients receiving intravenous bisphosphonates, as this population may present a greater risk of implant failure and bisphosphonate-related osteonecrosis of the jaw (BRONJ).

CONCLUSION

Compared with non-exposed individuals, patients receiving bisphosphonate therapy appeared to have a greater likelihood of dental implant failure based on the pooled evidence from the included studies. Nevertheless, implant failure remained a relatively uncommon event, and despite the more than twofold increase in relative risk, the absolute risk increase for most patients was modest. The overall certainty of the evidence should be interpreted with caution. Future well-designed prospective studies with standardized reporting of bisphosphonate therapy and rigorous control of confounding factors are needed to clarify the magnitude, clinical significance, and potential causal relationship of this association.

ETHICAL APPROVAL

Institutional ethical approval was not necessary for this systematic review and meta-analysis, as all data were derived from previously published literature and no direct involvement of human participants or identifiable patient information occurred.

INFORMED CONSENT

Patient informed consent was not applicable to this study, as it involved the synthesis and analysis of data from previously published literature and did not entail the recruitment of human participants or the use of animals.

FUNDING

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

CONFLICT OF INTEREST

The authors confirm that no conflicts of interest are associated with the conduct or publication of this research.

REFERENCES

1. Park J, Kim H, Lee J, Lee H, Kim J. Consequence of Bisphosphonate Use on Dental Implant Removal in Osteoporotic Patient: A Nationwide Cohort Study. Clinical Implant Dentistry & Related Research. 2025;27(3):1–9.
2. Mardiyantoro F, Pratiwi AR. One-Piece Dental Implant untuk Rehabilitasi Ruang Kaninus yang Sempit. ODONTO : Dental Journal. 2017;4(1):61. doi:10.30659/odj.4.1.61-66
3. Guillaume B. Dental implants: A review. Morphologie. 2016;100(331):189–98. doi:10.1016/j.morpho.2016.02.002
4. Kwon TG. Impacts of the rapid increase in aged patients on implant dentistry. JKAOMS. 2025;51(2):71–2. doi:10.5125/jkaoms.2025.51.2.71
5. Wijaya L, Suwandi T, Eddy E, Tjandrawinata R, Erawati J, Pratiwi D. Evaluation of Titanium Alloy Surface Roughness After Phosphoric Acid Etching. Odonto : Dental Journal. 2025;12(3):280. doi:10.30659/odj.12.3.280-291
6. Chandran M, Brind'Amour K, Fujiwara S, Ha YC, Tang H, Hwang JS, et al. Prevalence of osteoporosis and incidence of related fractures in developed economies in the Asia Pacific region: a systematic review. Osteoporos Int. 2023;34(6):1037–53. doi:10.1007/s00198-022-06657-8
7. Adami G, Fassio A, Gatti D, Viapiana O, Benini C, Danila MI, et al. Osteoporosis in 10 years time: a glimpse into the future of osteoporosis. Therapeutic Advances in Musculoskeletal. 2022;14:1759720X221083541. doi:10.1177/1759720X221083541
8. Fardellone P, Lello S, Cano A, De Sá Moreira E, Watanabe De Oliveira R, Julian GS, et al. Real-world Adherence and Persistence with Bisphosphonate Therapy in Postmenopausal Women: A Systematic Review. Clinical Therapeutics. 2019;41(8):1576–88. doi:10.1016/j.clinthera.2019.05.001
9. Arjunan D, Bhadada T, Mohankumar SB, Bhadada SK. Non-biological Antiresorptive: Bisphosphonates. JOIO. 2023;57(S1):120–6. doi:10.1007/s43465-023-01054-7
10. Jelin-Uhlig S, Weigel M, Ott B, Imirzalioglu C, Howaldt HP, Böttger S, et al. Bisphosphonate-Related Osteonecrosis of the Jaw and Oral Microbiome: Clinical Risk Factors, Pathophysiology and Treatment Options. IJMS. 2024;25(15):8053. doi:10.3390/ijms25158053
11. Fathurrahman H, Hudyono R. TITANIUM MESH APLICATION ON ANTERIOR ALVEOLAR PROCESS AUGMENTATION PROCEDUR : A CASE REPORT. ODONTO : Dental Journal. 2020;7(1):68. doi:10.30659/odj.7.1.68-72
12. Syahraini SI, Kiswanjaya B, Priaminiarti M, Bachtiar-Iskandar HH. Field of view and voxel size considerations in cone-beam computed tomography: a systematic review. Odonto: Dental Journal. 2024;11(2):221. doi:10.30659/odj.11.2.221-240
13. Kochar SP, Reche A, Paul P. The Etiology and Management of Dental Implant Failure: A Review. Cureus. 2022. doi:10.7759/cureus.30455
14. Jeffcoat MK. Safety of oral bisphosphonates: Controlled studies on alveolar bone. The Journal of Prosthetic Dentistry. 2007;97(2):106. doi:10.1016/j.prosdent.2006.08.021
15. Kim JY, Choi H, Park JH, Jung HD, Jung YS. Effects of anti-resorptive drugs on implant survival and peri-implantitis in patients with existing osseointegrated dental implants: a retrospective cohort study. Osteoporos Int. 2020;31(9):1749–58. doi:10.1007/s00198-019-05257-3
16. Siebert T, Jurkovic R, Statelova D, Strecha J. Immediate Implant Placement in a Patient With Osteoporosis Undergoing Bisphosphonate Therapy: 1-Year Preliminary Prospective Study. Journal of Oral Implantology. 2015;41(S1):360–5. doi:10.1563/AAID-JOI-D-13-00063
17. Kasai T, Pogrel MA, Hossaini M. The Prognosis for Dental Implants Placed in Patients Taking Oral Bisphosphonates. Journal of the California Dental Association. 2009;37(1):39–42. doi:10.1080/19424396.2009.12222946
18. Koka S, Babu NMS, Norell A. Survival of dental implants in post-menopausal bisphosphonate users. Journal of Prosthodontic Research. 2010;54(3):108–11. doi:10.1016/j.jpor.2010.04.002
19. Zahid TM, Wang BY, Cohen RE. Influence of Bisphosphonates on Alveolar Bone Loss Around Osseointegrated Implants. Journal of Oral Implantology. 2011;37(3):335–46. doi:10.1563/AAID-JOI-D-09-00114
20. Thiebot N, Hamdani A, Blanchet F, Dame M, Tawfik S, Mbapou E, et al. Implant failure rate and the prevalence of associated risk factors: a 6-year retrospective observational survey. J Oral Med Oral Surg. 2022;28(2):19. doi:10.1051/mbcb/2021045
21. Tobias G, Chackartchi T, Haim D, Mann J, Findler M. Dental Implant Survival Rates: Comprehensive Insights from a Large-Scale Electronic Dental Registry. JFB. 2025;16(2):60. doi:10.3390/jfb16020060
22. Hickin MP, Shariff JA, Jennette PJ, Finkelstein J, Papapanou PN. Incidence and Determinants of Dental Implant Failure: A Review of Electronic Health Records in a U.S. Dental School. Journal of Dental Education. 2017;81(10):1233–42. doi:10.21815/JDE.017.080

23. Lee ES, Tsai MC, Lee JX, Wong C, Cheng YN, Liu AC, et al. Bisphosphonates and Their Connection to Dental Procedures: Exploring Bisphosphonate-Related Osteonecrosis of the Jaws. Cancers. 2023;15(22):5366. doi:10.3390/cancers15225366
24. University Hospitals of North Midlands NHS Trust Dept of O and MS. Dental Management of Patients Prescribed Bisphosphonates - Clinical Guidance [Internet]. 2015. Available from: https://www.england.nhs.uk/mids-east/wp-content/uploads/sites/7/2015/03/bisphosphonates-guidelines-2015.pdf
25. American Dental Association Council on Scientific Affairs. Dental management of patients receiving oral bisphosphonate therapy. The Journal of the American Dental Association. 2006;137(8):1144–50. doi:10.14219/jada.archive.2006.0355