

GLOBAL RESEARCH TRENDS IN MEDICATION-RELATED OSTEONECROSIS OF THE JAW IN DENTISTRY: A BIBLIOMETRIC ANALYSIS.

Abstract:

The aim of this study was to perform a bibliometric analysis of research This study was designed to examine the scientific literature on medication-related osteonecrosis of the jaw in dentistry using bibliometric analysis. The dataset consisted of 1,863 publications indexed in the Web of Science Core Collection database between 2005 and 2025. Bibliometric analyses included annual scientific production, keyword co-occurrence analysis, thematic map analysis, and thematic evolution analysis. The findings demonstrated that scientific production on this topic has increased over time. Furthermore, research has progressively shifted toward more specific areas, including risk factors, prevention, treatment management, and the differential diagnosis of osteoradionecrosis.

Key words: Bibliometric analysis, Bisphosphonates, Dentistry, Osteonecrosis, Research trends.

Introduction: Medication-related osteonecrosis of the jaw is a condition characterized by exposed necrotic bone and fistula formation in the jaw following the use of certain medications. It may lead to various complications, including pain, infection, purulent discharge, and pathological fractures. Initially, this condition was reported in association with bisphosphonate therapy; however, subsequent studies have demonstrated that it may also develop following the use of other antiresorptive and antiangiogenic agents. In dentistry, invasive procedures such as tooth extraction, dental implant placement, and periodontal surgery are among the major triggering factors. Therefore, a comprehensive medical history should be obtained to minimize the risk of complications in patients receiving these medications. In addition, appropriate risk assessment should be performed, and suitable radiological examinations should be incorporated into treatment planning. Imaging modalities used in dentistry play a crucial role in the early detection of radiographic findings, assessment of lesion extent, treatment planning, and follow-up of medication-related osteonecrosis of the jaw (1-8).

In recent years, numerous studies have been published on medication-related osteonecrosis of the jaw in dentistry. However, information regarding the development of scientific production, research trends, and the conceptual structure of this field remains limited. Consequently, evaluating the current status of the research landscape and its evolution over time has become increasingly challenging. Bibliometric analysis provides a valuable approach to overcoming these challenges by quantitatively evaluating scientific productivity, the conceptual structure of the field, and thematic changes over time (9-13).

The aim of this study was to perform a bibliometric analysis of the literature on medication-related osteonecrosis of the jaw in dentistry and to investigate the field through annual scientific production, keyword co-occurrence analysis, thematic map analysis, and thematic evolution analysis in order to evaluate its current status and evolution over time.

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47 **Materials and Methods:** The present study was designed as a bibliometric analysis investigating
48 research on medication-related osteonecrosis of the jaw in dentistry. Owing to the nature of the
49 study, no human participants or animals were involved; therefore, ethical approval was not
50 required.

51 The data used in the present study were retrieved from the advanced search function of
52 the Web of Science Core Collection (WoSCC) database using the following search query:
53 ((MRONJ OR BRONJ OR ARONJ OR "medication-related osteonecrosis" OR "bisphosphonate-
54 related osteonecrosis" OR "antiresorptive agent-related osteonecrosis" OR osteonecrosis) AND
55 (dent* OR dentistry OR "oral surgery" OR "oral medicine" OR "oral radiology" OR "oral and
56 maxillofacial radiology" OR "oral and maxillofacial surgery" OR "dental implant*")). To
57 construct a homogeneous dataset, original articles and review articles published in English
58 between 2005 and 2025 were included, whereas conference proceedings, editorial letters, and
59 studies unrelated to the research topic were excluded.

60 Bibliometric analyses were performed using R (version 4.6.0), RStudio, Biblioshiny, and
61 the bibliometrix package (version 5.3.0). To evaluate scientific performance, annual scientific
62 production was analyzed. In addition, keyword co-occurrence analysis, thematic map analysis,
63 and thematic evolution analysis were performed to investigate the conceptual structure and
64 research trends in the field.

65 The conceptual structure of the literature was examined using a network-based clustering
66 approach. In the generated network, node size represented keyword frequency, line thickness
67 indicated the strength of co-occurrence, and different colors denoted distinct thematic clusters.
68 Only author keywords were included in the keyword co-occurrence analysis. The thematic map
69 analysis classified themes into motor themes, basic themes, niche themes, and emerging or
70 declining themes. To evaluate thematic changes over time, thematic evolution analysis was
71 performed using 2015 as the single time-slicing point.

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73 **Results:** A total of 1,863 publications published between 2005 and 2025 were included in the
74 present study. The annual scientific production analysis demonstrated a marked overall increase
75 in scientific output despite fluctuations over the years. The lowest scientific production was
76 observed in 2005 with 13 publications, whereas the highest scientific production was recorded in
77 2024 with 151 publications (Figure 1).

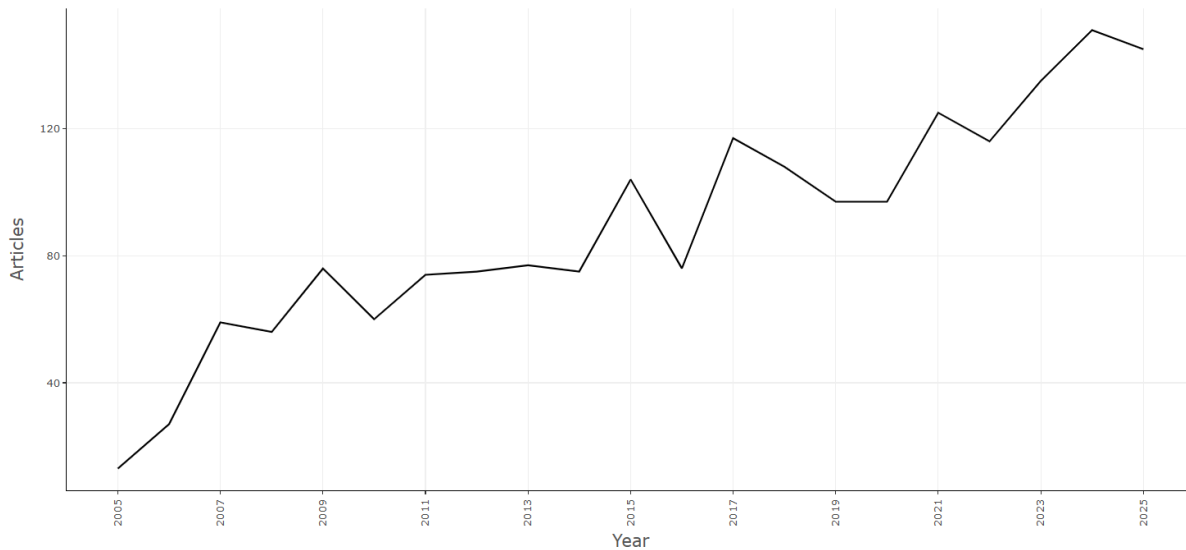


Figure 1. Annual distribution of publications on medication-related osteonecrosis of the jaw in dentistry.

The keyword co-occurrence analysis identified three distinct thematic clusters. In the red cluster, the keywords "osteonecrosis" and "bisphosphonates" had the largest node sizes and exhibited strong connections with other keywords. This cluster also included the keywords "jaw", "osteoporosis", "cancer", "mandible", "dental implants", and "bisphosphonate-associated osteonecrosis of the jaw". The blue thematic cluster comprised the keywords "bisphosphonate", "osteonecrosis of the jaw", "denosumab", "oral surgery", "dental implant", "zoledronic acid", "mronj", and "bronj". The green thematic cluster included the terms "osteoradionecrosis", "tooth extraction", and "medication-related osteonecrosis of the jaw" (Figure 2).

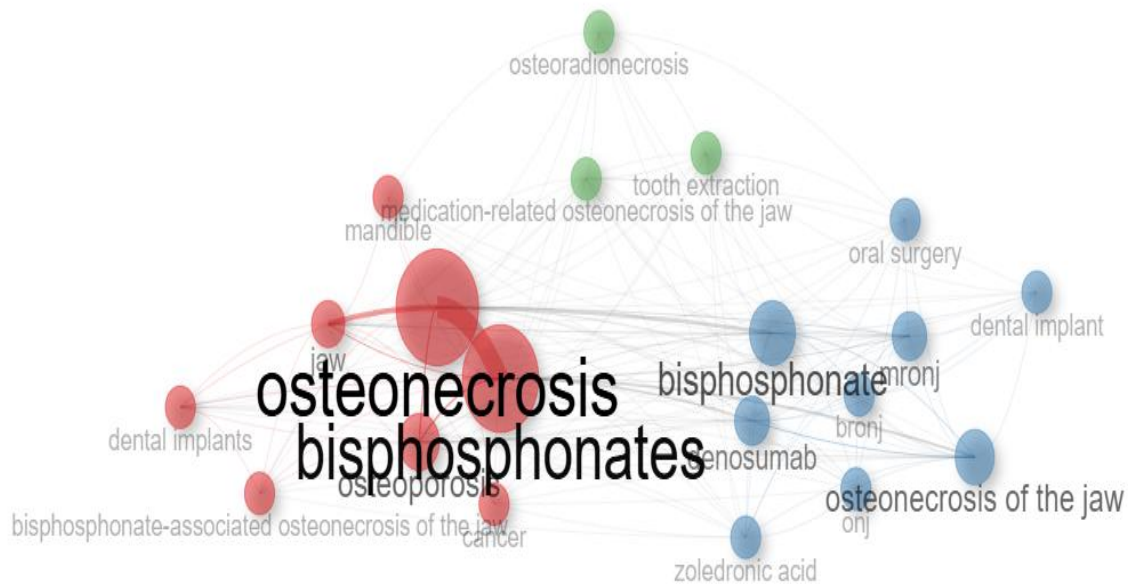


Figure 2. Keyword co-occurrence network in medication-related osteonecrosis of the jaw research in dentistry.

The thematic map analysis revealed that the terms "bisphosphonates", "risk factors", and "zoledronic acid" were located in the motor themes quadrant, whereas "osteonecrosis", "jaw", and "osteoporosis" were identified within the basic themes quadrant. The terms "prevention", "management", and "osteoradionecrosis" were classified as niche themes, while "bisphosphonate-related osteonecrosis", "medication-related osteonecrosis", and "association" were positioned within the emerging or declining themes quadrant (Figure 3).

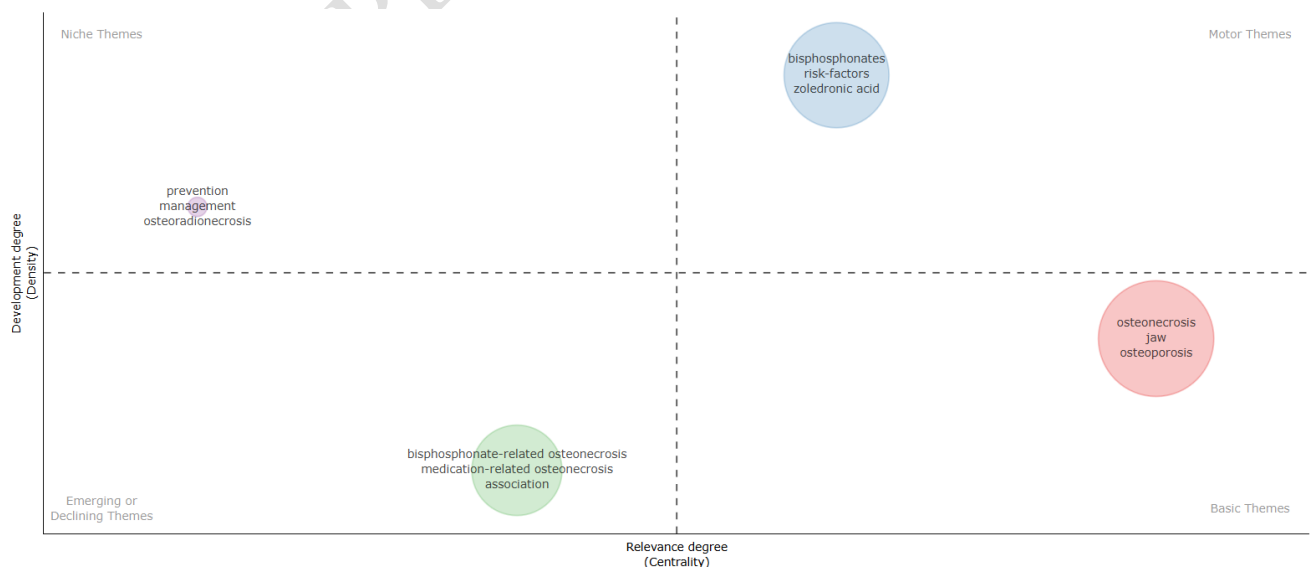


Figure 3. Thematic map of medication-related osteonecrosis of the jaw research in dentistry.

The thematic evolution analysis of research on medication-related osteonecrosis of the jaw in dentistry demonstrated that the keywords "osteonecrosis of the jaw", "osteoporosis", "alendronate", "bisphosphonates", and "oral surgery" predominated during the period up to and including 2015. In contrast, during the period from 2016 onward, the keywords "mronj", "osteonecrosis", "myeloma", "medication-related osteonecrosis of the jaw", "osteoradionecrosis", and "dental" became the predominant terms (Figure 4).

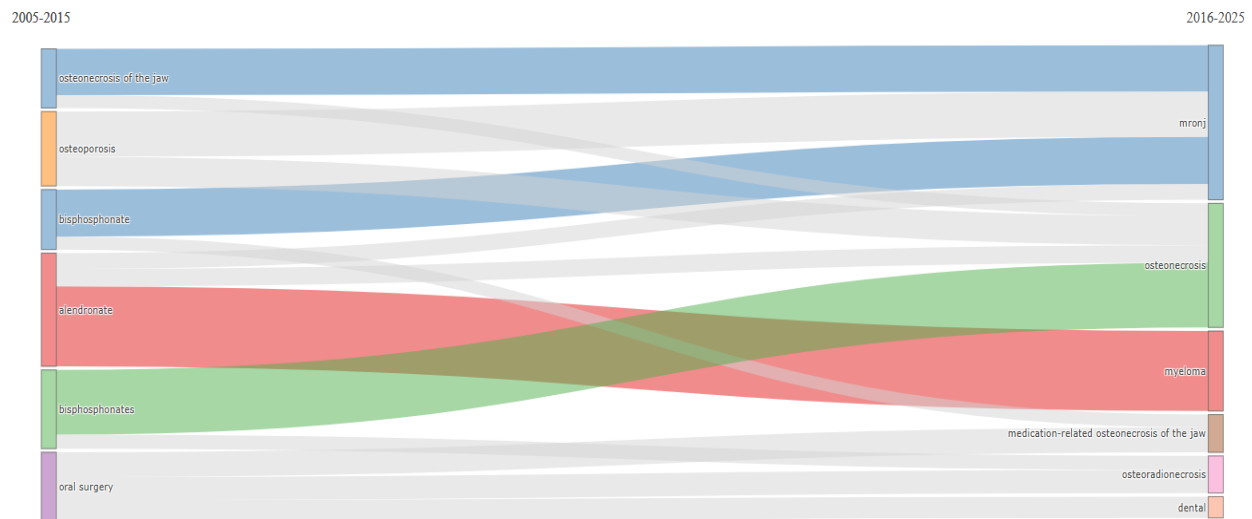


Figure 4. Thematic evolution of medication-related osteonecrosis of the jaw research in dentistry.

Discussion: Medication-related osteonecrosis of the jaw is associated with the use of medications that suppress bone resorption and inhibit angiogenesis. These agents are commonly prescribed for the management of bone metastases, osteoporosis, and multiple myeloma. Bisphosphonates and denosumab reduce bone resorption by inhibiting osteoclast activity, whereas antiangiogenic agents such as bevacizumab and sunitinib inhibit tumor growth and metastasis by suppressing angiogenesis. Despite their therapeutic benefits, these medications may impair bone remodeling, reduce vascularization, delay soft tissue healing, and compromise resistance to infection, thereby predisposing the jawbones to osteonecrosis. In addition, invasive dental procedures, including periodontal surgery, dental implant placement, periapical surgery, and tooth extraction, may trigger the development of osteonecrosis. However, medication-related osteonecrosis of the jaw has also been reported in the absence of surgical intervention in patients with periapical infections, periodontal disease, chronic trauma caused by ill-fitting prostheses, or poor oral hygiene. Therefore, dentists should obtain a comprehensive medical history and carefully evaluate the medications used by their patients. The radiographic features of medication-related osteonecrosis of the jaw vary according to the stage of the disease. Although radiographic findings are often subtle in the early stages, advanced lesions may demonstrate disruption of the trabecular bone architecture, cortical bone destruction, osteosclerosis, sequestrum formation, osteolytic lesions, periosteal new bone formation, and pathological

fractures. Compared with two-dimensional imaging techniques, three-dimensional imaging modalities such as cone-beam computed tomography are more effective in detecting subtle osseous changes associated with medication-related osteonecrosis of the jaw. Early diagnosis is essential for preventing disease progression, reducing the risk of infection, and establishing appropriate treatment strategies, ultimately contributing to an improved prognosis (1, 8, 14-23). Although numerous studies have been conducted on medication-related osteonecrosis of the jaw, information regarding the conceptual structure of this research field and its thematic evolution over time remains limited. Therefore, investigating the research trends and conceptual structure of this field is essential to provide a comprehensive understanding of its scientific development (24).

The annual scientific production analysis demonstrated an overall increasing trend despite fluctuations observed over the years. The highest scientific output was recorded in 2024 and 2025, indicating sustained academic interest in medication-related osteonecrosis of the jaw. The continuous increase in publications may be attributed to the expanding recognition that this condition, initially considered a complication associated exclusively with bisphosphonate therapy, is also related to the use of RANKL inhibitors, antiangiogenic agents, and various chemotherapeutic drugs (1, 22, 25).

The keyword co-occurrence analysis identified three distinct thematic clusters. Within the red cluster, the keywords "osteonecrosis" and "bisphosphonates" exhibited the largest node sizes and the strongest connections with other keywords. This finding may be explained by the fact that bisphosphonates have remained the primary focus of research on medication-related osteonecrosis of the jaw for many years. The presence of the keywords "osteoporosis" and "cancer" in the same cluster reflects the principal clinical indications for these medications, whereas the inclusion of "jaw", "mandible", and "dental implants" highlights the clinical relevance of medication-related osteonecrosis of the jaw in dental surgical practice. The blue cluster included the keywords "bisphosphonate", "denosumab", and "zoledronic acid", indicating that research has expanded beyond bisphosphonate-related osteonecrosis to encompass other classes of medications. The presence of the keywords "osteoradionecrosis" and "medication-related osteonecrosis of the jaw" in the green cluster suggests an increasing focus on the differential diagnosis between osteoradionecrosis and medication-related osteonecrosis of the jaw. Furthermore, the inclusion of the keyword "tooth extraction" in the blue cluster indicates growing research interest in potential triggering factors for the development of this condition (1, 15, 26-33).

The thematic map analysis revealed that the terms "Bisphosphonates", "risk factors", and "zoledronic acid" were classified as motor themes. This finding indicates that these topics represent well-developed research areas that play a central role in shaping the field. It also suggests that studies investigating the role of zoledronic acid, a member of the bisphosphonate drug class, in the development of medication-related osteonecrosis of the jaw have been a major focus of the literature. The terms "osteonecrosis", "jaw", and "osteoporosis" were identified as

basic themes, indicating that research on medications used in the management of osteoporosis occupies a central position in this field. Furthermore, the classification of "prevention", "management", and "osteoradionecrosis" as niche themes suggests that the differentiation of medication-related osteonecrosis of the jaw from osteoradionecrosis, as well as the prevention, treatment planning, and clinical management of medication-related osteonecrosis of the jaw, constitute specialized and well-developed areas of research (15, 33-36).

The thematic evolution analysis of medication-related osteonecrosis of the jaw research demonstrated notable changes in research focus over time. During the period up to and including 2015, the terms "osteonecrosis of the jaw", "osteoporosis", "alendronate", "bisphosphonates", and "oral surgery" were the predominant research topics. This finding indicates that early studies primarily focused on bisphosphonate use, osteoporosis treatment, and osteonecrosis associated with surgical procedures. From 2016 onward, the terms "mronj", "medication-related osteonecrosis of the jaw", and "dental" became increasingly prominent, suggesting that research expanded beyond bisphosphonate-related osteonecrosis to include other classes of medications. This shift is consistent with the 2014 update by the American Association of Oral and Maxillofacial Surgeons, which replaced the term "bisphosphonate-related osteonecrosis of the jaw (BRONJ)" with "medication-related osteonecrosis of the jaw (MRONJ)". Furthermore, the increasing prominence of the term "osteoradionecrosis" reflects growing interest in differentiating osteoradionecrosis from medication-related osteonecrosis of the jaw. The emergence of the term "myeloma" also suggests increasing attention to the effects of medications used not only in the treatment of osteoporosis but also in the management of malignant diseases on the jawbones (1, 15, 32, 37).

This study has several limitations. First, only the WoSCC database was used, and publications indexed exclusively in other databases were not included. Second, only articles published in English were considered, which may have resulted in the exclusion of relevant studies published in other languages. Furthermore, although bibliometric analysis provides valuable insights into the conceptual structure and research trends of a scientific field, it does not assess the methodological quality or clinical significance of the included studies. Despite these limitations, the rigorous indexing standards of the WoSCC database and the predominance of English as the primary language of scientific communication enhance the reliability of the present findings.

Conclusion: In conclusion, the present study demonstrated a substantial increase in the scientific production on medication-related osteonecrosis of the jaw in dentistry over time, accompanied by notable changes in research trends. The thematic evolution indicated that early research primarily focused on bisphosphonate-related osteonecrosis, whereas more recent studies have expanded to include other medication classes associated with this condition. In addition, research has increasingly emphasized specific topics such as risk factors, prevention, treatment

management, and the differential diagnosis of osteoradionecrosis. Future bibliometric studies should incorporate multiple databases and publications in different languages to provide a more comprehensive overview of the field.

References

1. Ruggiero SL, Dodson TB, Aghaloo T, Carlson ER, Ward BB, Kademani D. American Association of Oral and Maxillofacial Surgeons' position paper on medication-related osteonecrosis of the jaws—2022 update. *Journal of oral and maxillofacial surgery*. 2022;80(5):920-43.
2. Kawahara M, Kuroshima S, Sawase T. Clinical considerations for medication-related osteonecrosis of the jaw: a comprehensive literature review. *International journal of implant dentistry*. 2021;7(1):47.
3. Inchingolo AM, Malcangi G, Ferrara I, Patano A, Viapiano F, Netti A, et al. MRONJ treatment strategies: a systematic review and two case reports. *Applied Sciences*. 2023;13(7):4370.
4. Baghalipour N, Moztaizadeh O, Samar W, Gencur J, Volf V, Hauer L. Comprehensive review of prevention and management strategies for Medication-related osteonecrosis of the jaw (MRONJ). *Oral Health & Preventive Dentistry*. 2025;23:403.
5. Izzetti R, Gennai S, De Francesco P, Carli E, Graziani F, Nisi M. Panoramic radiography features of medication-related osteonecrosis of the jaws (MRONJ). *International Journal of Dentistry*. 2023;2023(1):5358849.
6. Ko YY, Yang W-F, Leung YY. The role of cone beam computed tomography (CBCT) in the diagnosis and clinical management of medication-related osteonecrosis of the jaw (MRONJ). *Diagnostics*. 2024;14(16):1700.
7. Goller-Bulut D, Özcan G, Avci F. Changes in dimension of neurovascular canals in the mandible and maxilla: A radiographic finding in patients diagnosed with MRONJ. *Medicina Oral, Patología Oral y Cirugía Bucal*. 2018;23(3):e282.
8. Limones A, Sáez-Alcaide LM, Díaz-Parreño SA, Helm A, Bornstein MM, Molinero-Mourelle P. Medication-related osteonecrosis of the jaws (MRONJ) in cancer patients treated with denosumab VS. zoledronic acid: A systematic review and meta-analysis. *Medicina oral, patología oral y cirugía bucal*. 2020;25(3):e326.
9. Bayram F, Kilic SS, Aydin V, Akici A, Ulucan K, Akkoc T. Medication-related osteonecrosis of the jaw: bibliometric analysis from 2003 to 2023. *Cell Biology and Translational Medicine, Volume 23: Stem Cell in Organoids, Signaling, Regeneration and Cancer*. 2024:119-30.
10. Ju B, Zhang J, Zhou Q, Liu W. A scientometric study on research trends and characteristics of medication-related osteonecrosis of the jaw. *Journal of Dental Sciences*. 2025.
11. Calderipe CB, Soares AC, Ribeiro MTL, Lopes MA, Santos-Silva AR, Vasconcelos ACU. Trends in adjunctive treatment of MRONJ: a bibliometric study of the 100 most cited articles. *Lasers in Dental Science*. 2026;10(1):22.
12. Donthu N, Kumar S, Mukherjee D, Pandey N, Lim WM. How to conduct a bibliometric analysis: An overview and guidelines. *Journal of business research*. 2021;133:285-96.
13. Passas I. Bibliometric analysis: the main steps. *Encyclopedia*. 2024;4(2).
14. AlRowis R, Aldawood A, AlOtaibi M, Alnasser E, AlSaif I, Aljaber A, et al. Medication-related osteonecrosis of the jaw (MRONJ): a review of pathophysiology, risk factors, preventive measures and treatment strategies. *The Saudi dental journal*. 2022;34(3):202-10.
15. Nicolatou-Galitis O, Schiødt M, Mendes RA, Ripamonti C, Hope S, Drudge-Coates L, et al. Medication-related osteonecrosis of the jaw: definition and best practice for prevention, diagnosis, and treatment. *Oral surgery, oral medicine, oral pathology and oral radiology*. 2019;127(2):117-35.
16. Guarneri V, Miles D, Robert N, Diéras V, Glaspy J, Smith I, et al. Bevacizumab and osteonecrosis of the jaw: incidence and association with bisphosphonate therapy in three large prospective trials in advanced breast cancer. *Breast cancer research and treatment*. 2010;122(1):181-8.
17. Vallina C, Ramirez L, Torres J, Casanas E, Hernandez G, Lopez-Pintor R-M. Osteonecrosis of the jaws produced by sunitinib: a systematic review. *Medicina Oral, Patología Oral y Cirugía Bucal*. 2019;24(3):e326.
18. Rosella D, Papi P, Giardino R, Cicalini E, Piccoli L, Pompa G. Medication-related osteonecrosis of the jaw: Clinical and practical guidelines. *Journal of International Society of Preventive and Community Dentistry*. 2016;6(2):97-104.

19. Lorenzo-Pouso AI, Pérez-Sayáns M, Chamorro-Petronacci C, Gándara-Vila P, López-Jornet P, Carballo J, et al. Association between periodontitis and medication-related osteonecrosis of the jaw: A systematic review and meta-analysis. *Journal of Oral Pathology & Medicine*. 2020;49(3):190-200.
20. Giovannacci I, Meleti M, Manfredi M, Mortellaro C, Greco Lucchina A, Bonanini M, et al. Medication-related osteonecrosis of the jaw around dental implants: implant surgery-triggered or implant presence-triggered osteonecrosis? *Journal of Craniofacial Surgery*. 2016;27(3):697-701.
21. Ruggiero SL. Diagnosis and staging of medication-related osteonecrosis of the jaw. *Oral and Maxillofacial Surgery Clinics*. 2015;27(4):479-87.
22. Domah F, Shah N, Domah J, Shah R. Medication-related osteonecrosis of the jaw—a current review. *Oral Surgery*. 2018;11(3):250-8.
23. Aslan E, Onem E, Mert A, Baksi BG. Qualitative radiographic characteristics of MRONJ-affected bone in oral and parenteral drug administration: comparison of panoramic radiography and cone-beam CT. *BMC Oral Health*. 2025;25(1):1068.
24. Diniz-Freitas M, Pena-Cristobal M, Pérez-López D, Lago-Méndez L, Fernández-Feijoo J, Limeres-Posse J. Bibliometric analysis of medication-related osteonecrosis of the jaw: high citation rates but low evidence. *Journal of Oral and Maxillofacial Surgery*. 2019;77(8):1655. e1-. e17.
25. Eguia A, Bagan L, Cardona F. Review and update on drugs related to the development of osteonecrosis of the jaw. *Medicina oral, patología oral y cirugía bucal*. 2019;25(1):e71.
26. Sher J, Kirkham-Ali K, Luo JD, Miller C, Sharma D. Dental implant placement in patients with a history of medications related to osteonecrosis of the jaws: a systematic review. *Journal of Oral Implantology*. 2021;47(3):249-68.
27. Son H-J, Kim J-W, Kim S-J. Pharmacoepidemiology and clinical characteristics of medication-related osteonecrosis of the jaw. *Maxillofacial Plastic and Reconstructive Surgery*. 2019;41(1):26.
28. Kuroshima S, Al-Omari FA, Sasaki M, Sawase T. Medication-related osteonecrosis of the jaw: a literature review and update. *Genesis*. 2022;60(8-9):e23500.
29. Tetradis S, Allen MR, Ruggiero SL. Pathophysiology of Medication-Related Osteonecrosis of the Jaw—A Minireview. *Journal of Bone and Mineral Research Plus*. 2023;7(8):e10785.
30. Thomas JG, Ouanounou A. Medication-related osteonecrosis of the jaw: a narrative review of risk factors, diagnosis, and management. *Frontiers of Oral and Maxillofacial Medicine*. 2023;5.
31. Guazzo R, Sbricoli L, Ricci S, Bressan E, Piattelli A, Iaculli F. Medication-related osteonecrosis of the jaw and dental implants failures: a systematic review. *Journal of Oral Implantology*. 2017;43(1):51-7.
32. Kün-Darbois J-D, Fauvel F. Medication-related osteonecrosis and osteoradionecrosis of the jaws: Update and current management. *Morphologie*. 2021;105(349):170-87.
33. Grisar K, Schol M, Schoenaers J, Dormaar T, Coropciuc R, Vander Poorten V, et al. Osteoradionecrosis and medication-related osteonecrosis of the jaw: similarities and differences. *International journal of oral and maxillofacial surgery*. 2016;45(12):1592-9.
34. Alsali A, Dam A, Lindberg P, Truedsson A. Medication-related osteonecrosis of the jaws initiated by zoledronic acid and potential pathophysiology. *Dentistry Journal*. 2021;9(8):85.
35. Aljohani S, Fliefel R, Ihbe J, Kühnisch J, Ehrenfeld M, Otto S. What is the effect of anti-resorptive drugs (ARDs) on the development of medication-related osteonecrosis of the jaw (MRONJ) in osteoporosis patients: A systematic review. *Journal of Cranio-Maxillofacial Surgery*. 2017;45(9):1493-502.
36. Otto S, Pautke C, Van den Wyngaert T, Niepel D, Schjødt M. Medication-related osteonecrosis of the jaw: Prevention, diagnosis and management in patients with cancer and bone metastases. *Cancer treatment reviews*. 2018;69:177-87.
37. Caggiano M, Di Spirito F, Acerra A, Galdi M, Sisalli L. Multiple-drugs-related osteonecrosis of the jaw in a patient affected by multiple myeloma: a case report. *Dentistry Journal*. 2023;11(4):104.