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The Use of Micro-Computed Tomography in Dentistry: A Bibliometric Analysis

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ABSTRACT: Micro-computed tomography (micro-CT) is widely used in dental research because it provides high-resolution three-dimensional imaging of mineralized tissues. The aim of this study was to evaluate scientific production, research trends, and thematic development related to the use of micro-CT in dentistry through bibliometric analysis. Publications published between 1995 and 2025 were retrieved from the Web of Science Core Collection database. A total of 3,358 articles and reviews were included in the analysis. Bibliometric analyses were performed using Bibliometrix and Biblioshiny. Annual scientific production, keyword co-occurrence, trend topics, thematic map, and thematic evolution analyses were examined. The results showed that the number of publications increased steadily over time and reached its highest level in 2025. Keyword co-occurrence analysis revealed that "micro-CT" and "micro-computed tomography" were the most frequently used terms and were closely associated with endodontics, periodontitis, dental implants, osseointegration, enamel, and caries. Trend analyses showed that research interests shifted from general imaging and in vitro studies to more specific topics such as endodontics, periodontitis, inflammation, bone regeneration, and dentin. In conclusion, the use of micro-CT in dentistry has increased considerably over the years and has become an important research tool in several dental disciplines.

KEYWORDS: Bibliometric analysis, Dentistry, Micro-computed Tomography, Research trends, Scientific production, Thematic evolution

I. INTRODUCTION

Micro-computed tomography (micro-CT) systems were developed in the 1980s. This technology enabled high-resolution imaging of mineralized tissues, such as teeth and bone, with voxel sizes ranging from 5 to 50 μm. Although the use of micro-CT in dentistry was initially limited, it became increasingly accessible over time (1, 2). Today, micro-CT is widely used in dentistry for the evaluation of enamel morphology, detection of accessory canals and foramina in root canal systems, quantitative assessment of bone mineralization and trabecular structure, analysis of forces generated in teeth and dental materials, evaluation of scaffold materials used in tissue engineering, investigation of mineralization in dental hard tissues, and assessment of implant osseointegration (2-6). The main disadvantages of micro-CT include high radiation exposure, high equipment costs, the need for large data storage capacity, difficulties in imaging large-volume structures, and long scanning and reconstruction times (2, 7-9). Despite these limitations, micro-CT offers several advantages. As a three-dimensional imaging modality, it allows multiplanar evaluation of structures. In addition, the entire specimen can be examined without destruction, and different analyses can be performed repeatedly on the same sample (7, 9, 10). However, advances in imaging technologies and the increased accessibility of micro-CT systems have contributed to the growing use of this method in dental research (11).

Although numerous studies have investigated the use of micro-CT in dentistry, information regarding the conceptual structure, scientific production, thematic development, and research trends of this field remains limited (2, 12) Evaluating the main themes and the evolution of this field over time is becoming increasingly difficult. Therefore, there is a need to examine its conceptual structure and research trends. Bibliometric analysis is a useful method for addressing this gap. It provides a quantitative overview of a research field through analyses such as Annual Scientific Production, Trend Topics Analysis, Keyword Co-occurrence Analysis, Thematic Map Analysis, and Thematic Evolution Analysis.

The aim of this study was to perform a bibliometric analysis of the use of micro-CT in dentistry and to examine Annual Scientific Production, Trend Topics Analysis, Keyword Co-occurrence Analysis, Thematic Map Analysis, and Thematic Evolution Analysis in order to provide an overview of the current status, research trends, and thematic evolution of the field.

II. MATERIALS and METHODS

As this study was designed as a bibliometric analysis, no human or animal subjects were involved. Therefore, ethical approval

was not required. To create the dataset, a search was performed in the advanced search section of the Web of Science Core Collection (WoSCC) database using the following query: (("micro-computed tomography" OR "micro computed tomography" OR micro-CT OR microCT) AND (dent* OR oral OR tooth OR teeth OR odontolog* OR endodont* OR periodont* OR orthodont* OR prosthodont* OR maxillofacial OR craniofacial OR implant*)). Only publications published in English between 1995 and 2025 were included. Publications unrelated to the use of micro-CT in dentistry, editorial letters, and conference proceedings were excluded. Articles and reviews were included in the final dataset.

Bibliometric analyses were performed using the Bibliometrix package (version 5.3.0) in R (version 4.6.0) through RStudio and Biblioshiny. Annual Scientific Production was used for performance analysis, Thematic Map Analysis and Thematic Evolution Analysis for thematic evaluation, and Trend Topics Analysis for trend evaluation.

The conceptual structure of the literature was assessed using network-based clustering approaches. In the Keyword Co-occurrence Analysis, authors' keywords were used to evaluate the conceptual structure of the field. Major research themes were identified using a network-based clustering algorithm. In the network visualizations, node size represented keyword frequency, whereas edge thickness represented co-occurrence strength. Thematic Map Analysis was used to identify motor themes, basic themes, niche themes, and emerging or declining themes. Changes in research themes over time were evaluated using Thematic Evolution Analysis, while research trends were examined using Trend Topics Analysis..

III. RESULTS

A total of 3,358 publications related to the use of micro-CT in dentistry published between 1995 and 2025 were analyzed. Annual Scientific Production showed an overall increasing trend over time. The number of publications remained relatively low until 2005 but increased steadily in the following years, reaching its highest level in 2025 (Figure 1).

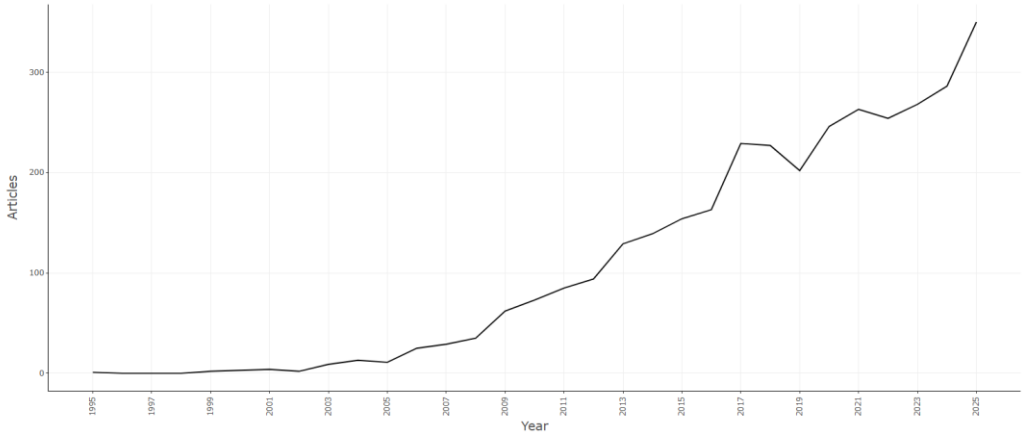

Figure 1. Annual scientific production in dental micro-CT research

The Co-occurrence Analysis of Authors' Keywords showed that "micro-CT" and "micro-computed tomography" had the largest node sizes and strong connections with other keywords in the network. In addition, "endodontics", "periodontitis", "alveolar bone loss", "dental implants", "osseointegration", "enamel", and "caries" were among the most prominent research topics in the field (Figure 2).

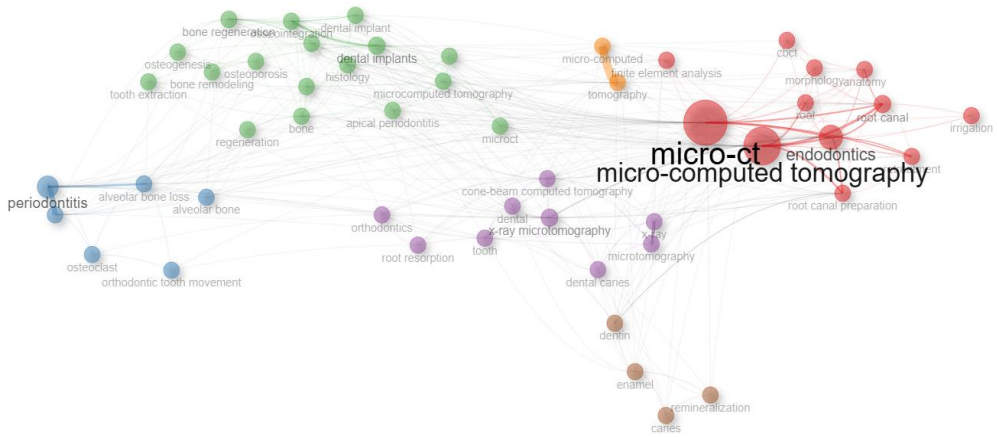

Figure 2. Keyword co-occurrence network of publications on micro-computed tomography in dentistry.

Trend Topics Analysis showed that no trend topics could be identified before 2011 because the frequency of keywords was insufficient during that period. The analysis revealed that research interests changed over time. In the early years, "ct" and "in-vitro" were the most prominent terms, whereas "dental implants", "bone", and "regeneration" became more prominent in subsequent years. In recent years, the research focus has shifted toward "endodontics", "periodontitis", and "inflammation" (Figure 3).

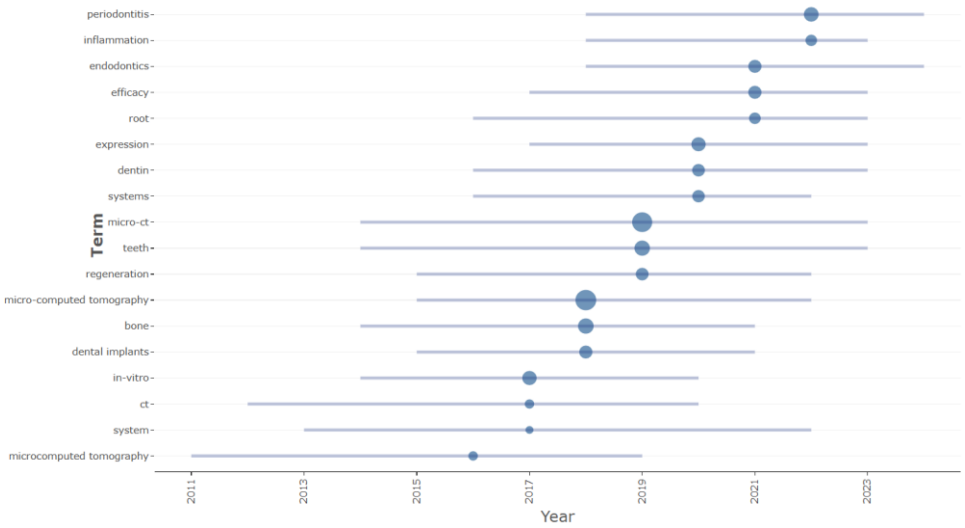

Figure 3. Trend topics and their temporal distribution in the dental micro-computed tomography literature.

Thematic Map Analysis revealed that "micro-computed tomography", "endodontics", and "efficacy" were located in the motor themes quadrant. "Micro-CT", "in-vitro", and "dentin" were identified as basic themes, whereas "bone", "periodontitis", and "expression" were classified as niche themes. In addition, "teeth", "morphology", and "x-ray microtomography" were located in the emerging or declining themes quadrant (Figure 4).

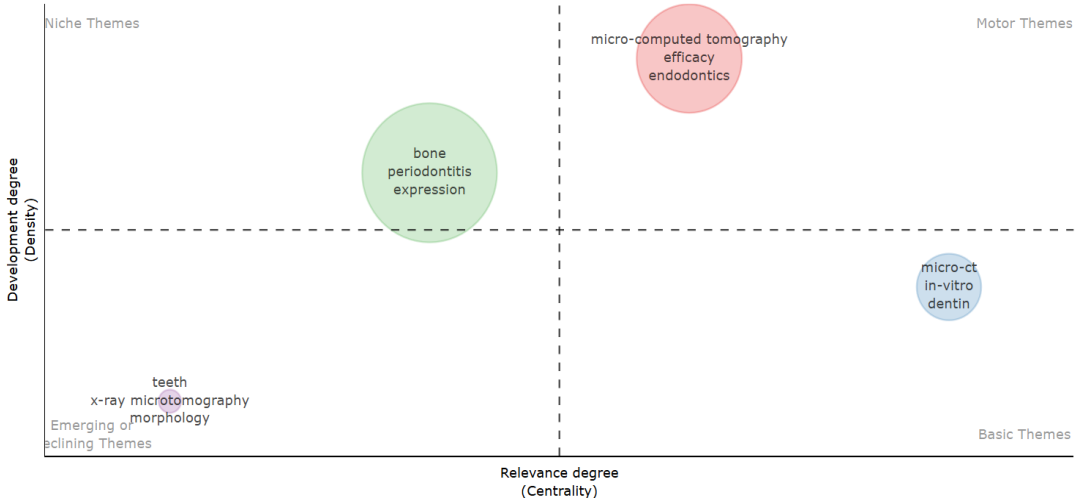

Figure 4. Thematic map of research themes in the dental micro-computed tomography literature.

Thematic Evolution Analysis showed that "micro-CT", "micro-computed tomography", "dental implants", "tomography", "cone beam computed tomography", and "finite element analysis" were the dominant themes between 1995 and 2015. In the period from 2016 onwards, "micro-CT" remained a prominent theme, while "bone regeneration", "periodontitis", "x-ray microtomography", and "dentin" also emerged as important research topics (Figure 5).

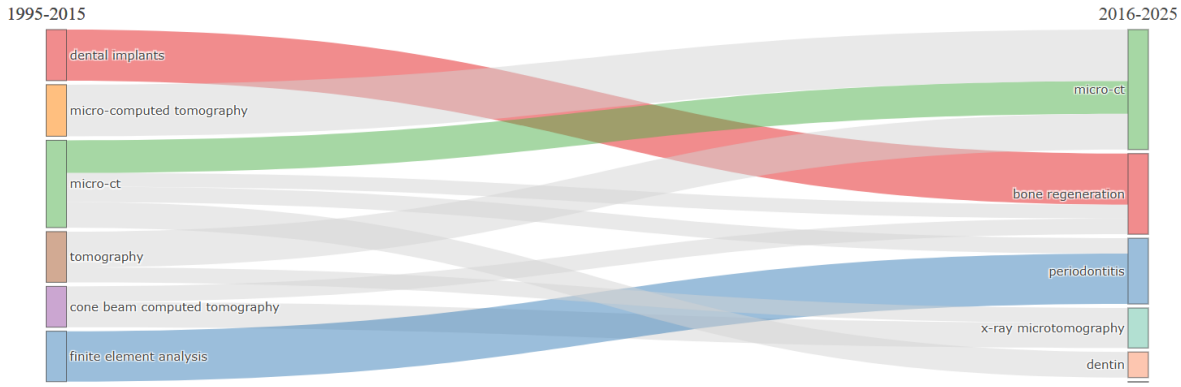

Figure 5. Thematic evolution of research topics in the dental micro-computed tomography (micro-CT) literature between 1995–2015 and 2016–2025.

IV. DISCUSSION

Micro-CT is an imaging technique that allows three-dimensional and cross-sectional evaluation of small structures. Although it has not been routinely used in clinical practice because of factors such as high radiation exposure, high cost, and limitations in imaging large structures, it has been applied in specific areas of dentistry. Its ability to evaluate small structures with high spatial resolution, together with its increased accessibility over time, has contributed to its growing use in dental research (2, 3, 7-9, 13). Micro-CT is used in several areas of dentistry, including the evaluation of dental hard tissues, the implant–bone interface, root canal systems, periodontal defects, bone loss, and restorative dental materials (14-18). Although numerous studies have been conducted on this topic, information regarding the conceptual structure, research trends, and scientific production of the field remains limited (2, 19). Therefore, the present study used Annual Scientific Production, Keyword Co-occurrence Analysis, Trend Topics Analysis, Thematic Map Analysis, and Thematic Evolution Analysis to investigate the conceptual structure, thematic evolution, and research trends related to the use of micro-CT in dentistry.

The Annual Scientific Production analysis showed a clear increase in the number of publications over time. In particular, publication output increased markedly after 2005 and reached its highest level in 2025. This finding indicates growing interest in the use of micro-CT in dentistry. The increase in scientific production may be attributed to improvements in image quality and the increased accessibility of micro-CT systems over time (2, 11). The high number of publications in recent years further suggests that the use of micro-CT in dentistry is a current and rapidly developing research field.

Keyword Co-occurrence Analysis showed that “micro-CT” and “micro-computed tomography” occupied central positions within the network and were strongly associated with “endodontics”. This finding may be explained by the widespread use of micro-CT in endodontic research, particularly for the evaluation of root canal morphology, root canal obliterations, and root canal preparation procedures (20, 21). The prominence of terms such as “periodontitis”, “alveolar bone loss”, “dental implants”, “osseointegration”, “enamel”, and “caries” may be attributed to the extensive use of micro-CT in periodontology, restorative dentistry, and implantology research (2). “Root canal morphology”, “bone regeneration”, and “trabecular bone” were other prominent terms identified within the network. The prominence of these terms suggests that micro-CT has become an important research tool for the three-dimensional evaluation of hard tissues (5, 8).

The prominence of the terms “ct” and “in-vitro” during the early period suggests that research was mainly focused on imaging techniques and experimental in vitro studies (22). The emergence of the terms “dental implants”, “bone”, and “regeneration” in subsequent years may be related to the increasing use of micro-CT for the evaluation of implant morphology, implant–bone interactions, and the relationship between bone and periodontal tissues (23). The increasing prominence of the terms “endodontics”, “periodontitis”, and “inflammation” in recent years may indicate that micro-CT has gained greater clinical relevance over time and that research interests have shifted toward more specific areas of dentistry (13).

Thematic Map Analysis showed that “endodontics” and “efficacy” were located in the motor themes quadrant, suggesting that these topics are well-developed and play an important role in shaping the field. The placement of “in-vitro” and “dentin” in the basic themes quadrant indicates that these themes are highly relevant and strongly connected with other research topics. In contrast, the presence of “periodontitis” and “expression” in the niche themes quadrant suggests that these topics represent more specialized research areas that may be investigated by relatively limited research communities.

Thematic Evolution Analysis demonstrated a thematic shift in dental micro-CT research over time. During the early period, “dental implants”, “tomography”, “cone beam computed tomography”, and “finite element analysis” were among the dominant themes, indicating a focus on implant-related applications and the combined use of different imaging techniques. In the later period, “bone regeneration”, “periodontitis”, and “dentin” emerged as prominent themes, suggesting increased interest in the

biological processes of periodontal diseases and the detailed evaluation of specific dental tissues. Overall, the findings indicate a shift from broader research topics toward more specialized areas over time.

This study has some limitations. Only the WoSCC database was used, and only English-language keywords were included in the search strategy. However, the high indexing quality of the WoSCC database and the widespread use of English in scientific publications support the reliability of the findings.

V. CONCLUSIONS

In conclusion, scientific production on the use of micro-CT in dentistry has increased considerably over time, with the highest publication output recorded in 2025. Endodontics, implantology, periodontology, and restorative dental materials were identified as the main research areas in the field. Thematic analyses revealed a shift from broader topics toward more specialized research themes over time. These findings indicate that micro-CT has become an important research tool in dentistry. Future studies should include different databases and keywords in multiple languages to provide a more comprehensive overview of the field.

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