ARTIFICIAL INTELLIGENCE in ORAL AND MAXILLOFACIAL RADIOLOGY: A BIBLIOMETRIC ANALYSIS of RESEARCH TRENDS and SCIENTIFIC DEVELOPMENT.

Abstract:

This bibliometric study was designed to evaluate the scientific production, conceptual structure, and thematic evolution of artificial intelligence research in oral and maxillofacial radiology. Data were retrieved from the Web of Science Core Collection database. A total of 2,939 publications were included in the bibliometric analysis. While the annual number of publications remained relatively limited until 2019, it increased markedly thereafter and reached its peak in 2025. The research focus evolved from more general topics toward more specific themes with direct implications for clinical applications. Artificial intelligence is expected to become an increasingly important research area in oral and maxillofacial radiology in the future.

Key words: Artificial intelligence, Bibliometric analysis, Deep learning, Dental radiology, Machine learning, Oral and maxillofacial radiology.

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Introduction: Artificial intelligence has led to major transformations across many fields in recent years. AI-based models, which have found applications in areas such as autonomous vehicles, financial analysis, and voice assistants, are also increasingly being used in oral and maxillofacial radiology (1, 2). Artificial intelligence models are fundamentally inspired by the organization and functioning of the human brain. Similar to the way the human brain operates, layered artificial intelligence software architectures are capable of identifying complex and nonlinear relationships(1, 3). Artificial intelligence models can recognize patterns in images and make predictive identifications based on them(4, 5). Many AI-based models rely on the analysis of imaging data. For this reason, artificial intelligence has found widespread application in oral and maxillofacial radiology. In this field, AI has been applied to a wide range of specific tasks, including caries detection, assessment of osteoporotic status, detection of temporomandibular joint disorders, evaluation of the relationship between impacted teeth and adjacent anatomical structures, detection of maxillary sinus pathologies, diagnosis of Sjögren's syndrome, assessment of dental restorative materials, and identification of pathologies in precancerous or cancerous conditions. These applications have been investigated using various imaging modalities, including periapical radiographs, bitewing radiographs, panoramic radiographs, near-infrared transillumination imaging, computed tomography, cone-beam computed tomography, magnetic resonance imaging, and ultrasonography(6-18). Although numerous studies have been conducted in this field, information regarding the conceptual structure and thematic evolution of the scientific production remains limited. As a result, it is becoming increasingly difficult to comprehensively evaluate the current state, development, and research trends of this field(19).

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Bibliometric analysis enables the evaluation of scientific productivity, conceptual structure, and thematic development within a research field through analyses such as Annual Scientific Production, Most Cited Documents, Keyword Co-occurrence Analysis, Thematic Map Analysis, and Thematic Evolution Analysis, while also presenting these findings quantitatively. In this way, it provides valuable insights into the conceptual structure and thematic evolution of scientific production in the field(20-22). The aim of the present study was to evaluate the current state of the field, scientific trends, and the evolution of themes over time by performing performance analysis and conceptual structure analysis of artificial intelligence research in oral and maxillofacial radiology.

Materials and Methods: Since the present study was designed as a bibliometric analysis in the field of oral and maxillofacial radiology, no human or animal subjects were involved. Therefore, ethics committee approval was not required.

The data used in this study were obtained from the Web of Science Core Collection (WoSCC) database. The following search query was entered into the advanced search section of WoSCC: (("artificial intelligence" OR "machine learning" OR "deep learning" OR "deep neural network*" OR "neural network*" OR "convolutional neural network*" OR CNN OR radiomics) AND ("dental radiology" OR "oral radiology" OR "maxillofacial radiology" OR "dentomaxillofacial radiology" OR radiolog* OR radiograph* OR imaging OR "image analysis" OR "cone beam computed tomography" OR CBCT OR "panoramic radiograph*" OR "panoramic imaging" OR panoramic OR "periapical radiograph*" OR cephalometr* OR "computed tomography" OR "MRI" OR "magnetic resonance imaging") AND (dent* OR tooth OR teeth OR oral OR odontolog* OR jaw OR mandib* OR maxill* OR craniofacial)). Studies published between 2005 and 2025 were considered. During the creation of the final dataset, non-English publications and publications unrelated to the use of artificial intelligence in oral and maxillofacial radiology were excluded. Editorial letters and conference proceedings were also excluded to ensure the homogeneity of the dataset.

The bibliometric analysis was performed using the Bibliometrix package (version 5.3.0) through R (version 4.6.0), RStudio, and Biblioshiny. As part of the performance analysis, Annual Scientific Production and Most Cited Documents analyses were conducted; Thematic Map Analysis and Thematic Evolution Analysis were performed as part of the thematic analysis; and Keyword Co-occurrence analysis was carried out as part of the conceptual structure analysis.

The conceptual structure of the literature was evaluated using network-based clustering approaches. In the Keyword Co-occurrence analysis, only author-provided keywords were used to assess the conceptual structure. In the generated networks, different colors represent different thematic clusters, node size indicates keyword frequency, and edge thickness reflects co-occurrence strength. Within the thematic map analysis, themes were examined as motor themes, basic themes, niche themes, and emerging/declining themes. Thematic evolution analysis was used to investigate changes in themes over time.

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Results: A total of 2,939 articles indexed in the WoSCC database between 2005 and 2025 were analyzed. Annual Scientific Production analysis showed that while annual scientific output remained relatively low and stable until 2019, it increased rapidly thereafter, reaching its highest level in 2025 (Figure 1).

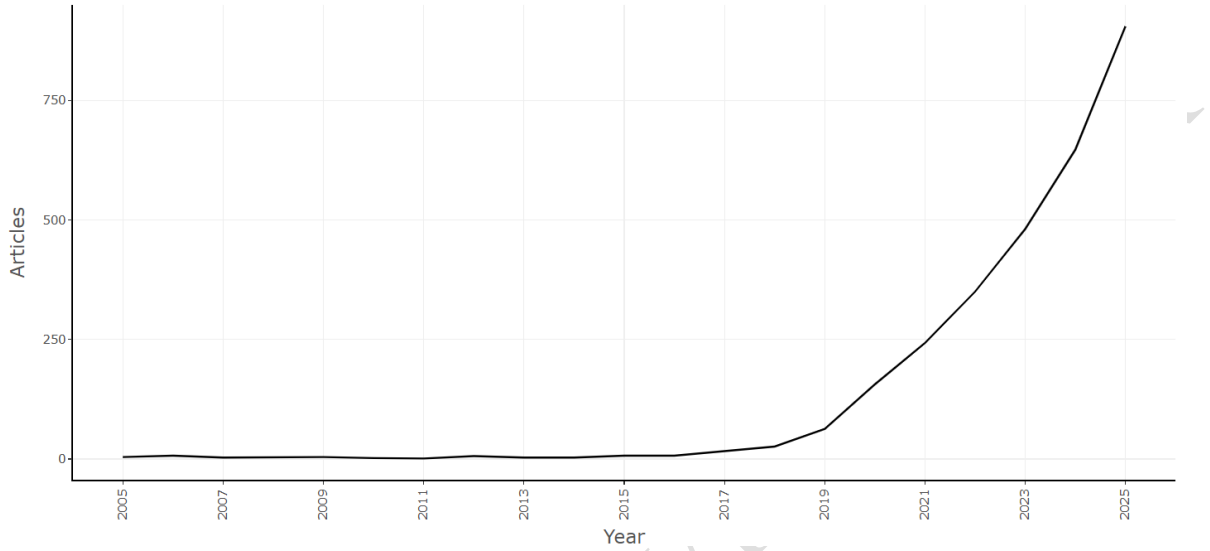

Figure 1. Annual Scientific Production of Publications on Artificial Intelligence in Dental Radiology

According to the Most Cited Documents analysis, the study by Schwendicke et al. (2)had the highest number of citations, with a total of 778 citations. It was followed by the study by Lee et al. (7)with 615 citations, and by the studies of Ibragimov and Xing (23)and Zhu et al., each with 410 citations (Figure 2).

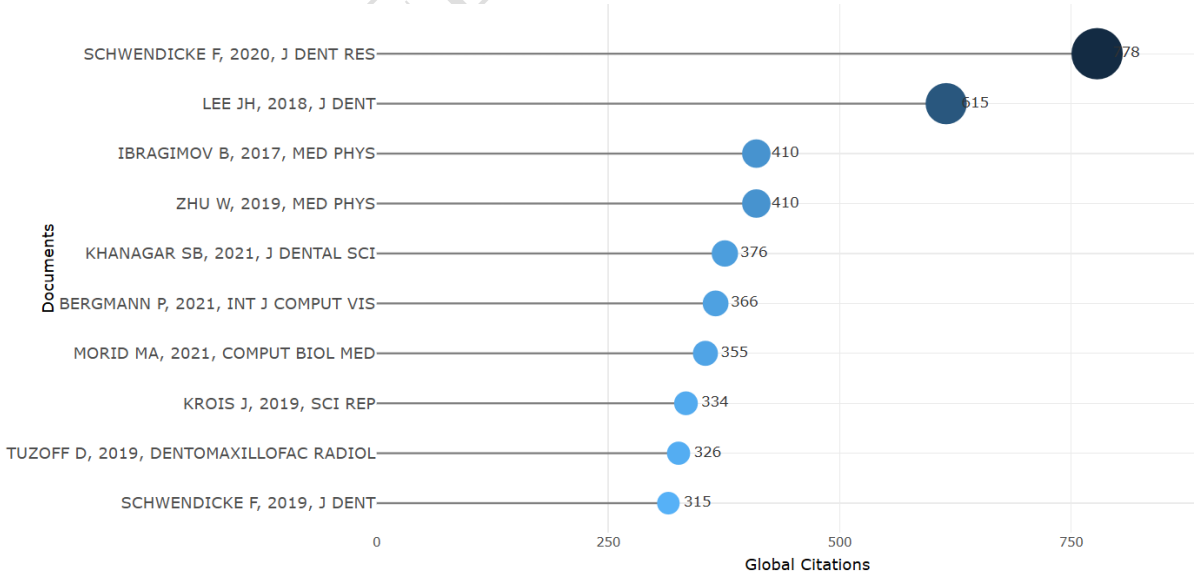

Figure 2. Most Cited Documents in Artificial Intelligence Research in Dental Radiology

Keyword Co-occurrence Analysis of artificial intelligence research in oral and maxillofacial radiology showed that the terms “artificial intelligence” and “deep learning” were located at the center of the network and exhibited strong relationships with other prominent terms. In addition to technical AI-related terms such as “radiomics,” “convolutional neural networks,” “segmentation,” and “image processing,” keywords including “panoramic radiography,” “cone-beam computed tomography,” “dental implant,” “dental caries,” “orthodontics,” and “oral cancer” were also found to be prominent (Figure 3).

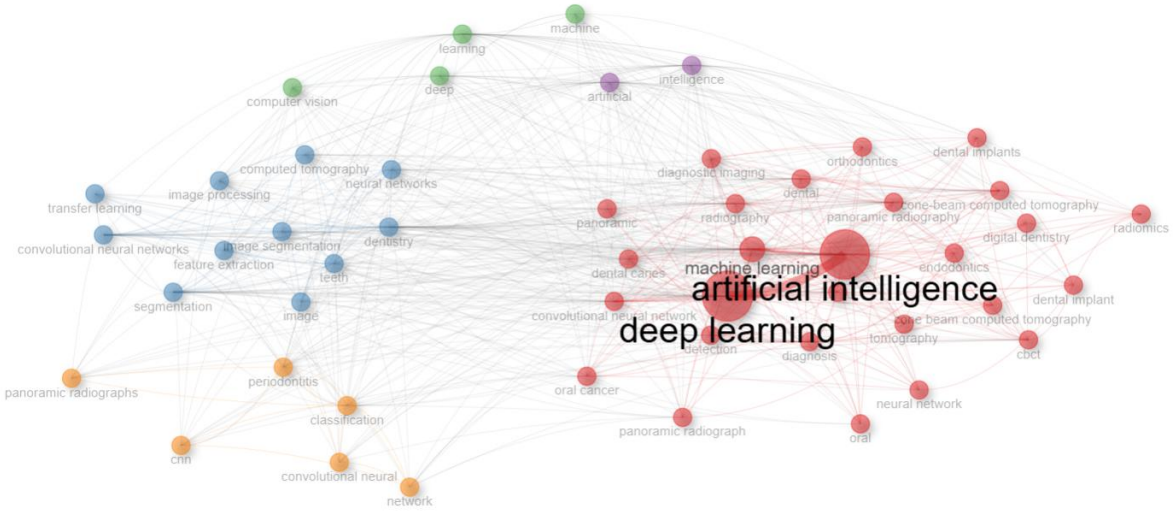

Figure 3. Keyword Co-occurrence Network of Artificial Intelligence Research in Dental Radiology

Thematic Map Analysis showed that the terms “dentistry,” “segmentation,” and “convolutional neural networks” were located within the motor themes cluster. The themes “artificial intelligence,” “deep learning,” and “machine learning” were positioned at the boundary between the motor and basic themes clusters, while “artificial,” “intelligence,” and “CBCT” were found within the basic themes cluster. In addition, “oral cancer,” “radiomics,” and “imaging” were located in the niche themes cluster, whereas “classification,” “panoramic radiography,” and “CNN,” as well as “learning,” “convolutional neural network,” and “deep,”

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were identified within the emerging or declining themes cluster (Figure 4).

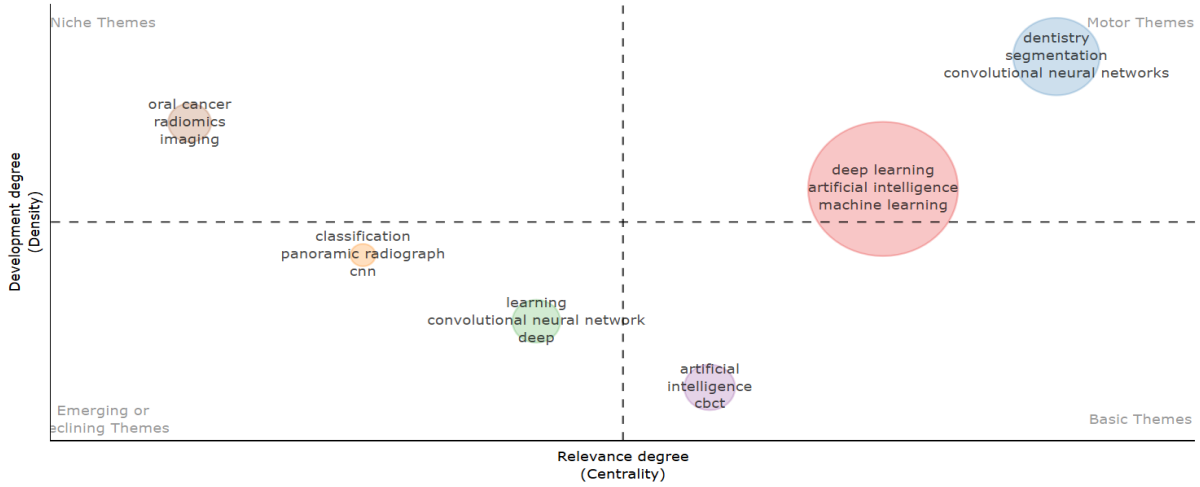

Figure 4. Thematic Map Analysis of Artificial Intelligence Research in Dental Radiology

In the field of oral and maxillofacial radiology, Thematic Evolution Analysis showed that during the first period, between 2005 and 2016, themes such as "artificial neural network," "classification," "diagnosis," "computer-assisted diagnosis," "machine learning," "image processing," "framework," "system," and "model" were prominent. In the later period, from 2016 to 2025, the terms "deep learning," "segmentation," "learning," "cancer," and "accuracy" emerged as the dominant themes (Figure 5).

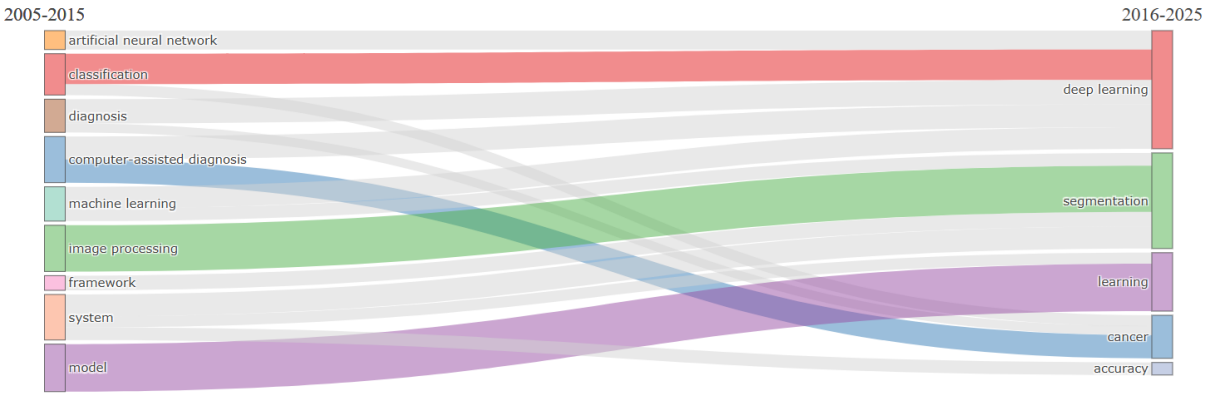

Figure 5. Thematic Evolution Analysis of Artificial Intelligence Research in Dental Radiology

Discussion: Artificial intelligence systems have led to a paradigm shift in dentistry in recent years. Rather than functioning merely as automated tools, AI systems increasingly serve as intelligent assistants that support dentists in meeting clinical needs and facilitating clinical workflows. By analyzing large volumes of radiographic images, these AI models can assist clinicians in a wide range of applications (24, 25). Oral and maxillofacial radiology may be considered one of the most prominent areas of artificial intelligence application in dentistry. This is because contemporary AI models are capable of interpreting patterns within imaging data and

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diagnosing radiographic conditions with high accuracy (24-26). In oral and maxillofacial radiology, artificial intelligence can be effectively applied to a wide range of tasks, including caries detection, evaluation of pathologies, identification of anatomical structures, and assessment of dental restorations (27).

Although numerous studies on artificial intelligence in oral and maxillofacial radiology have been published, information regarding the evaluation of scientific production, analysis of the conceptual structure, and assessment of the thematic evolution of this field remains limited in the literature. Therefore, investigating the conceptual structure and thematic evolution of this research area is necessary.

Annual Scientific Production analysis of the present topic showed a marked and continuous increase in scientific output after 2019, with the rate of increase becoming even more pronounced in recent years. The fact that the highest level of scientific production was reached in 2025 indicates that the field remains current and continues to attract academic interest. This increase in scientific output may be attributed to the integration of artificial intelligence models into oral and maxillofacial radiology and the growing use of decision-support systems. In addition, advances in technology may have facilitated the creation of large datasets and increased the accessibility of imaging systems and artificial intelligence models, thereby further contributing to the rise in scientific production(28-32).

The Most Cited Documents analysis showed that the study by Schwendicke et al. (2), with 778 citations, has become one of the key references in this field. Similarly, the studies by Lee et al.(7), Ibragimov and Xing (23)and Zhu et al. (33)also appear to have become foundational references in the application of artificial intelligence in oral and maxillofacial radiology. Examination of the most highly cited studies indicates that they primarily focus on clinical applications in dentistry and segmentation-related research that facilitates the use of artificial intelligence. In addition, topics such as tooth numbering, dental caries detection, and periodontal assessment were among the prominent subjects in the most cited studies. This suggests that these topics represent research areas attracting substantial scientific interest in oral and maxillofacial radiology.

Keyword co-occurrence analysis of artificial intelligence research in oral and maxillofacial radiology showed that the central position of the terms “deep learning” and “machine learning” suggests that these approaches constitute the conceptual foundation of AI-related research in this field. The prominence of technical terms such as “segmentation” and “image processing” indicates that research has largely focused on the technical aspects of identifying the morphology of anatomical structures and pathologies on imaging data. The prominence of “panoramic radiography” and “cone-beam computed tomography” may be attributed to the fact that panoramic radiography and CBCT are among the most commonly used imaging modalities in dentistry and that AI systems have been increasingly integrated with the data generated by these imaging methods (34). The appearance of the term “orthodontics” within

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the network suggests that AI-based research using dental imaging modalities is a topic investigated across different dental specialties. In addition, the prominence of the terms “dental implant,” “dental caries,” and “oral cancer” indicates that AI research in oral and maxillofacial radiology has focused on clinical applications such as implant assessment, caries detection, and the evaluation of oral cancers(35-37).

ThematicMap Analysis showedthattheterms “segmentation” and “convolutionalneuralnetworks” werelocatedwithinthe motor themescluster. Thissuggeststhatartificialintelligenceresearch in oral andmaxillofacialradiology has largelyfocused on technicalaspectssuch as imageprocessingandneural network-basedsystems, andthatthesetopicscurrentlyattractsubstantialacademicinterest. Theplacement of “deeplearning” and “machinelearning” at theboundarybetweenthe motor andbasicthemesclustersindicatesthatdifferentlymodeled AI systems not only define thecurrentresearchfocus but alsorepresentfundamentalcomponents of theliterature in thisfield. Theterms “oral cancer” and “radiomics” werelocatedwithinthenichethemescluster, suggestingthatresearch on theradiomicfeatures of imagingdataandthe AI-basedevaluation of oral cancersrepresentsspecializedandfocusedresearchareas. The presence of “panoramicradiography” withintheemergingordecliningthemesclustersuggeststhat AI applications in panoramicradiographymayeitherrepresent an emergingresearchdirectionor a topicbeginningtoloseprominence.

Thematic Evolution Analysis in oral and maxillofacial radiology showed that, in the earlier period, more general concepts such as “artificial neural network,” “classification,” “diagnosis,” “computer-assisted diagnosis,” “machine learning,” “image processing,” “framework,” “system,” and “model” were prominent. In the later period, the prominence of the terms “deep learning,” “segmentation,” “learning,” “cancer,” and “accuracy” indicates that research topics have evolved and shifted toward more specific areas. The prominence of “segmentation” suggests an increasing focus on the technical details involved in obtaining image-based outputs, whereas the emergence of “cancer” indicates that AI-based investigation of oral cancers on imaging data has become an increasingly popular topic in recent years.

Conclusion: As a result of this study, scientific production related to the use of artificial intelligence in oral and maxillofacial radiology was found to have increased markedly in recent years, while the research focus has shifted over time toward more specific and advanced applications. The findings indicate that technical topics such as segmentation, together with AI-based approaches aimed at clinical applications, have played a major role in shaping current research trends. It is expected that the scope of AI applications in oral and maxillofacial radiology will continue to expand in the future. Future studies should be designed to include publications in different languages and data from multiple databases.

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