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Bibliometric analysis and diagnostic efficacy of cone-beam computed tomography studies published in Imaging Science in Dentistry from 2011 to 2022

Kelda Zanchi Younan[1], Gabriel Francisco Krueger[1], Roberto Zimmer[1], Pedro Antonio González Hernández[2], Vania Regina Camargo Fontanella[3], Sergio Augusto Quevedo Miguens-Jr[4,*]

[1]*Graduate Program in Dentistry, Lutheran University of Brazil, Canoas, Rio Grande do Sul, Brazil*
[2]*Department of Oral and Maxillofacial Surgery, Graduate Program in Dentistry, Lutheran University of Brazil, Canoas, Rio Grande do Sul, Brazil*
[3]*Department of Surgery and Orthopedics, Faculty of Odontology, Federal University of Rio Grande do Sul, Porto Alegre, Brazil*
[4]*Department of Oral Medicine, Graduate Program in Dentistry, Lutheran University of Brazil, Canoas, Rio Grande do Sul, Brazil*

ABSTRACT

Purpose: This bibliometric analysis aimed to provide a comprehensive overview of the characteristics, trends, and level of diagnostic efficacy of studies on cone-beam computed tomography (CBCT) published in *Imaging Science in Dentistry* (ISD) from 2011 to 2022.

Materials and Methods: Publications related to CBCT identified in the electronic collection of ISD were selected according to eligibility criteria by 2 independent reviewers who collected data on the characteristics of the articles (year, authors, and country). The type and topic of studies were analyzed using VOSviewer v.1.6.18 (Centre for Science and Technology Studies, Leiden University, Leiden, Netherlands). The research articles were classified according to the hierarchical scale of diagnostic efficacy.

Results: Of the 236 articles included, most were from South Korea and Brazil. Bong-Hae Cho and Yun-Hoa Jung were the most prolific authors on the topic of CBCT. The most frequently published types of studies were cross-sectional and laboratory-based. The most popular topics WERE related to the diagnosis of pathologies and/or alterations, as well as anatomical variations. On the diagnostic efficacy scale, most studies were rated level 1 (technical efficacy) or 2 (diagnostic accuracy efficacy).

Conclusion: A steady increase was observed in publications related to CBCT, which are of both clinical and academic interest. The trends in these publications were analyzed, revealing that most are cross-sectional studies primarily exploring the capabilities of CBCT in diagnosing pathologies and/or changes in the oral and maxillofacial complex. These studies were typically classified as level 1 or 2 on the diagnostic efficacy scale. ***(Imaging Sci Dent 2023; 53: 335-44)***

KEY WORDS: Cone-Beam Computed Tomography; Diagnostic Imaging; Research; Bibliometrics

Introduction

Cone-beam computed tomography (CBCT) has revolutionized imaging in several clinical situations, both for diagnosis and treatment planning, monitoring, and case prognosis.[1-3] Nonetheless, the selection of an imaging modality for clinical use should be based on scientific evidence that points to the best diagnostic efficacy for making clinical decisions.[4,5]

The widespread use of CBCT in various fields of dentistry, coupled with the introduction of numerous tomographic devices in recent years, has led to scientific journals becoming the primary source of evidence-based information on this topic.[4,6] As changes in the scientific lit-

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*Correspondence to : Prof. Sergio Augusto Quevedo Miguens-Jr
Graduate Program in Dentistry, Lutheran University of Brazil, Av. Farroupilha, 8001, postal code 92425-020 - Canoas, RS, Brazil
Tel) 55-51-999359088, E-mail) samiguens@gmail.com

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Table 1. Hierarchical scale of diagnostic efficacy

	Level	Criteria
1.	Technical efficacy	Technical aspects of radiology equipment; spatial resolution; comparison of radiographs based on the technical criteria, grey-scale range; contrast-noise ratio; sharpness; modulation transfer function change.
2.	Diagnostic accuracy efficacy	Yield of abnormal or normal diagnoses in a case series; predictive values; sensitivity and specificity; ROC curve analysis.
3.	Diagnostic thinking efficacy	Number (percentage) of cases in a series in which an image judged "helpful" to making the diagnosis; difference in clinicians' pre- and post-test diagnoses.
4.	Therapeutic efficacy	Number (percentage) of times the image was helpful in planning patient management; proportion of cases in which prospectively stated treatment plan changed pre-test to post-test.
5.	Patient outcome efficacy	Percentage of patients improved pre-test to post-test; morbidity (or procedures) avoided after having test results; changes in life expectancy; cost saved with image information.
6.	Societal efficacy	Benefit/cost analysis from societal viewpoint; cost-effectiveness analysis from a societal viewpoint; cost per outcome change.

*Adapted from Fryback and Thornbury (1991)[5]

erature can occur over time, bibliometric analysis serves as a reliable tool. Through reproducible quantitative analysis, it offers a comprehensive perspective on a specific research subject, helping to identify trends and potential knowledge gaps in the topic under investigation.[7,8]

The *Korean Journal of Oral and Maxillofacial Radiology* was founded in 1971, and in 2011, it was renamed *Imaging Science in Dentistry* (ISD). ISD publishes articles on clinical, experimental, and educational aspects of oral and maxillofacial imaging. In addition, due to its broad scope and open access, it has become a reference journal in both academic and clinical dentistry radiology and related fields. Over the last decade, ISD has assumed a prominent position in the field of oral and maxillofacial radiology, effectively disseminating scientific evidence in the area. Since 2014, it has been classified by the Scimago Journal and Country Rank (SJR)[9] in quartile 2, a category that includes high-rated journals according to various indicators. It ranks 90th among the 215 journals that make up the area of dentistry.

Since the first bibliometric study in the health field was conducted in 1987, numerous bibliometric analyses have been undertaken with the goal of mapping and analyzing scientific articles across various health disciplines.[10] A bibliometric analysis can offer fresh insights into the readership of a journal, enabling students, professionals, and researchers alike to pinpoint key considerations in the interpretation of articles pertaining to a specific knowledge domain. This is particularly useful in identifying trends and gaps in the literature, which can inform their future research endeavors.[11]

Therefore, the present study carried out a bibliometric analysis in order to provide a comprehensive overview of the characteristics, trends, and level of diagnostic efficacy reported in studies related to CBCT published in ISD.

Materials and Methods

The study retrieved all publications in ISD from January 2011 to December 2022. The publications were accessed on the journal's website, which makes its volumes and issues available in digital format (https://isdent.org/). Articles related to CBCT published in the "review articles," "original articles," "case report," and "pictorial essay" sections were selected from the titles and abstracts. The "letter to the editor" and "technical report" sections were excluded from the analysis.

Data collection and analysis

The selected articles were independently read in full by trained and calibrated reviewers (KY, GFK), who collected the variables of interest. An experienced third reviewer (SMJ), was consulted in case of disagreements. From the articles included, general characteristics were collected (year, author, and country of origin of the first author), type of study (literature review, systematic review, case report or series, cross-sectional, case-control or longitudinal study, *in vitro* or *in vivo* laboratory studies, clinical trials or

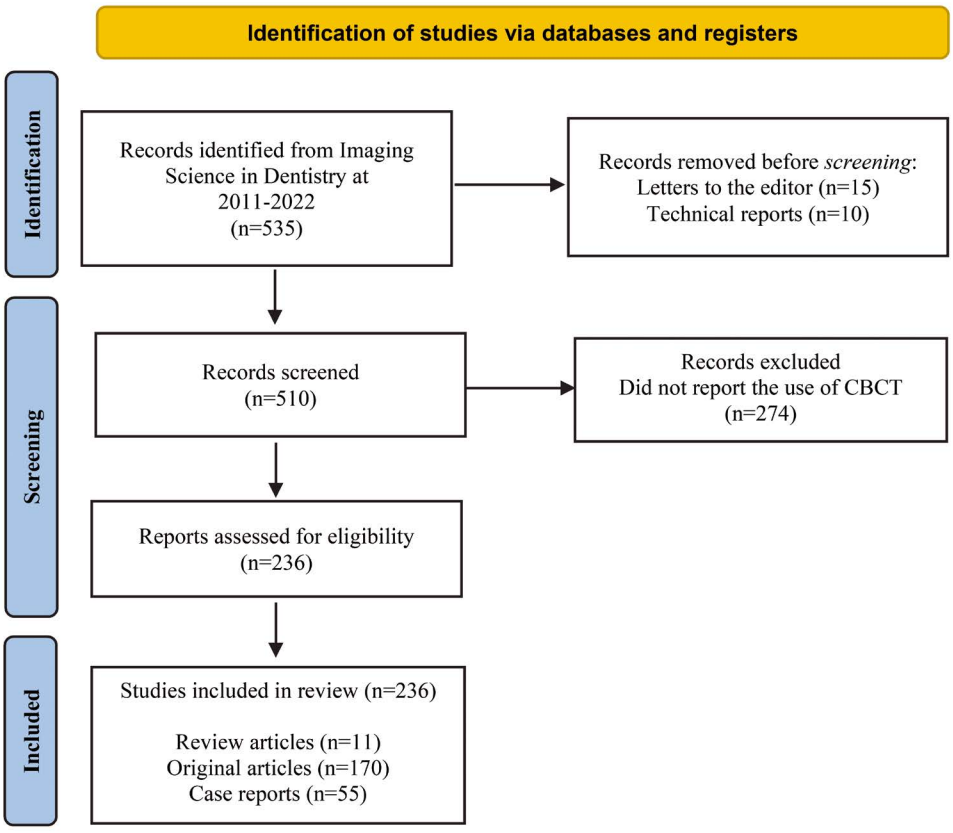

Fig. 1. Flow diagram of literature search and selection criteria.

randomized clinical trial), and topic of interest related to CBCT: 1) diagnostic accuracy, 2) diagnosis of pathologies and/or alterations of the oral and maxillofacial complex, 3) study of variations and/or anatomical references of the oral and maxillofacial complex, 4) investigation of technical resources and/or image quality, 5) radioprotection, 6) artificial intelligence and software, 7) teaching, and 8) forensic dentistry.

Classification of diagnostic efficacy levels

Research articles were classified regarding the level of diagnostic efficacy according to the hierarchical scale of diagnostic efficacy adopted from Fryback and Thornbury (1991),[5] in ascending order of efficacy levels (Table 1). Articles that did not meet the classification criteria were excluded from the present analysis.

Reviewer agreement analysis

Intra- and inter-reviewer calibration was performed in 2 stages with an interval of 2 weeks. To check the reviewers' calibration, 6 variables were selected (year, author, country of origin of the first author, study design, topic of interest related to CBCT and level of diagnostic efficacy), and the kappa or intraclass correlation coefficient (ICC) tests were applied for qualitative and quantitative variables, respectively. SPSS version 22.0 (IBM, Armonk, NY, USA) was used for these analyses. The reviewers were considered calibrated when the kappa or ICC tests showed values $\geq$ 80% of agreement.

Bibliometric analysis

The analysis was carried out in the Scopus electronic database to identify the top 10 most cited articles. Citation metrics were obtained by the number of citations and citation density, which is represented by the average number of citations of the article per year.[7] The VOSviewer software v.1.6.18 (Centre for Science and Technology Studies, Leiden University, Leiden, Netherlands) was employed due to its ability to map and extract text data from articles. This feature enables the construction and visualization of bibliometric networks. Networks of authors and keywords were subsequently created, and an analysis of the links between author collaborations and keyword co-occurrences was conducted.

Results

A total of 535 publications were identified among all sections of ISD. Of these, 236 articles met the eligibility criteria (Fig. 1) for the collection of variables by reviewers. The intra-reviewer calibration for these reviewers ranged from 0.94 to 1.0, while the inter-reviewer calibration ranged from 0.95 to 1.0.

Table 2. Countries of origin of publications related to cone-beam computed tomography in the period from 2011 to 2022

Country	n
South Korea	59
Brazil	35
Iran	34
United States of America	32
Turkey	19
India	12
Thailand	10
Belgium	6
China	5
Egypt	5
Japan	5
Italy	2
Indonesia	2
Syria	2
Chile	1
Germany	1
Malaysia	1
Mongolia	1
Poland	1
Spain	1
United Arab Emirates	1
United Kingdom	1
Total	236

Figure 2 shows that publications pertaining to CBCT were concentrated between 2018 and 2022. This time frame accounted for 49.6% of all the publications included in our current analysis.

The publications originated from 22 countries (Table 2). Authors from 4 countries produced the highest number of published articles: South Korea (n = 59), Brazil (n = 35), Iran (n = 34) and the USA (n = 32).

In total, 160 authors contributed to the publications, with 17 of these authors having 5 or more publications to their name (Fig. 3). The construction of the author network is depicted in Figure 4, where the largest "nodes" represent the authors with the most published articles. Consequently, Bong-Hae Cho and Yun-Hoa Jung emerged as the most prolific authors, as indicated by their overlapping circles. Figure 4 also illustrates the collaborative network among the authors, with the strength of their collaboration represented by the line density. This revealed a close collaboration among several authors, with the most notable active cooperation being between Jae Joon Hwang, Bong-Hae Cho, and Yun-Hoa Jung.

The keyword co-occurrence analysis pinpointed the 30 most frequently used keywords in the articles (Fig. 5). The cluster analysis conducted using VOSviewer revealed that the keyword "cone-beam computed tomography" appeared over 206 times. This was followed by "radiography" (n = 30), and other terms related to various anatomical regions of the jaws, such as "mandible" (n = 22) and "maxillary sinus" (n = 20). The analysis identified several clusters that represent trending topics in studies associated with

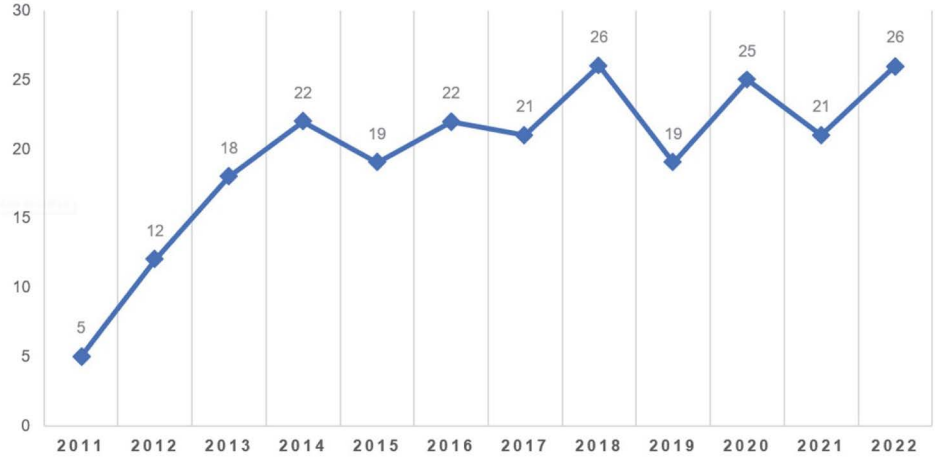

Fig. 2. Distribution of articles according to the year of publication from 2011 to 2022.

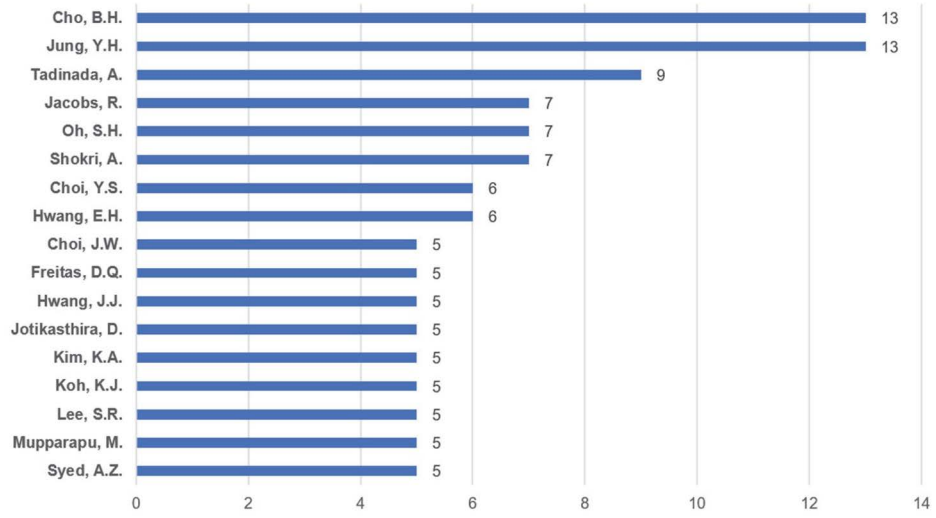

Fig. 3. The most prolific authors based on number of articles (the list included authors with a minimum of 5 articles).

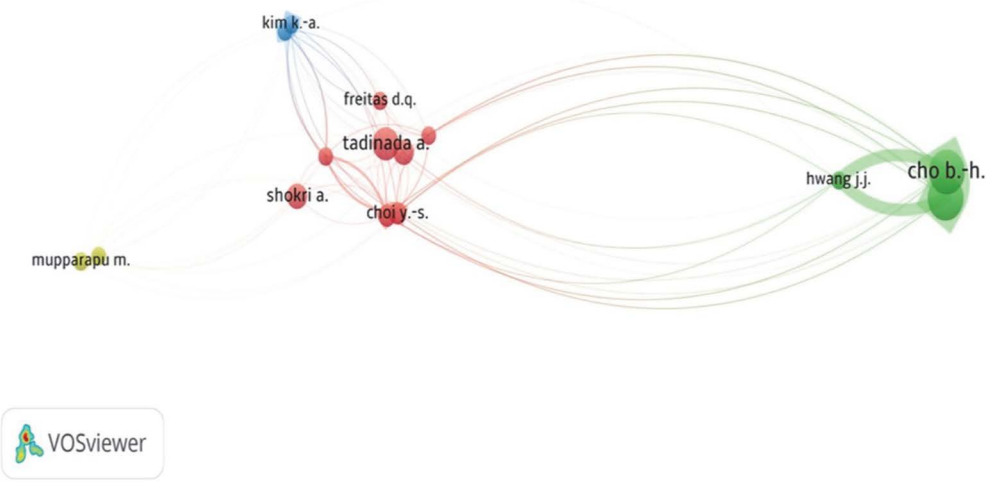

Fig. 4. Network of co-authorship and view of authors with the highest number of publications. The same colors represent the same cluster, and lines between clusters are co-citation links between the authors. The closer the authors are located to each other, the stronger their relatedness.

CBCT. The red clusters emphasize the term CBCT and primarily its related terms that have a strong correlation with other clusters. These include the yellow and green clusters, which are predominantly composed of terms associated with radiographs and dental or bone anatomical structures. Conversely, the light blue cluster, highlighted by the keyword "artifacts," demonstrates a strong connection with the keyword "cone-beam computed tomography." This suggests that it may still be a significant area of research in this field (Fig. 5).

The keyword analysis (Fig. 5) underscores publication trends related to CBCT in the ISD journal. This trend shows a higher concentration of studies focusing on anatomical variations and the diagnosis of alterations and/or pathologies, including odontogenic tumors, root fractures, and resorptions. These topics are evident in several clusters that have a strong correlation with the keyword "cone-beam computed tomography."

The analysis of hot topics confirmed a tendency for publication of studies related to the diagnosis of pathologies and/or other alterations of the oral and maxillofacial complex (n = 85), and studies on anatomical variations and references (n = 64) (Fig. 6). The third hot topic was the diagnostic accuracy of CBCT compared to other imaging tests (n = 46).

The majority of the articles studied were original re-

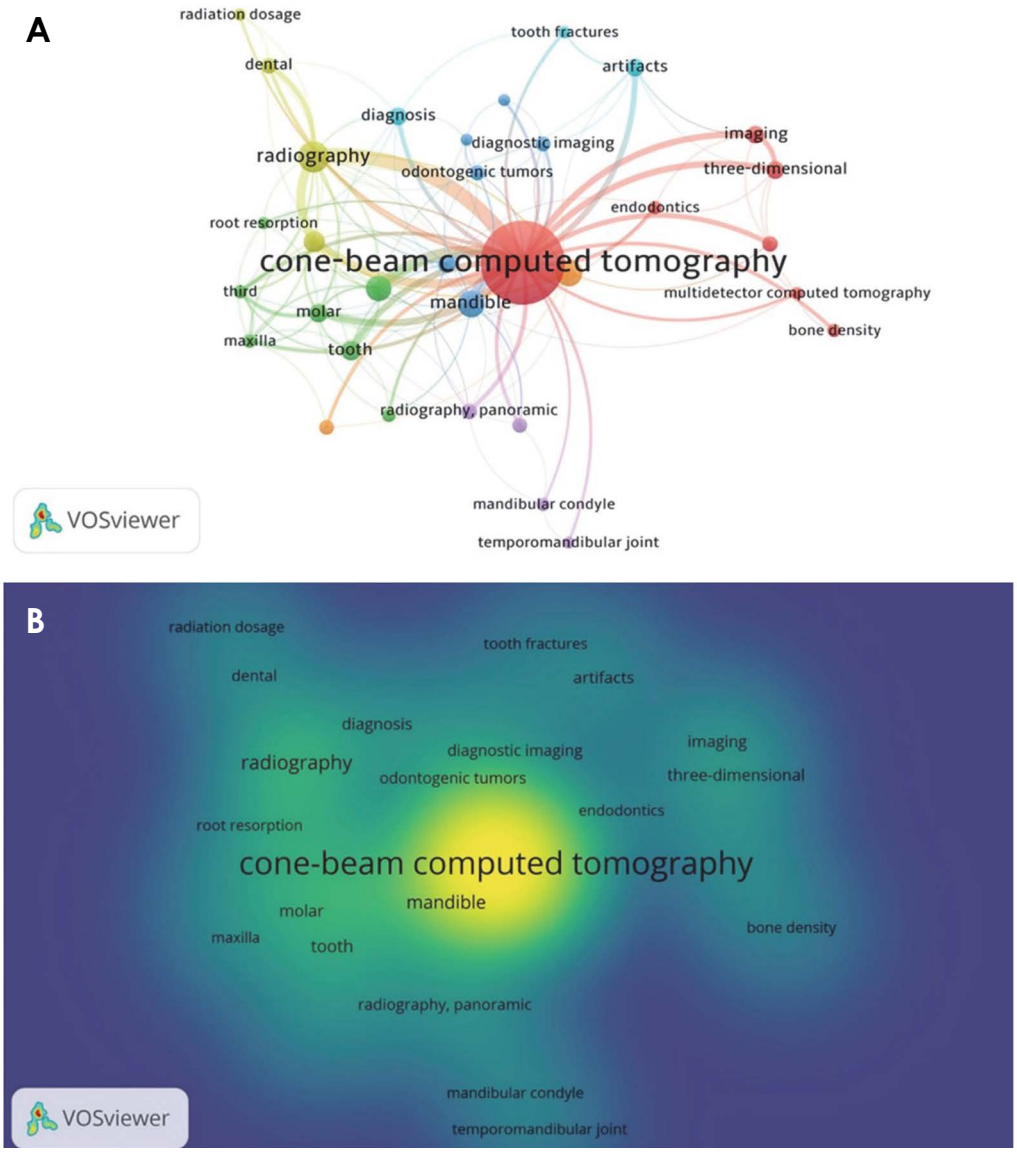

Fig. 5. Network of the 30 highest-frequency keywords used in the articles along the years of publications. A. Overlay visualization of the keyword co-occurrence network of publications. B. Keyword density visualization map.

search (72%) and case reports (23.3%) (Fig. 7). Among these research articles, the most frequently published were cross-sectional (n = 92) and laboratory studies (n = 63). Reviews (n = 11) and systematic reviews (n = 7) accounted for 7.6% of all the publications included in this sample. However, there were no publications related to CBCT that were clinical trials or randomized clinical trials.

Based on the eligibility criteria, 88 research articles were classified on the hierarchical scale of diagnostic efficacy (Fig. 8). The majority of these articles focused on level 1 - technical efficacy (n = 29), and level 2 - diagnostic accuracy efficacy (n = 56). Notably, no studies were classified under levels 5 and 6, which correspond to patient outcome efficacy and societal efficacy, respectively.

In the present study, the top 10 articles with the highest number and density of citations were identified (Table 3). The number of citations varied ranged from 38 to 95, averaging 52.8 citations per article. The citation density fluctuated between 4.1 and 9.5. The most citations were received by a review article titled "Patient radiation dose and protection from cone-beam computed tomography".[12] However, the most common theme among the top 10 articles was variations and/or anatomical references (n = 6), followed by the diagnosis of pathologies and/or other alterations in the oral and maxillofacial complex (n = 3) (Table 3).

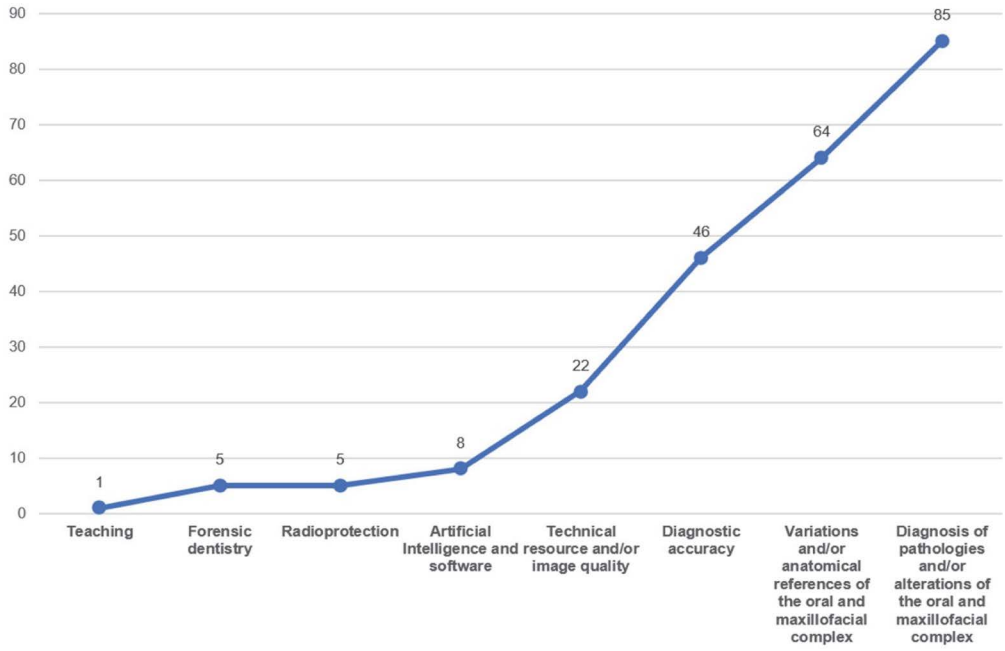

Fig. 6. Hot topics among articles related to cone-beam computed tomography from 2011 to 2022.

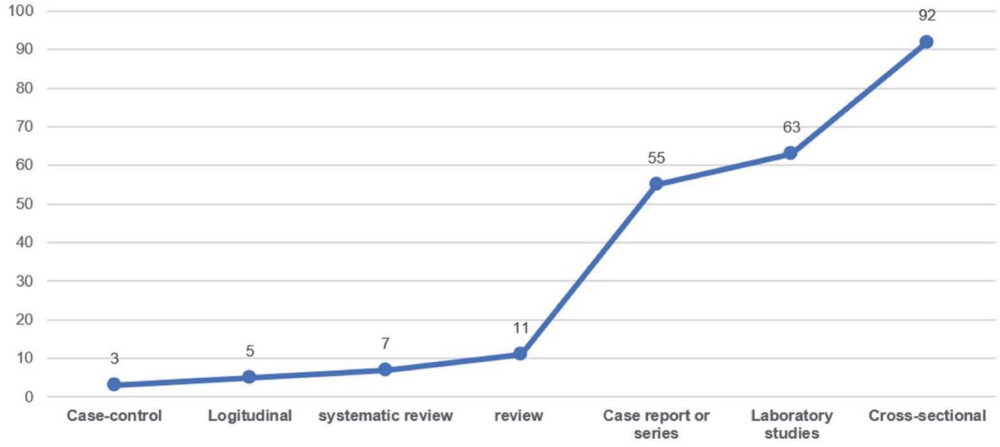

Fig. 7. Distribution of articles according to study type related to cone-beam computed tomography from 2011 to 2022.

Discussion

Cone-beam computed tomography has been widely used across various fields of dentistry, underscoring its status as a well-researched topic. The current study reveals that CBCT-related publications account for 44% of all articles published in ISD from 2011 to 2022.

The keyword cluster analysis revealed connections with various topic clusters, primarily the keyword "cone-beam computed tomography" and terms associated with anatomical references and pathologies. This suggests a research trend related to CBCT that concentrates on diagnosing alterations, pathologies, and anatomical variations within the oral and maxillofacial complex.

Cross-sectional and *in vitro* laboratory studies were the most frequently published during the period analyzed, although these results did not differ significantly from other studies. A bibliometric analysis conducted by Gondivkar et al. (2018)[22] identified the top 100 most cited articles on CBCT published between 1998 and 2012. The authors found that the most frequently researched topic was the diagnostic capabilities of CBCT across various dental disci-

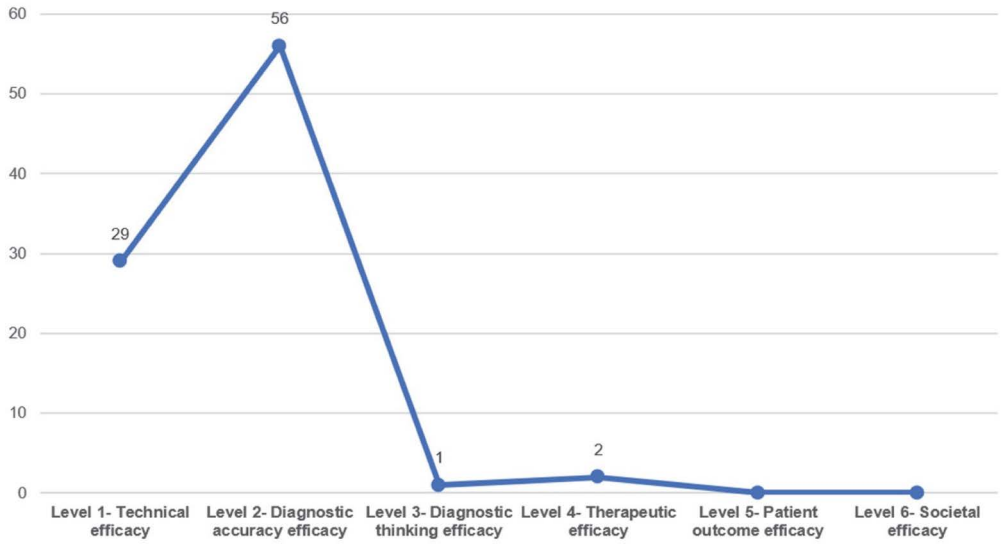

Fig. 8. Distribution of research articles according to the hierarchical scale of diagnostic efficacy (n = 88).

Table 3. Top 10 most-cited papers in Scopus related to cone-beam computed tomography, ordered by the number and density of citations

Rank	Articles	Type of study	Citations	Citation density
1	Patient radiation dose and protection from cone-beam computed tomography[12]	Review	95	9.5
2	Assessment of the relationship between the maxillary molars and adjacent structures using cone beam computed tomography[13]	Cross-sectional	61	5.5
3	Condylar bony changes in patients with temporomandibular disorders: a CBCT study[14]	Cross-sectional	56	5.0
4	The incidence and configuration of the bifid mandibular canal in Koreans by using cone-beam computed tomography[15]	Cross-sectional	52	5.7
5	Anatomy and morphology of the nasopalatine canal using cone-beam computed tomography[16]	Cross-sectional	51	5.1
6	Utility of the computed tomography indices on cone beam computed tomography images in the diagnosis of osteoporosis in women[17]	Case-control	50	4.1
7	Characterization of mandibular molar root and canal morphology using cone beam computed tomography and its variability in Belgian and Chilean population samples[18]	Cross-sectional	46	5.7
8	Comparison of micro-computerized tomography and cone-beam computerized tomography in the detection of accessory canals in primary molars[19]	Laboratory (*in vitro*)	40	5
9	Assessment of bifid and trifid mandibular canals using cone-beam computed tomography[20]	Cross-sectional	39	4.3
10	Radiographic evaluation of the maxillary sinus prior to dental implant therapy: a comparison between two-dimensional and three-dimensional radiographic imaging[21]	Cross-sectional	38	4.7

plines. Another bibliometric analysis,[23] covering the period from 1996 to 2005 and focusing on the journals *Dento-maxillofacial Radiology* and *Oral Surgery*, *Oral Medicine*, *Oral Pathology* and *Oral Radiology*, concluded that the majority of publications in the field of dental radiology were cross-sectional studies. Thus, it is evident that there has been no significant shift over the years in trends in publication types or research topics related to CBCT.

In the present study, most research articles fell into categories 1 and 2, which pertain to technical efficacy and diagnostic accuracy efficacy, respectively. This suggests that the focus remains on the lower tiers of the diagnostic

efficacy hierarchy, indicating a lack of substantial evidence to support clinical decision-making regarding the use of CBCT. This finding aligns with other published works in various journals. For instance, a systematic review by Horner et al. (2020)[24] concluded that the application of CBCT in various pediatric clinical scenarios yields inconsistent data. The authors recommended conducting studies with higher diagnostic efficacy levels. Another systematic review[25] found that 90% of studies utilizing CBCT in endodontics fell into categories 1 and 2 on the diagnostic efficacy scale. The authors concluded that the benefits of CBCT do not yet provide enough evidence to recommend its use in many endodontic clinical situations. Similarly, other systematic reviews on the use of CBCT for determining the need for extraction of impacted teeth[26] and detecting intraosseous and furcation defects[27] concluded that the benefits of CBCT are not yet supported by studies demonstrating sufficient diagnostic efficacy to justify its routine clinical use.

Conversely, the ongoing quest for the optimal protocol for the use and indication of CBCT may be the primary reason for the increased number of publications on levels 1 and 2 of the diagnostic efficacy scale. This is particularly relevant when considering the recent concept of "as low as diagnostically acceptable being indication-oriented and patient-specific" (ALADAIP). This concept emphasizes the need for tailoring the imaging exam to the individual patient's needs.[28] It also underscores the principles of radioprotection, particularly in relation to the radiation dose and its effects.

The present bibliometric analysis identified the top 10 most-cited papers, with the most frequently cited article being a review that discusses radioprotection. This trend underscores the prevalence of publications focusing on the technical aspects of CBCT.[12] This suggests that CBCT research is progressing well in terms of basic research. However, there is a need to develop robust clinical studies to enhance diagnostic efficacy.

The present study presents an analysis of the trends in CBCT-related publications over the past 11 years in ISD. It provides an overview of the current state of research and highlights the most frequently investigated topics. This information could serve as a valuable reference for researchers and future publications in the field of CBCT.

In conclusion, a steady increase in publications related to CBCT of both clinical and academic interest could be seen. In addition, publication trends were analyzed, and it was found that most articles were cross-sectional studies that investigated the capabilities of CBCT in the diagnosis of pathologies and/or alterations of the oral and maxillofacial complex, classified as level 1 or 2 on the diagnostic efficacy scale.

Conflicts of Interest: None

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