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Global Research Trends in the Radiographic Evaluation of Impacted Teeth: A Bibliometric Analysis

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Abstract

Radiographic evaluation of impacted teeth plays a crucial role in dentistry for diagnosis, treatment planning, and the prevention of complications. The present study was designed using bibliometric methods to examine the scientific productivity, conceptual structure, and thematic development of the literature on the radiographic evaluation of impacted teeth. The dataset consisted of articles and reviews published between 2000 and 2025 in the Web of Science Core Collection database. The analyses were performed using the bibliometrix package (version 5.3.0) through R (version 4.6.0), RStudio, and Biblioshiny. An overall increase in scientific production was observed, with the highest publication output recorded in 2024. The analyses revealed that research has primarily focused on cone-beam computed tomography, impacted third molars, and impacted canines. Over time, the research focus has shifted from the general evaluation of impacted teeth toward more specialized topics, such as the relationship between dentigerous cysts and impacted teeth. The findings indicate that the radiographic evaluation of impacted teeth is a rapidly evolving research field, with cone-beam computed tomography becoming the predominant imaging modality and research trends increasingly concentrating on more specialized topics.

Keywords: Bibliometrics, Cone-Beam Computed Tomography, Computed Tomography, Impacted Canine, Impacted Third Molar, Dental Radiology.

1. Introduction

Impacted teeth are teeth that remain completely or partially embedded within hard or soft tissues despite reaching their normal time of eruption. They represent a common clinical condition encountered in dental practice. Impacted third molars are the most frequently observed impacted teeth, followed by impacted maxillary canines; however, impaction may also occur in other teeth [1-4]. The etiology of impacted teeth is multifactorial and may involve genetic, systemic, or local factors. In addition to insufficient space within the jaws, impaction may result from supernumerary teeth obstructing the eruption pathway, abnormal positioning of the tooth germ, ankylosis, trauma, premature loss or prolonged retention of primary teeth, and systemic or genetic disorders affecting the eruption mechanism. Impacted teeth may cause various pathological changes in the affected teeth and surrounding tissues through different mechanisms [5-11]. Pericoronitis of the surrounding soft tissues, the development of odontogenic cysts and odontogenic tumors, odontogenic infections, root resorption

of adjacent teeth, malocclusion, dental crowding, caries in adjacent teeth, periodontal defects, and pain are among the complications associated with impacted teeth. In addition to these complications, impacted teeth may also cause esthetic concerns when they are located within the smile line [12-15]. Radiographic imaging is indispensable for the diagnosis of impacted teeth and treatment planning. Imaging modalities enable the assessment of tooth location, angulation, morphological abnormalities that may influence treatment planning, such as dilaceration, the relationship with adjacent anatomical structures, and associated pathologies. The choice of imaging modality depends on the specific clinical characteristics of the impacted tooth. Two-dimensional imaging techniques are limited in critical situations, such as evaluating the close relationship between impacted teeth and adjacent anatomical structures, because of inherent limitations including superimposition, magnification, and distortion. In such cases, three-dimensional imaging modalities are preferred [16-19].

A substantial number of studies have been published on the imaging of impacted teeth, and the volume of this literature continues to grow. Consequently, evaluating the current conceptual structure of the field and the overall pattern of scientific production has become increasingly challenging [20, 21]. Therefore, it is essential to evaluate the current status and research trends in the radiographic evaluation of impacted teeth. Bibliometric analysis represents an effective approach for this purpose, as it enables the assessment of scientific productivity, conceptual structure, thematic evolution, and research trends within a specific field [22, 23].

The aim of this study was to examine the literature on the radiographic evaluation of impacted teeth using Annual Scientific Production, Most Global Cited Documents Analysis, Keywords Co-occurrence Network Analysis, Thematic Map Analysis, and Thematic Evolution Analysis, in order to evaluate the scientific productivity, conceptual structure, and thematic evolution of this research field.

2. Materials and Methods

The present study was designed as a bibliometric analysis of the radiographic evaluation of impacted teeth; therefore, no human participants or animals were involved. Consequently, ethical approval was not required.

Data for this study were retrieved from the Web of Science Core Collection (WoSCC) database. The advanced search function of the WoSCC database was used with the following search query: TS = (("impacted tooth" OR "impacted teeth" OR "tooth impaction" OR "dental impaction" OR "unerupted tooth" OR "unerupted teeth" OR "impacted canine" OR "impacted canines" OR "impacted maxillary canine" OR "impacted mandibular canine" OR "impacted third molar" OR "impacted third molars" OR "impacted mandibular third molar" OR "impacted maxillary third molar" OR "wisdom tooth" OR "wisdom teeth" OR "third molar impaction") AND (radiograph OR radiolog OR imaging OR "diagnostic imaging" OR "dental imaging" OR "oral radiology" OR "maxillofacial radiology" OR CBCT OR "cone beam computed tomography" OR CT OR "computed tomography" OR MDCT OR MSCT OR "multidetector computed tomography" OR "multislice computed tomography" OR MRI OR "magnetic resonance imaging" OR ultrasonograph* OR ultrasound OR sonograph* OR "panoramic radiography" OR panoramic OR orthopantomograph* OR OPG OR "periapical radiography" OR "intraoral radiography" OR "occlusal radiography")). Articles and reviews published in English between 2000 and 2025 on the radiographic evaluation of impacted teeth were included. Studies unrelated to the topic, publications in languages other than English, editorial letters, and conference proceedings were excluded to ensure the homogeneity of the dataset.

Bibliometric analyses were performed using the bibliometrix package (version 5.3.0) through R (version 4.6.0), RStudio, and Biblioshiny. Annual Scientific Production and Most Global Cited Documents Analysis were used to evaluate the scientific performance of the research field, whereas Keywords Co-occurrence Network Analysis, Thematic Map Analysis, and Thematic Evolution Analysis were performed to examine its conceptual structure.

The conceptual structure of the literature was examined using a network-based clustering approach. In the resulting network, node size represented the frequency of keyword occurrence, different colors indicated distinct thematic clusters, and edge thickness reflected the strength of keyword co-occurrence. Only author-provided keywords were included in the Keywords Co-occurrence Analysis. In the Thematic Map Analysis, themes were classified as basic themes, motor themes, niche themes, and emerging or declining themes. Thematic Evolution Analysis was performed to investigate the temporal evolution of research themes within the field..

3. Results

A total of 1,602 publications on the radiographic evaluation of impacted teeth published between 2000 and 2025 were identified. Annual Scientific Production analysis demonstrated an overall increase in scientific output over the study period, despite some year-to-year fluctuations. This increase became more pronounced after 2020, with the highest annual scientific production recorded in 2024 (Figure 1).

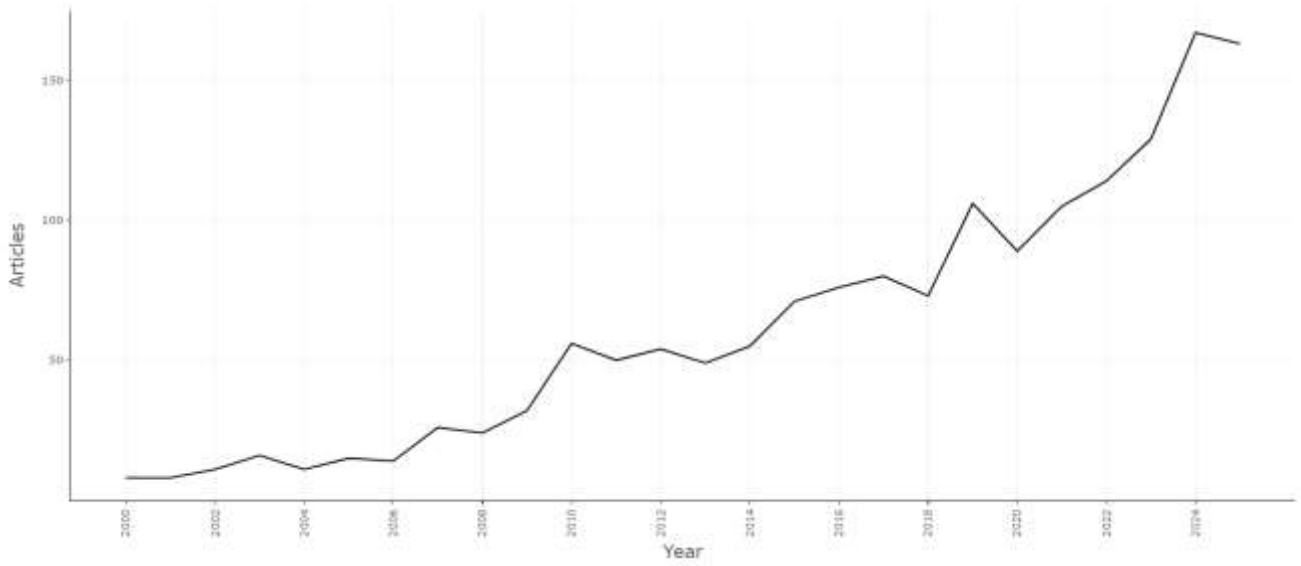

Figure 1. Annual scientific production in the radiographic evaluation of impacted teeth

Most Global Cited Documents Analysis revealed that the most highly cited publication was the study by Kapila and Nervina [24], with 281 citations. This was followed by the publications of Schmeling et al. [25] with 267 citations and Walker et al. [26] with 250 citations (Figure 2).

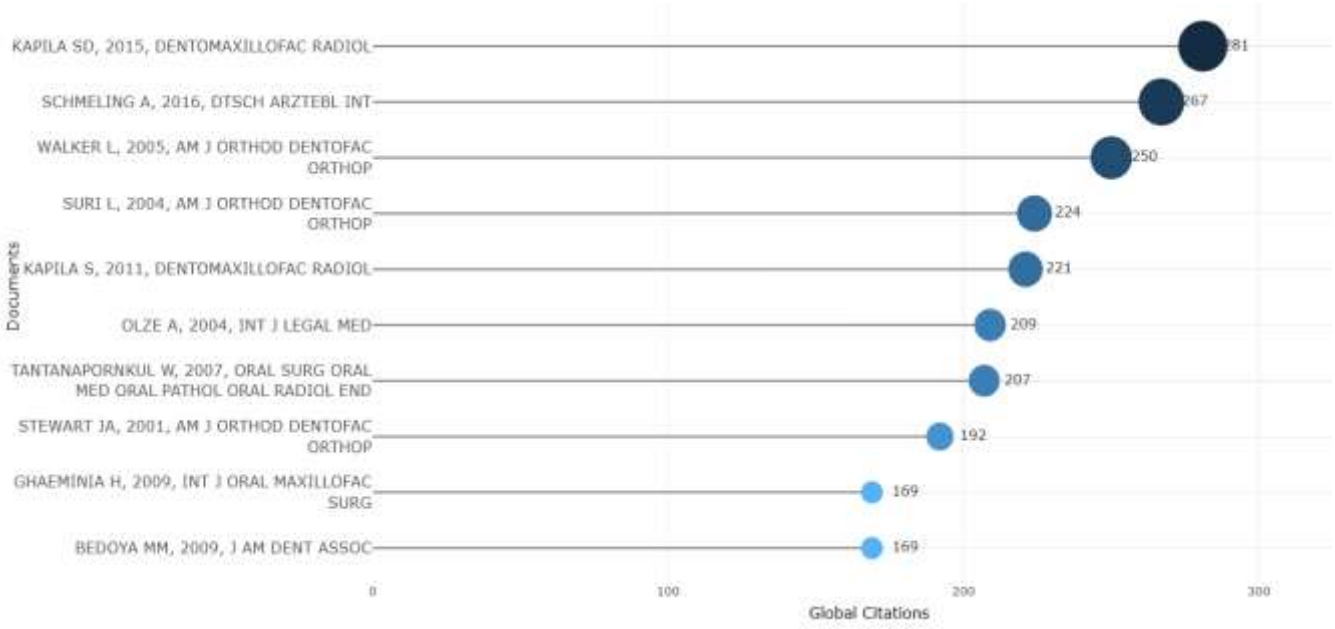

Figure 2. Most globally cited documents in the radiographic evaluation of impacted teeth.

Keywords Co-occurrence Network Analysis identified three distinct thematic clusters. The green cluster included the terms "cone beam computed tomography", "cbct", "impacted canine", "impacted teeth", "orthodontics", "root resorption", "tomography", and "impacted third molar". The red cluster comprised the terms "impacted tooth", "third molar", "impaction", "mandibular third molar", "dentigerous cyst", "extraction", "computed tomography", "panoramic radiography", "prevalence", and "mandible". Finally, the blue cluster contained the terms "cone-beam computed tomography", "impacted tooth", "molar", "third", "panoramic", and "radiography". Within the network, the terms "cone-beam computed tomography" and "third molar" exhibited the largest node sizes and showed strong connections with the other terms, indicating their central role in the research field (Figure 3).

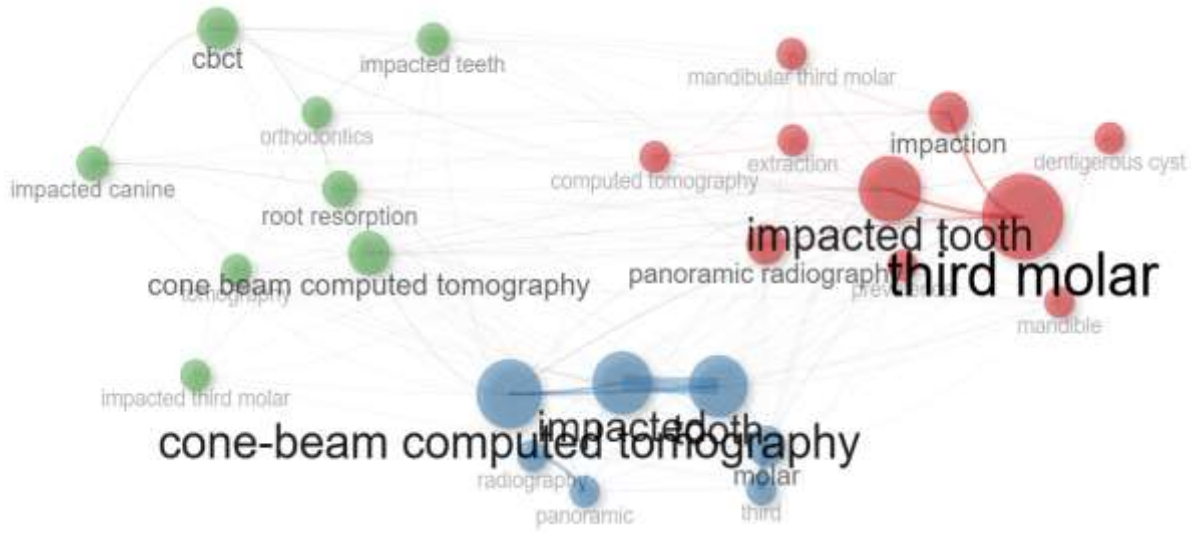

Figure 3. Keywords co-occurrence network analysis in the radiographic evaluation of impacted teeth.

Thematic Map Analysis revealed that the terms "teeth", "prevalence", and "eruption" were located within the basic themes cluster, whereas "extraction", "third molar", and "surgery" were classified as motor themes. The terms "accuracy", "population", and "wisdom tooth" were identified within the niche themes cluster, while "tooth", "impacted tooth", and "cone-beam computed tomography" were located in the emerging or declining themes cluster (Figure 4).

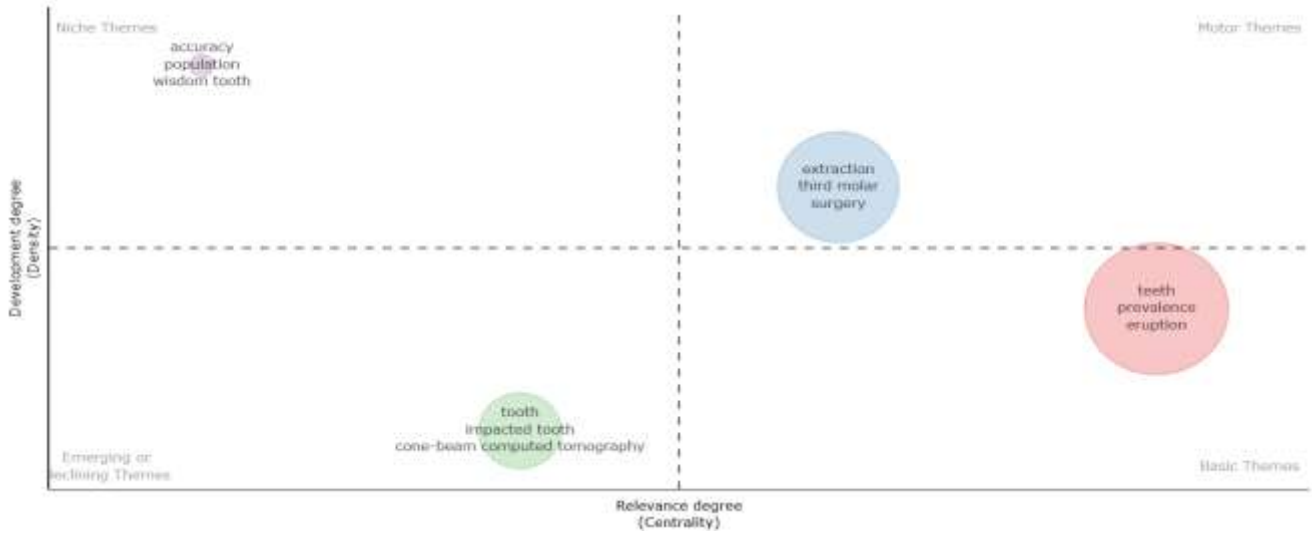

Figure 4. Thematic map in the radiographic evaluation of impacted teeth.

Thematic Evolution Analysis of publications on the radiographic evaluation of impacted teeth showed that the predominant themes between 2000 and 2013 were "angle fracture", "computed tomography", "impacted canine", "third molar", "impacted tooth", "radiology", "molar", and "tooth". Between 2014 and 2025, the dominant themes shifted to "cbct", "third molar", "cone-beam computed tomography", "teeth", "dentigerous cyst", and "cone beam computed tomography". The theme "canine impaction" from the first period was found to be associated with the "cbct" theme in the second period. Furthermore, the theme "third molar" persisted across both time periods, indicating its sustained importance within the research field (Figure 5).

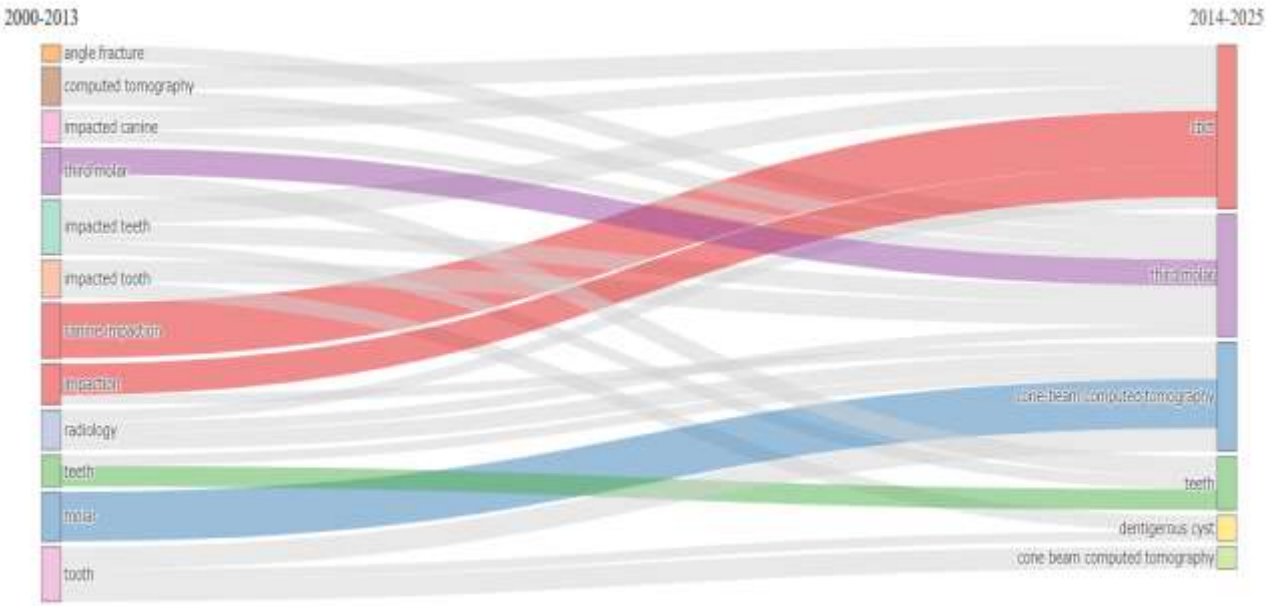

Figure 5. Thematic evolution analysis in the radiographic evaluation of impacted teeth.

4. Discussion

Problems associated with impacted teeth are among the most frequently encountered conditions in dental practice. Although some impacted teeth remain asymptomatic, others may present with various clinical manifestations. Common complications associated with impacted teeth include root resorption, odontogenic cysts, odontogenic tumors, pericoronitis, caries in adjacent teeth, periodontal defects, esthetic concerns, and pain. Some of these conditions can be detected radiographically. Therefore, careful radiographic examination is essential in the presence of impacted teeth. Furthermore, when surgical or orthodontic treatment is planned, information regarding the location, root and crown morphology, angulation, relationship with adjacent anatomical structures, and associated pathologies of the impacted tooth may significantly influence treatment planning [4, 12-16, 18].

Two-dimensional imaging modalities, particularly panoramic radiography, are widely used in routine dental practice for the evaluation of impacted teeth because of their low radiation dose and cost-effectiveness. However, these techniques are inherently limited by superimposition, distortion, and magnification. Furthermore, they cannot provide comprehensive spatial and volumetric information because of their two-dimensional nature. Consequently, the precise relationship between impacted teeth and adjacent anatomical structures, such as the inferior alveolar canal and the maxillary sinus, as well as associated pathologies, may not be accurately determined. Many of these limitations have been overcome with the widespread clinical use of three-dimensional imaging modalities. These techniques allow comprehensive assessment using multiplanar images and enable the accurate evaluation of the spatial position and anatomical relationships of impacted teeth [16-19, 27]. A considerable number of studies have investigated the imaging of impacted teeth in dentistry. Nevertheless, information regarding the scientific performance and conceptual structure of this research field remains limited [20, 28]. Therefore, it is necessary to investigate the current scientific productivity, conceptual structure, and temporal evolution of this research field.

Annual Scientific Production analysis demonstrated a progressive increase in scientific output on the radiographic evaluation of impacted teeth over time. The marked acceleration in publication activity

after 2020, culminating in the highest annual publication output in 2024, suggests that this topic has become an increasingly active and academically relevant research field. This growth may be attributed to the widespread adoption of three-dimensional imaging modalities over time and the increasing role of digital technologies, which have enhanced the use of three-dimensional imaging in diagnosis and treatment planning [29, 30].

Most Global Cited Documents Analysis revealed that the publication by Kapila and Nervina [24] was the most highly cited study in the dataset. This publication focuses on the use of cone-beam computed tomography in orthodontics. This finding suggests that the radiographic evaluation of impacted teeth represents a well-established and widely investigated research area in orthodontics. The publication by Schmeling et al. [25], another highly cited study, focuses on forensic age estimation. The high citation count of this study indicates that age estimation based on impacted teeth has attracted considerable academic interest and represents an important research topic within the field [31]. Evaluation of the other highly cited publications showed that research has predominantly focused on impacted third molars and impacted maxillary canines. This is likely because these are the most frequently impacted teeth encountered in clinical practice. Another highly cited research topic was age estimation, highlighting the important role of dental age assessment in forensic odontology. Furthermore, most of the highly cited studies employed cone-beam computed tomography and panoramic radiography. This may be attributed to the fact that these imaging modalities are the most commonly used for evaluating the morphology, spatial position, and relationships of impacted teeth with adjacent anatomical structures [26, 32-38].

Keywords Co-occurrence Network Analysis identified three distinct thematic clusters. The clustering of the terms "cone beam computed tomography", "impacted canine", "orthodontics", "root resorption", "tomography", and "impacted third molar" within the green cluster suggests that the literature has primarily focused on the three-dimensional evaluation of impacted teeth for orthodontic treatment planning. This may be explained by the superior ability of three-dimensional imaging modalities, such as CBCT, to detect root resorption of adjacent teeth caused by impacted teeth more accurately and reliably than two-dimensional imaging techniques. Furthermore, the co-occurrence of the terms "cone beam computed tomography" and "tomography" indicates that, in addition to CBCT, other three-dimensional imaging modalities, including conventional computed tomography, have also been used in the evaluation of impacted teeth. The clustering of the terms "dentigerous cyst", "extraction", "computed tomography", and "mandibular third molar" within the red cluster indicates that the diagnosis and management of dentigerous cysts constitute one of the major research focuses in the literature. Because dentigerous cysts are most commonly associated with impacted mandibular third molars, computed tomography, particularly cone-beam computed tomography (CBCT), is widely used to evaluate lesion size, its relationship with adjacent anatomical structures, and surgical treatment planning. Moreover, the presence of the term "extraction" within the same cluster suggests that research has focused not only on radiographic diagnosis but also on surgical treatment approaches, including impacted tooth extraction and cyst enucleation. This finding highlights the critical role of imaging modalities in both the diagnosis and treatment planning of dentigerous cysts. In the blue cluster, the co-occurrence of the terms "cone-beam computed tomography", "impacted tooth", "panoramic", and "radiography" indicates that different imaging techniques are used for the evaluation of impacted teeth. Finally, the large node sizes of the keywords "cone-beam computed tomography" and "third molar" within the network suggest that these

two concepts occupy a central position in the literature and play a pivotal role in shaping research in this field [39-43].

Thematic Map Analysis revealed that the terms "teeth", "prevalence", and "eruption" were located within the basic themes cluster. This finding indicates that the prevalence and eruption characteristics of impacted teeth constitute the core of this research field and represent topics with high centrality within the literature [44]. The presence of the terms "extraction", "third molar", and "surgery" within the motor themes cluster indicates that surgical procedures involving impacted third molars represent one of the most intensively investigated and well-developed research areas in the literature. This may be attributed to the critical importance of comprehensive preoperative radiographic assessment for appropriate treatment planning and for minimizing complications associated with third molar surgery, such as inferior alveolar nerve injury, lingual nerve injury, postoperative infection, and alveolar osteitis [45, 46]. The presence of the terms "accuracy", "population", and "wisdom tooth" within the niche themes cluster indicates that studies evaluating the prevalence, distribution, and diagnostic accuracy of third molars across different populations represent more specialized research areas within the field [47].

Thematic Evolution Analysis showed that the predominant themes between 2000 and 2013 were "computed tomography", "impacted canine", and "impacted teeth", indicating that research during this period was primarily focused on the evaluation of impacted teeth using computed tomography. In contrast, the emergence of the themes "cone-beam computed tomography" and "dentigerous cyst" between 2014 and 2025 suggests that cone-beam computed tomography became the predominant imaging modality during this period and that research began to focus on more specialized topics, particularly pathologies associated with impacted teeth. The transition from computed tomography to cone-beam computed tomography as the dominant imaging modality may reflect the widespread adoption of cone-beam computed tomography for the evaluation of impacted teeth in dental practice.

5. Conclusion

The findings of this study demonstrated a marked increase in scientific production related to the radiographic evaluation of impacted teeth over time. In addition, the principal research themes were concentrated around cone-beam computed tomography, impacted third molars, and impacted canines. While computed tomography was the predominant imaging modality during the earlier period, cone-beam computed tomography emerged as the dominant imaging technique in more recent years. Furthermore, research has gradually shifted from broader topics toward more specialized areas, particularly pathologies associated with impacted teeth, such as dentigerous cysts. Future bibliometric studies should incorporate multiple databases and publications in different languages to provide a more comprehensive overview of this research field.

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