

Role of biodentine in endodontics: a bibliometric and scientometric analysis

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Abstract

Objective. Vital Pulp therapy using Biodentine has advanced, introducing and allowing new procedures and treatments, hence medical education should focus on research and publication. The aim of the study was to perform a bibliometric and scientometric analysis of the literature on the role of biodentine in endodontics from 2013 to 2023.

Methodology: A bibliometric and scientometric quantitative study formed the basis of the methodology. Scientific production indicators were generated from 87 documents selected from Scopus using English keywords ("Biodentine", "Endodontic").

Results: Since 2016, the number of papers published on this topic increased (69%), indicating a growing interest towards this material. Brazil is the country with the highest scientific interest (19%), and the Universidade Estadual Paulista Júlio de Mesquita Filho with the most publications (n=9). The International Endodontic Journal received 344 citations, Tanomaru-Filho M. (n=6) being the most cited.

Conclusion: It is concluded that the role of biodentine in endodontics has grown not only in production and authorship, but also in scope and medical research, incorporating these resources in various scenarios and clinical settings.

Keywords: Biodentine, endodontics, bibliometric, scientometric, scientific production.

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1. Introduction

In the 1990s, mineral trioxide aggregate (MTA), a derivative of Portland cement, was developed and described. This marked the beginning of a new era of bioceramic materials in endodontics¹⁻⁴. For its part, bioceramics is a type of ceramic with biocompatible properties. It is non-toxic, stable in biological environments, and does not shrink during the setting process but expands slightly. In addition,

hydroxyapatite can be formed, which is not affected by water, unlike other materials^{5,6}.

Therefore, hydraulic materials have recently attracted the attention of clinicians from all specialties, including endodontists. Most nonsurgical root perforation (RP) closures (RP) have been met with Biodentine (BDT), one of the most recent generation of bioceramics³. Importantly, the physicochemical and biological characteristics of BDT made it widely recommended for use in clinical settings, being used as a substitute for dentin due to its elasticity modulus

analogous to dentin. Other features are its ability to seal, resistance to pressure and promoting the apposition of calcified tissues^{7,8}.

The components of BDT are a liquid and a powder. The powder consists of minerals such as zirconium oxide, calcium carbonate, dicalcium and tricalcium silicate. In addition to the water-soluble polymer that serves as a reductant, the liquid also contains an aqueous solution of calcium chloride⁹⁻¹². After preparation, within 10-12 minutes, the substance will have hardened. The radio opacity of zirconium oxide (over 3 mm thick, complying with ISO 6876/2001) allows it to be detected with X-rays¹³. Also, according to Boetto and Martinez⁷, BDT does not undergo clinically visible colour changes, which makes it the best choice for esthetically sensitive areas.

Biodentine offers a wide variety of uses due to its biocompatibility, physicochemical properties and easy handling, in situations where dentin replacement is necessary, such as in direct and indirect pulp capping, traditional endodontic operations and medical restorative cases¹⁴⁻¹⁷.

Given the importance of the topic, the various studies seek to establish or answer questions about bioceramics, such as:

1. whether or not they biomineralize at the bioceramic-dentin interface,
2. whether or not they can stimulate the growth of periodontal fibroblasts,
3. whether or not they can cause the differentiation of dental pulp cells, and
4. whether or not they are bioactive^{18,19}.

As a result, bibliometric indicators on this subject are established to provide numerical measures of the information obtained from the metric analysis of the scientific production associated with different fields of study²⁰⁻²³.

In this sense, the term "bibliometrics" refers to quantifying literature and other information media through mathematical calculation and statistics²⁴⁻²⁷. Shortly, it is linking quantitative techniques that can be used to describe and measure the scientific literature (number of publications, citations, etc.), with citation analysis, serving as the main tool for assessing the importance of scientific articles.

For its part, the field of scientometrics examines the numerical aspects of science and technology through communication²⁸⁻³⁰. That is, exemplifying the use of indicators for research and regulatory management, including citation, counting and delimitating scientific fields. Because of their shared focus on the quantitative aspects of exposing science, bibliometrics and scientometrics often work together.

Therefore, it is important to explain and represent the academic community's understanding of the role of biodentine in endodontics by organizing these data according to the year of publication, country, topic, document type, source, and authorship. Starting from this premise, the study aims to perform a bibliometric and scientometric analysis of the worldwide scientific literature on the role of biodentine in endodontics from 2013 to 2023.

2. Methods

In this bibliometric analysis of the studies published on the use of biodentine in endodontics between 2013 and 2023, qualitative and quantitative results are presented¹⁴. In addition, the information used was extracted from Elsevier's Scopus database.

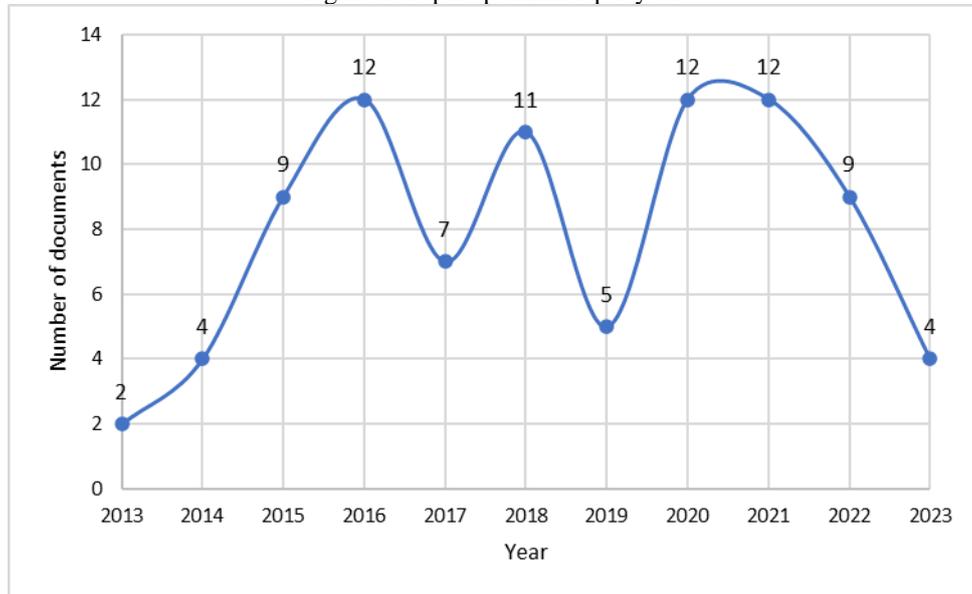
To start the information selection process, an exhaustive search was performed on the abstract, title or keywords of articles using the search terms "Biodentine" AND "Endodontic"^{31,32}. Subsequently, the resulting metadata was extracted using filters based on the descriptors applied, such as year of publication (2013-2023) and document type. To this end, a sample of 87 documents was extracted from the 151 articles and reviews that made up the primary data through duplicate exclusion and metadata normalization.

Finally, the correlation structure of the keywords (co-occurrence analysis) and other general aspects of the scientific production were analyzed. These included the year, source or journal, country of origin, author, type of document, subject area and institutional affiliation of the document's author. In addition, descriptive statistics were collected and analyzed in Excel, and the co-occurrence map data was visualized using VOSviewer V_1.6.19.

2. Results

The bibliometric and scientometric analysis made it possible to select 87 papers published in Scopus on the role of biodentine in endodontics between 2013 and 2023. Figure 1 shows the scientific researches of the first four years (2013-2016) amounting to twenty-seven articles, with a publication rate of 31%. Likewise, publications increased exponentially, with punctual oscillations, from 2017 onwards, by the end of the research period accounting for 69% (60 papers) of the total number of published papers.

Figure 1. Papers published per year.



Source: Scopus data (2023)

Table 1 shows the scientific researches from 33 countries, highlighting the regions with the most published studies on the subject under investigation. Eighty-four percent of the texts are written in English, and only 16% in Portuguese. Of

all the countries, Brazil has the highest percentage of scientific papers published (19%), followed by India (12%) and Turkey (11%).

Table 1. Publication of documents by country.

N°	Country	Ndoc	%	N°	Country	Ndoc	%
1	Brazil	21	19%	18	Egypt	1	1%
2	India	13	12%	19	Germany	1	1%
3	Turkey	12	11%	20	Guatemala	1	1%
4	Poland	7	6%	21	Japan	1	1%
5	Spain	6	6%	22	Lithuania	1	1%
6	United States	6	6%	23	Malta	1	1%
7	United Kingdom	5	5%	24	Mexico	1	1%
8	Italy	4	4%	25	Pakistan	1	1%
9	Belgium	3	3%	26	Palestine	1	1%
10	China	3	3%	27	Portugal	1	1%
11	Australia	2	2%	28	Romania	1	1%
12	Colombia	2	2%	29	Slovenia	1	1%
13	Denmark	2	2%	30	Switzerland	1	1%
14	France	2	2%	31	Switzerland	1	1%
15	Iran	2	2%	32	Venezuela	1	1%
16	Saudi Arabia	2	2%	33	Undefined	1	1%
17	Argentina	1	1%				
					Total Country	33	

Source: Scopus data (2023)

The scientific papers in the sample come from 45 different data sources. The journals that published the most articles related to the research field considered are listed in Table 2. The one that published the most papers was Materials nine (n=9) publications, Brazilian Oral Research six (n=6), Biomed Research International and Journal of Clinical and

Diagnostic five (n=5) each. In addition, there is a preponderance of high-impact sources among the Brazilian and British journals, with the majority appearing in the first and second quartile.

Table 2. Publication of documents by source or journal.

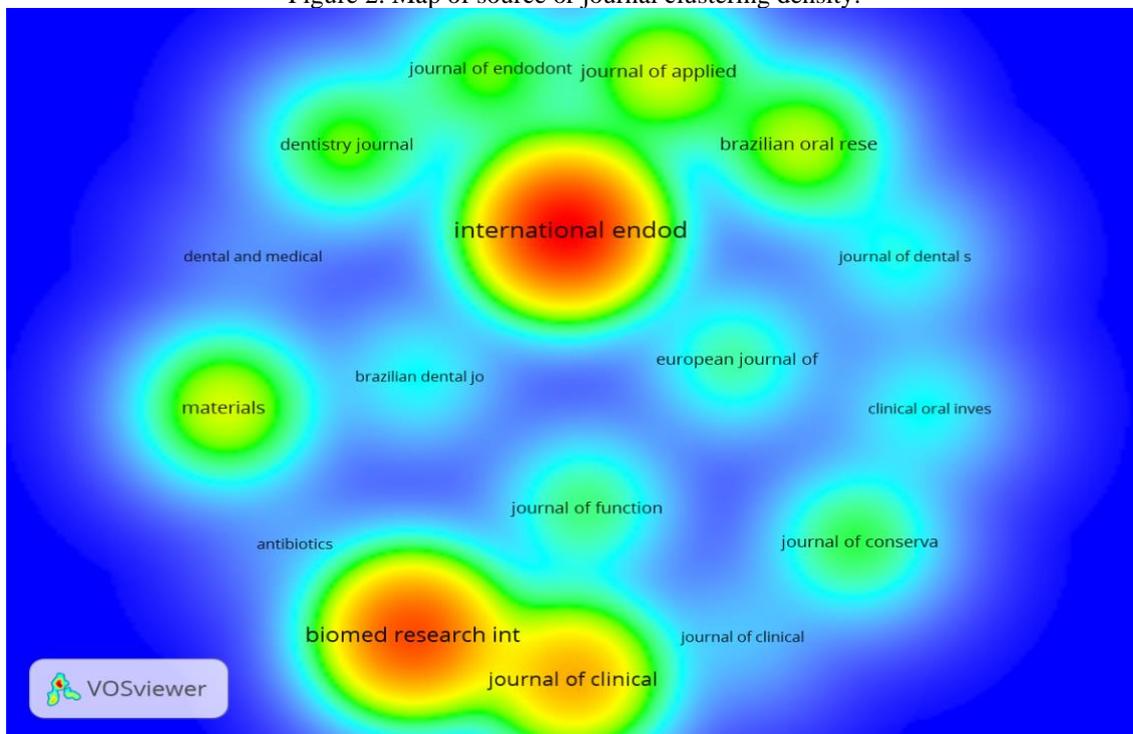
Source	Ndoc	Source	Ndoc	Source	Ndoc
Materials	9	European Journal of Dentistry	2	Dental Materials Journal	1
Brazilian Oral Research	6	Journal of Clinical and Experimental Dentistry	2	Dentomaxillofacial Radiology	1
Biomed Research International	5	Journal of Dental Sciences	2	Folia Médica	1
Journal of Clinical and Diagnostic Research	5	Journal of Functional Biomaterials	2	Indian Journal of Dental Research	1
Brazilian Dental Journal	4	Applied Sciences Switzerland	1	Indian Journal of Forensic Medicine and Toxicology	1
International Endodontic Journal	4	Arhiv Za Higijenu Rada I Toksikologiju	1	International Journal of Dentistry and Oral Science	1
Journal of Conservative Dentistry	4	BMC Oral Health	1	International Journal of Molecular Medicine	1
Journal of Applied Oral Science	3	Bioengineering	1	International Journal of Molecular Sciences	1
Journal of Endodontics	3	Biotechnology And Biotechnological Equipment	1	International Journal of Oral Science	1
Antibiotics	2	Brazilian Journal of Oral Sciences	1	Journal of Clinical Medicine	1
Clinical Oral Investigations	2	Clinical Case Reports	1	Journal of Dental Research	1
Dental and Medical Problems	2	Clujul Medical	1	Undefined	8
Dentistry Journal	2	Cumhuriyet Dental Journal	1	Total source	45

Source: Scopus data (2023)

A bibliographic clustering analysis was performed from the data published by the selected sources to establish the sets of sources or journals (Figure 2). Consequently, three main groups were determined: a first focus was the International Endodontic Journal (with 344 citations), followed by Biomed Research International (240 citations) and another

whose focus was Journal of Clinical and Diagnostic Research (with a citation of 132). Noticeably the sources that share a high number of citations with these journals tend to be paired according to the bibliographic cluster analysis.

Figure 2. Map of source or journal clustering density.



Source: Results in VOSviewer (2023)

In turn, the 87 papers were prepared by researchers from 154 universities. Figure 3 shows that during the selected study period, most of the papers on biodentine in endodontics were published by the Universidade Estadual Paulista Júlio de Mesquita Filho (n=9), followed by the Universidade de São Paulo (n=5). The Universitat de València, Universidade Federal do Rio Grande do Sul and Pomeranian Medical University in Szczecin have four scientific papers published each.

Figure 3. Documents published by institution.



Source: Scopus data (2023)

In total, 159 authors from 154 different institutions contributed to these papers. According to the data in Table 3, Tanomaru-Filho, M. is the author with the most scientific publications (6 in total) followed by Bosso-Martelo, R. and Torres, F.F.E., with four papers each.

Table 3. Published papers by author.

By author	Quantity	Ncit	By author	Quantity	Ncit
Tanomaru-Filho, M.	6	67	Sanz, J.L.	3	21

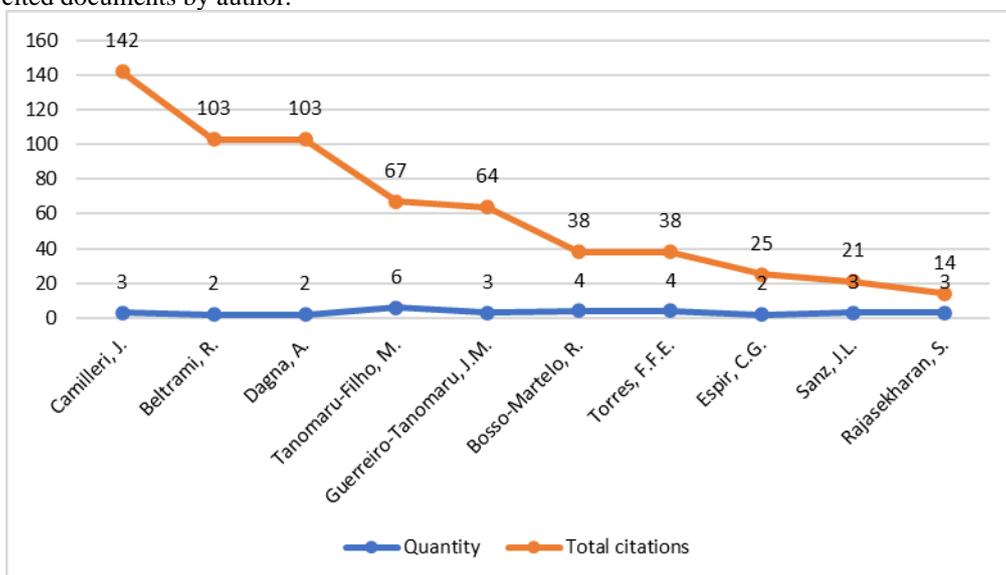
Bosso-Martelo, R.	4	38	Scarparo, R.K.	3	5
Torres, F.F.E.	4	38	Sipert, C.R.	3	3
Camilleri, J.	3	142	Beltrami, R.	2	103
Guerreiro-Tanomaru, J.M.	3	64	Chávez-Andrade, G.M.	2	13
Nogueira, F.N.	3	3	Dagna, A.	2	103
Nowicka, A.	3	11	Espir, C.G.	2	25
Rajasekharan, S.	3	14	Tanomaru-Filho, M.	6	67

Source: Scopus data (2023)

To complete the analysis of publications by author, a ranking of the most cited author was established (Figure 4) Camilleri, J. standing out with 142 citations, while Beltrami,

R. and Dagna, A. stand out on the second and third place with 103 citations each.

Figure 4. Most cited documents by author.



Source: Scopus data (2023)

Table 4 shows the publications generated throughout the study period (2013-2023) according to the purpose of dentistry use, and classifying them according to area or type. Data analysis shows that dentistry, biochemistry, genetics and molecular biology accounted for more than 52% of all the literature published within the 14 thematic areas assessed.

Table 4. Publication of documents by subject area and type.

By area	Quantity	%
Dentistry	48	39%
Biochemistry, Genetics and Molecular Biology	16	13%
Materials Science	14	11%
Medicine	11	9%
Immunology and Microbiology	10	8%
Engineering	7	6%
Pharmacology, Toxicology and Pharmacy	4	3%

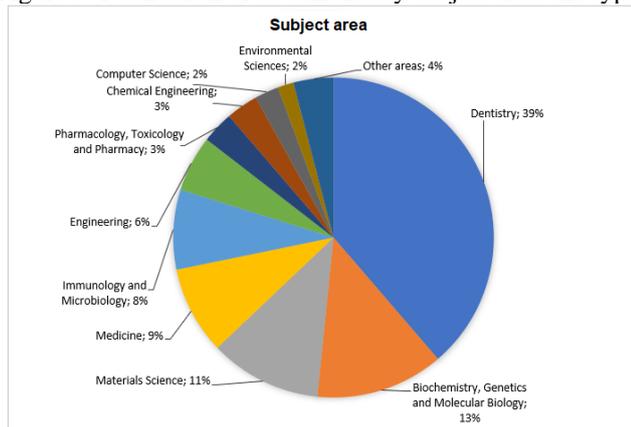
Chemical Engineering	4	3%
Computer Science	3	2%
Environmental Sciences	2	2%
Other areas	5	4%
Total	124	100%
Type of document	Quantity	%
Article	73	84%
Papers	14	16%
Total	87	100%

Source: Scopus data (2023)

Figure 5 shows that the area of dentistry accounted for 39% of all studies, followed by the fields of biochemistry, genetics and molecular biology (13%) and materials science (11%). Furthermore, when examining the publications according to the different types of documents created, it is observed that scientific articles represented the vast majority

of the publications (84%), whereas papers represented the remaining 16%.

Figure 5. Publication of documents by subject area and type.

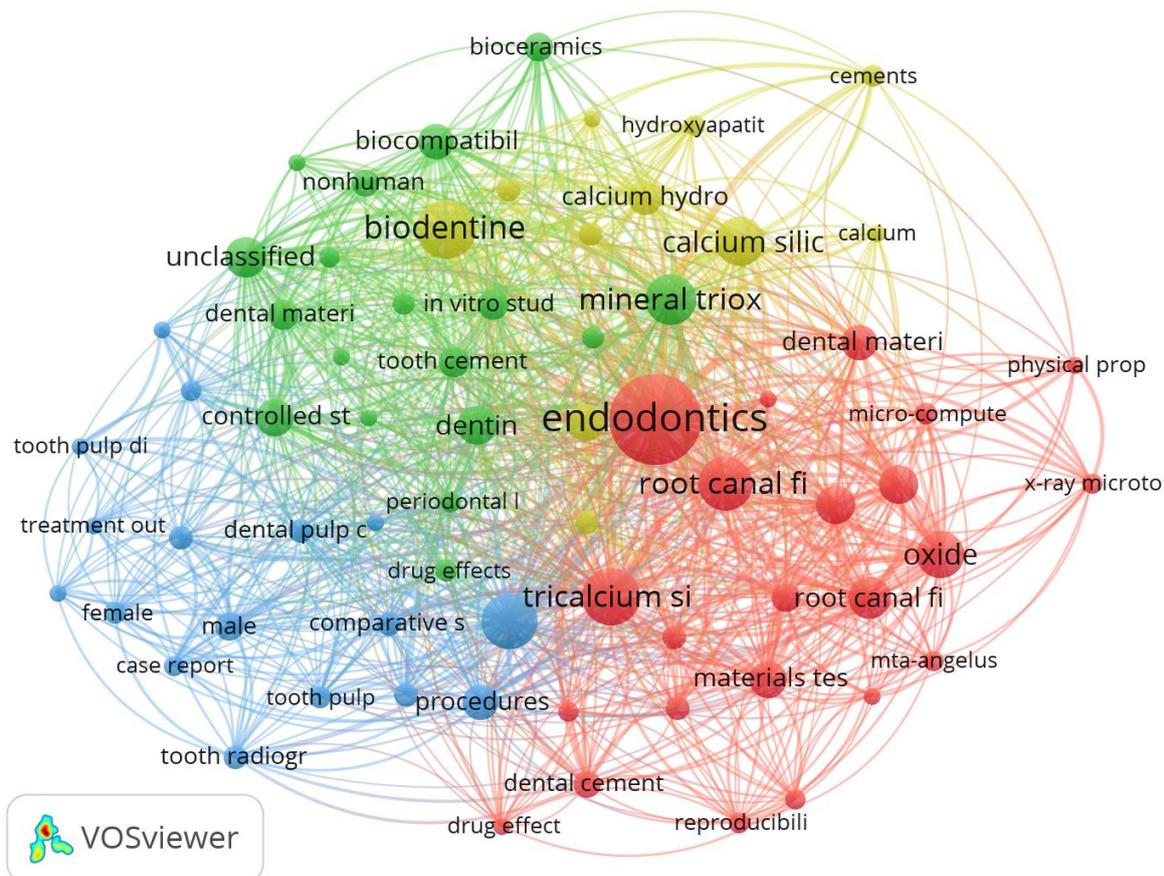


Source: Scopus data (2023)

Figure 6 shows the results of the keyword co-occurrence by selecting terms with more than three occurrences in the title, keywords and abstract fields. The degrees of connectedness calculated by VOSviewer were used to assign each colour to a set of words related to each other.

- Red cluster. "endodontics" clusters the following words: dental material, root canal filling, dental cement, reproducibility, oxide, MTA, x-ray microtomography, materials testing.
 - Yellow cluster. "biodentine", is integrated with the words: cements, calcium hydroxide, calcium silicate, and hydroxyapatite.
 - Green cluster. "mineral trioxide aggregate", refers to a group of related words including bioceramics, biocompatibility, non-human, dental material, dentin, periodontal ligament, dental cement, controlled study, in vitro study.
 - Blue cluster. "tricalcium silicate" is associated with the words: dental radiography, dental pulp disease, treatment outcome, comparative study, procedures, dental pulp, male, female, case report.
- The clusters show that the most frequently used terms are those intrinsically related to the subject of the study.

Figure 6. Map of keyword co-occurrence.



Source: Results in VOSviewer (2023)

2. Discussion

According to the results, the number of scientific papers that address the topic shows an increasing annual trend, where the years 2016, 2020 and 2021 together have the highest number of scientific papers published (n=36, representing 41%). According to Espinoza et al.,³¹ in recent years the amount of literature on the subject has increased. This is due to biodentine being used as a biological substitute material in endodontics for various procedures involving the repair, replacement and maintenance of dental tissues³²⁻³⁵.

Concerning the most relevant institutions by the number of publications, one Brazilian university stands out with nine publications, this being the Universidade Estadual Paulista Júlio de Mesquita Filho. Subsequently, Brazil was the country with the most scientific researches (19%), most of them written in English (84%). In addition, the author with the highest scientific production (n=6) was Tanomaru-Filho, M., from the Universidade Estadual Paulista. Most of the articles were published in two journals, *Materials* (n=9) and *Brazilian Oral Research* (n=6), whereas the *International Endodontic Journal*, *Biomed Research International* and *Journal of Clinical and Diagnostic Research*, had the highest impact factors.

According to Reynoso³⁶, global collaboration is essential for academic progress in the field of scientific studies. Biological replacement of dental structures and tissues is possible thanks to biodentine in endodontics, opening a wide range of possibilities for researchers in terms of treatment, including the implementation of tissue engineering and temporal and spatial assembly of stem cells, among others³⁷⁻³⁹. This helps researchers to meet the challenge of scientific research and to establish the mechanical qualities and rapid setting of biodentine as the material of choice for root and coronal dentin replacement.

Likewise, the publications analyzed stand out in the area of dentistry, however interdisciplinarity is observed in the area of: Biochemistry, Genetics and Molecular Biology, Materials Science, Medicine, among others. In addition, 84% of all the researches in terms of types of documents, were scientific articles. Concerning the keywords with the highest co-occurrence, they were "endodontics" and "biodentine", which constitute the basis of the study. Apart from these two terms, the other keywords -such as: "mineral trioxide aggregate" and "tricalcium silicate"- are not too far away from what the authors researched.⁴⁰⁻⁴²

Therefore, since biodentine has demonstrated its efficacy in numerous trials as a direct pulp capping material, the absence of staining in anterior teeth and the generation of an adequately configured dentin bridge while maintaining pulp vitality, the material was highly recommended by the available literature⁴³⁻⁴⁷. Finally, the keywords related to biodentine in endodontics point towards a multidisciplinary strategy.⁴⁸⁻⁵³ Thus, the co-occurrence network of terms reveals the salient content of articles and

research topics as a whole in the form of clusters^{54,55}. In this way, co-occurrence maps are illuminating because they show how different fields of study contribute to the genesis of scientific articles⁵⁶⁻⁵⁹.

2. Conclusions

The aim of the present study was to perform a bibliometric and scientometric analysis of the world scientific literature on the role of biodentine in endodontics from 2013 to 2023. The analysis of 87 articles published in the Scopus database between 2013 and 2023 on the role of biodentine in endodontics suggests that the characteristics, processes and applications of biodentine can be used in a wide variety of treatments. Moreover, sixty publications have been published since 2016, representing 69% of the total output, indicating a significant upturn in production. Moreover, of the 33 countries studied, Brazil is responsible for 13% (21 articles) of the total global scientific researches on this topic.

In addition, *Materials* based journals have published more articles than any other journal, with nine in total. In addition, the Universidade Estadual Paulista Júlio de Mesquita Filho has produced nine academic articles. For its part, Tanomaru-Filho, M. registered the highest number of studies (n=6), however, Camilleri, J. had more citations in published research on the subject. It was observed that the vast majority of the works are scientific articles (84%), focused on the area of dentistry (39%). Also, from the results of the keyword analysis carried out with the VOSviewer program, it was determined that "endodontics" and "biodentine" were the most frequently used terms.

Finally, it is concluded that the field of biodentine's role in endodontics has grown not only in terms of production and authorship but also in terms of scope in the various topics that tend to grow along with the advancement of medical research, biochemistry and materials studies, incorporating these resources in multiple scenarios and clinical settings. Also, since the importance of the subject promotes the creation of new scientific works, it is convenient to perform a comprehensive bibliometric and scientometric analysis of studies on calcium silicate-based biomaterials (Biodentine) to find out the latest advances in this field and recognize the contributions of emerging researchers.

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