



Lasers in Dentistry: A Scientometric Study From 2014-2023

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Abstract

Introduction: The use of lasers in dentistry has evolved significantly, becoming integral to various diagnostic and therapeutic procedures. The aim of the present study is to conduct a quantitative and qualitative analysis of scientific production on the application of lasers in dentistry in the Web of Science database over the past decade.

Methods: This is a scientometric study evaluating scientific documents indexed in the Web of Science database in the field of laser applications in dentistry up to the end of 2023, using quantitative and qualitative indicators. Data analysis was conducted using Excel and VOSviewer software.

Results: The graphs for article and citation growth showed a steady and steeper upward trend over the past ten years, respectively. The countries with the highest production, ranked first to third, were Brazil, the USA, and China, with the top two institutions also located in Brazil. The most prominent journals publishing studies on laser applications in dentistry, in order, were Journal of Prosthetic Dentistry, Clinical Oral Investigations, and BMC Oral Health. Aoki was the most-cited author, with 230 citations in a Q1 journal from Japan, though ranked sixth in terms of production. The highest scientific collaborations were observed in the USA, followed by Brazil and China. Although the Journal of Periodontology ranked ninth in terms of the number of publications, it ranked first in co-citation. In terms of thematic keyword analysis, six clusters were identified: low-power laser and photodynamic therapy in dentistry, antibacterial properties of laser in dentistry, laser applications in implant treatment, laser use in restorative treatments, laser applications for dental caries prevention, and laser use for pulp vitality assessment.

Conclusion: Researchers should stay regularly informed of ranking results to make more accurate decisions in research and clinical practices. Therefore, given these findings and the importance and saturation of various topics and their applications in dental practices, there is a need for institutions and researchers to reassess research priorities.

Keywords: Dentistry; Lasers; Scientometrics; Bibliometrics; Thematic analysis.



Introduction

Since the discovery of the laser, humanity has become familiar with new optical industries and their remarkable properties, which has opened the way for diverse scientific, industrial, medical, military, pharmaceutical, communication, and particularly dental research and applications. Today, it is believed that lasers represent the most significant step forward in dental services. Lasers have various applications in dentistry, and the scope of their use across different branches of dentistry is vast and diverse. Initial research on laser applications in dentistry began in 1960 and led to groundbreaking innovations in the field. Since then, there has been significant growth in studies on laser applications in dentistry. This vast amount of information requires deep analysis and review so that other researchers can benefit from these studies with more precision and higher quality.

Given the increasing production of scientific knowledge, evaluating scientific outputs in various fields has become an essential and undeniable task. One of the most common methods for assessing scientific production is scientometrics. Scientometrics is the science of measuring science, which evaluates knowledge progress through various methods and comparisons of researchers, groups, institutions, and countries. In 2012, Gutiérrez-Vela et al¹ conducted a scientometric study on the scientific production of the past 30 years in periodontal regenerative surgery. In 2017, Ganjipour² reviewed the collaboration indices of Iranian dentists in articles indexed in the Scopus database from 2010 to 2014. By studying 1282 documents, they found that the scientific output of Iranian dental researchers in the Scopus database during these years had been increasing. Additionally, the authors showed a growing tendency toward scientific collaboration and

group science production. Two years later, Ghaffari et al³ evaluated the scientific output of Iranian dental researchers from 2010 to 2017 in the ISC database. This study used co-occurrence keyword analysis, a form of content analysis and scientometric methods, to show that researchers most frequently focused on topics related to teeth and oral health. The topic of “dental plaque” was also identified as a new or less-researched topic in this field.

In 2020, Makkizadeh⁴ conducted a scientometric study on laser applications in the biomedical literature. In another study in 2022, Paschoal et al⁵ analyzed the top 100 most-cited articles on laser applications in dentistry with a bibliometric approach. Johari et al,⁶ who were interested in the use of calcium phosphate (CaP) as a mineral material to remineralize enamel and dentin in oral health care, also analyzed the scientific production in this field with bibliometric and scientometric approaches in the same year. Velasquez et al also conducted a bibliometric study on the scientific output related to artificial intelligence in dentistry in 2022. In 2023, many researchers, including Roghanizadeh et al,⁷ Mayta-Tovalino et al⁸, Erdinç,⁹ Salazar et al,¹⁰ Hamid et al,¹¹ and Mayta-Tovalino et al,¹² focused on dental journals and topics such as the use of activated carbon in oral health, graphene in dentistry, photobiomodulation (PBM) in dentistry, removable partial dentures in dentistry, and the use of probiotics in oral health. This year, Inchingolo et al¹³ and Alvitez-Temoche et al¹⁴ studied ceramic biomaterials and veterinary dentistry using scientometric approaches.

A review of the literature indicates that researchers have shown considerable attention, especially in the last five years, to various aspects of dentistry using bibliometric and scientometric approaches. However, there has been no comprehensive study examining the scientific output of laser applications in dentistry on such a large scale. As laser applications have recently attracted significant attention from researchers, this gap has been felt. Therefore, the researchers decided to conduct a quantitative and qualitative analysis of the past decade's scientific production on laser applications in dentistry using the Web of Science database.

Methods

This research is a scientometric study utilizing quantitative and qualitative indicators to evaluate scientific documents indexed in the field of laser applications in dentistry up to the end of 2023 in the Web of Science database.

Search Strategy and Data Extraction

Various search strategies were employed within the Web of Science database to retrieve relevant data. Ultimately, the best strategy, with minimal false positives and the most relevant findings, was used as follows:

$WC = (Dentistry, Oral\ Surgery \& Medicine) AND$

$(TI = (laser\ OR\ photobiomodulation\ OR\ PBM\ OR\ PBMT) OR\ AB = (laser\ OR\ photobiomodulation\ OR\ PBM\ OR\ PBMT))$,

where WC=Web of Science Category, TI=Title, and AB=Abstract.

The time range was set to a ten-year span (from 2014 to 2023) using the database filters. The research data was collected from May 5 to May 9, 2024. The data were normalized for lexical analysis.

Inclusion and Exclusion Criteria

Inclusion criteria: All global scientific studies from the last decade published in the Web of Science database.

Exclusion criteria: Studies from 2024 were excluded, as the year had not concluded. Additionally, non-English articles, conference papers, books, and irrelevant sources were removed.

Data Analysis

Data analysis involved descriptive statistics (frequency and percentage) using Excel software, while citation indicators (H-index, impact factor, scientific collaborations, etc.) and visualization of scientific networks were performed using VOSviewer software.

Figure 1 illustrates the stages of data collection and extraction, as well as the citation analysis and visualization process. The total number of documents reviewed in this study was 3578.

Results

The number of documents in the field of laser applications in dentistry over the past ten years amounts to 3578, with these documents receiving a total of 44,705 citations. The H-index for these documents is 72, indicating that 72 documents have received at least 72 citations each. The citation per document index is 12.49 (Table S1). According to Figure S1 and Figure 2, the citation per document index increased nearly 60-fold, from 0.37 in 2014 to 21.58 in 2023.

Figure S1 displays the publication trend in this field over the last 10 years. According to the figure, the highest and lowest numbers of articles were published in 2021 and 2017, with 461 and 250 articles, accounting for 12.88% and 6.9%, respectively. The overall trend of publications over these ten years is upward, with slight fluctuations from 2016 to 2017, where publication counts slightly decreased.

Figure 2 shows the citation trend for articles on laser applications in dentistry published in the Web of Science database from 2014 to 2023. According to the figure, the overall trend in citations is upward. The 3578 published articles in this field collectively received 44,705 citations (an average of 12.49 citations per article), with an H-index of 72. The highest number of citations received was for articles published in the last three years (2021, 2022, and 2023), with 8099, 8955, and 9560 citations, respectively.

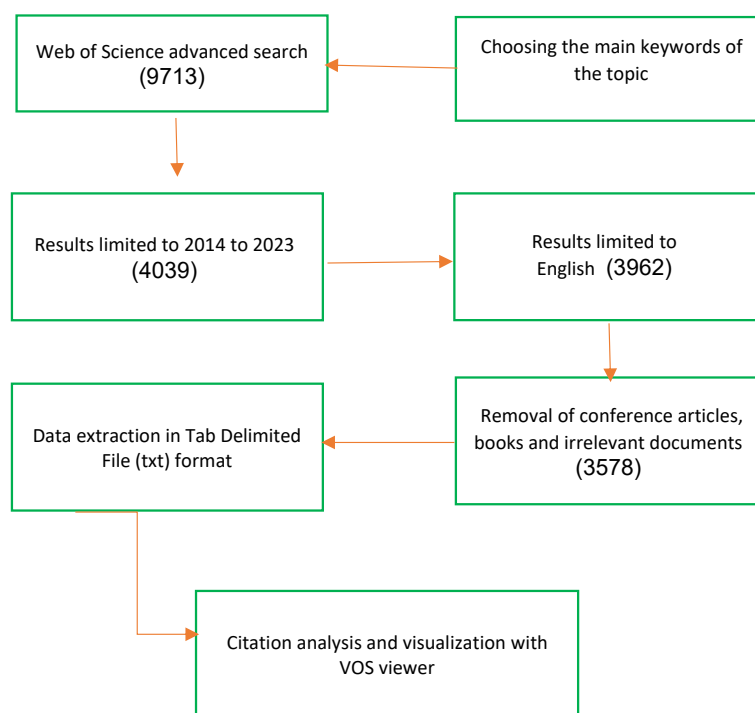


Figure 1. Steps of Data Collection

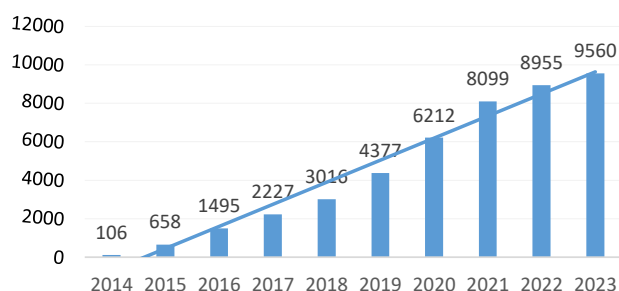


Figure 2. Distribution of the Frequency of Received Citations of Published Documents in the Field of Laser Application in Dentistry (2014-2023)

By comparing Figure S1 and Figure 2, we observe that, in terms of the citation per article index, citations have steadily increased from 2014 to 2023. The lowest citations were in the first three years under review, and the highest were in the last three years. Articles published in 2023 and 2022 have the highest citation per article index, with 21.58 and 19.72, respectively, while articles in 2015 and 2014 have the lowest citation per article index, with 2.30 and 0.37, respectively.

According to Table 1, which displays the top 10 core journals in laser applications in dentistry from 2014 to 2023, approximately 30% of the total 3578 articles were published in these journals (1077 articles). The *Journal of Prosthetic Dentistry*, *Clinical Oral Investigations*, and *BMC Oral Health* rank first, second, and third, with 190, 187, and 131 articles, respectively. Regarding citation impact, *Journal of Dentistry* has the highest impact factor (IF=4.8) among core journals. In terms of the H-index, *Journal of Endodontics* ranks the highest (H-Index=180),

indicating that this journal has 180 articles with at least 180 citations each. The list includes two Q2 and eight Q1 journals, with four published in the United States, three in the United Kingdom, and one each in the Netherlands, Japan, and Germany.

Table S2 shows the most active countries and institutions in the Web of Science database in the field of laser applications in dentistry from 2014 to 2023. Brazil ranks first with 575 articles (16.07% of the total), and the top-producing institutions (first, second, and fifth places) are also from Brazil. China ranks as the third most active country in this area. Turkey and Iran rank fourth and tenth, respectively, among contributing Middle Eastern countries. Egypt's *Egyptian Knowledge Bank (EKB)* is the third most productive institution in the Middle East.

Table 2 presents the most-cited articles (Top 10) on laser applications in dentistry, collectively receiving 1671 citations (3.73% of the total 44,705 citations). The most-cited articles, with 230, 219, and 177 citations, respectively, are *Periodontal and Peri-Implant Wound Healing Following Laser Therapy* by Aoki et al, *Selective Laser Melting Technique of Co-Cr Dental Alloys: A Review of Structure and Properties and Comparative Analysis with Other Available Techniques* by Koutsoukis et al, and *In Vitro Biocompatibility of CoCrMo Dental Alloys Fabricated by Selective Laser Melting* by Hedberg et al. Nine of these most-cited articles (90%) were published in Q1 journals, with one article in a Q3 journal.

Table S3 displays the most productive researchers in the field of laser applications in dentistry in the Web of Science database for the period under review. Three

Table 1. Ten Core Journals on the Use of Lasers in Dentistry (2014-2023)

Row	Journal's Name	Documents (N= 3578)		Publisher	Impact Factor (Quartile)	H-index	Country
		n	%				
1	Journal of Prosthetic Dentistry	190	5.310	Elsevier Inc.	4.3 (Q1)	149	United States
2	Clinical Oral Investigations	187	5.226	Springer Verlag	3.1 (Q1)	101	Germany
3	BMC Oral Health	131	3.661	BioMed Central Ltd	2.6 (Q1)	73	United Kingdom
4	Journal Of Endodontics	112	3.130	Elsevier Inc.	3.5 (Q1)	180	United States
5	Dental Materials	100	2.795	Elsevier Inc.	4.6 (Q1)	179	United States
6	Archives of Oral Biology	78	2.180	Elsevier Inc.	2.2 (Q2)	104	United Kingdom
7	Dental Materials Journal	75	2.096	Japanese Society for Dental Materials and Devices	1.9 (Q2)	70	Japan
8	Journal of Dentistry	75	2.096	Elsevier B.V.	4.8 (Q1)	139	Netherlands
9	Journal of Periodontology	65	1.817	John Wiley & Sons Inc.	4.2 (Q1)	178	United States
10	Journal of Prosthodontics Implant Esthetic and Reconstructive Dentistry	64	1.789	Wiley-Blackwell Publishing Ltd	3.4 (Q1)	80	United Kingdom

Table 2. Ten Highly Cited Articles on the Use of Lasers in Dentistry

Rank	Title	First Author (y)	Source Title (Quartile)	Total Citations	First Author's Affiliation/Country
1	Periodontal and peri-implant wound healing following laser therapy	Aoki, Akira (2015)	Periodontology 2000 (Q ₁)	230	Tokyo Medical & Dental University/Japan
2	Selective Laser Melting Technique of Co-Cr Dental Alloys: A Review of Structure and Properties and Comparative Analysis with Other Available Techniques	Koutsoukis, Theodoros (2015)	Journal of Prosthodontics-Implant Esthetic And Reconstructive Dentistry (Q1)	219	King Saud University/Saudi Arabia
3	In vitro biocompatibility of CoCrMo dental alloys fabricated by selective laser melting	Hedberg, Yolanda S. (2014)	Dental Materials (Q1)	177	Western University (University of Western Ontario)/Canada
4	A New Noninvasive Model to Study the Effectiveness of Dentin Disinfection by Using Confocal Laser Scanning Microscopy	Ma, Jingzhi (2011)	Journal of Endodontics (Q1)	167	Huazhong University of Science & Technology/China
5	Efficacy of low-intensity laser therapy in reducing treatment time and orthodontic pain: A clinical investigation	Doshi-Mehta, Gauri (2012)	American Journal of Orthodontics and Dentofacial Orthopedics (Q1)	164	Government Dental College & Hospital/India
6	Treatment of peri-implantitis using an Er:YAG laser or an air-abrasive device: a randomized clinical trial	Renvert, Stefan (2011)	Journal of Clinical Periodontology (Q1)	156	University of Hong Kong/ Hong Kong
7	Accuracy of a Digital Impression System Based on Parallel Confocal Laser Technology for Implants with Consideration of Operator Experience and Implant Angulation and Depth	Gimenez, Beatriz (2014)	International Journal of Oral & Maxillofacial Implants (Q3)	151	Academic Center for Dentistry Amsterdam/Netherlands
8	Antibiofilm activity of three irrigation protocols activated by ultrasonic, diode laser or Er:YAG laser in vitro	Neelakantan, P. (2015)	International Endodontic Journal (Q1)	149	University of Hong Kong/ Hong Kong
9	Defects-tolerant Co-Cr-Mo dental alloys prepared by selective laser melting.	Qian, B. (2015)	Dental Materials (Q1)	138	Stockholm University/Sweden
10	Metallurgical and interfacial characterization of PFM Co-Cr dental alloys fabricated via casting, milling or selective laser melting	Al Jabbari, Y. S. (2014)	Dental Materials (Q1)	120	King Saud University/Saudi Arabia

researchers, each with 21 articles, share the third place. The most active researcher (ranked first) is *Junji Tagami* from Tokyo Medical and Dental University in Japan, with 31 articles (0.866% of the total). This list includes three Japanese researchers, two from Italy, two from Brazil, and two from the USA. All three Japanese researchers are affiliated with Tokyo Medical and Dental University.

In total, 14,136 authors contributed to 3578 articles, with 2498, 224, and 37 authors co-authoring at least 2, 5, and 10 articles, respectively. According to [Figure S2](#), the seven authors with the highest number of co-authorships

were Tagami, Aoki, Shimada, Guarnieri, Mizutani, Palaia, and Taniguchi, with link strengths of 82, 61, 57, 50, 48, 48, and 48, respectively.

[Figure S3](#) illustrates the co-authorship network among countries in the field of laser applications in dentistry. Researchers from 90 countries collaborated on 3578 articles. Among them, authors from 84, 66, and 52 countries co-authored at least 2, 5, and 10 articles, respectively. According to the figure, most collaborations occurred between researchers in the United States, Brazil, China, the United Kingdom, and Italy, with total link

strengths of 478, 200, 172, 150, and 141, respectively.

Figure S4 and Figure S5 illustrate the co-citation network of authors and sources cited by articles on laser applications in dentistry published in the Web of Science database from 2014 to 2023. A total of 48,399 authors and 9749 sources were cited in the 3,578 reviewed articles. Among them, 18,395, 5620, 2196, and 760 authors were cited at least 2, 5, 10, and 20 times, respectively. Additionally, 3998, 1791, 1007, and 563 sources were cited at least 2, 5, 10, and 20 times, respectively. Due to high overlapping, some authors and sources are not visible on the map. The top three referenced authors are Schwarz, Aoki, and Renvert, with link strengths of 15,200, 5430, and 4573, respectively. The top five journals, in order of citations received, are *Journal of Periodontology*, *Journal of Lasers in Medical Sciences*, *Journal of Clinical Periodontology*, *Journal of Endodontics*, and *Dental Materials*. All journals are indexed in the Web of Science, with four in the Q1 category and impact factors of 4.2, 5.8, 3.5, and 4.6, respectively. The second journal is part of the ESCI, with no Q ranking.

Thematic Analysis

In total, 6,086 unique keywords were used by authors of 3578 articles published in the Web of Science database. A total of 1673, 958, 482, and 200 keywords appeared at least 2, 3, 5, and 10 times, respectively. In Figure 3, keywords with a threshold of 10 occurrences were included to map the clustering of themes. After creating a thesaurus and normalizing keywords, we redrew the co-occurrence keyword map. Larger circles represent more frequently

repeated keywords. The map shows six clusters in red, green, blue, yellow, purple, and light blue. Table 3 displays the color, cluster number, related keywords in each cluster, their frequency, and the main concept of each cluster. As observed, Cluster 1 consists of studies that use low-power lasers and photodynamic therapy in dentistry. Cluster 2 relates to studies focusing on the antibacterial properties of lasers in dentistry. Cluster 3 refers to the application of lasers in implant treatment. Cluster 4 is associated with laser applications for restorative treatments. Cluster 5 involves the use of lasers in preventing dental caries, and studies in Cluster 6 explore the application of lasers in assessing pulp vitality.

Table S4 shows the 20 most frequent keywords in article titles, with the top five keywords appearing over 100 times: *lasers*, *low-level laser therapy*, *biofilms*, *dental implants*, and *diode lasers*, with 346, 198, 170, 162, and 111 occurrences, respectively.

Figure S6 represents a chronological (time-based) mapping of frequently used keywords. The color bar below the map serves as a guide to indicate the time frame when specific keywords were most prominent. The most frequently occurring keywords date from 2018 to 2020. Dark blue keywords were prominent in early 2018, light blue keywords from mid-2018 to mid-2019, dark and light green keywords from mid-2019 to late 2019, and yellow keywords became most prevalent from late 2019 onwards. The results of the map indicate that during the study period (2014–2023), articles published in the Web of Science database on laser applications in dentistry primarily featured keywords such as *lasers*, *low-level laser*

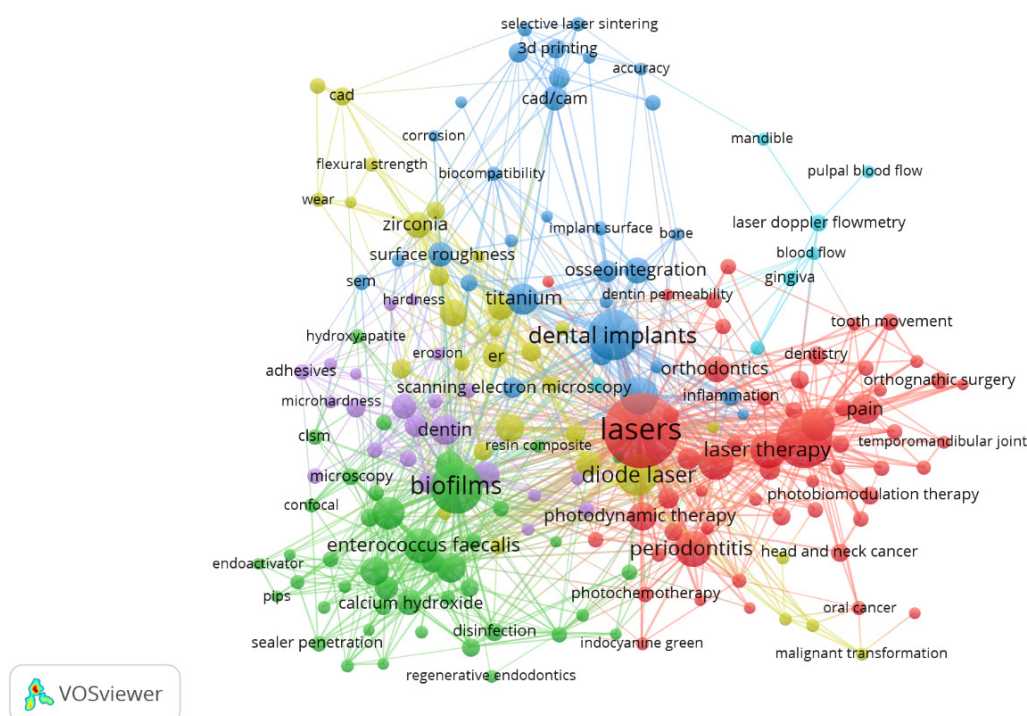


Figure 3. Clustering of Keywords in Articles Related to the Use of Lasers in Dentistry (2014–2023)

Table 3. Clustering of Keywords of Articles Related to the Use of Laser in Dentistry (2014-2023)

Cluster	Keywords	Main Concept
1	Lasers, low level laser therapy, periodontitis, laser therapy, systematic review, photobiomodulation, pain, photodynamic therapy, orthodontics, meta-analysis, periodontal diseases, wound healing, photobiomodulation therapy, head and neck cancer, oral lichen planus, radiotherapy, dentistry, chronic periodontitis, orthognathic surgery, surgery, clinical trial, quality of life, tooth movement, dentin hypersensitivity, porphyromonas gingivalis, temporomandibular disorders, treatment, oral surgery, oral mucositis, photochemotherapy, dentin sensitivity, bone regeneration, tooth bleaching, saliva, tooth extraction, ...	Use of low power laser and photodynamic therapy in dentistry
2	Biofilms, enterococcus faecalis, confocal laser scanning microscopy, endodontics, sodium hypochlorite, streptococcus mutans, calcium hydroxide, irrigation, chlorhexidine, antimicrobial, disinfection, root canal, confocal microscopy, edta, microscopy, antibacterial, mineral trioxide aggregate, candida albicans, bacteria, smear layer, clsm, nanoparticles, regeneration, sealer penetration, confocal, dental tubules, hydroxyapatite, ultrasonic, regenerative endodontics, confocal laser scanning microscope, root canal irrigants, dentine, laser-activated irrigation, chitosan	Use of antibacterial properties of lasers in dentistry
3	dental implants, peri-implantitis, titanium, osseointegration, surface roughness, cad/cam, decontamination, implants, selective laser melting, scanning electron microscopy, 3d printing, additive manufacturing, inflammation, surface properties, sem, computer-aided design, implant surface, removable partial denture, biocompatibility, selective laser sintering, cytotoxicity, bone, accuracy, laser sintering, peri-implant mucositis, peri-implant diseases, laser treatment, mucositis, fibroblasts, corrosion, mechanical properties	Use of lasers in implant treatment
4	diode laser, er:yag laser, shear bond strength, zirconia, bond strength, co2 laser, er, resin cement, yag laser, nd:yag laser, er:cr:ysgg laser, surface treatment, erbium laser, cad, nd, adhesion, primary teeth, cam, microleakage, wear, flexural strength, recurrence, laser surgery, oral leukoplakia, ysgg laser, scanning electron microscope, malignant transformation, microtensile bond strength, frenectomy, lithium disilicate	Using lasers for restorative treatments
5	Dentin, dental caries, enamel, fluoride, caries, remineralization, optical coherence tomography, dental enamel, Fluorescence, laser fluorescence, demineralization, adhesives, prevention, tooth remineralization, microhardness, tooth wear, composite resin, ozone, erosion, white spot lesions, dental bonding, hardness	The use of lasers in the prevention of tooth decay
6	laser doppler flowmetry, gingiva, temperature, dental pulp, blood flow, pulpal blood flow, mandible	Using a laser to determine the life of the dental pulp

therapy, biofilms, dental implants, and diode lasers, which are highlighted in green and greenish-yellow on the map. The color guide of the map indicates that these keywords became most common after 2019. Additionally, upon examining [Table 3](#) and [Figure 3](#), each of these frequent keywords can be categorized across the six thematic clusters.

Discussion

The total number of reviewed documents in the field of laser applications in dentistry over the past decade is 3578, with these documents receiving 44,705 citations. The H-index of these documents is 72. In a study by Asgary et al¹⁵ on the scientometric analysis of dentistry articles by Iranian authors published in PubMed, a total of 3835 articles were reviewed. The citation per document index in the current study is 12.49. Based on [Figure S1](#) and [Figure 2](#), the citation per document index has increased nearly 60-fold, from 0.37 in 2014 to 21.58 in 2023. The findings of this study contrast with those of Mayta-Tovalino et al, who conducted a bibliometric analysis of scientific publications from 2013 to 2022 on the use of probiotics in oral health from a scientometric approach. In that study, the average citations per article gradually decreased, from 32.44 in 2013 to 2.41 in 2022. Since the metadata of scientific articles was retrieved from the core Web of Science collection, the comparison accuracy was enhanced. In other words, both the current study's data and Mayta-Tovalino and colleagues' study data were derived from the WoS dataset, and the calculation methods for the indicators were the same. Velasquez

et al analyzed the bibliometric characteristics, impact, and perspectives of scientific publications on artificial intelligence in dentistry in 2022. The findings showed that the number of publications in indexed scientific journals increased from 2017 to 2022.¹⁶ In 2017, Ganjipour² studied the collaboration indices of Iranian dentists in articles indexed in Scopus from 2010 to 2014. In their review of 1282 documents, they found that Iranian dental authors' scientific output in Scopus increased over the specified years. Alvitez-Temoche and colleagues' study, conducted from 1990 to 2023, aimed to analyze the academic literature on veterinary dentistry using a descriptive approach with scientometric methods and metadata from the Web of Science database.¹⁴ The average citation per article was 4.55 in Mayta-Tovalino and colleagues' study, the average citations per document were 15.2.⁸

The highest and lowest numbers of articles were published in 2021 and 2017, with 461 and 250 articles (12.88% and 6.9%), respectively. The overall trend of publications over the past decade has been upward, except for minor changes between 2016 and 2017, when there was a slight decrease. The overall citation trend has also been upward. The 3578 articles published in this field received a total of 44,705 citations, with an H-index of 72. The articles published in the last three years received the highest number of citations. In the current study, the growth rate of publications from 2014 to 2023 was approximately 1.5 times, while the citation growth rate was almost 60 times. This result contrasts with Asgari and colleagues¹⁵ research, which showed a sevenfold increase in publications indexed by PubMed between

2008 and 2015. Studies by Ghaffari et al³ and Naraghian and Mohammadesmail,¹⁷ which analyzed the scientific output of Iranian researchers, also found a growing trend in dental research publications, aligning with the present study's findings. In Mayta-Tovalino and colleagues' study, the number of published articles gradually increased from 2013 to 2022.¹² In 2023, Erdinç conducted a scientometric study to analyze leading countries, preferred journals, common keywords, and the most productive authors in the field of graphene. The study showed a significant increase in the number of published articles and a steady increase in citations.⁹ In 2022, Saiff Johari et al. conducted a bibliometric and scientometric analysis on the application of CaP as a mineral for enamel and dentin remineralization in oral health care. The findings indicated that the highest number of CaP-related articles was published over the past decade, providing insights into past trends and recent developments in CaP applications in oral care,⁶ which aligns with the present study. Makkizadeh,⁴ in an analytical approach identifying research areas and revealing the intellectual structure of knowledge in laser research in the biomedical literature from 2009 to 2018, demonstrated a steady growth in laser research.

In the current study, the top ten journals identified in the field of laser applications in dentistry include *Journal of Prosthetic Dentistry*, *Clinical Oral Investigations*, *BMC Oral Health*, *Journal of Endodontics*, *Dental Materials*, *Archives of Oral Biology*, *Dental Materials Journal*, *Journal of Dentistry*, *Journal of Periodontology*, and *Journal of Prosthodontics Implant Esthetic and Reconstructive Dentistry*. The findings align with Zeraatkar and colleagues' study,¹⁸ which noted the use of *Journal of Endodontics* by researchers. A study by Gutiérrez-Vela et al in 2012 identified *Journal of Periodontology* and *Journal of Clinical Periodontology* as the core journals in periodontal regenerative surgery, ranking 14th and 1st, respectively, in their field's citation reports.¹ Hamid et al¹¹ performed a bibliometric analysis in 2023 on studies related to removable partial dentures in dentistry, where *Journal of Prosthetic Dentistry*, *Journal of Oral Rehabilitation*, and *Journal of Prosthetic Research* were among the preferred journals. In 2023, Roghanizadeh et al conducted a bibliometric study on the 101 most-cited dental articles from Middle Eastern and North African countries published between 2011 and 2021. *European Journal of Dentistry* from Turkey, *Journal of Saudi Dentistry* from Saudi Arabia, *Journal of Endodontics* in Iran, and *Journal of Laser in Medical Sciences* from Iran held the highest SCImago rankings and bibliometric scores among MENA dental journals.⁷ Eghbal et al¹⁹ identified five top-ranked endodontics journals indexed by PubMed in the field of endodontics: *Oral Surgery*, *Oral Medicine*, *Oral Pathology*, *Oral Radiology*, and *Endodontics*, *Journal of Endodontics*, *International Endodontic Journal*, *Endodontics* and

Dental Traumatology, and *Australian Endodontic Journal*. Velasquez et al found that most high-output journals were from the United States and the United Kingdom, with *Journal of Dental Research* having the highest impact (14.9 citations per publication) and the most publications.¹⁶ Due to the variety of fields within dentistry studied in these articles, a diverse range of journals is used by researchers. In Erdinç's study, *Dental Materials* had the highest publication count,⁹ while in Hamid and colleagues' study, *Journal of Prosthetic Research* showed the highest average normalized citation rate.¹¹

According to the results of the current study, Brazil is the most productive country in this field, and the most productive institutions (ranking first, second, and fifth) also belong to this country. The United States ranks second, and China is the third most active country in laser applications in dentistry publications. Turkey and Iran rank fourth and tenth, respectively, among the most productive countries in the Middle East in this field, with the *Egyptian Knowledge Bank (EKB)* being the third most productive institution in Egypt in the Middle East. In Ganesh's study,²⁰ the United States and Brazil had the highest number of publications. The findings of the current study align with Ganesh's study, although with a reversed ranking for the first and second positions. In the study by Taghdissi Kashani et al,²¹ University College London and the University of Bern had the highest publication counts, and the United States and the United Kingdom were the most productive countries, with Brazil ranking third. This ranking does not align with the findings of the current study. Iqbal et al¹⁹ confirmed that significant differences exist in root-related scientific publications across countries in the neighboring, Middle Eastern, Central Asian, Caucasian, and EMRO regions, with Turkey ranking first in the total number of articles, followed by Israel, Iran, Jordan, and Saudi Arabia. Velasquez et al also found that the United States is the country with the most published articles, while *Charité - Universitätsmedizin Berlin* in Germany exhibited the highest expected performance relative to the global average.¹⁶ In Mayta-Tovalino's study, the top-producing countries were the United States, Italy, and China.⁸ Erdinç found that Singapore and China were the leading countries for published articles.⁹ Johari et al also identified the United States, China, and India as the top three productive countries.⁶ Paschoal et al reported that most articles originated from Europe and Anglo-Saxon America.⁵

The most-cited articles, with 230, 219 and 177 citations respectively, were *Periodontal and Peri-Implant Wound Healing Following Laser Therapy* by Aoki et al., *Selective Laser Melting Technique of Co-Cr Dental Alloys: A Review of Structure and Properties and Comparative Analysis with Other Available Techniques* by Koutsoukis et al, and *In Vitro Biocompatibility of CoCrMo Dental Alloys*

Fabricated by Selective Laser Melting by Hedberg et al. Four of these articles were published in 2015, and three in 2014, with 90% of the most-cited articles published in Q1 journals. The list also includes one Q3 journal. Aoki et al's article, ranked first in this study, was ranked 95th in Paschoal and colleagues' study⁵ with 129 citations. This substantial difference may be attributed to the different strategies used and the time frame covered. Three researchers with 21 articles each occupy the third position in productivity. The most active researcher, *Junji Tagami* from Tokyo Medical & Dental University in Japan, published 31 articles. The list includes three Japanese researchers, two Italian researchers, two Brazilian researchers, and two American researchers, with all three Japanese researchers affiliated with Tokyo Medical & Dental University. Taghdissi Kashani et al²¹ analyzed the bibliometrics and visualization of top dental articles from 2012 to 2022 based on ESI indicators. Their findings identified Mariano Belin Sanz from Spain and Maurizio S. Tonetti from China as the top two authors, which does not align with the results of the current study. In 2023, Erdinç conducted a scientometric analysis to identify leading countries, preferred journals, commonly used keywords, and the most productive authors in the field of graphene. Dr. Roza, who had the highest number of citations, is identified as the most influential author.⁹ In Hamid and colleagues' study, the most impactful authors with the highest number of citations were from Japan. Velasquez et al conducted a bibliometric analysis in 2022, examining the characteristics, impact, and perspectives of scientific publications in the field of artificial intelligence in dentistry, where Krois Joachim from Germany was identified as the author with the highest performance.¹¹

In total, 14,136 authors collaborated on 3578 articles. Among them, 2498, 224, and 37 authors co-authored at least 2, 5, and 10 articles, respectively. The top seven co-authors were Tagami, Aoki, Shimada, Guarnieri, Mizutani, Palaia, and Taniguchi. According to the chart, the highest collaborations were among authors from the United States, Brazil, China, the United Kingdom, and Italy.

Figure S4 and Figure S5 display the co-citation network of authors and sources referenced by articles in the field of laser applications in dentistry published in the Web of Science database from 2014 to 2023. A total of 48,399 authors and 9749 sources were cited in the 3578 reviewed articles. Among them, 18,395, 5620, 2196, and 760 authors were cited at least 2, 5, 10, and 20 times, respectively, while 3998, 1791, 1007, and 563 sources were cited at least 2, 5, 10, and 20 times. Due to substantial overlap, some authors and sources are not visible on the map. The three most-referenced authors were Schwarz, Aoki, and Renvert. In a 2023 study by Hamid et al. analyzing the research areas in removable partial denture (RPD) studies, Wakabayashi and Fueki were the most prominent researchers, based

on three-field plot analysis.¹¹ The top five core journals cited by reviewed articles are *Journal of Periodontology*, *Journal of Lasers in Medical Sciences*, *Journal of Clinical Periodontology*, *Journal of Endodontics*, and *Dental Materials*, all indexed in the Web of Science. Four of these journals are in the Q1 quartile, with impact factors of 4.2, 5.8, 3.5, and 4.6, respectively. The second journal is listed in ESCI without a quartile rank.

In total, 6086 unique keywords were used by authors of the 3578 articles published in the Web of Science database. The five most frequently appearing keywords in article titles, each used over 100 times, are lasers, low-level laser therapy, biofilms, dental implants, and diode lasers. The keyword map results indicate that these keywords have become more prominent since 2019. Furthermore, the findings indicate six thematic clusters, with the most focus on clusters related to "low-power laser use and photodynamic therapy in dentistry," "antibacterial properties of lasers in dentistry," and "laser use in implant treatment." In contrast, the least attention was given to the cluster on "laser use in pulp vitality assessment". Huang et al²² performed a bibliometric analysis of recent trends (2010 to 2019) in dental implant research. Overall, 72 high-frequency keywords were extracted from selected articles, identifying four clusters and seven subcategories through dual clustering analysis in dental implant research. The survival rate of dental implants and subsequent restoration has consistently been a core focus of research. Sinus lift and guided bone regeneration, due to their reliability, are recommended for further exploration. In 2023, Erdinç⁹ conducted a scientometric analysis of commonly used keywords in graphene studies. Graphene has been widely studied in dentistry across various materials, with graphene, graphene oxide, and peri-implantitis as the most frequently used keywords. In 2023, Hamid et al¹¹ conducted a bibliometric analysis on studies related to removable partial dentures in dentistry, identifying CAD/CAM and 3D printing as emerging themes from 2020 to 2022, while selective laser melting was a popular keyword from 2017 to 2019. Research on "oral health and quality of life" was identified as a primary research area in studies related to RPD. Taghdissi Kashani et al²¹ analyzed the co-occurrence of keywords, finding that the most common keywords in the field of dentistry were periodontitis, dental implant, periodontal disease, mechanical properties, peri-implantitis, oral health, dental caries, dental materials, and 3D printing. Makkizadeh's study,⁴ which took an analytical approach to identify research areas and uncover the intellectual structure of knowledge in laser research within the biomedical literature from 2009 to 2018, showed that the most common keywords in the laser field were lasers, solid-state, laser therapy, and lasers, excimer, among others. The cluster analysis results shaped laser-related concepts into seven clusters, with the lasers, excimer cluster being well-developed and highly

influential, while clusters such as photo-chemotherapy, skin diseases with an emphasis on lasers, gas, laser effects, laser dentistry, and corneal surgery, laser were relatively underdeveloped. In 2022, Paschoal et al⁵ examined the 100 most-cited articles on laser applications in dentistry using a bibliometric perspective. Most of these articles focused on lasers in surgery and medical sciences and on lasers in restorative dentistry and periodontics. Salazar et al¹⁰ conducted a systematic review of recent trends in PBM in dentistry from 2018 to 2022, showing that scientific production on PBM follows a power-law growth pattern, exhibiting exponential and linear growth phases. Notably, recent research trends emphasize critical concepts like laser therapy, orthodontics, and dental pulp stem cells, highlighting the growing interest in using PBM as a complementary alternative in dental practices. In Hamid and colleagues' study¹¹ analyzing research areas in published articles on RPD research, they found that from 1948 to 1999, most laboratory and clinical research focused on the fundamental concept of RPD using cobalt-chromium as a framework, which shifted to titanium in 2000. After 2012, RPD research has focused on new technology and non-metallic frameworks as alternatives.¹¹

Conclusion

In summary, this quantitative and qualitative scientometric analysis provides insightful perspectives on the application and trends of lasers and their methods in dentistry. In recent years, there has been an increasing interest in laser applications in dentistry, as reflected by the growth charts of publications and citations. Most articles were published by authors from Brazil, the USA, and China, with the top two institutions also located in Brazil. Major journals publishing studies on laser applications in dentistry included *Journal of Prosthetic Dentistry*, *Clinical Oral Investigations*, and *BMC Oral Health*. The USA leads in scientific collaborations, followed by Brazil and China, indicating that the USA has a considerably higher level of international collaboration compared to Brazil and China.

In terms of thematic keyword analysis, the application of lasers in dentistry and the level of attention given by researchers to these topics, based on cluster volume, includes low-power laser and photodynamic therapy, antibacterial properties of lasers, laser applications in implant treatment, laser use in restorative treatments, laser use in preventing dental caries, and laser applications in pulp vitality assessment. Emphasis has been placed on the importance of international collaboration, which leads to high-quality studies and citations and promotes the widespread use of low-level lasers in daily dentistry practices.

Therefore, considering the importance and saturation of these thematic areas and their applications in dental

practices, there is a need for institutions and researchers to reassess research priorities.

Authors' Contribution

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Competing Interests

None declared.

Ethical Approval

This project was approved by Ahvaz Jundishapur University of Medical Sciences under IR.AJUMS.REC.1401.509 ethical code.

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Supplementary files

Supplementary file 1 contains Tables S1-S4 and Figures S1-S6.

References

- Gutiérrez-Vela MM, Díaz-Haro A, Berbel-Salvador S, Lucero-Sánchez A, Robinson-García N, Cutando-Soriano A. Bibliometric analysis of research on regenerative periodontal surgery during the last 30 years. *J Clin Exp Dent*. 2012;4(2):e112-8. doi: [10.4317/jced.50646](https://doi.org/10.4317/jced.50646).
- Ghazi Mirsaied SJ, Ganjipour Z. A survey on scientific collaboration of Iranian researchers in the field of dentistry in the Scopus during 2010-2014. *J Dent Med*. 2017;30(2):111-9. [Persian].
- Ghaffari S, Zakiani S, Mirnejad F, Akbari P. Assessment and evaluation of scientific output of Iranian dental researchers during 2010-2017 in ISC. *J Res Dent Sci*. 2019;16(4):295-302. doi: [10.29252/jrds.16.4.295](https://doi.org/10.29252/jrds.16.4.295). [Persian].
- Makkizadeh F. An analysis of laser researches in biomedicine literature with a scientometric approach. *Int J Inf Sci Manag*. 2020;18(2):189-201.
- Paschoal MA, Belém FV, Clementino LC, Martins-Júnior PA. Application of lasers in dentistry: a bibliometric study of the top 100 most-cited papers. *Braz Oral Res*. 2022;36:e104. doi: [10.1590/1807-3107bor-2022.vol36.0104](https://doi.org/10.1590/1807-3107bor-2022.vol36.0104).
- Johari AS, Zulkepli NA, Tarmizi NH, Mokhtar N, Sarmoko. Application of calcium phosphate as remineralizing agent in oral healthcare: a bibliometric and scientometric analysis. *Healthscope*. 2022;5(2):45-55.
- Roghanizadeh L, Akbarzadeh Baghban A, Azizzadeh J, Asgary S. A bibliometric study on the top 101 most-cited articles of dental journals of the Middle East/North Africa countries from 2011 to 2021. *J Lasers Med Sci*. 2023;14:e15. doi: [10.34172/jlms.2023.15](https://doi.org/10.34172/jlms.2023.15).
- Mayta-Tovalino F, Espinoza-Carhuanchi F, Alvitez-Temoche D, Mauricio-Vilchez C, Munive-Degregori A, Barja-Ore J,

- et al. Dynamicity, emerging patterns, and spatiotemporal trends of scientific production on the use of activated carbon in oral health: a scientometric study. *BMC Oral Health*. 2023;23(1):668. doi: [10.1186/s12903-023-03375-3](https://doi.org/10.1186/s12903-023-03375-3).
9. Erdinc G. Graphene on dentistry: a bibliometric and scientometric analysis. *Niger J Clin Pract*. 2023;26(1):65-72. doi: [10.4103/njcp.njcp_246_22](https://doi.org/10.4103/njcp.njcp_246_22).
 10. Rodriguez Salazar DY, Málaga Rivera JA, Laynes Effio JE, Valencia-Arias A. A systematic review of trends in photobiomodulation in dentistry between 2018 and 2022: advances and investigative agenda. *F1000Res*. 2023;12:1415. doi: [10.12688/f1000research.140950.2](https://doi.org/10.12688/f1000research.140950.2).
 11. Abdul Hamid NF, Ariffin F, Ahmad R. A bibliometric analysis of removable partial denture-related research in dentistry. *Arch Orofac Sci*. 2023;18(2):103-24. doi: [10.21315/aos2023.1802.RV03](https://doi.org/10.21315/aos2023.1802.RV03).
 12. Mayta-Tovalino F, Espinoza-Carhuancho F, Alvitez-Temoche D, Calderon I, Munive-Degregori A, Barja-Ore J, et al. A 10-year scientometric study of the emerging patterns and spatial-temporal trends of probiotics in dentistry. *J Contemp Dent Pract*. 2023;24(12):981-6. doi: [10.5005/jp-journals-10024-3617](https://doi.org/10.5005/jp-journals-10024-3617).
 13. Inchingolo F, Inchingolo AD, Charitos IA, Cazzolla AP, Colella M, Gagliano-Candela R, et al. Ceramic biomaterials in dentistry: chemical structure and biosafety - a review and a bibliometric visual mapping on Scopus database. *Eur Rev Med Pharmacol Sci*. 2024;28(4):1242-58. doi: [10.26355/eurrev_202402_35446](https://doi.org/10.26355/eurrev_202402_35446).
 14. Alvitez-Temoche D, Del Aguila E, Galarza-Valencia D, Calderón I, Espinoza-Carhuancho F, Pacheco-Mendoza J, et al. Current trends and spatial-temporal dynamics of veterinary dentistry research: a scientometric study. *Vet World*. 2024;17(3):666-71. doi: [10.14202/vetworld.2024.666-671](https://doi.org/10.14202/vetworld.2024.666-671).
 15. Asgary S, Sabbagh S, Sarraf Shirazi A, Ahmadyar M, Shahravan A, Ahmad Akhoundi MS. PubMed-indexed dental publications from Iran: a scientometric study. *J Dent (Tehran)*. 2016;13(3):157-67.
 16. Velasquez R, Barja-Ore J, Salazar-Salvatierra E, Gutiérrez-Ilave M, Mauricio-Vilchez C, Mendoza R, et al. Characteristics, impact, and visibility of scientific publications on artificial intelligence in dentistry: a scientometric analysis. *J Contemp Dent Pract*. 2022;23(8):761-7. doi: [10.5005/jp-journals-10024-3386](https://doi.org/10.5005/jp-journals-10024-3386).
 17. Naraghian N, Mohammadesmeil F. A pattern of mutual collaboration in the dental field between years of 2011 to 2015. *J Res Dent Sci*. 2018;14(4):244-50. [Persian].
 18. Zeraatkar N, Vara NA, Ghazi Mirsaeid SJ. Review of 10 years of scientific production of Iranian dentistry community in the ISI database (2000-2009). *J Islam Dent Assoc Iran*. 2012;24(3):244-50. [Persian].
 19. Eghbal MJ, Davari Ardakani N, Asgary S. A scientometric study of PubMed-indexed endodontic articles: a comparison between Iran and other regional countries. *Iran Endod J*. 2012;7(2):56-9.
 20. Ganesh C, Victor Samuel A, Purushothaman D, Magesh KT, Vivek N. Bibliometric analysis of dental caries detection. *Cureus*. 2023;15(6):e40741. doi: [10.7759/cureus.40741](https://doi.org/10.7759/cureus.40741).
 21. Taghdisi Kashani A, Batooli Z, Mozafari M. Bibliometric analysis and visualization of top papers in dentistry from 2012 to 2022 based on essential science indicators. *Clin Exp Dent Res*. 2024;10(1):e832. doi: [10.1002/cre2.832](https://doi.org/10.1002/cre2.832).
 22. Huang X, Bai J, Liu X, Meng Z, Shang Y, Jiao T, et al. Scientometric analysis of dental implant research over the past 10 years and future research trends. *Biomed Res Int*. 2021;2021:6634055. doi: [10.1155/2021/6634055](https://doi.org/10.1155/2021/6634055).