

# Research Performance of Saudi Arabia in Endodontics: A Bibliometric Analysis

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**ABSTRACT** Endodontics is a subdivision of dentistry that deals with diseases and injury of the soft tissues inside the teeth. The current study aimed to investigate the bibliometric properties of endodontics publications contributed by Saudi Arabia from 2010 to 2022. The quantitative bibliometric research method was applied to the meta-data retrieved from the Web of Science on December 7, 2022. The word Endodonti\* was written in the main search bar, and from the year's filter, selected starting year 2010 to the date of data collection. In the first phase, to access the global publication growth of endodontics, no country/region filter was used. After getting the summary of the global intellectual landscape, we selected Saudi Arabia from the country/region filter to analyze certain characteristics of endodontics documents. Periodical growth, accessibility modes, collaboration patterns, influential institutions, frequently used sources, international research collaboration, and most-cited documents were analyzed by using Microsoft Excel (v.16) and SPSS (v.20). The authors affiliated with Brazil contributed the highest number of documents and Saudi Arabia stood in the eighth rank in endodontics research. The growing tendency was observed in Saudi Arabia from 1.29% in 2010 to 7.60% in 2022 from a global perspective. The quality of nonopen-accessed documents was higher than open-accessed as per citation impact, similarly, the documents written on international collaboration got a higher ratio of citations compared with national collaboration. King Saud University was found the most prolific institution and the *Journal of Endodontics* was the most preferred source of publications. The maximum research collaboration at the international level was performed with the authors of the United States. Fifteen most-cited papers obtained 21.42% of the citations. The findings show that endodontics research in Saudi Arabia has increased significantly over the years. The research collaboration at the national level has increased, which shows that teams of national researchers in endodontics have been prepared and conducting valuable research in a national context.

**KEYWORDS:** *Bibliometric, endodontics, research productivity, Saudi Arabia*

## INTRODUCTION

This study illustrates the status of endodontics research in Saudi Arabia. Generally, Saudi Arabia is an important country in the world and

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particularly, in the Arab World. The country has an aspiration for leadership in higher education, research, and development. The country has recognized that innovative research is vital for the long-term sustainable development of society.<sup>[1]</sup> There are about 64 universities in Saudi Arabia<sup>[2]</sup> and 27 universities offering dental education.<sup>[3]</sup> Twenty-one universities are listed in the Times Higher Education Ranking of 2023. King Abdulaziz University is top-ranked placed in 101 followed by King Fahd University of Petroleum and Minerals and King Saud University in 201–250 and 250–300 ranking bands, respectively.<sup>[4]</sup> Cultivation of the research culture in higher education is one of the objectives of the National Development Plan to attain social and economic goals, particularly its transaction from an oil-based economy to a knowledge-based society.<sup>[1]</sup>

Saudi Arabia invested in healthcare infrastructure, enhanced enrollment in medical, dental, and allied health sciences, as well as initiated research scholarships. The provision of quality higher education and research in medical as well as dental sciences has a direct impact on the quality of health of the community. Saudi Arabia has improved the healthcare system and enhanced research productivity in all areas of biomedical sciences, especially during the past 2 decades.<sup>[2,5]</sup>

Dental treatment quality also depends on the excellence of dental education and research. The visibility of research and a global outlook is considered a significant meter in the development of dentistry in the country. Haq *et al.*<sup>[6]</sup> stated that among the 22 Arab countries, about 38% of the dental research was produced in Saudi Arabia from 1998 to 2017. Anas *et al.*<sup>[3]</sup> also reported that 39.19% of the dental research in the Arab World was contributed by Saudi Arabia, followed by Egypt (12.86%) and Jordan (9.95%).

Bibliometric analysis is applied to construct this paper. This term was introduced by Prichard<sup>[7]</sup> in 1969. To quantify the growth of the intellectual, scientific, and scholarly publication at the global level, within one region or country, in one institution or group of institutions, and even a particular subject fields, a tool of bibliometric has been used.<sup>[8]</sup> Bibliometric is an advanced form of statistical bibliography. The first notable study on this genre was performed in 1917 to assess the progress of the literature published about Comparative Anatomy from 1543 to 1860.<sup>[9]</sup> After that, another study quantified the English International Catalogue of Scientific Literature<sup>[10]</sup> and Gross and Gross<sup>[11]</sup> evaluated the citation analysis of college libraries and chemical education. After the advent of electronic databases and the Internet, bibliometric

studies have become a buzzword in the academic world. The findings of these studies are used for decision-making, allocating funds, and formulating research policies. The research output and its citation impact are vital indicators for ranking agencies to rank universities and countries.

Endodontics is an important branch of dental sciences and a number of researchers evaluated the endodontics literature from a different perspective. In the Saudi Arabian context, one study explored the bibliometric features of the papers published in the *Saudi Endodontics Journal*, whereas another study focused on endodontics research in the Gulf Cooperation Countries (GCC) region.<sup>[12,13]</sup>

A substantial amount of literature regarding endodontics has been published by Saudi Arabian authors.<sup>[12]</sup> It is important that the growth and impact of the endodontic literature produced in Saudi Arabia be assessed exclusively. The findings of this study would be the benchmark for future studies. The present study aimed to explore the bibliometric characteristics of endodontics publications contributed by Saudi Arabia from 2010 to 2022 as indexed in the Web of Science (WOS) database. The study was carried out to accomplish the following objectives:

1. To examine the endodontics research growth at the global level and identify the most productive countries with publication counts and citation impact for the targeted period of 2010–2022.
2. To calculate the share of Saudi Arabia in endodontics research and review its share by year.
3. To segregate the documents by accessibility mode with citation impact.
4. To draw the comparison of research collaboration at national and international levels.
5. To highlight the most influential research institutions of Saudi Arabia in endodontics research.
6. To review the most frequently used sources of publications.
7. To investigate the characteristics of the most-cited papers.

## MATERIAL AND METHODS

The quantitative bibliometric research method was applied to the meta-data about “Endodontics” The dataset was retrieved from the globally recognized source, WOS on December 7, 2022. The word Endodonti\* was typed in the main search box, and from the year’s filter, selected starting year 2010 to the date of data collection. To achieve the first objective, we first measure the publication growth of

endodontics at a global level. The country/region filter was not applied. After getting the findings of the global intellectual landscape, we selected Saudi Arabia from the country/region filter to analyze certain characteristics of endodontics documents contributed by the authors affiliated with Saudi Arabia. Periodic growth, accessibility modes such as open and nonopen accesses, patterns of national and international research collaborations, top 15 most influential institutions, top 15 most frequently used sources, top 15 countries in international research collaboration, and top 15 most-cited documents were analyzed by using Microsoft Excel (v.16), Redmond, Washington (USA). Duplication was checked, no duplicate records were found [Figure 1].

## RESULTS

A total of 17,879 documents on endodontics have been published globally from January 1, 2010, to December

7, 2022, as indexed in all databases (indices) of WOS. The dataset was limited to WOS only, although WOS provides limited coverage compared with Scopus and Google Scholar databases, the quality of publications indexed in WOS has been higher. The authors' and journals' self-citations have not also been excluded from the citation counts. The dataset for the year 2022 was not completed because the data were collected on December 7, 2022. We relied on the indices of WOS for bibliometric indicators set in the objectives.

The list of top 10 most productive countries in endodontics is shown in Table 1. The highest number of documents has been contributed by Brazil (15.90%), followed by the United States (12.33%), China (5.31%), India (5.31%), and Turkey (5.08%). Saudi Arabia occupies the eighth rank with (3.29%) of the documents. England achieved the highest citation impact (24.71

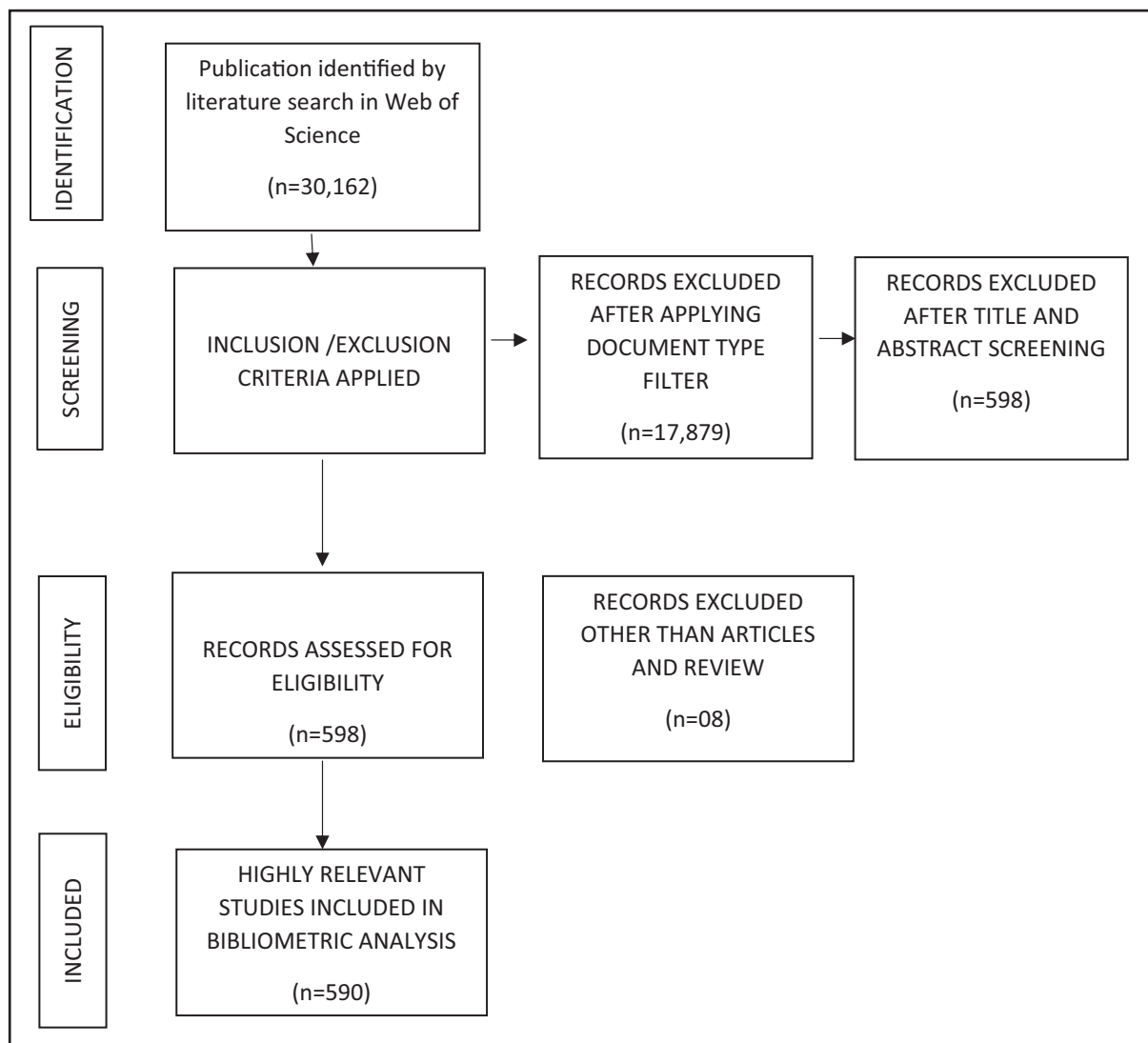


Figure 1: Selection criteria

**Table 1: Most productive countries in endodontics research from 2010 to 2022**

Serial No.	Country	Total documents (%)	Total citations	Citation impact
1.	Brazil	2844 (15.90)	42,517	14.95
2.	United States	2205 (12.33)	48,278	21.89
3.	China	950 (5.31)	17,918	18.86
4.	India	950 (5.31)	7817	8.23
5.	Turkey	910 (5.08)	11,325	12.45
6.	Italy	855 (4.78)	16,947	19.82
7.	Germany	655 (3.66)	12,796	19.54
8.	Saudi Arabia	590 (3.29)	4481	7.59
9.	England	583 (3.26)	14,405	24.71
10.	Iran	492 (2.75)	7300	14.84

Periodical growth in endodontics research in Saudi Arabia

**Table 2: Distribution of endodontics research in Saudi Arabia from a global perspective**

Years	Global research in endodontics	Research output by Saudi Arabia	Percentage of research in Saudi Arabia
2010	929	12	1.29
2011	977	15	1.53
2012	1107	18	1.62
2013	1208	13	1.07
2014	1377	20	1.45
2015	1345	25	1.85
2016	1409	44	3.12
2017	1464	35	2.39
2018	1399	39	2.78
2019	1446	54	3.73
2020	1732	79	4.56
2021	1870	113	6.04
2022	1617	123	7.60
Total	17,880	590	3.29

cites/doc), followed by the United States (21.89 cites/doc) and Italy (19.82 cites/doc). The research produced by Saudi Arabia has been cited with an average of 7.59 cites/doc.

Table 2 demonstrates the development of endodontics research in Saudi Arabia and a total of 590 documents have been identified. In 2010, the contribution of Saudi authors was 1.29% of the global research in endodontics, it reaches 3.12% in 2016, whereas the last year of the study shows a remarkable growth of 7.60%. Overall, Saudi Arabia contributed 3.29% of the global endodontics research, and more than half of the research (53%) has been published in the last 3 years of the study (2020–2022).

#### ACCESSIBILITY MODEL OF DOCUMENTS

The analysis of the accessibility model of documents shows that 61.69% ( $n = 364$ ) of the documents on endodontics produced in Saudi Arabia are open-accessed, whereas 38.31% ( $n = 226$ ) of the documents are nonopen-accessed. The nonopen-accessed documents gained a higher citation ratio ( $n = 2258$ ) with an average of 9.99 cites/doc compared with

open-access documents, which were cited 2223 times with an average of 6.11 cites/doc.

#### COMPARISON BETWEEN NATIONAL AND INTERNATIONAL RESEARCH COLLABORATION

Table 3 displays that Saudi authors contributed to 590 documents from 2010 to 2022, and these documents were cited 4481 times with an average of 7.59 cites/doc. The documents with national research collaborations gained the lower impact with an average of 6.09 cites/doc, whereas those written with international research collaborations gained 8.66 cites/doc.

In the present study, one sample “ $t$ ” test was used to analyze the difference in citations of national and international collaboration documents, it is evident from the analysis that international collaboration gained a significantly higher citation, mean of 114.38, 95% confidence interval (55.75–173.02), than national collaboration ( $P = 0.001$ ).

Approximately the ratio of indigenous research is found to be 42%, which means all contributors are affiliated with Saudi Arabia in 246 documents. The research collaboration with international authors is found in 58%

**Table 3: Comparison of research collaborations at the national and international levels**

Year	Research documents			Citations		
	Total	National collaboration	International collaboration	Total	National collaboration	International collaboration
2010	12	4	8	306	135	171
2011	15	4	11	345	32	313
2012	18	7	11	418	96	322
2013	13	3	10	273	80	193
2014	20	6	14	256	57	199
2015	25	10	15	332	119	213
2016	44	18	26	560	224	336
2017	35	19	16	444	264	180
2018	39	16	23	318	125	193
2019	54	23	31	386	132	254
2020	79	31	48	534	126	408
2021	113	48	65	258	86	172
2022	123	57	66	51	23	28
	590	246	344	4481	1499	2982

**Table 4: Top 15 most influential institutions in endodontic research in Saudi Arabia**

Serial No.	Institution	Total documents	Total citation	Citation impact
1	King Saud University	168	1932	11.50
2	King Abdulaziz University	92	550	5.98
3	King Saud bin Abdulaziz University for Health Sciences	52	473	9.10
4	Imam Abdulrahman Bin Faisal University	47	415	8.83
5	King Khalid University	42	170	4.05
6	Taibah University	39	418	10.72
7	Qassim University	37	181	4.89
8	Jazan University	33	118	3.58
9	Princes Nourah Bint Abdulrehman University	31	95	3.06
10	Prince Sattam bin Abdulaziz University	30	81	2.70
11	Riyadh Elm University	20	56	2.80
12	Al Jouf University	18	95	5.28
13	Ministry of Health, Saudi Arabia	26	92	3.54
14	King Faisal University	17	109	6.41
15	Umm Al Qura University	16	66	4.13

of the documents. The ratio of international research collaboration was higher (64.62%) from 2010 to 2016 compared with collaboration at the national level (35.37%). It is interesting to reveal that the tendency of research collaboration at the national level has increased from 35.37% in the first phase (2010–2016) to 43.79% in the next phase (2017–2022). Yates corrected Chi-square analysis revealed a significant ( $P = 0.03$ ) increase in national collaboration compared with the international collaboration before and after 2016.

#### INFLUENTIAL INSTITUTIONS IN ENDODONTICS RESEARCH IN SAUDI ARABIA

King Saud University has been found to be the most influential not only in terms of research productivity but also in citation impact. More than one-fourth of the documents ( $n = 168$ ; 28.47%) were contributed by the authors of this university and these documents

gained 43% ( $n = 1932$ ) of the citations with an average of 11.50 cites/doc. King Abdulaziz University secured the second rank with 92 documents, followed by King Saud bin Abdulaziz University for Health Sciences, Imam Abdulrahman Bin Faisal University, and King Khalid University with 52, 47, and 42 documents, respectively. The second highest citation impact has been obtained by Taibah University, with an average of 10.72 cites/doc, followed by King Saud bin Abdulaziz University of Health Sciences (9.10 cites/doc) [Table 4].

#### MOST FREQUENTLY USED SOURCES FOR PUBLICATIONS

The maximum number of documents have been published in the *Journal of Endodontics* ( $n = 2263$ ) at the global level, followed by the *International Endodontics Journal* ( $n = 1232$ ), *Journal of Conservative Dentistry* ( $n = 438$ ), *Clinical Oral Investigation* ( $n = 424$ ), and *Australian Endodontics Journal* ( $n = 345$ ). The top 15

**Table 5: Top 15 most frequently used sources for publications**

Serial No.	Name of journal	Total documents	Total citation	Citation impact
1	Journal of Endodontics	54	1,136	21.04
2	Saudi Dental Journal	29	213	7.34
3	International Endodontic Journal	19	308	16.21
4	Materials Basal	18	61	3.39
5	BMC Oral Health	17	94	5.53
6	Cureus; Journal of Medical Science	16	72	4.50
7	International Journal of Dentistry	15	74	4.93
8	European Endodontic Journal	14	40	2.86
9	Applied Sciences Basel	11	22	2.00
10	Australian Endodontics Journal	11	45	4.09
11	Photodiagnosis and Photodynamic Therapy	11	109	9.91
12	Saudi Medical Journal	11	102	9.27
13	Case Reports in Dentistry	10	13	1.30
14	International Society of Preventive and Community Dentistry	10	52	5.20
15	Journal of Prosthetic Dentistry	10	151	15.10

**Table 6: Top 15 research collaborative countries**

Serial No.	Country's name	Total documents	Total citation	Citation impact
1	United States	86	984	11.44
2	India	64	224	3.50
3	Egypt	58	296	5.10
4	Pakistan	43	225	5.23
5	Italy	40	698	17.45
6	England	32	245	7.66
7	Malaysia	20	60	3.00
8	Yemen	19	133	7.00
9	Syria	18	240	13.33
10	United Arab Emirates	14	63	4.50
11	Brazil	12	186	15.50
12	Jordan	11	235	21.36
13	Cambodia	10	11	1.10
14	Germany	10	166	16.60
15	Qatar	10	43	4.30

preferred sources used by Saudi authors have been given in Table 5. *Journal of Endodontics* has been the top preference with 54 documents, followed by the *Saudi Dental Journal* and *International Endodontics Journal* with 29 and 19 documents, respectively. *Journal of Endodontics* has also been the most influential in terms of citations, the 54 documents published in this journal gain one-fourth of the total citations ( $n = 1136$ ; 25.35%) with an average of 21.04 cites/doc, followed by *International Endodontics Journal* (16.21 cites/doc) and *Saudi Medical Journal* (9.91 cites/doc). *Case Reports in Dentistry* obtained the lowest citation impact among the top 15 sources of publications.

#### INTERNATIONAL RESEARCH COLLABORATION

Saudi Arabia contributed 58% of the documents to an international research collaboration. Table 6 shows that

among the top 15 research collaborative countries, the maximum research collaboration has been performed with the United States ( $n = 86$ ), followed by India ( $n = 64$ ), Egypt ( $n = 58$ ), Pakistan ( $n = 43$ ), and Italy ( $n = 40$ ). The endodontics research contributed by the authors of Jordan gained the highest citation impact (21.36 cites/doc), followed by Italy (17.45 cites/doc), Germany (16.60 cites/doc), and Brazil (15.50 cites/doc). The lowest citation impact is found in research collaborated with Cambodia, Malaysia, and India.

#### MOST INFLUENTIAL DOCUMENTS

Table 7 describes the 15 most-cited papers comprising nine original research articles and six review articles, and these papers are published in eight international journals, and most of the papers are published in the *Journal of Endodontics* ( $n = 6$ ) and the *International*

Table 7: Top 15 most influential documents

Rank	Bibliographic description of paper	Total citations	Type of document
1	Al-Omiri MK, Mahmoud AA, Rayyan MR, Abu-Hammad O. Fracture resistance of teeth restored with post retained restorations: an overview. <b>Journal of Endodontics</b> . 2010;36(9):1439-49.	105	Review
2	Testarelli L, Plotino G, Al-Sudani D, Vincenzi V, Giansiracusa A, Grande NM, Gambarini G. Bending properties of a new nickel-titanium alloy with a lower percent by weight of nickel. <b>Journal of Endodontics</b> . 2011;37(9):1293-5.	84	Article
3	Gambarini G, Gergi R, Naaman A, Osta N, Sudani D. Cyclic fatigue analysis of twisted file rotary NiTi instruments used in a reciprocating motion. <b>International Endodontic Journal</b> . 2012;45(9):802-6.	78	Article
4	Al-Hadlaq SM, AlJarbou FA, AlThumairy RI. Evaluation of cyclic flexural fatigue of M-wire nickel-titanium rotary instruments. <b>Journal of Endodontics</b> . 2010;36(2):305-7.	77	Article
5	Siddiqui SH, Awan KH, Javed F. Bactericidal efficacy of photodynamic therapy against <i>Enterococcus faecalis</i> in infected root canals: a systematic literature review. <b>Photodiagnosis and Photodynamic Therapy</b> . 2013; 10(4):632-43.	72	Review
6	Gambarini G, Plotino G, Grande NM, Al-Sudani D, De Luca M, Testarelli L. Mechanical properties of nickel–titanium rotary instruments produced with a new manufacturing technique. <b>International Endodontic Journal</b> . 2011;44(4):337-41.	72	Article
7	Madarati AA, Hunter MJ, Dummer PM. Management of intracanal separated instruments. <b>Journal of Endodontics</b> . 2013;39(5):569-81.	67	Review
8	Gambarini G, Rubini AG, Sudani D, Gergi R, Culla A, De Angelis F, Di Carlo S, Pompa G, Osta N, Testarelli L. Influence of different angles of reciprocation on the cyclic fatigue of nickel-titanium endodontic instruments. <b>Journal of Endodontics</b> . 2012;38(10):1408-11.	62	Article
9	Al Jabbari YS, Fehrman J, Barnes AC, Zapf AM, Zinelis S, Berzins DW. Titanium nitride and nitrogen ion implanted coated dental materials. <b>Coatings</b> . 2012; 2(3):160-78.	58	Review
10	AlShwaimi E, Bogari D, Ajaj R, Al-Shahrani S, Almas K, Majeed A. In vitro antimicrobial effectiveness of root canal sealers against <i>Enterococcus faecalis</i> : a systematic review. <b>Journal of Endodontics</b> . 2016;42(11):1588-97.	57	Review
11	Alamri HM, Sadrameli M, Alshalloob MA, Alshehri MA. Applications of CBCT in dental practice: a review of the literature. <b>General Dentistry</b> . 2012;60(5):390-400.	51	Article
12	Al-Sudani D, Grande NM, Plotino G, Pompa G, Di Carlo S, Testarelli L, Gambarini G. Cyclic fatigue of nickel-titanium rotary instruments in a double (S-shaped) simulated curvature. <b>Journal of Endodontics</b> . 2012; 38(7):987-9.	51	Article
13	Alghamdi F, Shakir M. The influence of <i>Enterococcus faecalis</i> as a dental root canal pathogen on endodontic treatment: A systematic review. <b>Cureus</b> . 2020;12(3).	50	Review
14	Bottino MC, Yassen GH, Platt JA, Labban N, Windsor LJ, Spolnik KJ, Bressiani AH. A novel three-dimensional scaffold for regenerative endodontics: materials and biological characterization. <b>Journal of Tissue Engineering and Regenerative Medicine</b> . 2015; 9(11):E116-23.	47	Article
15	Plotino G, Testarelli L, Al-Sudani D, Pongione G, Grande NM, Gambarini G. Fatigue resistance of rotary instruments manufactured using different nickel–titanium alloys: a comparative study. <b>Odontology</b> . 2014; 102(1):31-5.	45	Article

*Journal of Endodontics* ( $n = 3$ ). All most-cited papers gained 960 citations with an average of 64 cites/doc. In three papers, all contributors belong to Saudi Arabia, whereas 12 papers result from international collaboration. The authors of King Saud University contributed to 10 papers in the international research collaboration, Italy is on the top with six papers, followed by the United States with three papers. All most-cited papers are collaborative works, varying from 2 to 10 authors, with an average of 5.26 authors per paper. Dina Al-Sudani of King Saud University Saudi Arabia and Gianluca Gambarini of the University

of Rome, Italy, contributed six papers to the research collaboration.

## DISCUSSION

Research is a significant component of any business or area of knowledge. An evaluation of scholarly communication in a particular subject assists peers in comprehending the factors of its progress.<sup>[14]</sup> Bibliometric studies have been a very popular research method to assess the characteristics of publications.<sup>[15]</sup>

More than one-fourth (28.23%) of the global research on endodontics was contributed by the two countries,

Brazil and the United States, whereas the share of Saudi Arabia was counted at 3.29%. Brazil, the United States, and other European countries attained prominent stature in research productivity because they had established modern research institutions long ago, and they gave extraordinary priority to research activities. Comparatively, Saudi Arabia is a young nation in the field of modern higher education and research. Most new universities and research centers were established across the country after the 21st century and upgraded the existing educational resources. The allocation in the education sector has been enhanced extensively during the last 2 decades.<sup>[5]</sup>

Our findings reveal that Saudi Arabia has shown a promising growth from 1.29% in 2010 of the global endodontics research to 7.60% in 2022. The growing trend is also reported by Ababneh *et al.*<sup>[15]</sup> in periodontics research in Saudi Arabia and Alfadley *et al.*<sup>[13]</sup> in endodontics research in the GCC region. Haq *et al.*<sup>[6]</sup> also endorsed the growing trend in Saudi Arabia's dental research.

Khayat and Rajeh<sup>[16]</sup> reviewed the dental research produced in Saudi Arabia from 2010 to 2020, and 5.89% of the papers were related to Endodontics, whereas the highest number of papers were written on dental public health ( $n = 371$ ; 19.53%). Anas *et al.*<sup>[3]</sup> testified that Arab dental universities contributed about 15% of the research on endodontics. Alfadley *et al.*<sup>[12]</sup> examined 280 articles published in *Saudi Endodontics Journal* from 2011 to 2020. These articles were cited with an average of 3.8 cites/article. The laboratory was the most preferred study design, followed by case reports and surveys, as this journal is being published in Saudi Arabia, the highest number of articles were contributed by native authors. Another study evaluated the publication growth of endodontics in six countries of the GCC region from 2001 to 2020. The authors belonging to this region contributed 2.82% of the global endodontic research and approximately 61% of the research was published during the last 5 years of study. Saudi Arabia demonstrated remarkable research performance, 80% of the total GCC region. *Journal of Endodontics* was found at the top among the sources of publication, and the maximum collaboration was performed with the authors of the United States.<sup>[13]</sup>

Ababneh *et al.*<sup>[17]</sup> reviewed the periodontics research of Saudi Arabia that was published between 2012 and 2021. Overall, Saudi Arabia contributed 4.40% ( $n = 1323$ ) of the research and stood at eighth rank worldwide. The quality of Saudi publications is reflected by the promising citation impact (9.61 cites/doc). About 66% of the research was produced with

international collaboration and the United States was found on the top, followed by India, Egypt, and Pakistan.

Fardi *et al.*<sup>[18]</sup> examined the 100 top-cited articles published in five journals and reported that endodontic microbiology was the preferred research theme, and basic science was identified as the most frequent article type. Adnan and Ullah<sup>[19]</sup> analyzed the bibliometric characteristics of 100 top-cited articles on regenerative endodontics. These articles were published between the years 1991 and 2018 and about two-thirds of the articles were published in the *Journal of Endodontics*. The authors from the United States contributed 51% of the articles. Yilmaz *et al.*<sup>[20]</sup> analyzed the 103 top-cited articles on endodontics, and these articles were cited 2115 times with an average of 20.53 cites/article. More than one-third ( $n = 36$ ) of the articles were published in the *Journal of Endodontics* and the United States contributed 41 articles. Endodontic microbiology was found the top research theme and Torabinejad M emerged as the most prolific author with 12 articles. Aksoy *et al.*<sup>[21]</sup> assessed the publication trend of endodontics by using microcomputed-tomography. Root canal preparation was the main subarea of research and Brazil contributed the maximum number of papers. About half of the papers were published in the *Journal of Endodontics* and the *International Endodontic Journal*. The study concluded that the bibliometric studies provide insight, deep understanding, and the developmental process of the subject. Krishnan *et al.*<sup>[22]</sup> examined 76 articles contributed by Indian authors in regenerative endodontics. The first article was published in 2008, and the highest number of articles ( $n = 12$ ) were published in 2015. Case studies and case series were found the favorite study designs. A maximum of 12 articles were published in the *Journal of Conservative Dentistry*.

One of the quality indicators of the research is a citation. A citation is the recognition of the author's work, when other authors cited his article as a reference to his research, it has been counted as a citation. The citation impact denotes how many times an article is cited in subsequent publications.<sup>[23]</sup> WOS, Scopus, and Google Scholar maintain the record of citations gained for each publication. The process of citing the previous research is a perfect example of a fair exchange of knowledge that creates integrity in the academic world.<sup>[12,24]</sup> Ahmad and Elgamal<sup>[23]</sup> evaluated the 50 most-cited articles published in the *Journal of Endodontics* from 1975 to 2010. The study collected the citations from WOS, Scopus, and Google Scholar and made the comparison. The most covered areas of research were



mineral trioxide aggregate, canal instrumentation, irrigants, and endodontics microbiology. Most of the articles ( $n = 38$ ) were contributed by the United States, and Loma Linda University was found the most prolific institute with 15 articles.

The endodontics research produced in England gained the highest citation with an average of 24.71 citations per paper, followed by the United States (21.89 citations/per paper). The research produced by Saudi Arabia was cited with an average of 7.59 cites/doc. Haq and Alfouzan<sup>[6]</sup> reviewed the citation impact of dental research contributed by Saudi Arabia from 2009 to 2018. A total of 1771 papers were identified and these papers gained an average of 5.83 citations per paper. The study also stated that about one-fourth of the research, collaboration was done with the United States ( $n = 437$ ; 24.67%), but the collaboration with Italy got the highest citation impact (13.63 cites/paper).

A total of 364 (61.69%) documents on endodontics produced in Saudi Arabia are open-accessed, whereas the other 38.31% are nonopen-accessed, but the nonopen-accessed documents gain the highest citations with an average of 9.99 cites/paper, whereas the open-accessed documents were cited with an average of 6.11 cites/paper. Nonopen access journals have higher citations compared with open access, this may be due to libraries procuring nonopen access journals with high-impact factors, which are made available to researchers. Usually, where no or less access to nonopen access journals is prevalent, their open access journals receive more citations.<sup>[25]</sup> In line with these findings, Alfadley et al.<sup>[13]</sup> reported that there was a complete contrast between the citation impact of open and nonopen-accessed documents, open-accessed documents cited less (6.3 cites/doc) compared with nonopen-accessed (14.71 cites/doc) in the endodontics research contributed by GCC region.

The current study depicted that the proportion of international research collaboration was found in 58% of the publications, and these publications also got a higher citation impact. Shehatta and Mahmood<sup>[26]</sup> analyzed the research collaboration in Saudi Arabia from 1980 to 2014. The study stated that the single-author pattern decreased after 2005, and international research collaboration dramatically increased from 2005 onward. About 47% of the papers had been published with international collaboration in 34 years, and the study concluded that collaboration had an affirmative effect on the quality and productivity of research.

Saudi authors performed maximum endodontics research in collaboration with the United States, followed by India and Egypt, but the research contributed in Jordan gained the highest citation impact, followed by Italy, Germany, and Brazil. It is evident that papers on research collaborative to talent-rich countries are usually published in high-impact journals, and subsequently, these papers gain more attention and citations.

Shehatta and Mahmood<sup>[26]</sup> reported that about one-third (30.85%) of Saudi Arabian research from 1984 to 2014 was produced by King Saud University. The same institution emerged as the most productive and influential institute in our study. More than one-fourth of the documents were (28.47%) contributed by the researchers of this university and these documents gained citations with an average of 11.50 citations per paper.

At the global level, the highest number of papers ( $n = 2263$ ) was published in the *Journal of Endodontics* and the *International Endodontic Journal* ( $n = 1232$ ). Saudi authors also contributed the highest number of papers ( $n = 54$ ) in the *Journal of Endodontics*, but the second most preferred is the locally published source, *Saudi Dental Journal*.

Of the top 15 most-cited papers, six papers were published in the *Journal of Endodontics*, and three papers were in the *International Endodontic Journal*. Most-cited papers gained the highest citation impact, with an average of 64 cites/doc. Twelve papers had written with international collaboration. King Saud University produced the highest number of papers ( $n = 10$ ), whereas Italy was at the top in the international research collaboration, followed by the United States. The research collaboration between Dina Al-Sudani and Gianluca Gambarini produced the six most-cited papers.

## CONCLUSION

The present study has elaborated on the scholarly work on endodontics contributed by the authors in Saudi Arabia during 2010–2022. Government investment in human capital has been significantly associated with an increasing number of endodontic researchers in the country. Similarly, the reliance on international researchers for research publications has been decreasing. The findings of this paper would support academicians, researchers, and practitioners interested in endodontics. Saudi Arabia contributed 3.29% of the global endodontic research, and 58% of the papers were the result of international research collaboration.

**FUTURE STUDY RECOMMENDATION**

Future research can explore the subject dispersion and methodologies to highlight the strong and weak areas of endodontics and develop an action plan to focus on the weaker areas. This study will pave the way for other dental scholars to dig out similar studies on other areas of dentistry.

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**CONFLICTS OF INTEREST**

There are no conflicts of interest.

**AUTHORS CONTRIBUTIONS**

N.A.A. and I.U.H. planned the article. I.U.H. performed the article search. K.I. and L.K.B. contributed to statistics and article writing. N.A.A., K.A., and I.U.H. reviewed and edited the manuscript. All authors collectively proofread and approved the manuscript's final version for publication.

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Not applicable.

**PATIENT DECLARATION OF CONSENT**

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