Five decades of the International Endodontic Journal: bibliometric overview 1967-2020

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Running Title: Bibliographic analysis of the IEJ

Keywords: bibliometric analysis; citations; endodontics; endodontology; International Endodontic Journal

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Abstract

Aim The *International Endodontic Journal* (*IEJ*) has served as a platform for research and clinical practice in Endodontics since 1967. This study provides a bibliographic analysis and overview of the publications that have appeared in the *IEJ* from 1967-2020.

Methodology A literature search was performed in Elsevier's Scopus database to locate all the publications of the *International Endodontic Journal*. Various bibliometric software packages including the open-source visualization software Gephi and Biblioshiny (version 2.0) were employed for data visualisation and analysis.

Results A total of 3739 records with citation and bibliographic details were selected and retrieved to allow a bibliometric analysis to be performed. The bibliometric analysis indicates that the *IEJ* has grown both in terms of productivity and influence. Over time, the journal has been associated with an increase in the number of manuscripts published and the citations they have attracted, but with minor downward fluctuations in citations in the last few years. Bibliographic coupling of the *IEJ* articles revealed that the major research themes published in the journal include "endodontics", "root canal treatment", "calcium hydroxide", "apical periodontitis", "mineral trioxide aggregate", "microbiology", "cyclic fatigue", "cone-beam computed tomography", and "micro-computed tomography". Authors affiliated to the UK were the major contributors to the journal and linked with other countries such as Brazil, United States, and Malaysia. The largest number of publications were from the University of São Paulo, Brazil.

Conclusion The *IEJ* is one of the leading journals in Endodontology and has been providing a platform for innovative research and clinical reports for the last 53 years. Publications have been associated with a wide range of authors, institutions, and countries around the world.

Introduction

Endodontology is that branch of dental sciences dealing with health, injuries to, and diseases of the pulp and periradicular region, and their relationship with systemic health and well-being. The specialty encompasses both basic and clinical sciences including the aetiology, diagnosis, prevention, and treatment of pulp and periradicular conditions. Research in Endodontology covers a wide variety of clinical, biological, microbiological, mechanical, and material-based topics that aim to improve the diagnosis, understanding of disease processes, and management of normal and injured dental pulps and periradicular tissues (Ordinola-Zapata *et al.* 2020).

The *International Endodontic Journal* (*IEJ*) is a peer-reviewed journal in the field of Endodontology and is the official publication of the British Endodontic Society and the European Society of Endodontology. The journal was initially named the *Journal of the British Endodontic Society* that was published from 1967 to 1980 (Ahmad *et al.* 2019) but was then relaunched as the *International Endodontic Journal* in 1980. Currently, the *IEJ* is published monthly and strives to publish original articles of the highest quality to disseminate scientific and clinical information; all manuscripts are subjected to anonymous peer review. Original scientific articles are published in the areas of biomedical science, applied materials science, bioengineering, epidemiology, and the social sciences relevant to endodontic disease and its management, and to the restoration of endodontically treated teeth. In addition, review articles, reports of clinical cases, book reviews, summaries, and abstracts of scientific meetings and news items are published periodically.

In 2019, the Journal Citation Reports of Clarivate Analytics ranked the *IEJ* at 6 out of 91 journals in the category of “Dentistry, Oral Surgery & Medicine”. Its 2019 impact factor of 3.801 reflects the interest of authors and readers in the journal. According to Scimago, the *IEJ* has an h-

index of 114 with an SJR of 1.808 (SCImago Journal Rank 2019). The CiteScore of the journal in the Scopus database was 6.2 for the year 2019 which is expected to increase to more than 7 in 2020 as projected by the Scopus CiteScore tracker (data as per 7th December 2020). The Scopus CiteScore ranks the *IEJ* among the top five (No. 3/113) journals in the general dentistry category. The Source Normalized Impact per Paper (SNIP) of the *IEJ* was 1.825 for the year 2019. The journal is indexed in leading healthcare search engines, including Google Scholar, MEDLINE, PubMed, Scopus, and Web of Science. Such quality indicators establish that the journal publishes original and world-leading research and clinical articles in the field of Endodontology and follows globally accepted standards in publishing.

A comprehensive analysis of a journal using bibliometric methods and techniques provides an in-depth analysis of the trends and influence of its publications (Calma & Davies 2015, Şenel & Demir 2018). It also highlights the evolution and foci of treatments and techniques in the same field. Thus, in the scientific community, bibliometric analysis has gained substantial interest (Hafeez *et al.* 2019). Over the years, several bibliometric analyses have been conducted on dental journals, for example, Cartes-Velásquez & Delgado (2014) analysed both original and review articles published in ISI dental journals in terms of qualitative and quantitative measures across countries and reported that the number of manuscripts published annually increased by 24.3% between 2007 and 2011. Adnan & Ullah (2018) undertook a bibliometric study aiming to identify the top 100 most-cited articles published in regenerative endodontics and to analyse their main characteristics to help clinicians identify the most prevalent protocols and procedures used for the regeneration of tissues within root canals with necrotic pulps.

In 2017, the *IEJ* achieved its 50th year of publication and during that time, three studies have been conducted to analyse retrospectively a variety of publication trends. A retrospective

observational study analysed the number and trends of publications in the *IEJ* and *Journal of Endodontics* (*JOE*) from 2009 to 2014 (Mishra *et al.* 2016). Ahmad *et al*. (2019) undertook an analysis of the top 100 most-cited randomized controlled trials, systematic reviews, and meta-analyses within seven endodontic journals, including the *IEJ*. Ordinola-Zapata *et al.* (2020) investigated the topics of the most-cited papers published in the *IEJ* and *JOE* between 1980 and 2019. The current study aims to provide a detailed bibliometric analysis of publications from *IEJ* from its launch to 2020 by answering the following primary research questions.

1. What are the publication and citation trends of the *IEJ*?
2. What are the authorship and collaboration research patterns of *IEJ* publications?
3. Which keywords have been used frequently in *IEJ* articles?
4. What are the key authors, institutions, countries, and manuscripts in terms of quantity and impact?
5. What are the co-citations of journals in the *IEJ*?
6. What is the bibliographic coupling of countries, institutions, and authors publishing in the *IEJ*?

Methodology

A literature search was performed in Elsevier's Scopus database on 9 December 2020. The database had an indexing record of *IEJ* manuscripts from 1967 to 1972 and 1974 to the present. The other indexing and citation databases such as PubMed and Web of Science started indexing IEJ manuscripts from 1980 and 1981, respectively. The search was performed in the "Sources" search interface of the Scopus database in the "Source Title" field with the input of journal-title "International Endodontic Journal".

Inclusion/exclusion criteria

A comprehensive search strategy including inclusion/exclusion criteria was adopted to retrieve the publication records of *IEJ* (Figure 1). Language, geographical, and date filters were not applied. The search was limited to articles, review articles, and conference papers. Editorials, letters, and erratum type of documents were excluded. Scopus defines articles as original research or opinion. However, case reports, *in vitro* studies, *in vivo* studies, technical and research notes, and short communications are also considered to be articles (Scopus-Content Coverage Guide).

Data Analysis and Visualisation

Network visualisation of keywords co-occurrences, co-citation, and bibliographic coupling was performed using the open-source visualisation software Gephi (https://gephi.org). Biblioshiny (version 2.0), another open-source data visualisation tool, was used to explore the thematic evolution and collaboration trends in the manuscripts. Authors and institutions with the largest number of publications and citations were considered along with the most productive authors and institutions. Data provided in the supplementary material for special issues were retrieved from the official website of the journal website by using following link: https://onlinelibrary.wiley.com/page/journal/13652591/homepage/special_issues.html (*International Endodontic Journal - Wiley Online Library* 2021).

The bibliometric terminology and abbreviations used in the analysis are defined as: (TP) total publications; (TC) total citations; (PY) publication year; (NCP) number of cited publications; (C/P) average citations per publication; (C/CP) average citations per cited publication; (CPY) average citations per year; (H) h-index; (IF) impact factor; (CoL) co-citation links.

Results

The search retrieved 3949 records of *IEJ* publications from 1967 to 2020. Finally, 3739 records [research articles (3510), review articles (229)] with citation and bibliographic details were selected and retrieved for the bibliometric analysis.

Citation structure of IEJ manuscripts

Table 1 provides an insight into the citation structure of the *IEJ*. Publications in its foundational year received 24 citations, averaging four citations per publication and six citations per cited publications. Data indicated that 2002 was the most productive year and impactful in terms of the number of citations and h-index of *IEJ* publications in any one year. With an average of 50.95 citations per publication, *IEJ* publications attracted 6521 citations with an h-index of 49 in 2002. Each publication in the year 2002 was cited at least once. With regard to citations per publication and citations per cited publication, the year 2001 was the most influential with 66.55 citations per publication and citations per cited publication.

Evolution of publications and their associated citations appearing in the IEJ

Figure 2 presents the evolution of publications and citations of the *IEJ* over time. An overall incremental trend was observed in publications with minor downward fluctuations in some years. Broadly, the publication life of the *IEJ* spans five decades. The journal published six articles in its inaugural year, 1967. It published 40 articles with an average of 13.33 manuscripts annually during its first three years from 1967 to 1969. The journal published 149 papers during the second decade (1970s), averaging 16.55 publications per year, with 1973 being a fallow year. During the third decade (1980s), the journal published more than double the number of articles (n=343) than the

previous ten years with an average of 34.3 publications per year. The journal published 515 papers in the next decade (1990s) and increased its number of publications to more than 100 publications every year except for the first two years (2000, 2001) of the 21st century. It published 1110 and 1399 articles during the fourth and fifth decades of its existence, respectively. The volume of publications increased three times during the twenty-one years of the 21st century compared to the preceding thirty-three years of the 20th century.

A gradual increase occurred in the total number of citations received by *IEJ* publications with the highest (n=6521) in the year 2002. The inaugural year 1967 and 1970 received the lowest number of citations (n=24). As expected, citations of manuscripts have fallen over the last fifteen years, i.e. from 2006 to 2020.

Authorship pattern of IEJ manuscripts

Authorship pattern deals with the level of collaboration in the form of single or multiple authorship of a manuscript. The authorship pattern of *IEJ* publications (Figure 3) reveals that articles with the collaborative effort of three authors occurred most frequently (n=700) followed by those with four authors (n=640). Single-author manuscripts constituted only 13% of *IEJ* publications with fourteen publications being the result of a collaboration of 11 or more authors. The highest average citation impact factor (37.77) was recorded for manuscripts with four authors followed by those with two authors, which had an average citation impact of 35.88. Single-author manuscripts were among those with the lowest citation impact (below the average of 20 citations per publication). Of all the authorship patterns, manuscripts with 9 authors had the lowest average of 13.28 citations per publication.

Most cited manuscripts in the IEJ

Table 2 shows the most frequently cited manuscripts published in the *IEJ* in descending order. The article titled "*Influence of infection at the time of root filling on the outcome of endodontic treatment of teeth with apical periodontitis*" by Sjögren *et al.* (1997), received the largest number of citations (n=735) with an average of 32 citations per year. The largest number of average citations per year were received by the European Society of Endodontology's treatment guidelines, "*Quality guidelines for endodontic treatment: consensus report of the European Society of Endodontology*" (ESE 2006), which received on average 33 citations per year. The least cited manuscript among the top 20 most cited papers received 299 citations with an average of 13.59 citations per year.

Analysis of author keywords in IEJ manuscripts

Table 3 provides a temporal analysis of keywords provided by authors of the manuscripts and provides an overview on the use of these keywords over the life span of the journal. The life span was divided into three different periods to identify the frequency of keywords over time. The largest number of studies (316) used the keyword "endodontics". The studies published using this keyword also received the greatest number of citations. A little less than half of the articles with this keyword were published during the last decade (2011-2020). The keyword "root canal treatment" was the second most frequently used, and it remained equally popular during the last two decades. Other keywords, which have gained attention based on their occurrences during the last decade were; "apical periodontitis", "smear layer", "chlorhexidine", "mineral trioxide aggregate", "*Enterococcus faecalis*", "cytotoxicity", "cone-beam computed tomography", "micro-computed tomography", "cyclic fatigue", "biofilm", and "fracture resistance".

Most productive authors

Table 4 lists the top 25 authors with the most publications and citations in the *IEJ*. Dummer PMH was the most prolific author, and the only researcher who authored more than a hundred manuscripts (112 publications). Wesselink PR from the Academic Centre for Dentistry, Amsterdam, was associated with the second highest number of publications and had the most citations (n=4903) with 74.29 citations per year and a h-index of 40. Wu MK, another researcher from the Academic Centre for Dentistry, Amsterdam received the highest average of 80.18 citations per year. Twenty-five authors published more than 25 manuscripts in *IEJ* over the period from 1967-2020.

Journals citing IEJ articles

The top journals citing *IEJ* publications are listed in Table 5. Manuscripts published in the *JOE* cited *IEJ* publications the most (n=28048). The manuscripts of the *IEJ* received 16180 citations within other manuscripts published in the *IEJ*. The journal *Biomaterials* had the highest impact factor of 10.317 among the top journals citing articles published in the *IEJ*. The *Journal of Oral Rehabilitation* was on the bottom of the list of the top citing journals with less than four hundred citations. Most of the journals citing *IEJ* publications were listed in Journal Citation Reports of Clarivate Analytics as having impact factors.

The most cited manuscripts within IEJ articles

Table 6 presents the list of manuscripts that were most frequently cited within *IEJ* manuscripts. The article titled "*Factors affecting the long-term results of endodontic treatment*" by Sjögren *et al.* (1990) published in the *JOE* was the most frequently cited within *IEJ* articles.

The article received citations in 108 articles published within the *IEJ*. Another article from the same journal titled "*Root canal irrigants*" (Zehnder 2006), received the second highest number of citations from articles published within the *IEJ*. The "*Fatigue Resistance of Engine-Driven Rotary Nickel-Titanium Instruments Produced by New Manufacturing Methods*" (Gambarini *et al.* 2008) published in the *JOE* attracted the lowest number of citations (n=33) among the top 25 most cited articles within *IEJ* manuscripts.

The top contributing countries

The authors affiliated with institutions within the United Kingdom had the most publications and citations in the *IEJ* (Table 7). The United Kingdom contributed 680 manuscripts and 21052 citations with a h-index of 75 and 30.96 citations per publication in the *IEJ* from 1967 to 2020. Authors associated with Brazilian academic organisations had the second-highest contribution in terms of the number of publications and citations. There were 25 countries from around the world whose authors had more than 50 publications and 500 citations in the *IEJ*.

The top contributing institutions

Two organisations affiliated with the authors of manuscripts within the *IEJ* had more than one hundred publications each. The authors affiliated with the University of São Paulo, Brazil had the largest number of publications (146) and authors affiliated with the Academic Centre for Dentistry, Amsterdam published 105 manuscripts in the *IEJ* and received the greatest number of citations (6047) with 57.59 citations per publication and a h-index of 45. Table 8 provides the details of the top 25 institutions affiliated with the authors of a minimum of 31 manuscripts published in the *IEJ*.

Keywords co-occurrences

Co-occurrence analysis of the most frequently used keywords supplied by authors that occurred at least 30 times in *IEJ* manuscripts between 1967 and 2020 are presented in Figure 4. Five clusters of keywords are represented by five different colours. The size of each cluster represents the degree of co-occurrence, whereby the thickness of the line depicts the frequency of usage of these keywords together. “Sodium hypochlorite”, “root canal”, “root canal treatment”, and “smear layer” were the keywords that were used most frequently in *IEJ* manuscripts. “Endodontics” had the strongest link followed by “sodium hypochlorite” and “calcium hydroxide”, respectively.

Co-citations of journals

Graphical visualisation of co-citations of journals is depicted in Figure 5. The visual map revealed the citation relationship of journals and identified the most closely linked journals. Five colours were used to cluster the journals. With a minimum threshold of 450 citations, 25 journals appeared in the figure. The results revealed a dominant connection between the *IEJ* and the *JOE* as depicted by a thick line. The thickness of the link is proportional to the number of co-citations between the journals.

Bibliographic coupling of countries

Figure 6 presents bibliographic coupling of the countries of the authors of *IEJ* manuscripts. A threshold of at least 50 manuscripts and 500 citations was set for the analysis of coupling. Twenty-five countries met the criteria and appeared on the map. Three different colours in the figure represent three different clusters. The representation of several countries in the map

indicates that the *IEJ* published articles from around the world. The United Kingdom had the strongest link on the number of manuscripts and citations in the *IEJ*. The width of the node revealed that Brazil had the strongest coupling strength with the United Kingdom and the United States. The other countries such as Malaysia, Spain, and The Netherlands had affiliation with the United Kingdom, whereby Brazil also had affiliations with Turkey and Italy. The node size represents the links uniting or departing from the node. The thickness of the link denotes the level of collaboration.

Bibliographic coupling of authors

Networking of the most prolific authors was visualized using Gephi software. The bibliographic coupling network presented in Figure 7 exposes the intellectual connections among the prolific authors of *IEJ*. With the threshold of 25 manuscripts and 400 citations, 30 authors met the criteria to appear in the bibliographic coupling network. The thickness of the link between the two authors indicates the level of connectivity and prominence of authors amid the nexus of an authors' network. Five colours in the figure represent five different clusters. The figure reveals that the most contributing authors of the *IEJ* fall into five broad groups of intellectual clusters. Cluster 1 (purple) had the largest number of authors (n=12) with connections while cluster 5 (dark green) was the smallest one with two authors only. The strongest link among the *IEJ* authors was associated with Dummer PMH based on the number of manuscripts and citations. The collaboration of six *IEJ* authors formed cluster 2. De-Deus G had the strongest link with the most citations in cluster 2. Cluster 3 (blue) consisted of five authors. Wesselink PR and Wu MK had the strongest intellectual link from cluster 3 (blue). Cluster 4 represented in orange colour was made

of five authors with Hülsmann M having the greatest impact in terms of total link strength and citations. Two *IEJ* authors formed cluster 5 represented by the dark green colour.

Bibliographic coupling of the institutions of the authors of IEJ manuscripts

A bibliographic coupling of the institutions of the *IEJ* authors is presented in Figure 8. The coupling was generated for the institutions whose affiliated authors had published at least ten manuscripts in the *IEJ*. Eighteen institutions of the world met the threshold and appeared on the map. The size of the node signifies the number of relational ties, whilst the line thicknesses indicate the strength of connections between the two organisations. Eight institutions from six different countries formed cluster 1 (purple), the largest cluster on the map. University College London, United Kingdom had the strongest weight based on the number of citations among the institutes in cluster 1. Cluster 2 (dark green) is represented by three Turkish and a German Universities. King's College London and Malmo University, Sweden formed cluster 3 (blue). Cluster four (red) consisted of the University of Malta, Malta. Cluster 5 (orange) is represented by two Brazilian universities. Cluster 6 (dark green), represented by the Cardiff University, United Kingdom and International Medical University, Malaysia had the strongest total link strength, respectively among the institutions that appeared on the bibliographic coupling map.

Cardiff University, United Kingdom, and International Medical University, Malaysia, formed the strongest connection. Another significant connection was found between Fluminense Federal University, Brazil, and Grande Rio University, Brazil. University College London, United Kingdom was another prominent institution on the map based on the weight of citations.

Supplementary Table S1 presents the seven special issues published (2017-2019) in the *IEJ*. Along with the information pertaining to the volume and issue number of the IEJ; the table

also provides the title/theme of the special issue and the editors. Dummer PMH was the editor of all special issues. The themes of special issues were related to “bioactive endodontic cements”, “canal irrigation”, “pulp and periapical pathosis”, “clinical outcome studies and endodontic regeneration”.

Discussion

This study undertook a comprehensive bibliometric analysis of the *IEJ* using the Scopus database. In 2009, Elsevier combined the features of the Web of Science and PubMed to develop the Scopus database. These combined features improved the efficacy of citation analysis and literature research (Falagas *et al.* 2008). In 2004, Google Scholar was launched, however, its low data quality raises questions about its suitability for evaluation of publications in scientific journals. Thus, the Web of Science and Scopus remain today the main sources of citation data (Mongeon & Paul-Hus 2016). Scopus includes a larger range of journals (n = 12,850) than the Web of Science (n = 8,700), and also includes more articles than that of the Web of Science, in addition, the citation analysis is more rapid (Walsh *et al.* 2018). In a study performed to assess the accuracy of citation data in the Scopus and Web of Science databases, it was reported that the Web of Science had 55% missing references, 26.7% errors in references (e.g. incorrect publication year or volume number), and 16.7% incorrect references (Van Eck & Waltman 2019). Based on these features, Scopus was considered the most appropriate tool for the bibliographic study of the *IEJ.*

The bibliometric analysis within this study revealed a non-linear behaviour in citations of articles published in the *IEJ*, with the maximum citations received by articles per year being observed in 2002 followed by 2003 and 2006. However, the maximum average number of citations per publication was observed in 2001 (66.55). Obviously, regardless of the impact, older

publications inevitable receive more citations than more recent papers (Ugolini *et al.* 2012), and it has been reported that articles published in the last 15 years usually do not attract the most citations in many fields of research (Feijoo *et al.* 2014). However, in the present study, a mixed trend was observed, whereby articles published in 2009 and 2012 received 5061 and 5465 citations with 41.09 and 36.41 citations per publication, respectively. It is assumed that these high citation counts reflect the quality of an article and its relevance to research and/or clinical practice. The trend of the present study revealed that in the last 5 years, the average number of citations per article decreased, however, it is too early to predict whether these publications will be cited more often as time passes.

The other features such as scientific collaboration and team-based scientific work were evaluated by authorship patterns. It has been established that interdisciplinary collaboration with multiple numbers of authors per publication can improve the quality of research (Parish *et al.* 2018). A similar trend was observed in this study, where the majority of articles in the *IEJ* involved 3-5 authors. This reflects collaboration between various institutes, countries, and researchers to expedite the development of their areas of interest. It is well-established that research output is now reliant on transnational cooperation, driving the publication of papers authored by experts not just from different research institutions and departments but from different parts of the world (Osareh *et al.* 2010). An interesting trend was found where the largest number of authors (9-11) were associated with the least number of publications. It could be because most journals now discourage a large number of authors (more than 6) to avoid the trend of "guest authorship" (Gasparyan *et al.* 2013); however, this has never been a policy of the *IEJ*.

The number of citations indicates the impact of an article. It is generally accepted that a high-quality paper will receive more citations; however, evaluating the quality of paper is

challenging. At the same time, manuscripts can be cited as a negative example of poorly designed research (Aksnes & Sivertsen 2004, Harwood 2008). The current study analysed the highly cited papers within the *IEJ* and found that most were clinical studies, review articles and others in the field of basic sciences (mainly based on microbiological analysis in relation to Endodontics). It has been reported previously that review articles receive more citations than intervention studies (Frosch *et al.* 2010). The present analysis also confirmed that review articles received relatively high citations per year compared to other studies. Tahamtan *et al.* (2016) concluded that several factors can influence the frequency of citations and classified them into three categories: "Paper related factors", "Author related factors" and "Journal related factors" (Table S2).

The most highly cited article between 1967 and 2020 was published by Sjögren *et al.* (1997) (735 citations). The large number of citations reflects the recognition of this article by the scientific community and its contribution to the specialty. The article was based on microbiological analysis of the root canals of single-rooted teeth with necrotic pulps and apical periodontitis. The authors suggested that the outcome of root canal treatment depended on the bacteriological status of the root canal at the time of root filling, with a negative bacteriological status being important for periapical health. It further suggested that using antimicrobial medicaments between appointments reduced bacterial counts; however, the manuscript emphasised it was not possible to eradicate all infection from the root canal in one treatment visit. A study using the ISI Web of Knowledge Database reported that this article was at number 6 in top 100 cited articles in Endodontology and received 283 citations (Fardi *et al.* 2011). Another bibliographic study (Ahmed *et al.* 2019) also revealed that until December 2018, this article had received 656, 575, 100, and 1354 citations in Scopus, Web of Science, PubMed, and Google Scholar, respectively. The

citations per year were on average 31.23, whereas this figure in the present study has changed little and is 31.96.

The second most-cited article (588 citations) was by Molander *et al.* (1998), which assessed the microbiological status of root filled teeth that required root canal retreatment due to post-treatment disease or for technical reasons. They reported that in cases with post-treatment disease, facultative anaerobic species were predominant with *Enterococci* being the most frequently isolated genera, while fewer bacterial strains were observed in retreatment cases due to technical reasons. The present study revealed that the number of citation per year received by this article was 26.73, whereas as in a previous bibliographic study (Ahmed *et al.* 2019), it was marginally higher at 27.10.

The third most-cited article was published by Ray & Trope (1995) (574 citations). The article was a retrospective radiographic evaluation that assessed the effect of the quality of root canal filling and coronal restorations on the periapical status of root filled teeth. A good coronal restoration had a significant association with the absence of periapical inflammation compared to good quality root fillings, which emphasised the importance of providing high-quality restorations after root canal treatment.

The fourth most-cited article by Byström *et al.* (1985) (502 citations), evaluated the antimicrobial effect of sodium hypochlorite (NaOCl) and ethylene diamine tetra-acetic acid (EDTA) irrigation in single-rooted teeth. The authors concluded that the combined use of NaOCl and EDTA was more effective in reducing bacterial counts with fewer bacteria surviving after use of an intra-canal medicament.

Generally, the number of citations received by an article increases shortly after publication to reach a peak and then generally reduces over time (Barnett & Fink 2008). However, this pattern

was not true for some of the exceptional manuscripts in the present analysis. Of the top 20 most-cited articles that only 6 were published in the last 15 years, i.e. from 2005-2020.

The fifth most-cited article was published by the European Society of Endodontology (ESE 2006) (461 citations), which revised the quality guidelines for endodontic treatment from an earlier version published in 1994.

In research, keywords are an important aid when searching the literature and are useful in place of phrases and sentences. Indeed, keywords tend to provide more pertinent information (Asghari & Navimipour 2018). Therefore, it is important to use and select keywords, which can allow relevant articles to be identified more effectively. The variety and number of keywords in a paper can increase its citations (So *et al.* 2014).

The bibliometric analysis revealed the main topics of articles published in *IEJ* during the last 30 years. Not surprisingly, the keywords "endodontics" and "root canal treatment" were used most frequently, whilst cone-beam computed tomography (CBCT) and micro-computed tomography (micro-CT) gained interest in the last decade or so. The technological developments in the field of imaging have allowed a wide variety of techniques to be successfully used to visualise facial, oral and dental structures three-dimensionally (Aksoy *et al.* 2020). The use of CBCT in diagnosing and managing endodontic cases has increased globally and this is reflected in an increased number of publications.

Mineral trioxide aggregate (MTA) was another keyword which was used commonly. Publications on MTA in the *IEJ* began in 2001, and the material has been tested extensively in the last two decades leading to an increased publication trend up to 2020. These findings are in accordance with another bibliographic study (Ahmad & Elqamal 2020), which also reported that the most-cited articles covered the topic of MTA. Topics based on calcium hydroxide revealed a

non-linear trend, however, in the last decade, a decrease in publication occurred. The other topics associated with an increase in articles were related to microbiology and cytotoxicity, whereby, in the last decade, a significant increase was observed. Recently, another bibliographic study reported a similar trend, where endodontic materials including root filling materials and root canal sealers underwent biological testing the most (63.7%) compared to testing of mechanical (59%) and physical (53%) properties (Iftikhar *et al.* 2021). This increasing trend in the last 10 years in endodontic research is evidence of the ongoing quest for more biocompatible materials. Moreover, topics related to biological properties also revealed a trend towards using regenerative and bioactive materials in root canals. The reason to mention the most-commonly used keywords was to provide assistance and guidance to researchers in terms of searching relevant papers to Endodontology.

The study revealed that the most productive authors were from developed countries such as the United Kingdom, The Netherlands, United States, Brazil, China, Japan, Australia, and New Zealand with very few from Asia (Iran, India, Taiwan, and Malaysia), however, none of the most productive authors were from the Middle East or Africa, which aligns with previous studies (Baltussen & Kindler 2004a, b, Coelho *et al.* 2014). This trend is likely due to limited resources, language barriers, and a lack of access to information. However, there is a real need for research related to dentistry to be promoted in low- to middle-economic countries (Uthman *et al.* 2013). The most productive authors also have high citations per year and h-indices. The well-known authors achieve more citations due to their prominence and prestige in their field of study (Collet *et al.* 2014). It has been reported that the h-index of the author group influences citation frequency (Hurley e*t al.* 2013). The authors' co-occurrence analysis revealed that prolific authors led the way in their research group and bridged the way among different groups (Newman 2004). The

advantage of this analysis is that it allows a rapid visualisation of the main authors and their linkages with others. The importance of a networks lies in the size and number of their nodes and the thickness and number of edges that connect nodes. This study revealed that some networks worked independently from other networks, and were therefore analysed separately. It has been established that research collaborations are linked to research productivity (Lee & Bozeman 2005) and research impact (Gazni & Didegah 2011). Ding (2011) reported that the prolific authors tend to collaborate with or cite other researchers, and highly cited authors are likely to interact with or cite each other. This present study revealed that the most prolific authors were mainly from the developed countries and were linked with authors from both developing and developed countries. However, the trend also revealed that few authors developed networks within the same institution. The importance of collaboration between researchers to enhance the translation and use of research in practice has been recognised (Gredig *et al.* 2020). The productivity and input from the developed countries reflect the incentive mechanisms that have been implemented by research agencies, availability of research grants, and facilities in research institutes. Bibliographic coupling measures the similarity of subject matters in publications. The bibliographic coupling network of institutions reveals that these institutions have similarities in their sources of intellectual influence presented in the *IEJ* publications. The graphical representation of inter-institutional collaboration networks provides a rapid and accurate understanding of the linkages among institutions based on co-author collaborations. This present study revealed that the most collaborative research ties are among institutions of the same country such as the United Kingdom. The largest number of publications were from the University of São Paulo, Brazil, which is likely a result of the support provided by funding agencies for scientific production and technological innovation of educational institutions in the state of São Paulo (Souza *et al.* 2016). Brazilian research output in the *IEJ* was mainly in

collaboration with the United States and the United Kingdom. Similarly, other countries such as Malaysia, Spain, and Sweden, etc. also linked strongly with the United Kingdom and contributed substantially in terms of publications and citations. These findings strongly support the concept of interdisciplinary and global research. The concept of combined developed-developing country research can lead to an effective outcome. This present study revealed that authors from institutions from the United Kingdom published many articles in the *IEJ*, which might be due to the strong linkage of the *IEJ* with the the British Endodontic Society and the European Society of Endodontology. This could be another reason that authors from European institutions also published their papers in the *IEJ*.

In many ways, the success of journals and authors depends on citations. Therefore, it is important for authors to select the most appropriate journal to publish their work. This study also evaluated articles frequently cited in *IEJ*. The most frequently cited article was published by Sjögren *et al.* (1990) in the *JOE*. The article assessed the success rate of RCT for 356 cases after 8-10 years and determined the effect of various factors on the treatment outcome. The overall success rate was 91%, where teeth with vital pulps preoperatively had a 96% success rate compared to 86% in teeth with necrotic pulps and periapical radiolucency, indicating a significant effect of the presence of a periapical lesion. The total number of citations of this article in the *IEJ* was 108, however, to-date the overall number of citations (Scopus) is 938. A recent bibliographic study reported this most cited article in the *JOE*, whereby the average citation per year was 26.10 (Ahmad & Elqamal 2020). The second most-cited article was again published in the *JOE* by Zehnder (2006) (80 citations), which is a review on root canal irrigants. The article discusses available irrigating and chelating agents including sodium hypochlorite, hydrogen peroxide, chlorhexidine, and citric acid with an overview of their properties. Other bibliographic studies also

reported this in the list of most-cited articles within Endodontics. The overall Scopus citations of this article are 968.The third (78 citations), fourth (75 citations), and fifth (66 citations) most-cited articles were published in the *IEJ* and were tabulated among the top-cited articles in the journal (second, first, and fourth). The articles were written by Molander *et al.* (1998), Sjögren *et al.* (1997), and Byström *et al.* (1985), respectively.

Limitation of the study and future research directions

This study has several limitations, including;

- Institutions and countries were selected according to the author's affiliation at the time of publication and the author's current affiliation were not known or described.
- The detailed methodology of each article was not assessed.
- The study used the Scopus database as a data source; *IEJ* manuscripts indexed in the Web of Science, PubMed, and Google Scholar are likely to report a different number of citations.

Future research could use altmetrics to check the impact on online interactions (scholarly bookmarks, Publons, Twitter, shares on social media, views, download statistics). An analysis of the correlations between traditional citations and other metrics (usage, captures, mentions, and social media) could also explore the wider impact of *IEJ* publications.

Conclusion

This study presents an overview of publications appearing in the *IEJ* since its launch. A total of 3739 articles and review papers were published from 1967 to 2020. Over this period, the journal was associated with an increase in the number of publications and citations with minor

downward fluctuations in the last few years, with the maximum number of citations in 2002. The authorship pattern revealed that the largest number of publications had 3-4 authors and the lowest number had 9 authors. The greatest number of citations for an individual article was 735 with an average of 32 citations per year. The bibliometric analysis revealed the most studied themes and topics with, not surprisingly, the theme "endodontics" and "root canal treatment" dominating the journal content, whereas the other related themes were "calcium hydroxide", "apical periodontitis", and "mineral trioxide aggregate". In the last decade, emerging topics were based on "microbiology", "cyclic fatigue", "cone-beam computed tomography" and "micro-computed tomography". Dummer PMH was the most prolific author and the authors affiliated with the institutions of the United Kingdom had the most publications and citations in the *IEJ*. The largest number of publications were from the University of São Paulo, Brazil. The *JOE* cited *IEJ* publications the most. There has been a continuous increase in the impact factor of the *IEJ*, whereby in 2015 it was 2.842 and in 2019 it was 3.801 with a 5-year impact factor of 3.418. The *IEJ* is ranked 6/91 in Dentistry, Oral Surgery & Medicine, and ranked no. 1 in Endodontics specifically. In conclusion, the *IEJ* has been providing a forum for innovative reports for the last 50 years. The bibliometric analysis confirms that the *IEJ* is a prominent international journal in the specialty of Endodontology.

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Table 1. Citation structure of the manuscripts appearing in the *IEJ* between 1967 and 2020.

PY	TP	NCP	TC	C/P	C/CP	H-index
1967	6	4	24	4.00	6.00	2
1968	14	7	99	7.07	14.14	4
1969	20	6	51	2.55	8.50	3
1970	16	6	24	1.50	4.00	3
1971	19	6	31	1.63	5.17	4
1972	21	11	45	2.14	4.09	4
1974	30	8	59	1.97	7.38	4
1975	20	4	191	9.55	47.75	3
1976	15	7	78	5.20	11.14	3
1977	9	6	29	3.22	4.83	3
1978	9	7	56	6.22	8.00	4
1979	10	7	67	6.70	9.57	3
1980	22	14	299	13.59	21.36	9
1981	37	22	300	8.11	13.64	11
1982	26	25	567	21.81	22.68	12
1983	24	24	404	16.83	16.83	11
1984	25	22	438	17.52	19.91	8
1985	29	29	1428	49.24	49.24	14
1986	41	36	771	18.80	21.42	18
1987	37	35	772	20.86	22.06	16
1988	60	45	1222	20.37	27.16	19

1989	42	39	901	21.45	23.10	16
1990	34	32	1146	33.71	35.81	18
1991	42	38	1353	32.21	35.61	16
1992	41	40	1015	24.76	25.38	19
1993	73	53	1971	27.00	37.19	23
1994	51	49	1470	28.82	30.00	23
1995	50	50	1982	39.64	39.64	21
1996	49	49	1993	40.67	40.67	23
1997	59	59	3078	52.17	52.17	26
1998	53	52	2725	51.42	52.40	28
1999	63	63	3085	48.97	48.97	31
2000	65	64	3512	54.03	54.88	31
2001	87	87	5790	66.55	66.55	39
2002	128	128	6521	50.95	50.95	49
2003	115	114	6372	55.41	55.89	44
2004	103	103	4910	47.67	47.67	45
2005	117	117	5327	45.53	45.53	47
2006	113	113	6140	54.34	54.34	46
2007	113	113	5346	47.31	47.31	43
2008	136	133	5260	38.68	39.55	40
2009	133	128	5465	41.09	42.70	44
2010	133	133	4466	33.58	33.58	42
2011	137	135	4322	31.55	32.01	35

2012	139	139	5061	36.41	36.41	41
2013	136	135	3544	26.06	26.25	35
2014	129	127	2769	21.47	21.80	31
2015	139	139	2712	19.51	19.51	29
2016	120	120	2009	16.74	16.74	24
2017	135	133	1969	14.59	14.80	24
2018	162	157	1735	10.71	11.05	19
2019	169	162	980	5.80	6.05	14
2020	183	87	222	1.21	2.55	6

Total number of *IEJ* publications (TP), number of cited publications (NCP), total citations (TC), average citations per publication (C/P), average citations per cited publication (C/CP), and h-index (h).

Table 2. The 20 most frequently cited manuscripts in the *IEJ* between 1967 and 2020

TC	Title	Author(s)	Year	CPY
735	Influence of Infection at The Time of Root Filling on The Outcome of Endodontic Treatment of Teeth with Apical Periodontitis	Sjögren U; Figdor D; Persson S; Sundqvist G	1997	31.96
588	Microbiological Status of Root-Filled Teeth with Apical Periodontitis	Molander A; Reit C; Dahlen G; Kvist T	1998	26.73
574	Periapical Status of Endodontically Treated Teeth in Relation to The Technical Quality of The Root Filling and The Coronal Restoration	Ray HA; Trope M	1995	22.96
502	The Antibacterial Action of Sodium Hypochlorite and EDTA in 60 Cases of Endodontic Therapy	Byström A; Sunvqvist G	1985	14.34
461	Quality Guidelines for Endodontic Treatment: Consensus Report of The European Society of Endodontology	European Society of Endodontology	2006	32.93
444	Mechanisms of Antimicrobial Activity of Calcium Hydroxide: A Critical Review	Siqueira Jr. JF; Lopes HP	1999	21.14
440	The Antimicrobial Effect of Calcium Hydroxide as A Short term Intracanal Dressing	*Sjögren* U; Figdor D; Spångberg L; Sundqvist G	1991	15.17

415	Aetiology of Root Canal Treatment Failure: Why Well-Treated Teeth Can Fail	Siqueira Jr. JF	2001	21.84
410	On the Causes of Persistent Apical Periodontitis: A Review	Nair PNR	2006	29.29
406	Effects of Four Ni-Ti Preparation Techniques on Root Canal Geometry Assessed by Micro Computed Tomography	Peters OA; Schönenberger K; Laib A	2001	21.37
375	An Overview of Nickel-Titanium Alloys Used in Dentistry	Thompson SA	2000	18.75
344	Endodontic Leakage Studies Reconsidered. Part I. Methodology, Application and Relevance	Wu MK; Wesselink PR	1993	12.74
340	Outcome of Primary Root Canal Treatment: Systematic Review of The Literature - Part 2. Influence of Clinical Factors	Ng YL; Mann V; Rahbaran S; Lewsey J; Gulabivala K	2008	28.33
333	The Potential Applications of Cone Beam Computed Tomography in The Management of Endodontic Problems	Patel S; Dawood A; Pitt Ford T; Whaites E	2007	25.62
331	Passive Ultrasonic Irrigation of The Root Canal: A Review of The Literature	Van Der Sluis LWM; Versluis M; Wu MK; Wesselink PR	2007	25.46
328	Enterococcus Faecalis - A Mechanism for Its Role in Endodontic Failure	Love RM	2001	17.26

326	In-Vitro Antibacterial Susceptibility of Bacteria Taken from Infected Root Dentine to A Mixture of Ciprofloxacin, Metronidazole and Minocycline	Hoshino E; Kurihara-Ando N; Sato I; Uematsu H; Sato M; Kota K; Iwaku M	1996	13.58
316	Microorganisms from Canals of Root-Filled Teeth with Periapical Lesions	Pinheiro ET; Gomes BP; Ferraz CC; Sousa EL; Teixeira FB; Souza-Filho FJ	2003	18.59
315	Canal Preparation Using Only One Ni-Ti Rotary Instrument: Preliminary Observations	Yared G	2008	26.25
299	Apical Limit of Root Canal Instrumentation and Obturation, Part 2. A Histological Study	Ricucci D; Langeland K	1998	13.59

Total citations (TC), Average citations per year (CPY).

Table 3. Temporal analysis of author keywords of manuscripts published in the *IEJ* between 1967 and 2020.

Topics	TP	TC	C/P	P1 1991-2000	P2 2001-2010	P3 2011-2020
Endodontics	316	10795	34.16	68	101	147
Root canal treatment	139	6413	46.14	28	56	55
Calcium hydroxide	136	6691	49.20	39	57	40
Apical periodontitis	125	3804	30.43	9	35	81
Mineral Trioxide Aggregate	116	5524	47.62	0	48	68
Nickel-Titanium	108	5265	48.75	23	61	24
Sodium hypochlorite	104	4667	44.88	14	32	58
Dentine	70	2533	36.19	13	22	35
Enterococcus *faecalis*	68	3072	45.18	3	20	45
Cytotoxicity	65	1674	25.75	2	24	39
Irrigation	64	3037	47.45	2	29	33
Smear layer	62	3996	64.45	23	25	14
Dental pulp	62	1003	16.18	6	26	30
Cone Beam Computed Tomography	55	2295	41.73	0	6	49
Gutta-percha	54	1914	35.44	8	31	15
Micro-CT	51	1227	24.06	0	2	49
Inflammation	50	724	14.48	3	15	32

Biocompatibility	49	1739	35.49	2	19	28
Chlorhexidine	41	2146	52.34	2	17	22
Cyclic fatigue	40	1897	47.43	2	9	29
Biofilm	40	1273	31.83	0	8	32
Fracture resistance	40	1139	28.48	0	21	19

Total number of *IEJ* articles classified under the respective theme (TP), total citations associated with these publications (TC), and average citations per publication (C/P). The remaining three columns (P1, P2, and P3) depict the temporal evolution of the author keywords over three periods (1991–2000, 2001–2010, and 2011-2020 respectively) and present the respective count of publications for each period.

Table 4. The top 25 most productive authors with publications within the *IEJ* between 1967 and 2020. This table lists the top "*International Endodontic Journal*" authors with at least 26 publications and 500 citations between 1967 and 2020.

Authors	Affiliation	Country	TP	TC	CPY	H
Dummer PMH	Cardiff University	United Kingdom	112	4354	38.88	40
Wesselink PR	Academic Centre for Dentistry Amsterdam	The Netherlands	66	4903	74.29	40
Gutmann JL	Texas A&M University Baylor College of Dentistry, Dallas	United States	63	1957	31.06	27
Gulabivala K	University of London	United Kingdom	61	3770	61.80	27
De-Deus G	Fluminense Federal University	Brazil	55	1529	27.80	24
Ng YL	University College London	United Kingdom	48	3474	72.38	27
Wu MK	Academic Centre for Dentistry Amsterdam	Netherlands	44	3528	80.18	33
Silva EJNL	Grande Rio University	Brazil	43	406	9.44	12
Patel S	King's College London	United Kingdom	42	2533	60.31	25
Gomes BPFA	State University of Campinas	Brazil	38	2219	58.39	22
Sousa-Neto MD	University of São Paulo	Brazil	36	1189	33.03	21

Mannocci F	King's College London	United Kingdom	35	1608	45.94	22
Zehnder M	University of Zürich	Switzerland	35	1390	39.71	22
Tanomaru-Filho M	São Paulo State University	Brazil	33	732	22.18	16
Versiani MA	Oral Health Department, Brazilian Military Police	Brazil	32	1156	36.13	19
Saunders WP	University of Glasgow Dental School	United Kingdom	32	1052	32.88	20
Schäfer E	University of Münster	Germany	31	1739	56.10	21
Hülsmann M	University of Göttingen	Germany	31	2060	66.45	25
Camilleri J	Department of Building and Civil Engineering	Malta	29	1803	62.17	21
Van Der Sluis LWM	Academic Centre for Dentistry Amsterdam	Netherlands	28	1468	52.43	20
Ørstavik D	University of Oslo	Norway	28	2202	78.64	23
Pitt Ford TR	King's College London, Guy's Hospital	United Kingdom	27	1628	60.30	17
Abbott PV	University of Western Australia	Australia	27	1110	41.11	17
Love RM	University of Otago	New Zealand	26	1231	47.35	17
Souza EM	Federal University of Maranhão	Brazil	26	557	21.42	14

A total number of *IEJ* publications by each author (TP), total citations associated with these publications (TC) citations per publication (C/P), and h-index (h).

Table 5. The top 25 journals citing papers from the *IEJ* between 1967 and 2020.

	Journal	Publisher	Country	TC	IF 2019
1	*Journal of Endodontics*	Elsevier Inc	United States	28048	3.118
2	*International Endodontic Journal*	Wiley-Blackwell Publishing Ltd	United Kingdom	16180	3.801
3	*Journal of Dental Research*	SAGE Publications Inc.	United States	2905	4.914
4	*Oral Surgery, Oral Medicine and Oral Pathology*	Elsevier Inc	United States	5406	1.601
5	*British Dental Journal*	Nature Publishing Group	United Kingdom	1258	1.306
6	*Journal of The American Dental Association*	American Dental Association	United States	1201	2.803
7	*Dental Materials*	Elsevier Sci Ltd	United Kingdom	1143	4.494
8	*Archives of Oral Biology*	Pergamon-Elsevier Science Ltd	United Kingdom	1085	1.931
9	*Journal of Prosthetic Dentistry*	Mosby-Year Book Inc	United States	972	2.444
10	*Journal of Dentistry*	Elsevier Sci Ltd	United Kingdom	917	3.242

11	*Dental Traumatology*	John Wiley & Sons	United States	821	1.53
12	*European Journal of Oral Sciences*	John Wiley & Sons	United States	721	2.22
13	*Dental Clinics of North America*	W.B. Saunders Ltd	United Kingdom	691	N/A
14	*Endodontic Topics*	John Wiley & Sons	United States	660	N/A
15	*Journal of Periodontology*	Amer Acad Periodontology	United States	633	3.742
16	*Quintessence International*	Quintessence Publ Co Inc	United States	597	1.46
17	*Biomaterials*	Elsevier Sci Ltd	United Kingdom	546	10.317
18	*Clinical Oral Investigations*	Springer Heidelberg	Germany	539	2.812
19	*Brazilian Dental Journal*	Associacao Brasileira de Divulgacao Cientifica	Brazil	510	N/A
20	*Acta Odontologica Scandinavica*	Scandinavian University Press	Norway	498	1.573
21	*Australian Dental Journal*	Australian Dental Assn Inc	Australia	483	1.401

22	*Oral Microbiology and Immunology*	John Wiley & Sons	United States	475	2.905
23	*Operative Dentistry*	Operative Dentistry Inc	United States	442	2.213
24	*Journal of Clinical Periodontology*	John Wiley & Sons Ltd	United States	424	5.241
25	*Journal of Oral Rehabilitation*	John Wiley & Sons Ltd	United States	362	2.304

TC equals total citations associated with these journals.

Table 6. Top 25 articles appearing most frequently in the reference lists of *IEJ* manuscripts.

Authors	Title	Journal	Year	Citations
Sjögren ULF; Hägglund B; Sundqvist G; Wing K	Factors Affecting the Long-Term Results of Endodontic Treatment	*Journal of Endodontics*	1990	108
Zehnder M	Root Canal Irrigants	*Journal of Endodontics*	2006	80
Molander A; Reit C; Dahlen G; Kvist T	Microbiological Status of Root-Filled Teeth with Apical Periodontitis	*International Endodontic Journal*	1998	78
Sjögren U; Figdor D; Persson S; Sundqvist G	Influence of Infection at The Time of Root Filling on The Outcome of Endodontic Treatment of Teeth with Apical Periodontitis	*International Endodontic Journal*	1997	75
Byström A; Sundqvist G	The Antibacterial Action of Sodium Hypochlorite and Edta in 60 Cases of Endodontic Therapy	*International Endodontic Journal*	1985	66
Peters OA	Current Challenges and Concepts in The Preparation of Root Canal Systems: A Review	*Journal of Endodontics*	2004	62
Schilder H	Cleaning and Shaping the Root Canal	*Dental Clinics of North America*	1974	61

Byström A; Sundqvist G	Bacteriologic Evaluation of The Efficacy of Mechanical Root Canal Instrumentation in Endodontic Therapy	*Scandinavian Journal of Dental Research*	1981	56
Torabinejad M; Chivian N	Clinical Applications of Mineral Trioxide Aggregate	*Journal of Endodontics*	1999	50
Weine FS; Kelly RF; Lio PJ	The Effect of Preparation Procedures on Original Canal Shape and On Apical Foramen Shape	*Journal of Endodontics*	1975	47
Byström A; Claesson R; Sundqvist G	The Antibacterial Effect of Camphorated Paramonochlorophenol, Camphorated Phenol and Calcium Hydroxide in The Treatment of Infected Root Canals	*Endodontics and Dental Traumatology*	1985	44
Baumgartner JC; Mader CL	A Scanning Electron Microscopic Evaluation of Four Root Canal Irrigation Regimens	*Journal of Endodontics*	1987	41
Haapasalo M; Ørstavik D	In Vitro Infection and Disinfection of Dentinal Tubules	*Journal of Dental Research*	1987	41
Ray HA; Trope M	Periapical Status of Endodontically Treated Teeth in Relation to The	*International Endodontic Journal*	1995	41

	Technical Quality of The Root Filling and The Coronal Restoration			
Thompson SA	An Overview of Nickel-Titanium Alloys Used in Dentistry	*International Endodontic Journal*	2000	41
Esposito PT; Cunningham CJ	A Comparison of Canal Preparation with Nickel-Titanium and Stainless Steel Instruments	*Journal of Endodontics*	1995	40
Moorer WR; Wesselink PR	Factors Promoting the Tissue Dissolving Capability of Sodium Hypochlorite	*International Endodontic Journal*	1982	40
Peters OA; Schonenberger K; Laib A	Effects of Four Ni-Ti Preparation Techniques on Root Canal Geometry Assessed by Micro Computed Tomography	*International Endodontic Journal*	2001	40
Kuttler Y	Microscopic Investigation of Root Apexes	*Journal of The American Dental Association*	1955	39
Torabinejad M; Ung B; Kettering JD	In Vitro Bacterial Penetration of Coronally Unsealed Endodontically Treated Teeth	*Journal of Endodontics*	1990	39

Ørstavik D; Kerekes K; Eriksen HM	The Periapical Index: A Scoring System for Radiographic Assessment of Apical Periodontitis	*Endodontics and Dental Traumatology*	1986	35
Pruett JP; Clement DJ; Carnes DL	Cyclic Fatigue Testing of Nickel-Titanium Endodontic Instruments	*Journal of Endodontics*	1997	34
Torabinejad M; Hong CU; Mcdonald F; Pitt Ford TR	Physical and Chemical Properties of a New Root-End Filling Material	*Journal of Endodontics*	1995	34
Gambarini G; Grande NM; Plotino G	Fatigue Resistance of Engine-Driven Rotary Nickel-Titanium Instruments Produced by New Manufacturing Methods	*Journal of Endodontics*	2008	33

Table 7. The top 25 countries affiliated with authors of manuscripts published within the *IEJ* between 1967 and 2020

Rank	Country	TP	TC	C/P	h
1	United Kingdom	680	21052	30.96	75
2	Brazil	617	16639	26.97	58
3	United States	419	12806	30.56	58
4	Turkey	217	5561	25.63	40
5	Germany	188	7969	42.39	51
6	Italy	158	5735	36.30	43
7	China	154	2859	18.56	31
8	Japan	144	4363	30.30	37
9	Netherlands	135	6474	47.96	47
10	Australia	131	4683	35.75	39
11	Switzerland	130	5801	44.62	43
12	Sweden	109	5248	48.15	35
13	Spain	106	2662	25.11	31
14	Norway	86	4054	47.14	36
15	Greece	81	2164	26.72	26
16	Canada	79	2685	33.99	29
17	Iran	68	2866	42.15	32
18	France	66	2505	37.95	30
19	Israel	65	1535	23.62	24
20	India	65	1252	19.26	22

21	Belgium	61	2454	40.23	28
22	Taiwan	57	1375	24.12	22
23	New Zealand	56	2341	41.80	25
24	South Korea	56	1183	21.13	19
25	Malaysia	50	548	10.96	13

A total number of *IEJ* publications (TP) total citations associated with these papers (TC), citations per publication (C/P), and h-index (h).

Table 8. The top 25 institutions affiliated with the authors of manuscripts within the *IEJ* between 1967 and 2020.

Rank	Institution	TP	TC	NCP	C/P	H
1	University of São Paulo	146	3558	138	24.37	37
2	Academic Centre for Dentistry Amsterdam	105	6047	104	57.59	45
3	University College London	83	4347	74	52.37	31
4	São Paulo State University - International	81	1815	74	22.41	26
5	Guy's Hospital, King’s College London	78	2559	68	32.81	27
6	Cardiff University	77	2342	70	30.42	27
7	State University of Campinas	74	2646	71	35.76	27
8	University of Zurich	69	4066	67	58.93	35
9	Texas A&M College of Dentistry	64	1618	61	25.28	24
10	University of Birmingham	59	1394	55	23.63	22
11	University of Otago	55	2341	53	42.56	25
12	University of Melbourne	52	2328	51	44.77	30
13	University of Gothenburg	51	3019	51	59.20	22
14	Glasgow Dental Hospital and School	46	1155	44	25.11	20
15	Fluminense Federal University	45	611	39	13.58	14
16	University of Newcastle	43	1072	43	24.93	16
17	Tokyo Medical and Dental University	41	990	39	24.15	19
18	Tel Aviv University	41	876	39	21.37	18
19	Ege University	40	1266	39	31.65	21
20	Federal University of Minas Gerais	40	749	36	18.73	18

21	Aristotle University	40	1362	38	34.05	22
22	Wuhan University	35	737	35	21.06	15
23	University of Oslo	35	2140	35	61.14	22
24	University of Toronto	33	105	31	3.18	19
25	University of Hong Kong	31	1041	31	33.58	18

Total number of *IEJ* publications (TP), number of cited publications (NCP), total citations of these publications (TC), citations per publication (C/P), and the h-index (h).

Legends

Tables

Table 1. Citation structure of the manuscripts appearing in the *IEJ* between 1967 and 2020.

Table 2. The 20 most frequently cited manuscripts in the *IEJ* between 1967 and 2020.

Table 3. Temporal analysis of author keywords of manuscripts published in the *IEJ* between 1967 and 2020.

Table 4. The top 25 most productive authors with publications within the *IEJ* between 1967 and 2020. This table lists the top "*International Endodontic Journal*" authors with at least 26 publications and 500 citations between 1967 and 2020.

Table 5. The top 25 journals citing papers from the *IEJ* between 1967 and 2020.

Table 6. Top 25 articles appearing most frequently in the reference lists of *IEJ* manuscripts.

Table 7. The top 25 countries affiliated with authors of manuscripts published within the *IEJ* between 1967 and 2020.

Table 8. The top 25 institutions affiliated with the authors of manuscripts within the *IEJ* between 1967 and 2020.

Figures

Figure 1. Flow diagram of data retrieval and filtration of *IEJ* publications.

Figure 2. Evolution of *IEJ* publications and citations over the publication history of the journal.

Figure 3. Authorship pattern of *IEJ* articles outlining single and multiple authorships with the citations, whereby the x-axis represents the number of authors.

Figure 4. Keyword co-occurrences of manuscripts published in the *IEJ* with a threshold of 30 occurrences.

Purple (cluster 1), green (cluster 2), blue (cluster 3), orange (cluster 4), and dark green (cluster 5)

Figure 5. Co-citation of journals with a citation threshold of 450.

Purple (cluster 1), green (cluster 2), blue (cluster 3), orange (cluster 4), yellow (cluster 5)

Figure 6. Bibliographic coupling of countries that published in *IEJ* with the threshold of 50 documents and 500 citations.

Purple (cluster 1), orange (cluster 2), green (cluster 3).

Figure 7. Bibliographic coupling of authors with the threshold of 25 documents and 400 citations.

Purple (cluster 1), green (cluster 2), blue (cluster 3), orange (cluster 4), dark green (cluster 5)

Figure 8. Bibliographic coupling of the institutions of the authors of the IEJ manuscripts.

Purple (cluster 1), dark green (cluster 2), blue (cluster 3), red (cluster 4), orange (cluster 5), Green (cluster 6).

Figures

Figure 1. Flow diagram of data retrieval and filtration of *IEJ* publications.

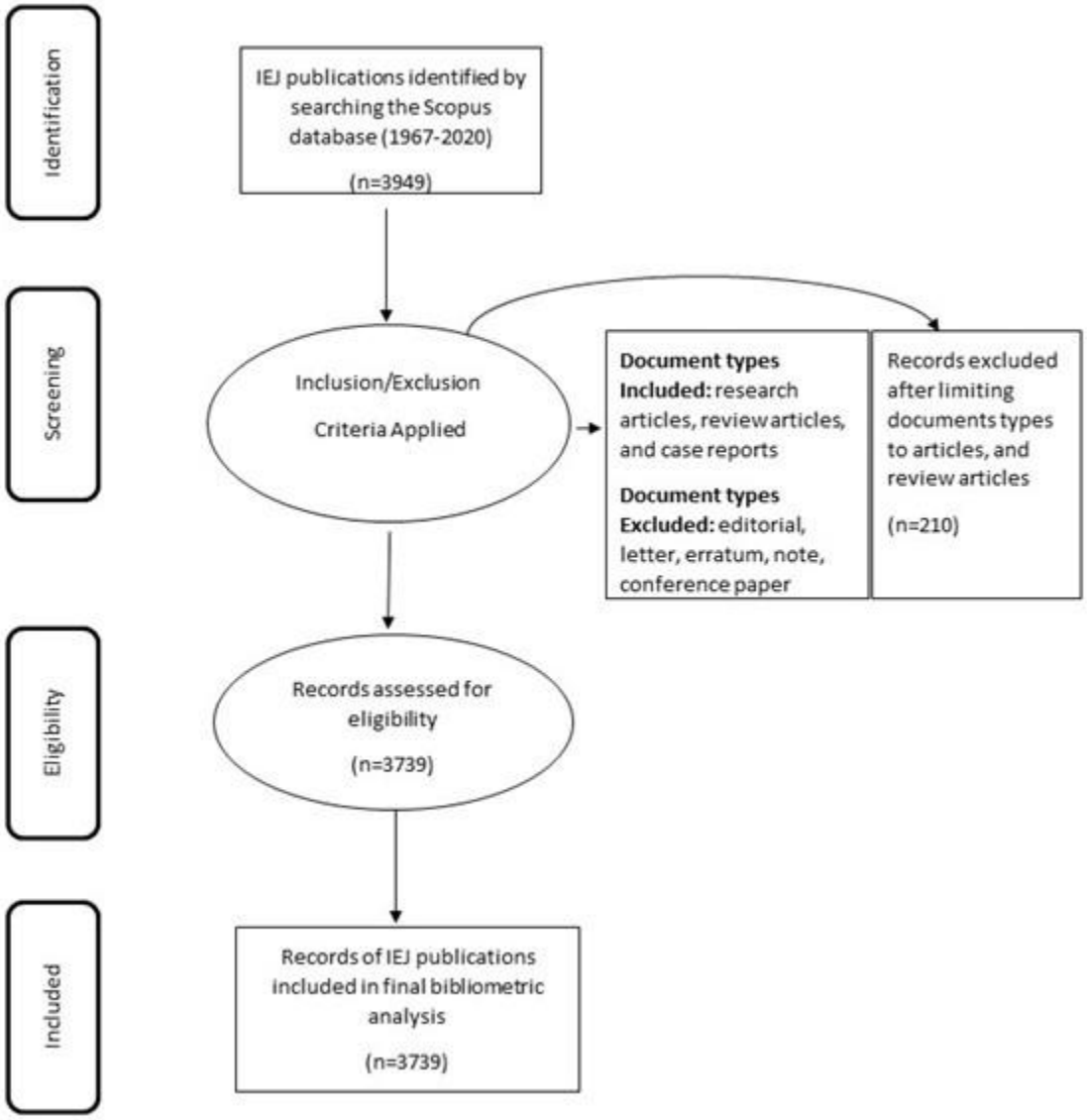


Figure 2. Evolution of *IEJ* publications and citations over the publication history of the journal.

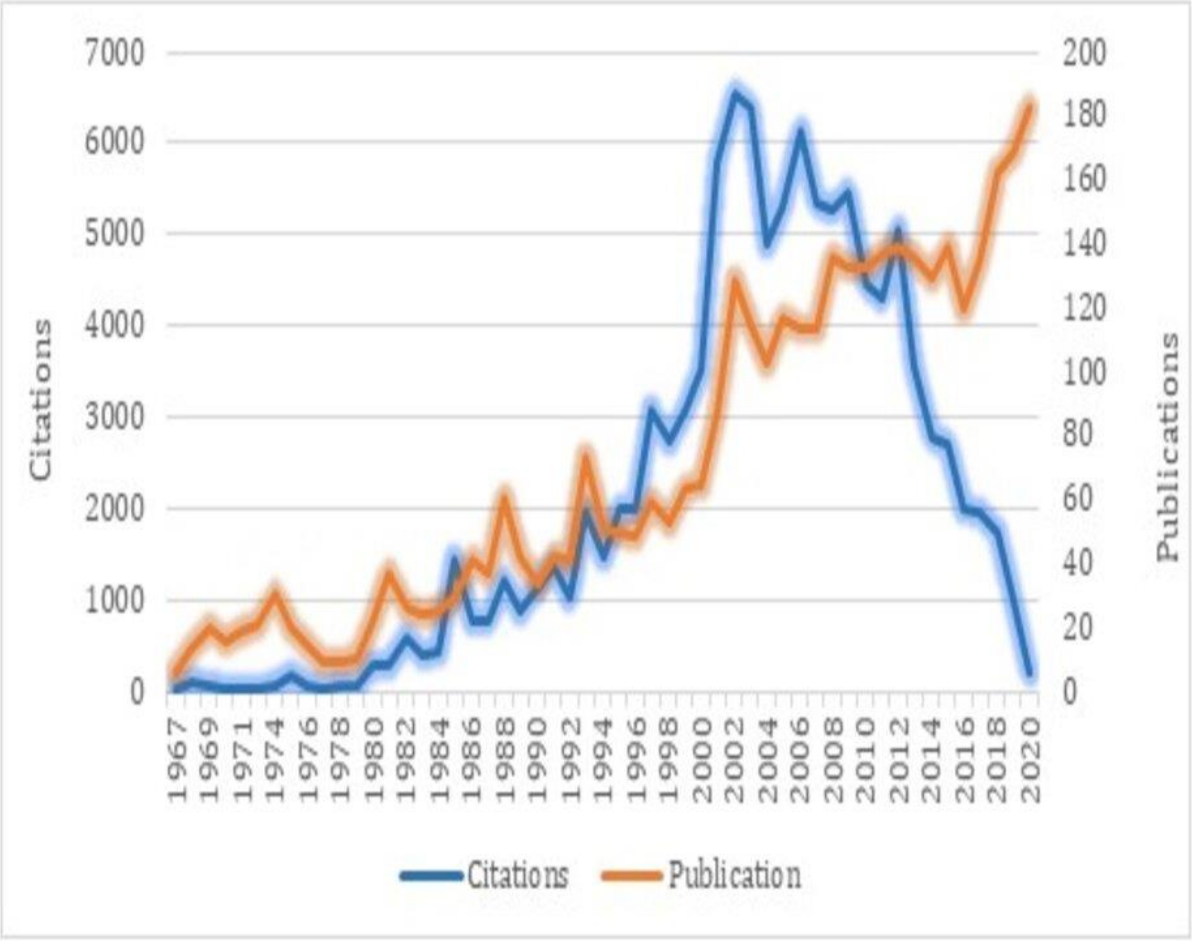


Figure 3. Authorship pattern of *IEJ* articles outlining single and multiple authorships with the citations, whereby the x-axis represents the number of authors.

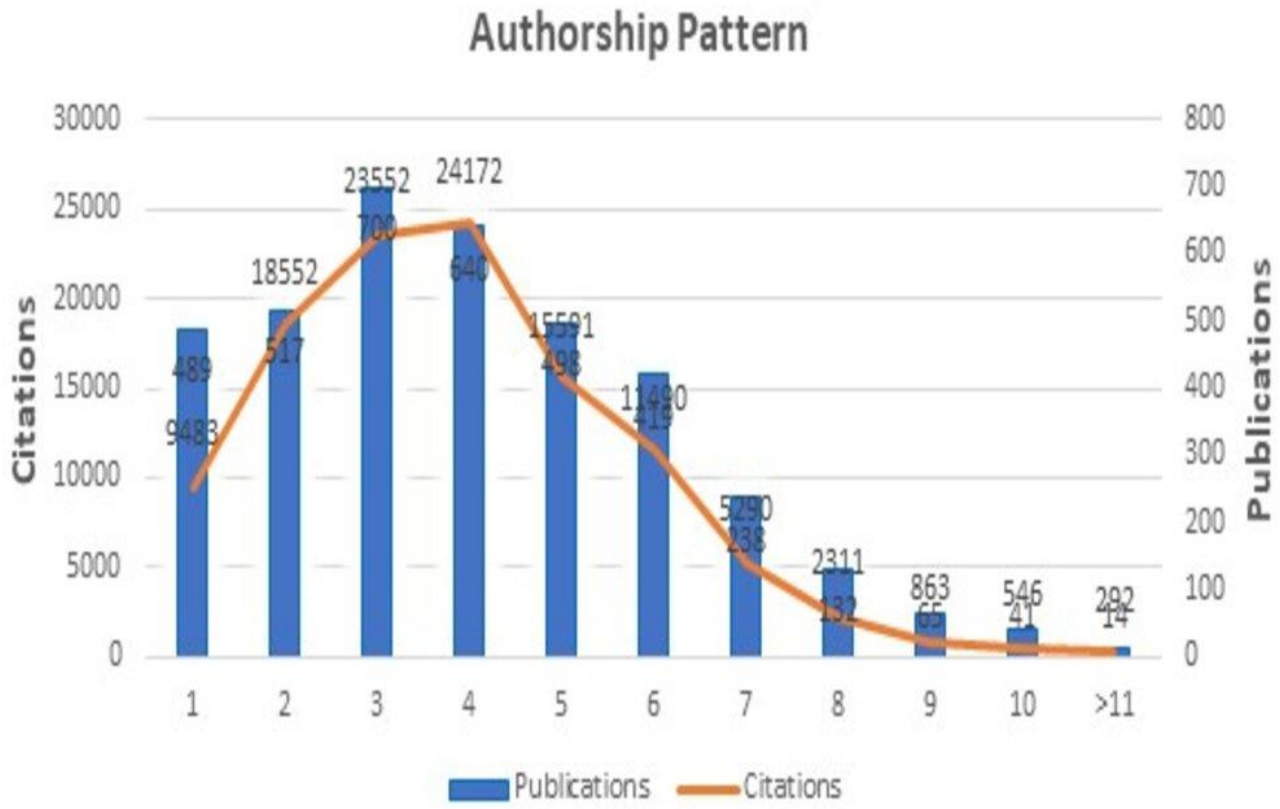


Figure 4. Keyword co-occurrences of manuscripts published in the *IEJ* with a threshold of 30 occurrences.

Purple (cluster 1), green (cluster 2), blue (cluster 3), orange (cluster 4), and dark green (cluster 5)

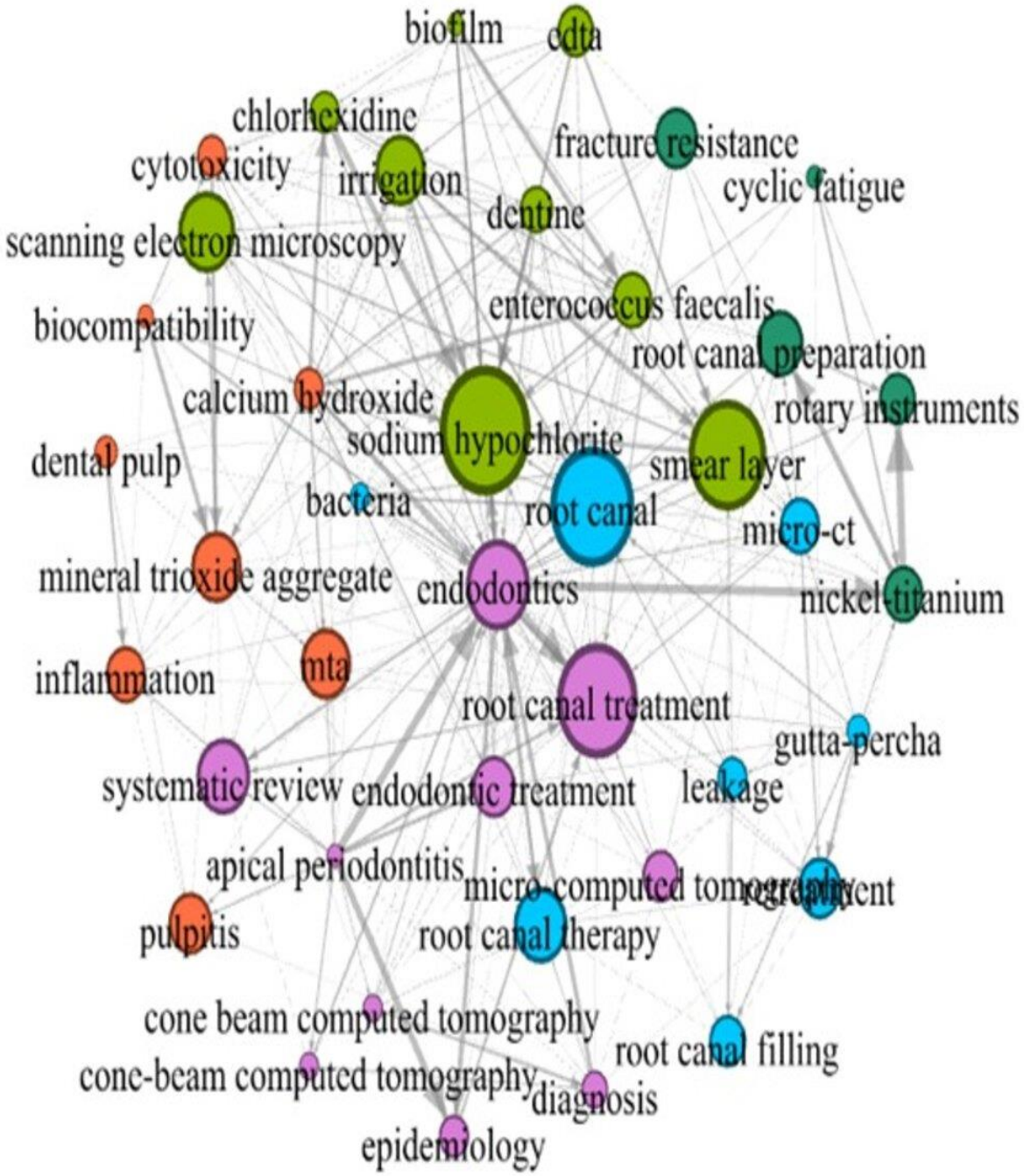


Figure 5. Co-citation of journals with a citation threshold of 450.

Purple (cluster 1), green (cluster 2), blue (cluster 3), orange (cluster 4), yellow (cluster 5)

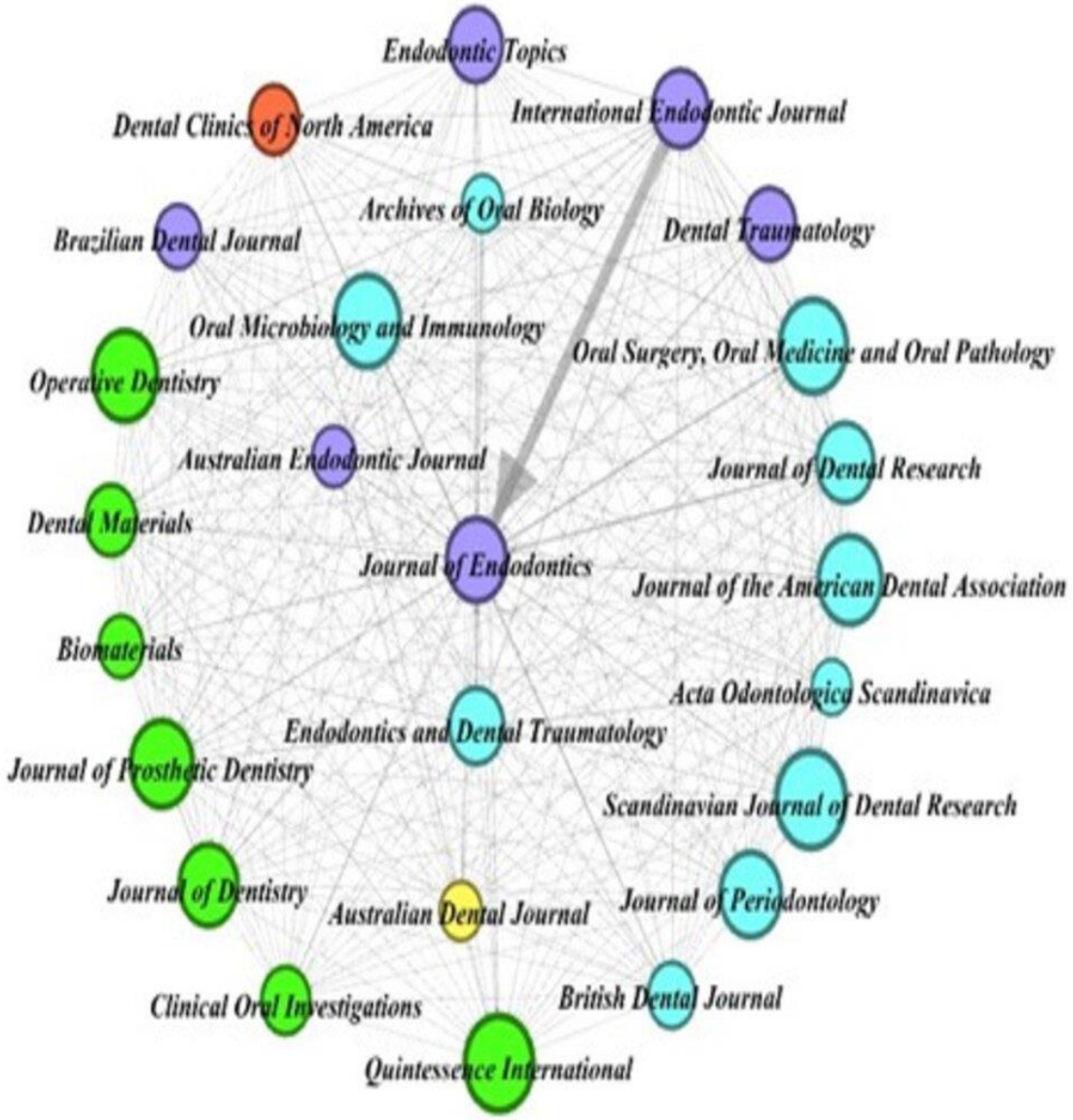


Figure 6. Bibliographic coupling of countries that published in *IEJ* with the threshold of 50 documents and 500 citations.

Purple (cluster 1), orange (cluster 2), green (cluster 3).

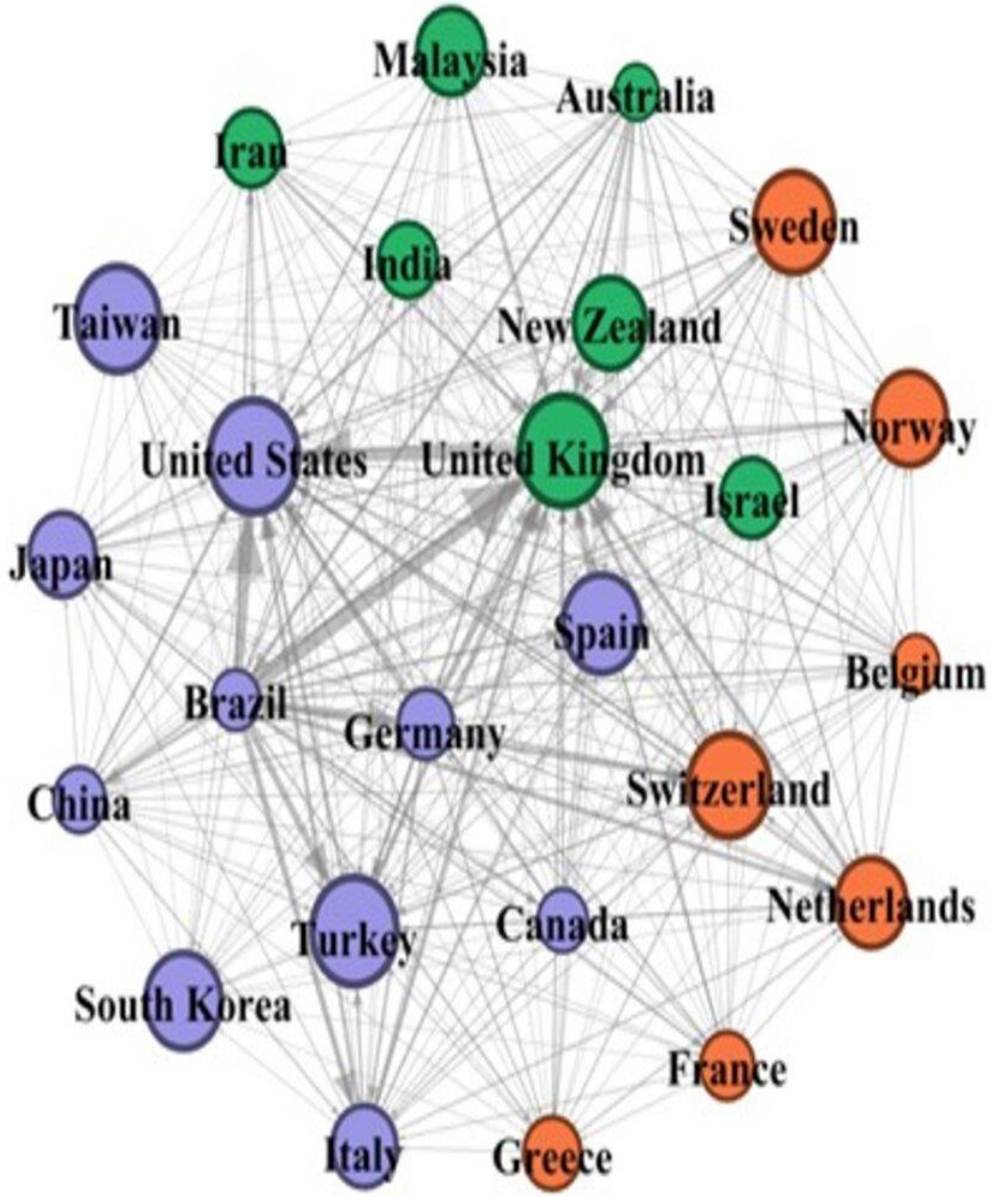


Figure 7. Bibliographic coupling of authors with the threshold of 25 documents and 400 citations. Purple (cluster 1), green (cluster 2), blue (cluster 3), orange (cluster 4), dark green (cluster 5)

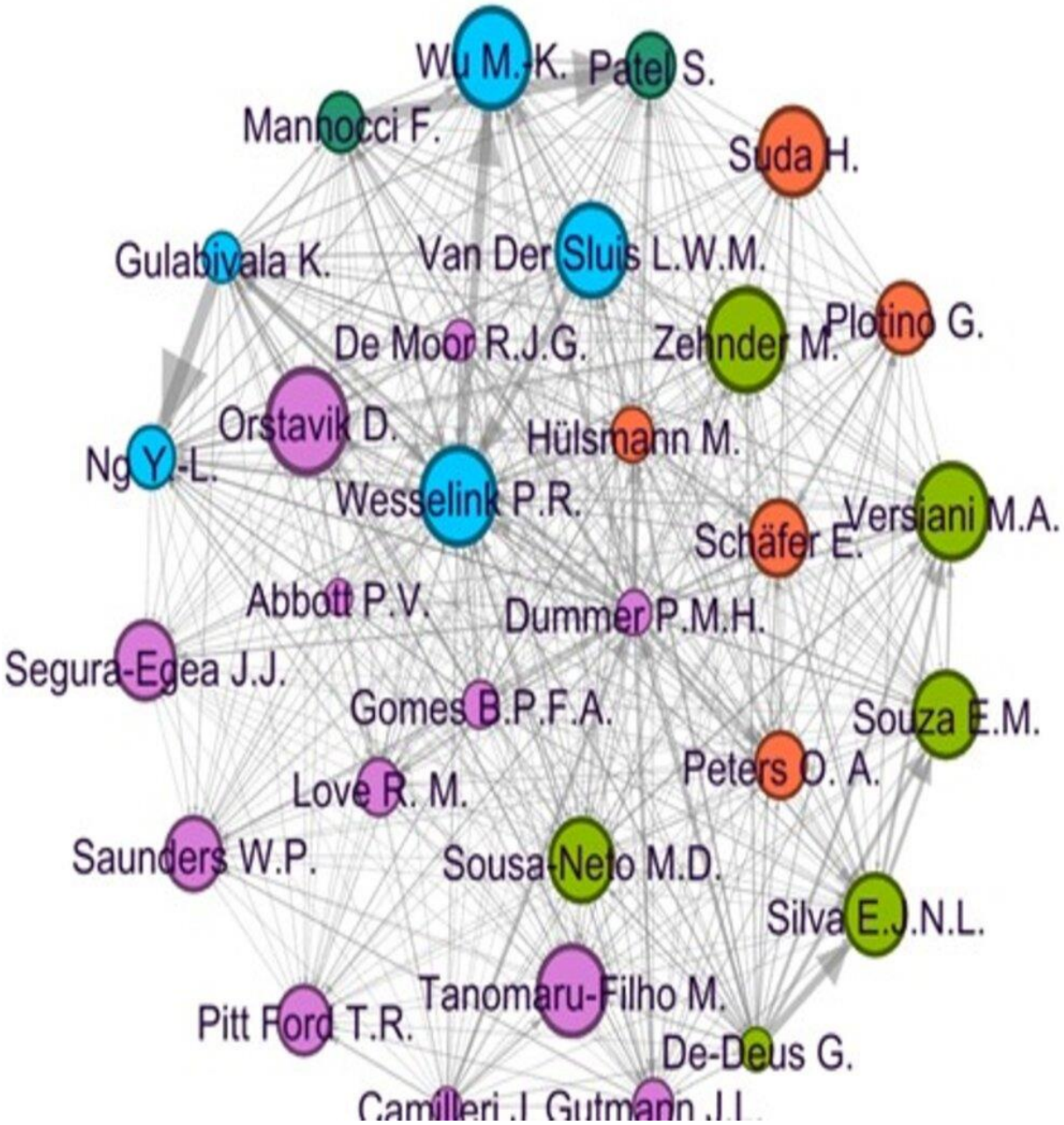
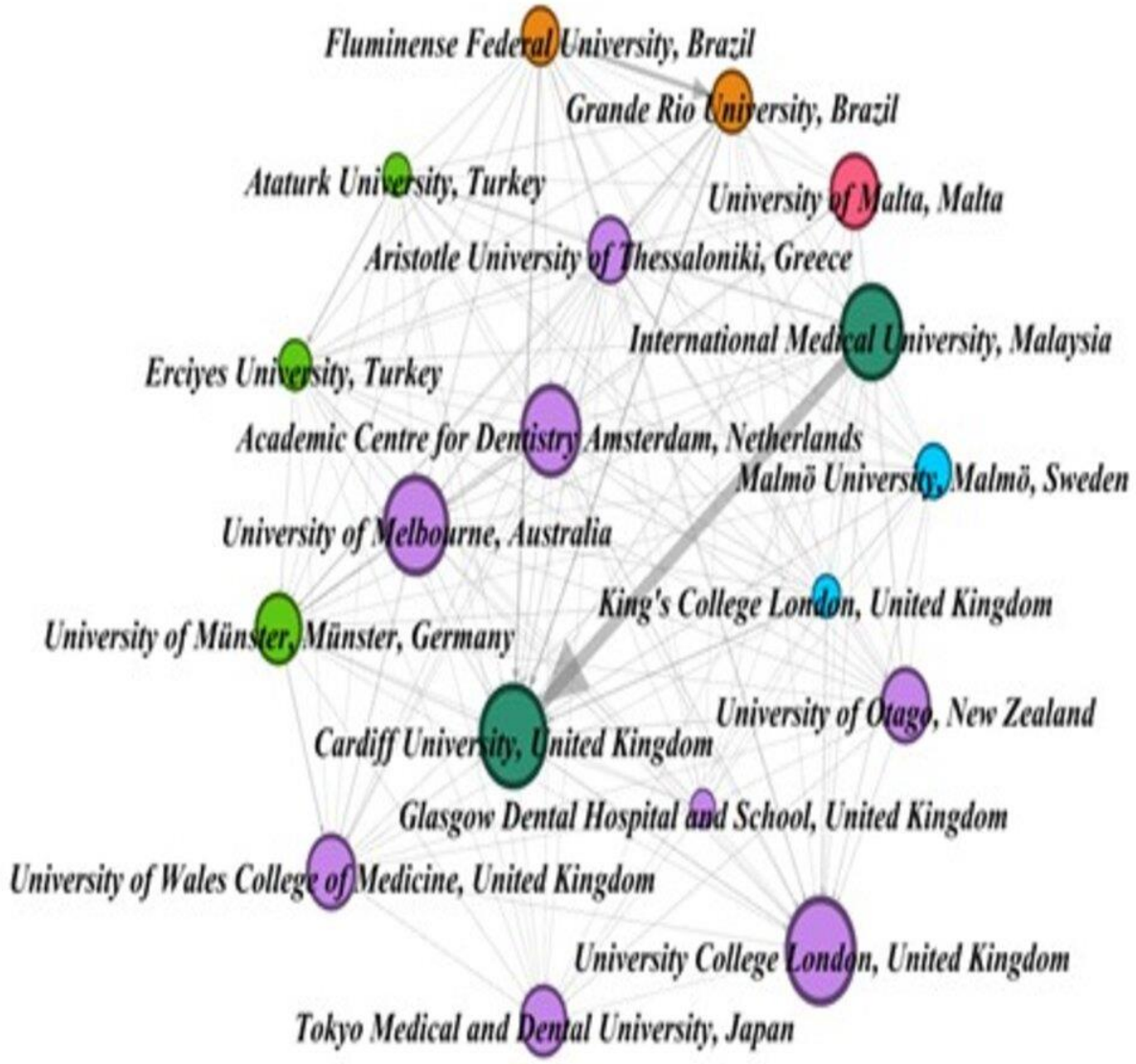


Figure 8. Bibliographic coupling of the institutions of the authors of the IEJ manuscripts. Purple (cluster 1), dark green (cluster 2), blue (cluster 3), red (cluster 4), orange (cluster 5), Green (cluster 6).



Supplementary Table S1. Special issues and (or) sections published in IEJ between 1967 and 2020

Volume	Issue	Year	Issue Title	Editor
50	S1	2017	European Society of Endodontology: Abstracts from the Biennial Congress 2017, 14-16 September 2017, Brussels, Belgium	
50	S2	2017	Bioactive endodontic cements Special 50th Anniversary Virtual Issue	
51	S1	2018	Canal Irrigation	Dummer PMH
51	S2	2018	Pulp and Periapical Pathosis	
51	S3	2018	Clinical Outcome Studies	
51	S4	2018	Endodontic Regeneration	
52	S1	2019	European Society of Endodontology: Abstracts from the Biennial Congress 2019, 11-14 September 2019, Austria Center Vienna, Austria	

Table S2 Factors which can influence the citations of the published articles

Factors
"Paper" related factors
1. Quality of paper
2. Novelty, popularity and interest of subject
3. Characteristics of fields/subfields of a discipline and study subject/topics
4. Methodology
5. Document type
6. Study design
7. Characteristics of results, discussions and other sections
8. Use of figures and appendix in papers
9. Characteristics of the title, abstract and keywords
10. Characteristics of references
11. Length of paper
12. Age of cited paper (age effect)
13. Early citation and speed of citation
14. Accessibility and visibility of papers
"Journal" related factors
15. Journal impact factor and prestige
16. Language of journal (paper's language)
17. Scope and coverage of journal
18. Form of publication and presentation (conference, journal)
"Author" related factors
19. Number of authors and co-authorship
20. Author's reputation and previous citations
21. Author's academic rank
22. Self-citation
23. International and national collaboration of authors
24. Authors' country
25. The gender, age and race of authors
26. Author's productivity
27. Organizational features of authors
28. Funding and grants received by authors