**Abstract**

**Aim** To identify and analyse the main features of the top 100 most-cited randomized controlled trials, systematic reviews, and meta-analyses published in endodontic journals.

**Methodology** The Clarivate Analytics' Web of Science (WoS) was used to search and analyse the 100 most frequently cited RCTs, systematic reviews, and meta-analyses having "randomized", "randomised", "randomized controlled", "randomised controlled", "randomized controlled trial", "randomized controlled trials", "clinical trial", "systematic", "systematic review", "meta-analysis", and "meta-analyses" in the title section. The "*International Endodontic Journal*", "*Journal of Endodontics*", "*Oral Surgery Oral Medicine Oral Pathology Oral Radiology and Endodontology*", "*Australian Endodontic Journal*", "*Endodontics & Dental Traumatology*", "*Endo-Endodontic Practice Today*", and "*European Endodontic Journal*" were included in the publication name section. After ranking the articles in a descending order based on their citation counts, each article was cross-matched with the citation counts in Elsevier's Scopus and Google Scholar. The articles were analysed and information on citation counts, citation density, year of publication, contributing authors, institutions, and countries, journal of publication, study design, topic of the article and keywords was extracted.

**Results** The citation counts of the 100 most-cited articles varied from 235 to 20 (WoS), 276 to 17 (Scopus), and 696 to 1 (Google Scholar). The year in which the top 100 articles were published was 2010 (n=13). Among 373 authors, the greatest number of articles was associated with three individuals namely Reader A (n=5), Beck M (n=5), and Kvist T (n=5). Most of the articles originated from the United States (n=24) with the greatest contribution from Ohio State University (USA) (n=5). RCTs were the most frequent study design (n=45) followed by systematic reviews (n=30) with outcome studies of root canal treatment being the major topic (n=35). The *JOE* published the largest number of included articles (n=70) followed by the *IEJ* (n=27). Among 259 unique keywords, meta-analysis (n=23) and systematic review (n=23) were the most frequently used.

**Conclusion** This study has revealed that year of publication had no obvious impact on citation count. The bibliometric analysis highlighted the quantity and quality of research as well as the evolution of scientific advancements made in the field of Endodontology over time.

## Introduction

Citation analysis in the field of bibliometrics utilizes citation data to quantify the importance of research as indicated by the citation count of an article. Analysing the most-cited research papers is often undertaken in order to determine past, current and future research within particular fields as well as to recognize the contributing institutions, authors and journals (Hirsch 2005, Ahmad *et al.* 2019). The term "citation classics" is a bibliometric concept, the purpose of which is to identify as well as acknowledge the most frequently cited manuscripts and thus authors who have had the greatest impact on a particular specialty (Aslam-Pervez & Lubek 2018). A scientific paper with more than 400 citations, is considered by some to be a "classic" article (Fardi *et al.* 2011), however, based on the specific field of scientific and clinical research, an article having 100 or more citations can also be considered as a "classic" (Andersen *et al.* 2006, Heldwein *et al.* 2010, Feijoo *et al.* 2014, Gondivkar *et al.* 2018).

The most renowned citation databases are Clarivate Analytics' Web of Science, Elsevier's Scopus, Google Scholar and PubMed Central. (Kolahi & Khazaei 2016). Influential publishers such as Wiley (https://www.wiley.com/en-us), Nature Publishing Group (https://www.nature.com/), BioMed Central (https://www.biomedcentral.com/), Elsevier (https://www.elsevier.com/en-xs), Frontiers (https://www.frontiersin.org/) and PLOS (https://www.plos.org/) provide citation statistics for their readers (Fardi *et al.* 2011, Feijoo *et al.* 2014, Van Noorden *et al.* 2014, Corbella *et al.* 2017).

Interestingly, although several studies have been conducted to identify and analyse the 'classic' articles in the field of Medicine (Baltussen & Kindler 2004, Coats 2005, Ponce & Lozano 2010, Tam *et al.* 2013, Shuaib *et al.* 2015a) as well as Dentistry (Fardi *et al.* 2011, Feijoo *et al.* 2014, Corbella *et al.* 2017, Tarazona *et al.* 2018, Wu *et al.* 2018), no bibliometric analysis has been performed on the most influential evidence level 1 articles in the field of Endodontology, that is randomized controlled trials, systematic review, and meta-analyses. Therefore, this study aims to identify and analyse the top 100 most-cited evidence level 1 articles in endodontic journals to highlight the most impactful manuscripts and authors over time.

## Materials and methods

### Search strategy

The literature search was performed on 1st April 2019 from 1961 to 2018 using Clarivate Analytics' Web of Science "All Databases". The following journals were considered as they had titles containing the word "Endodontology" or "Endodontic" or "Endodontics": *International Endodontic Journal*, *Journal of Endodontics*, *Oral Surgery Oral Medicine Oral Pathology and Oral Radiology (formerly known as Oral Surgery Oral Medicine Oral Pathology Oral Radiology and Endodontology)*, *Endo-Endodontic Practice Today*, and *European Endodontic Journal*. The journal *Dental Traumatology* was also included because it was known as *Endodontics & Dental Traumatology* until 2001. The search subjects were "randomized", "randomised", "randomized controlled", "randomised controlled", "randomized controlled trial", "randomized controlled trials", "clinical trial", "systematic", "systematic review", "meta-analysis", and "meta-analyses" in the title section. There was no restriction on the publication year of the article. According to the Web of Science "All Databases", out of 516 results, the top 100 most-cited articles were identified based on the number of citations received and these were then cross-matched with data from Google Scholar and Elsevier's Scopus. Using the Clarivate Analytics' Web of Science "All Databases", the selected articles were ranked in descending order on the basis of their citation counts. Screening was performed by two reviewers independently and finally a unanimous decision was made on the list of the top 100 most-cited manuscripts from the randomized controlled trials, systematic reviews, and meta-analyses that were included.

### Data extraction and bibliometric parameters

Article title, citation count, citation density, year of publication, authorship, contributing institution and country, journal of publication, methodological design, article topic, and keywords of each article were recorded for the top 100 most-cited evidence level 1 papers.

### Country

The institution and the country of origin of the papers was identified by the institutional address given for the corresponding author. A single-institution origin was scored if all the authors belonged to the same institution, regardless of their department.

### Methodological design

The articles were classified as; randomized controlled trials (RCTs), systematic reviews, meta-analyses, and systematic reviews and meta-analyses.

## Results

### Citation count and citation density

The top 100 most-cited evidence level 1 articles received a total of 5206 (Web of Science), 5781 (Scopus), and 11563 (Google Scholar) citations. The citation range was 235 to 20 (Web of Science), 276 to 17 (Scopus), and 696 to 1 (Google Scholar). Citation density, i.e. the average number of citations per annum was 52.06 (Web of Science), 57.81 (Scopus), and 115.63 (Google Scholar) collectively. The most cited paper with 235 (Web of Science), 276 (Scopus), 696 (Google Scholar) citations was "Outcome of primary root canal treatment: systematic review of the literature – Part 2. Influence of clinical factors" (Ng *et al.* 2008a), with an average citation per annum of 23.50. The second ranked paper with 163 (Web of Science), 185 (Scopus), 388 (Google Scholar), citations was "Outcome of primary root canal treatment: systematic review of the literature – Part 1. Effects of study characteristics on probability of success" (Ng *et al.* 2007), with an average citation per annum of 14.81. The third ranked paper with 154 (Web of Science), 177 (Scopus), 366 (Google Scholar), citations was "Histological, ultrastructural and quantitative investigations on the response of healthy human pulps to experimental capping with mineral trioxide aggregate: a

randomized controlled trial" (Nair *et al.* 2008), with an average citation per annum of 15.40. Table 1 summarizes the ranking of the 100 most-cited evidence level 1 articles in Endodontics.

**Randomized controlled trials:** A total of 45 randomized controlled trials were included in the top 100 most-cited evidence level 1 articles. These RCTs received a total of 1885 (Web of Science), 2072 (Scopus), and 4059 (Google Scholar) citations. The citation range was 154 to 21 (Web of Science), 177 to 17 (Scopus), and 366 to 29 (Google Scholar). Citation density was 41.88 (Web of Science), 46.04 (Scopus), and 90.20 (Google Scholar) collectively. The most cited RCT with 154 (Web of Science), 177 (Scopus), and 366 (Google Scholar) citations was "Histological, ultrastructural and quantitative investigations on the response of healthy human pulps to experimental capping with mineral trioxide aggregate: a randomized controlled trial" (Nair *et al.* 2008), with an average citation per annum of 15.40.

**Systematic reviews:** A total of 30 systematic reviews were included in the top 100 most-cited evidence level 1 articles. These systematic reviews received a total of 1911 (Web of Science), 2137 (Scopus), and 4134 (Google Scholar) citations. The citation range was 235 to 20 (Web of Science), 276 to 17 (Scopus), and 696 to 1 (Google Scholar). Citation density was 63.70 (Web of Science), 71.23 (Scopus), and 137.80 (Google Scholar) collectively. The most cited systematic review with 235 (Web of Science), 276 (Scopus), and 696 (Google Scholar) citations was "Outcome of primary root canal treatment: systematic review of the literature–Part 2. Influence of clinical factors" (Ng *et al*. 2008), with an average citation per annum of 23.50.

**Meta-analyses:** A total of 10 meta-analyses were included in the top 100 most-cited evidence level 1 articles. These meta-analyses received a total of 634 (Web of Science), 677 (Scopus), and 1509 (Google Scholar) citations. The citation range was 104 to 34 (Web of Science), 103 to 34 (Scopus), and 265 to 73 (Google Scholar). Citation density was 63.40 (Web of Science), 67.70 (Scopus), and 150.9 (Google Scholar) collectively. The most cited meta-analysis with 104 (Web of Science), 103 (Scopus), and 265 (Google Scholar) citations was "Success rate of endodontic treatment of teeth with vital and nonvital pulps. A meta-analysis" (Kojima *et al.* 2004), with an average citation per annum of 9.00.

**Systematic reviews and meta-analyses:** A total of 15 combined systematic reviews and meta-analyses were included in the top 100 most-cited evidence level 1 articles. They received a total of 776 (Web of Science), 845 (Scopus), and 1861 (Google Scholar) citations. The citation range was 99 to 20 (Web of Science), 125 to 19 (Scopus), and 284 to 35 (Google Scholar). Citation density was 51.73 (Web of Science), 56.33 (Scopus), and 124.06 (Google Scholar) collectively. The most cited meta-analysis with 99 (Web of Science), 125 (Scopus), and 284 (Google Scholar) citations was "Effect of smear layer on sealing ability of canal obturation: a systematic review and meta-analysis" (Shahravan *et al.* 2007), with an average citation per annum of 7.42.

**Year of publication**

The top 100 articles were published between 1999 (Kvist & Reit 1999) and 2016 (Caviedes-Bucheli *et al.* 2016, Chang *et al.* 2016, Kherlakian *et al.* 2016, Leonardi Dutra *et al.* 2016, Rôças *et al.* 2016, Talwar *et al.* 2016) (Figure 1). The most papers published in a single year was 13, and this occurred in 2010. The number of the top 100 most-cited articles published by decade was 1 during the 1990s, 55 during the 2000s and 44 during the 2010s. The number of articles reached its zenith from 2009 to 2013, that is 51. Interestingly, 99% of the articles were published after 1999.

**Randomized controlled trials:** The randomized controlled trials were published between 1999 (Kvist & Reit 1999) and 2016 (Kherlakian *et al.* 2016, Rôças *et al.* 2016). The most RCTs published in a single year was 7, and this occurred in both 2009 and 2012. The number of RCTs among the top 100 most-cited articles published by decade was 1 during the 1990s, 24 during the 2000s and 20 during the 2010s. The number of articles reached its zenith from 2005 to 2010, that is 26. Interestingly, 44 out of 45 RCTs were published after 1999.

**Systematic reviews:** The systematic reviews were published between 2001 (Peterson & Gutmann 2001) and 2016 (Chang *et al.* 2016). The most systematic reviews published in a single year was 4, and this

occurred in 2008, 2010, 2011, and 2012. The number of systematic reviews among the top 100 most-cited articles published by decade was 9 during the 2000s and 21 during the 2010s. The number of systematic reviews reached its zenith from 2010 to 2016, that is 21. Interestingly, 21 out of 30 systematic reviews were published after 2009.

**Meta-analyses:** The meta-analyses were published between 2004 (Kojima *et al.* 2004) and 2015 (Li *et al.* 2015). The most meta-analyses published in a single year was 2, and this occurred in 2010 and 2013. The number of systematic reviews among the top 100 most-cited articles published by decade was 4 during the 2000s and 6 during the 2010s.

**Systematic reviews and meta-analyses:** The systematic reviews and meta-analyses were published between 2005 (Sathorn *et al.* 2005) and 2016 (Caviedes-Bucheli *et al.* 2016, Dutra *et al.* 2016, Talwar *et al.* 2016). The most meta-analyses published in a single year was 2, and this occurred in 2010 and 2013. The number of systematic reviews among the top 100 most-cited articles published by decade was 4 during the 2000s and 6 during the 2010s.

**Contributing authors**

A total of 373 authors contributed to the top 100 most-cited articles. The most contributions were made by three individuals namely Reader A (n=5), Beck M (n=5), and Kvist T (n=5). Amongst the top 100 papers, seven authors were included in four articles and eight authors were included in three articles each (Table 2).

**Randomized controlled trials:** A total of 181 authors contributed to the randomized controlled trials among the top 100 most-cited articles. The most contributions were made by Reader A (n=5) and Beck M (n=5) followed by Nusstein J (n=4), Reit C (n=3), Meechan JG (n=3), Whitworth JM (n=3), Drum M (n=3), Kanaa MD (n=3), Kvist T (n=3), Molander A (n=2), Manzur AJ (n=2), Corbett IP (n=2), Friedman S (n=2).

**Systematic reviews:** A total of 99 authors contributed to the systematic reviews among the top 100 most-cited articles. The most contributions were made by Gulabivala K, Mann V, and Ng YL who contributed to four articles each; Norlund A, Frisk F, Bergenholtz G, Sandberg H, Lewsey J, Pak JG, Hakeberg M, Petersson, Axelsson S, Rahbaran S, Tranæus S, White SN, Davidson T, Kvist T contributed two articles each.

**Meta-analyses:** A total of 36 authors contributed to the meta-analyses among the top 100 most-cited articles. The most contributions were made by Karabucak B, Rosen E, Setzer FC, Tsesis I, Kohli MR, Shah SB, Kim S who contributed two articles each.

**Systematic reviews and meta-analyses:** A total of 69 authors contributed to the systematic reviews and meta-analyses among the top 100 most-cited articles. The most contributions were made by Messer HH (N=3) followed by Law AS, Sathorn C, Nixdorf DR, Moana-Filho EJ, Hodges JS, McGuire LA, John MT, Parashos P, Loushine RJ who contributed two articles each.

**Contributing countries and institutions**

Based on the institutional address of the corresponding author, individuals from 23 countries contributed to the top cited articles. Among these, the United States had the largest number of publications (n=24) followed by the United Kingdom (n=8), Brazil (n=8), China (n=7), Sweden (n=6), Iran (n=6), Italy (n=5), Thailand (n=4), Netherlands (n=4), Israel (n=4), India (n=4), Canada (n=3), Australia (n=3), Switzerland (n=2), Germany (n=2), Denmark (n=2), Colombia (n=2), South Korea (n=1), Portugal (n=1), Morocco (n=1), Mexico (n=1), Japan (n=1), UAE (n=1) (Figure 2).

Among 66 institutions, the greatest contribution to the top 100 most-cited articles was made by The College of Dentistry, The Ohio State University, USA (n=5) followed by UCL Eastman Dental Institute, UK (n=4), School of Dental Science, University of Newcastle Upon Tyne, UK (n=4), Maurice and Gabriela Goldschleger School of Dental Medicine, Tel Aviv University, Israel (n=4), School of Dental Sciences,

The University of Melbourne, Australia (n=3), West China School of Stomatology, Sichuan University, China (n=3), School of Dental Medicine, University of Milan, Italy (n=3), Faculty of Dentistry, University of Toronto, Canada (n=3), School of Dental Medicine, University of Pennsylvania, USA (n=3), Faculty of Odontology, Malmö University, Sweden (n=3). The complete list of contributing institutions is shown in Table 3.

**Randomized controlled trials:** Individuals from 16 countries contributed to the randomized controlled trials among the top cited articles. Among these, the United States had the largest number of publications (n=11) followed by Iran (n=5), Brazil (n=4), the United Kingdom (n=4), India (n=3), Italy (n=3), Sweden (n=3), Canada (n=2), Germany (n=2), and the Netherlands (n=2).

**Systematic reviews:** Individuals from 14 countries contributed to the systematic reviews among the top cited articles. Among these, the United States had the largest number of publications (n=8) followed by the United Kingdom (n=4), Sweden (n=3), China (n=2), Italy (n=2), the Netherlands (n=2), and Thailand (n=2).

**Meta-analyses:** Individuals from five countries contributed to the meta-analyses among the top cited articles. Among these, the United States and China had the largest number of publications (n=3) followed by Israel (n=2).

**Systematic reviews and meta-analyses:** Individuals from nine countries contributed to the systematic reviews and meta-analyses among the top cited articles. Among these, the United States had the largest number of publications (n=4) followed by Brazil (n=3) and Australia (2).

**Journal of publication**

The top 100 most-cited articles were published across three different journals namely *Journal of Endodontics* (n=70), *International Endodontic Journal* (n=27), and *Oral Surgery Oral Medicine Oral Pathology Oral Radiology and Endodontics* (n=3).

**Randomized controlled trials:** The randomized controlled trials among the top 100 most-cited articles were published by *Journal of Endodontics* (n=35), *International Endodontic Journal* (n=9), and *Oral Surgery Oral Medicine Oral Pathology Oral Radiology and Endodontics* (n=1).

**Systematic reviews:** The systematic reviews among the top 100 most-cited articles were published by *Journal of Endodontics* (n=16) and *International Endodontic Journal* (n=14).

**Meta-analyses:** The meta-analyses among the top 100 most-cited articles were published by *Journal of Endodontics* (n=9) and *Oral Surgery Oral Medicine Oral Pathology Oral Radiology and Endodontics* (n=1).

**Systematic reviews and meta-analyses:** The systematic reviews and meta-analyses among the top 100 most-cited articles were published by *Journal of Endodontics* (n=10), *International Endodontic Journal* (n=4), and *Oral Surgery Oral Medicine Oral Pathology Oral Radiology and Endodontics* (n=1).

**Study design and topic of the article**

The majority of the 100 most-cited articles were randomized controlled trials (n=45) followed by systematic review (n=30), systematic review and meta-analysis (n=15), and meta-analysis (n=10) (Table 4).

Major topics of interest in the top 100 most-cited papers were outcome studies (n=35) followed by local anaesthesia (n=14), radiology (n=10), canal instrumentation (n=7), mineral trioxide aggregate (n=6), intracanal medicaments (n=5), irrigants (n=5), endodontic microbiology (n=4), pulp capping (n=3), canal filling (n=3), inflammatory markers in endodontics (n=3), root canal anatomy (n=1), smear layer (n=1), traumatic dental injuries (n=1), restorations (n=1), and lasers in endodontic therapy (n=1) (Table 4).

**Randomized controlled trials:** Major topics of interest within the randomized controlled trials among the top 100 most-cited papers were local anaesthesia (n=14) followed by outcome studies (n=12), mineral

trioxide aggregate (n=6), endodontic microbiology (n=3), radiology (n=3), irrigants (n=3), canal instrumentations (n=3), and intracanal medicaments (n=1).

**Systematic reviews:** Major topics of interest within the systematic reviews among the top 100 most-cited papers were outcome studies (n=12) followed by irrigants (n=12), pulp capping (n=2), inflammatory markers in endodontics (n=2), endodontic microbiology (n=1), intracanal medicaments (n=1), canal instrumentations (n=1), root canal anatomy (n=1), traumatic dental injuries (n=1), canal filling (n=1), and lasers in endodontic therapy (n=1).

**Meta-analyses:** Major topics of interest within the meta-analyses among the top 100 most-cited papers were outcome studies (n=6) followed by canal filling (n=2), intracanal medicaments (n=1), and canal instrumentations (n=1).

**Systematic reviews and meta-analyses:** Major topics of interest within the systematic reviews and meta-analyses among the top 100 most-cited papers were outcome studies (n=5), radiology (n=2), intracanal medicaments (n=2), and canal instrumentations (n=1) followed by smear layer (n=1), restorations (n=1), root canal anatomy (n=1), pulp capping (n=1), and inflammatory markers in endodontics (n=1).

**Key words**

Of the 100 top-cited articles, a total of 259 unique words were identified. The most frequently occurring keywords were meta-analysis (n=23) and systematic review (n=23) followed by success, lidocaine, outcome, apical periodontitis, post-operative pain, root canal treatment, calcium hydroxide, and irreversible pulpitis (Table 5).

**Randomized controlled trials:** The randomized controlled trials among the 100 top-cited articles had a total of 56 unique words. The most frequently occurring keywords were randomized clinical trial (n=13) followed by outcome (n=3), success (n=3), and lidocaine (2).

**Systematic reviews:** The systematic reviews among the 100 top-cited articles had a total of 143 unique words. The most frequently occurring keywords were systematic review (15) followed by outcome (n=5) and apical periodontitis (n=3).

**Meta-analyses:** The meta-analyses among the 100 top-cited articles had a total of 47 unique words. The most frequently occurring keywords were meta-analysis (n=4) followed by outcome (n=3), post-operative pain (n=2), and apical periodontitis (n=2).

**Systematic reviews and meta-analyses:** The systematic reviews and meta-analyses among the 100 top-cited articles had a total of 61 unique words. The most frequently occurring keywords were systematic review (n=4) and meta-analysis (n=4) followed by outcome (n=2) and lidocaine (n=2).

## Discussion

This bibliometric study aimed to determine and analyse the top 100 most-cited randomized controlled trials, systematic reviews, and meta-analyses published in endodontic journals from 1961 to 2018. Generally, a scientific article on a list of the most frequently cited papers in its respective field suggests that it has achieved a landmark (Tarazona *et al.* 2018). In theory, the recognition of a research article within the scientific community (citation count) and how it influences the understanding of a disease and/or its management as well as whether it gives rise to new research trends, reflects its quality (Fardi *et al.* 2017). Thus, when a research article manages to secure its position in the list of 'classic' articles in a specific field, it confirms that the international clinical and scientific communities have acknowledged both the paper and the journal as having made a considerable contribution to the area of expertise. Thus, the results of the current study not only present a historical perspective on scientific progress in the field of Endodontology but also display key trends in research as well as clinical practice (Fardi *et al.* 2011, Ahmad *et al.* 2019).

An article having secured 100 or more citations is normally regarded as a 'classic' based on the field of research (Andersen *et al.* 2006). Therefore, in the present study, seven of the 100 articles can be

considered as ‘classic’ articles based on their citation counts. The ‘classic’ papers were cited between 235 and 20 times when the analysis was performed using Clarivate Analytics’ Web of Science “All Databases”. That database was used as a benchmark because it measures citations in scientific articles over an extensive time-span between 1945 and the present (Jafarzadeh *et al.* 2015). A fluctuation in citation counts was evident when other databases were interrogated, for instance, the number of citations per article varied between 276 to 17 times (Scopus), and between 696 to 1 (Google Scholar). The fluctuation seen in the results yielded by the various databases highlights the importance of selecting a suitable database in Scientometry. It must be appreciated that Scopus only records citations from 1996 onwards, which is likely to produce inaccurate results. However, in future, Scopus is planning to overcome this discrepancy by taking into consideration citations earlier than 1996. Google Scholar includes citations from dissertations, technical reports, preprints, books and conference papers, which can affect the assessment of the top citations when the target is more specific as in the present study that evaluated only articles in journals (Ahmad *et al.* 2019).

Although, the number of citations may reflect the influence of a particular article on a specific field of research and identify the researchers affiliated with the topic, the number of citations does not necessarily signify its scientific value. For example, publications related to “Respirology” (615 to 2918) (Tam *et al.* 2013) and “Cardiology” (331 to 3484) (Shuaib *et al.* 2015b) are more frequently cited than articles within “Dentistry” (326 to 2050) (Feijoo *et al.* 2014), although all three areas may have similar scientific importance. The results of the current study indicate a trend for more high-quality evidence level 1 articles to be published in Endodontology in more recent times, and also reflect the limited number of researchers, faculty and clinicians within the specialty.

The year of publication has an obvious impact on the citation count a paper receives. However, it is almost impossible to determine the true impact of a study for at least two decades after its publication (Baltussen & Kindler 2004, Feijoo *et al.* 2014, Ahmad *et al.* 2019). It is obvious that older publications normally will tend to gain more citations than recent papers, regardless of their impact (Ugolini *et al.* 2012).

This tendency is observed in almost all specialties (Philipsen & Reichart 1999). According to Kuhnian philosophy (Lefaivre *et al.* 2011), there is a disposition for sticking to a pattern in a scientific society, which can cause a "snowball effect" with citations, as authors are inclined towards a publication that is already abundantly cited rather than re-assessing its relevance and quality (Lareau *et al.* 2015). Nevertheless, an opposite trend has been observed in the current study since 99% of the papers were published after 1999. Normally, papers published in the last 10 years have only a small probability of appearing in the list of the most frequently cited articles in any field of research. Even so, 73 out of the 100 papers were published in the last 10 years, i.e. from 2008 to 2018 to reflect the evolution of research in Endodontology that now has a much greater focus on evidence derived from RCTs, systematic reviews, and meta-analyses to inform clinical practice. One of the most prominent features of this study was the inclusion of six articles in the top 100 that were published in 2016 (Caviedes-Bucheli *et al.* 2016, Chang *et al.* 2016, Kherlakian *et al.* 2016, Leonardi Dutra *et al.* 2016, Rôças *et al.* 2016, Talwar *et al.* 2016). This highlights the effect of the topic of the article, its quality and its relevance to clinical practice and research. Articles published after 2016 also received a reasonable number of citations, although it is too early to foresee whether these publications will gain even more citations as time passes.

Several authors were associated with the top-cited publications with most of them contributing as both corresponding author and first authors at the same time. Overall, the greatest contribution was made by Reader A (n=5), Beck M (n=5), and Kvist T (n=5). Tsesis I contributed the most as the corresponding author and the first author (n=4). Seven authors contributed to four articles each and eight authors contributed to three papers each. Out of the top 100 articles included, 20 were written by three authors each and nine articles were written by two authors each. Interestingly, four out of the top six articles in Table 1 were written by the same author, Ng YL who contributed as the first as well as the corresponding author of all the articles (Ng *et al.* 2007, 2008a, 2008b, 2010). All of these authors must be considered as important contributors in the specialty of Endodontology.

As evidence by the current study and in conformity with several others, academic institutions from the United States of America were involved most often in the list of the top 100 most-cited articles (Paladugu *et al.* 2002, Baltussen & Kindler 2004, Loonen *et al.* 2008, Brandt *et al.* 2010, Lefaivre *et al.* 2010, Fardi *et al.* 2011). The presence of an extensive scientific community as well as larger research budgets probably contributed to the major contribution made by the United States (Shadgan *et al.* 2010).

Keywords are a vital component of a research paper. While searching the literature, the use of keywords retrieves more relevant results than using sentences or phrases. They act as "codes" to source the required scientific research articles (Natarajan *et al.* 2010). Therefore, it is imperative to choose and include keywords that can be readily searched to identify relevant references when scrutinizing an infinite body of rich materials (Asghari & Navimipour 2018). Unfortunately, several articles in the present study did not contain keywords (Kvist & Reit 1999, Kojima *et al.* 2004, Kvist *et al.* 2004, Lindeboom *et al.* 2005, Schaeffer *et al.* 2005, Torabinejad *et al.* 2005, Chala *et al.* 2011).

In health care, the importance of systematic reviews and meta-analyses has been increasing (Moher *et al.* 2009). Clinicians read such articles in order to keep up-to-date with their field of practice; they are also used as a starting point to develop clinical practice guidelines (Swingler *et al.* 2003). In 1996, an international group formulated guidelines known as the QUOROM Statement (*QU*ality *O*f *R*eporting *O*f *M*eta-analyses) to address the sub-optimal reporting of meta-analyses, which focused on the reporting of meta-analyses of randomized controlled trials (Moher *et al.* 2000). The terminology "QUOROM" has evolved over time and for the purpose of encompassing both systematic reviews and meta-analyses, the name QUOROM was changed to PRISMA (*P*referred *R*eporting *I*tems for *S*ystematic reviews and *M*eta-*A*nalyses) (Moher *et al.* 2009).

When randomized controlled trials are appropriately designed, performed and reported, they depict the gold standard to evaluate healthcare interventions (Schulz *et al*. 2010). Unfortunately, in the past, the reporting of RCTs was often sub-optimal (Dwan *et al*. 2008). For example, before 1996, it was not mandatory for authors to mention the terms 'randomized controlled trial' in the title of an article, which

resulted in many such trials not being identified using the electronic search methodology used in the present study. According to Fardi *et al.* (2011), the top 100 most-cited articles published in endodontic journals did not include any randomized controlled trials, however, at least one randomized controlled trial (Byström & Sunvqvist 1985) was overlooked probably because it did not contain the terms randomised clinical trial in the title and at that time, keywords were not used commonly. This deficiency in accurately designing, conducting, and reporting trials resulted in the inception of the original CONSORT (Consolidated Standards of Reporting trials) statement (Begg *et al.* 1996), which was revised subsequently (Moher *et al*. 2001, Schulz *et al*. 2010). The introduction of these statements has improved the reporting quality of randomized controlled trials (Plint *et al.* 2006, Hopewell *et al.* 2010), nevertheless, reports of many trials remain sub-optimal (Chan & Altman 2005), including in the field of Endodontics (Lucena *et al.* 2017, Nagendrababu *et al*. 2019).

**Limitations**

It is important to recognize the limitation of the current study. As the title suggests, several articles had to be excluded from the present study since only the 100 most-cited articles were included. The last position in the ranking list was secured by an article that secured 20 citations (Web of Science) but unfortunately four articles, having the same citation count, had to be excluded (Day *et al.* 2011, Aggarwal *et al.* 2012, Monteiro *et al.* 2015, Rosen *et al.* 2015).

Another limitation is the fact that the search strategy relied on the relevant search terms being included in the title or appearing as keywords. The requirement for these terms to be included in such a way was adopted following the publication of the CONSORT guidelines (Begg *et al.* 1996). Prior to that date, authors were not obliged to include such terms and these articles could not be identified in the current electronic search. As a consequence, a number of well-known and ‘classic’ articles were excluded (for example, Byström & Sunvqvist 1985, Sjögren *et al.* 1991, Chong *et al.* 2003, Shipper *et al.* 2004).

## Conclusion

This is the first study to identify and discuss the top 100 most-cited evidence level 1 articles published in Endodontology. Despite limitations, this bibliometric analysis reveals useful information on the scientific advancement of Endodontology over time. Several ‘classic’ articles have been identified; however, many published before 1996 were not included as a result of the less rigorous standard of reporting at that time.

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**Table 1** List of the 100 most-cited articles

| Rank | Title of the article | No. of citation (Web of Science) | No. of citation (Scopus) | No. of citation (Google Scholar) | No. of citation (Citation density) |
|---|---|---|---|---|---|
| 1 | Ng YL, Mann V, Rahbaran S, Lewsey J, Gulabivala K (2008) Outcome of primary root canal treatment: systematic review of the literature–Part 2. Influence of clinical factors. *International Endodontic Journal* **41**, 6-31. | 235 | 276 | 696 | **23.50** |
| 2 | Ng YL, Mann V, Rahbaran S, Lewsey J, Gulabivala K (2007) Outcome of primary root canal treatment: systematic review of the literature–part 1. Effects of study characteristics on probability of success. *International Endodontic Journal* **40**, 921-39. | 163 | 185 | 388 | **14.81** |
| 3 | Nair P, Duncan H, Pitt Ford T, Luder H (2008) Histological, ultrastructural and quantitative investigations on the response of healthy human pulps to experimental capping with mineral trioxide aggregate: a randomized controlled trial. *International Endodontic Journal* **41**, 128-50. | 154 | 177 | 366 | **15.40** |
| 4 | Torabinejad M, Corr R, Handysides R, Shabahang S (2009) Outcomes of nonsurgical | 118 | 133 | 315 | **13.11** |

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| | retreatment and endodontic surgery: a systematic review. *Journal of Endodontics* **35**, 930-7. | | | | |
| 5 | Ng YL, Mann V, Gulabivala K (2008) Outcome of secondary root canal treatment: a systematic review of the literature. *International Endodontic Journal* **41**, 1026-46. | 106 | 121 | 1 | **10.60** |
| 6 | Ng YL, Mann V, Gulabivala K (2010) Tooth survival following non-surgical root canal treatment: a systematic review of the literature. *International Endodontic Journal* **43**, 171-89. | 105 | 124 | 224 | **13.12** |
| 7 | Kojima K, Inamoto K, Nagamatsu K, Hara A, Nakata K, Morita I, Nakagaki H, Nakamura H (2004) Success rate of endodontic treatment of teeth with vital and nonvital pulps. A meta-analysis. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology* **97**, 95-9. | 104 | 103 | 265 | **7.42** |
| 8 | Setzer FC, Shah SB, Kohli MR, Karabucak B, Kim S (2010) Outcome of endodontic surgery: a meta-analysis of the literature—part 1: comparison of traditional root-end surgery and endodontic microsurgery. *Journal of Endodontics* **36**, 1757-65. | 99 | 101 | 225 | **12.37** |

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| 9 | Shahravan A, Haghdoost AA, Adl A, Rahimi H, Shadifar F (2007) Effect of smear layer on sealing ability of canal obturation: a systematic review and meta-analysis. *Journal of Endodontics* **33**, 96-105. | 99 | 125 | 284 | **9.00** |
| 10 | Aguilar P, Linsuwanont P (2011) Vital pulp therapy in vital permanent teeth with cariously exposed pulp: a systematic review. *Journal of Endodontics* **37**, 581-7. | 96 | 111 | 222 | **13.71** |
| 11 | de Pablo ÓV, Estevez R, Sánchez MP, Heilborn C, Cohenca N (2010) Root anatomy and canal configuration of the permanent mandibular first molar: a systematic review. *Journal of Endodontics* **36**, 1919-31. | 94 | 118 | 238 | **11.75** |
| 12 | Gillen BM, Looney SW, Gu LS, Loushine BA, Weller RN, Loushine RJ, Pashley DH, Tay FR (2011) Impact of the quality of coronal restoration versus the quality of root canal fillings on success of root canal treatment: a systematic review and meta-analysis. *Journal of Endodontics* **37**, 895-902. | 93 | 89 | 220 | **13.28** |
| 13 | Kanaa MD, Whitworth JM, Corbett IP, Meechan JG (2006) Articaine and lidocaine mandibular buccal infiltration anesthesia: a | 93 | 100 | 201 | **7.75** |

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| | prospective randomized double-blind cross-over study. *Journal of Endodontics* **32**, 296-8. | | | | |
| 14 | Kvist T, Reit C (1999) Results of endodontic retreatment: a randomized clinical study comparing surgical and nonsurgical procedures. *Journal of Endodontics* **25**, 814-7. | 89 | 102 | 213 | **4.68** |
| 15 | Sathorn C, Parashos P, Messer H (2005) Effectiveness of single-versus multiple-visit endodontic treatment of teeth with apical periodontitis: a systematic review and meta-analysis. *International Endodontic Journal* **38**, 347-55. | 83 | 96 | 208 | **6.38** |
| 16 | Tsesis I, Rosen E, Tamse A, Taschieri S, Kfir A (2010) Diagnosis of vertical root fractures in endodontically treated teeth based on clinical and radiographic indices: a systematic review. *Journal of Endodontics* **36**, 1455-8. | 82 | 82 | 168 | **10.25** |
| 17 | Pak JG, White SN (2011) Pain prevalence and severity before, during, and after root canal treatment: a systematic review. *Journal of Endodontics* **37**, 429-38. | 80 | 93 | 165 | **11.42** |
| 18 | Sathorn C, Parashos P, Messer H (2008) The prevalence of postoperative pain and flare-up in single-and multiple-visit endodontic treatment: | 78 | 92 | 198 | **7.80** |

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| | a systematic review. *International Endodontic Journal* **41**, 91-9. | | | | |
| 19 | Kvist T, Molander A, Dahlen G, Reit C (2004) Microbiological evaluation of one- and two-visit endodontic treatment of teeth with apical periodontitis: a randomized, clinical trial. *Journal of Endodontics* **30**, 572-6. | 78 | 84 | 191 | **5.57** |
| 20 | Bitter K, Noetzel J, Stamm O, Vaudt J, Meyer-Lueckel H, Neumann K, Kielbassa AM (2009) Randomized clinical trial comparing the effects of post placement on failure rate of postendodontic restorations: preliminary results of a mean period of 32 months. *Journal of Endodontics* **35**, 1477-82. | 76 | 76 | 142 | **8.44** |
| 21 | Molander A, Warfvinge J, Reit C, Kvist T (2007) Clinical and radiographic evaluation of one- and two-visit endodontic treatment of asymptomatic necrotic teeth with apical periodontitis: a randomized clinical trial. *Journal of Endodontics* **33**, 1145-8. | 71 | 76 | 160 | **6.45** |
| 22 | Sathorn C, Parashos P, Messer H (2007) Antibacterial efficacy of calcium hydroxide intracanal dressing: a systematic review and meta-analysis. *International Endodontic Journal* **40**, 2-10. | 68 | 94 | 219 | **6.18** |

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| 23 | Gomes MS, Blattner TC, Sant'Ana Filho M, Grecca FS, Hugo FN, Fouad AF, Reynolds MA (2013) Can apical periodontitis modify systemic levels of inflammatory markers? A systematic review and meta-analysis. *Journal of Endodontics* **39**, 1205-17. | 68 | 67 | 106 | **13.60** |
| 24 | Schaeffer MA, White RR, Walton RE (2005) Determining the optimal obturation length: a meta-analysis of literature. *Journal of Endodontics* **31**, 271-4. | 67 | 66 | 186 | **5.15** |
| 25 | Lindeboom JA, Frenken JW, Kroon FH, van den Akker HP (2005) A comparative prospective randomized clinical study of MTA and IRM as root-end filling materials in single-rooted teeth in endodontic surgery. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology* **100**, 495-500. | 63 | 65 | 129 | **4.84** |
| 26 | Mejàre I, Axelsson S, Davidson T, Frisk F, Hakeberg M, Kvist T, Norlund A, Petersson A, Portenier I, Sandberg H (2012) Diagnosis of the condition of the dental pulp: a systematic review. *International Endodontic Journal* **45**, 597-613. | 62 | 68 | 121 | **10.33** |
| 27 | Su Y, Wang C, Ye L (2011) Healing rate and post-obturation pain of single-versus multiple- | 61 | 62 | 117 | **8.71** |

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| | visit endodontic treatment for infected root canals: a systematic review. *Journal of Endodontics* **37**, 125-32. | | | | |
| 28 | Setzer FC, Kohli MR, Shah SB, Karabucak B, Kim S (2012) Outcome of endodontic surgery: a meta-analysis of the literature—part 2: comparison of endodontic microsurgical techniques with and without the use of higher magnification. *Journal of Endodontics* **38**, 1-10. | 60 | 63 | 132 | **10.00** |
| 29 | von Arx T, Peñarrocha M, Jensen S (2010) Prognostic factors in apical surgery with root-end filling: a meta-analysis. *Journal of Endodontics* **36**, 957-73. | 59 | 59 | 119 | **7.37** |
| 30 | Nixdorf DR, Moana-Filho EJ, Law AS, McGuire LA, Hodges JS, John MT (2010) Frequency of persistent tooth pain after root canal therapy: a systematic review and meta-analysis. *Journal of Endodontics* **36**, 224-30. | 59 | 64 | 130 | **7.37** |
| 31 | Manzur A, Gonzalez AM, Pozos A, Silva-Herzog D, Friedman S (2007) Bacterial quantification in teeth with apical periodontitis related to instrumentation and different intracanal medications: a randomized clinical trial. *Journal of Endodontics* **33**, 114-8. | 59 | 67 | 145 | **5.36** |

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| 32 | Tsesis I, Rosen E, Taschieri S, Strauss YT, Ceresoli V, Del Fabbro M (2013) Outcomes of surgical endodontic treatment performed by a modern technique: an updated meta-analysis of the literature. *Journal of Endodontics* **39**, 332-9. | 58 | 80 | 130 | **11.60** |
| 33 | Peng L, Ye L, Tan H, Zhou X (2007) Outcome of root canal obturation by warm gutta-percha versus cold lateral condensation: a meta-analysis. *Journal of Endodontics* **33**, 106-9. | 58 | 62 | 165 | **5.27** |
| 34 | Aeinehchi M, Dadvand S, Fayazi S, Bayat-Movahed S (2007) Randomized controlled trial of mineral trioxide aggregate and formocresol for pulpotomy in primary molar teeth. *International Endodontic Journal* **40**, 261-7. | 57 | 63 | 136 | **5.18** |
| 35 | Pak JG, Fayazi S, White SN (2012) Prevalence of periapical radiolucency and root canal treatment: a systematic review of cross-sectional studies. *Journal of Endodontics* **38**, 1170-6. | 55 | 69 | 122 | **9.16** |
| 36 | Tsesis I, Faivishevsky V, Kfir A, Rosen E (2009) Outcome of surgical endodontic treatment performed by a modern technique: a meta-analysis of literature. *Journal of Endodontics* **35**, 1505-11. | 54 | 66 | 136 | **6.00** |

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| 37 | Sgolastra F, Petrucci A, Gatto R, Monaco A (2011) Effectiveness of laser in dentinal hypersensitivity treatment: a systematic review. *Journal of Endodontics* **37**, 297-303. | 54 | 59 | 107 | **7.71** |
| 38 | Figini L, Lodi G, Gorni F, Gagliani M (2008) Single versus multiple visits for endodontic treatment of permanent teeth: a Cochrane systematic review. *Journal of Endodontics* **34**, 1041-7. | 54 | 63 | 142 | **5.40** |
| 39 | Olsson H, Petersson K, Rohlin M (2006) Formation of a hard tissue barrier after pulp cappings in humans. A systematic review. *International Endodontic Journal* **39**, 429-42. | 54 | 65 | 109 | **4.50** |
| 40 | Petersson A, Axelsson S, Davidson T, Frisk F, Hakeberg M, Kvist T, Norlund A, Mejàre I, Portenier I, Sandberg H (2012) Radiological diagnosis of periapical bone tissue lesions in endodontics: a systematic review. *International Endodontic Journal* **45**, 783-801. | 51 | 47 | 94 | **8.50** |
| 41 | Sterzenbach G, Franke A, Naumann M (2012) Rigid versus flexible dentine-like endodontic posts--clinical testing of a biomechanical concept: seven-year results of a randomized controlled clinical pilot trial on endodontically | 51 | 53 | 96 | **8.50** |

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| | treated abutment teeth with severe hard tissue loss. *Journal of Endodontics* **38**, 1557-63. | | | | |
| 42 | Menhinick KA, Gutmann J, Regan J, Taylor S, Buschang P (2004) The efficacy of pain control following nonsurgical root canal treatment using ibuprofen or a combination of ibuprofen and acetaminophen in a randomized, double-blind, placebo-controlled study. *International Endodontic Journal* **37**, 531-41. | 50 | 57 | 112 | **3.57** |
| 43 | Panitvisai P, Parunnit P, Sathorn C, Messer HH (2010) Impact of a retained instrument on treatment outcome: a systematic review and meta-analysis. *Journal of Endodontics* **36**, 775-80. | 48 | 48 | 110 | **6.00** |
| 44 | Paredes-Vieyra J, Enriquez FJ (2012) Success rate of single- versus two-visit root canal treatment of teeth with apical periodontitis: a randomized controlled trial. *Journal of Endodontics* **38**, 1164-9. | 48 | 50 | 109 | **8.00** |
| 45 | Penesis VA, Fitzgerald PI, Fayad MI, Wenckus CS, BeGole EA, Johnson BR (2008) Outcome of one-visit and two-visit endodontic treatment of necrotic teeth with apical periodontitis: a randomized controlled trial with one-year evaluation. *Journal of Endodontics* **34**, 251-7. | 48 | 57 | 122 | **4.80** |

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| 46 | Pasqualini D, Mollo L, Scotti N, Cantatore G, Castellucci A, Migliaretti G, Berutti E (2012) Postoperative pain after manual and mechanical glide path: a randomized clinical trial. *Journal of Endodontics* **38**, 32-6. | 47 | 54 | 109 | **7.83** |
| 47 | Figueiredo FED, Martins-Filho PRS, Faria-e-Silva AL (2015) Do metal post–retained restorations result in more root fractures than fiber post–retained restorations? A systematic review and meta-analysis. *Journal of Endodontics* **41**, 309-16. | 44 | 48 | 82 | **14.66** |
| 48 | Nixdorf DR, Moana-Filho EJ, Law AS, McGuire LA, Hodges JS, John MT (2010) Frequency of nonodontogenic pain after endodontic therapy: a systematic review and meta-analysis. *Journal of Endodontics* **36**, 1494-8. | 43 | 43 | 94 | **5.37** |
| 49 | Kanaa MD, Meechan JG, Corbett IP, Whitworth JM (2006) Speed of injection influences efficacy of inferior alveolar nerve blocks: a double-blind randomized controlled trial in volunteers. *Journal of Endodontics* **32**, 919-23. | 43 | 39 | 84 | **3.58** |
| 50 | Chrepa V, Kotsakis GA, Pagonis TC, Hargreaves KM (2014) The effect of | 42 | 46 | 67 | **10.50** |

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| | photodynamic therapy in root canal disinfection: a systematic review. *Journal of Endodontics* **40**, 891-8. | | | | |
| 51 | Gondim E Jr., Setzer FC, Dos Carmo CB, Kim S (2010) Postoperative pain after the application of two different irrigation devices in a prospective randomized clinical trial. *Journal of Endodontics* **36**, 1295-301. | 42 | 50 | 106 | **5.25** |
| 52 | Zhou L, Wang Q (2013) Comparison of fracture resistance between cast posts and fiber posts: a meta-analysis of literature. *Journal of Endodontics* **39**, 11-5. | 41 | 34 | 73 | **8.20** |
| 53 | Evans G, Nusstein J, Drum M, Reader A, Beck M (2008) A prospective, randomized, double-blind comparison of articaine and lidocaine for maxillary infiltrations. *Journal of Endodontics* **34**, 389-93. | 40 | 47 | 102 | **4.00** |
| 54 | Chala S, Abouqal R, Rida S (2011) Apexification of immature teeth with calcium hydroxide or mineral trioxide aggregate: systematic review and meta-analysis. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology* **112**, e36-e42. | 40 | 57 | 99 | **5.71** |
| 55 | Christiansen R, Kirkevang LL, Hørsted-Bindslev P, Wenzel A (2009) Randomized | 39 | 42 | 87 | **4.33** |

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| | clinical trial of root-end resection followed by root-end filling with mineral trioxide aggregate or smoothing of the orthograde gutta-percha root filling--1-year follow-up. *International Endodontic Journal* **42**, 105-14. | | | | |
| 56 | Kanaa MD, Whitworth JM, Meechan JG (2012) A prospective randomized trial of different supplementary local anesthetic techniques after failure of inferior alveolar nerve block in patients with irreversible pulpitis in mandibular teeth. *Journal of Endodontics* **38**, 421-5. | 39 | 48 | 89 | **6.50** |
| 57 | Fernandez C, Reader A, Beck M, Nusstein J (2005) A prospective, randomized, double-blind comparison of bupivacaine and lidocaine for inferior alveolar nerve blocks. *Journal of Endodontics* **31**, 499-503. | 39 | 35 | 80 | **3.00** |
| 58 | Aggarwal V, Singla M, Kabi D (2010) Comparative evaluation of effect of preoperative oral medication of ibuprofen and ketorolac on anesthetic efficacy of inferior alveolar nerve block with lidocaine in patients with irreversible pulpitis: a prospective, double-blind, randomized clinical trial. *Journal of Endodontics* **36**, 375-8. | 38 | 42 | 66 | **4.75** |

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| 59 | Zhang C, Du J, Peng Z (2015) Correlation between Enterococcus faecalis and Persistent Intraradicular Infection Compared with Primary Intraradicular Infection: A Systematic Review. *Journal of Endodontics* **41**, 1207-13. | 37 | 38 | 59 | **12.33** |
| 60 | Peng L, Ye L, Guo X, Tan H, Zhou X, Wang C, Li R (2007) Evaluation of formocresol versus ferric sulphate primary molar pulpotomy: a systematic review and meta-analysis. *International Endodontic Journal* **40**, 751-7. | 37 | 42 | 95 | **3.36** |
| 61 | Peterson J, Gutmann JL (2001) The outcome of endodontic resurgery: a systematic review. *International Endodontic Journal* **34**, 169-75. | 35 | 31 | 74 | **2.05** |
| 62 | Saini HR, Tewari S, Sangwan P, Duhan J, Gupta A (2012) Effect of different apical preparation sizes on outcome of primary endodontic treatment: a randomized controlled trial. *Journal of Endodontics* **38**, 1309-15. | 35 | 40 | 64 | **5.83** |
| 63 | Song M, Kim E (2012) A prospective randomized controlled study of mineral trioxide aggregate and super ethoxy-benzoic acid as root-end filling materials in endodontic microsurgery. *Journal of Endodontics* **38**, 875-9. | 35 | 37 | 67 | **5.83** |

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| 64 | Li Z, Cao L, Fan M, Xu Q (2015) Direct Pulp Capping with Calcium Hydroxide or Mineral Trioxide Aggregate: A Meta-analysis. *Journal of Endodontics* **41**, 1412-7. | 34 | 43 | 78 | **11.33** |
| 65 | Ashraf H, Kazem M, Dianat O, Noghrehkar F (2013) Efficacy of articaine versus lidocaine in block and infiltration anesthesia administered in teeth with irreversible pulpitis: a prospective, randomized, double-blind study. *Journal of Endodontics* **39**, 6-10. | 33 | 38 | 67 | **6.60** |
| 66 | Chang E, Lam E, Shah P, Azarpazhooh A (2016) Cone-beam Computed Tomography for Detecting Vertical Root Fractures in Endodontically Treated Teeth: A Systematic Review. *Journal of Endodontics* **42**, 177-85. | 32 | 32 | 56 | **16.00** |
| 67 | Liang YH, Jiang LM, Jiang L, Chen XB, Liu YY, Tian FC, Bao XD, Gao XJ, Versluis M, Wu MK, van der Sluis L (2013) Radiographic healing after a root canal treatment performed in single-rooted teeth with and without ultrasonic activation of the irrigant: a randomized controlled trial. *Journal of Endodontics* **39**, 1218-25. | 31 | 28 | 58 | **6.20** |
| 68 | Ravanshad S, Adl A, Anvar J (2010) Effect of working length measurement by electronic | 31 | 41 | 103 | **3.87** |

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| | apex locator or radiography on the adequacy of final working length: a randomized clinical trial. *Journal of Endodontics* **36**, 1753-6. | | | | |
| 69 | Suebnukarn S, Ngamboonsirisingh S, Rattanabanlang A (2010) A systematic evaluation of the quality of meta-analyses in endodontics. *Journal of Endodontics* **36**, 602-8. | 31 | 37 | 45 | **3.87** |
| 70 | Meechan JG, Kanaa MD, Corbett IP, Steen IN, Whitworth JM (2006) Pulpal anaesthesia for mandibular permanent first molar teeth: a double-blind randomized cross-over trial comparing buccal and buccal plus lingual infiltration injections in volunteers. *International Endodontic Journal* **39**, 764-9. | 30 | 33 | 55 | **2.50** |
| 71 | Tsesis I, Rosen E, Tamse A, Taschieri S, Del Fabbro M (2011) Effect of guided tissue regeneration on the outcome of surgical endodontic treatment: a systematic review and meta-analysis. *Journal of Endodontics* **37**, 1039-45. | 30 | 39 | 83 | **4.28** |
| 72 | Niederman R, Theodosopoulou JN (2003) A systematic review of in vivo retrograde obturation materials. *International Endodontic Journal* **36**, 577-85. | 29 | 29 | 77 | **1.93** |

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| 73 | Poorni S, Veniashok B, Senthilkumar AD, Indira R, Ramachandran S (2011) Anesthetic efficacy of four percent articaine for pulpal anesthesia by using inferior alveolar nerve block and buccal infiltration techniques in patients with irreversible pulpitis: a prospective randomized double-blind clinical trial. *Journal of Endodontics* **37**, 1603-7. | 29 | 32 | 62 | **4.14** |
| 74 | Nekoofar MH, Sheykhrezae MS, Meraji N, Jamee A, Shirvani A, Jamee J, Dummer PMH (2015) Comparison of the effect of root canal preparation by using WaveOne and ProTaper on postoperative pain: a randomized clinical trial. *Journal of Endodontics* **41**, 575-8. | 28 | 33 | 52 | **9.33** |
| 75 | Gross R, McCartney M, Reader A, Beck M (2007) A prospective, randomized, double-blind comparison of bupivacaine and lidocaine for maxillary infiltrations. *Journal of Endodontics* **33**, 1021-4. | 27 | 26 | 42 | **2.45** |
| 76 | Martins JN, Marques D, Mata A, Caramês J (2014) Clinical efficacy of electronic apex locators: systematic review. *Journal of Endodontics* **40**, 759-77. | 26 | 33 | 61 | **6.50** |
| 77 | Del Fabbro M, Ceresoli V, Lolato A, Taschieri S (2012) Effect of platelet concentrate on | 25 | 21 | 41 | **4.16** |

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| | quality of life after periradicular surgery: a randomized clinical study. *Journal of Endodontics* **38**, 733-9. | | | | |
| 78 | Keenan JV, Farman AG, Fedorowicz Z, Newton JT (2006) A Cochrane systematic review finds no evidence to support the use of antibiotics for pain relief in irreversible pulpitis. *Journal of Endodontics* **32**, 87-92. | 25 | 17 | 51 | **2.08** |
| 79 | Kiatwateeratana T, Kintarak S, Piwat S, Chankanka O, Kamaolmatyakul S, Thearmontree A (2009) Partial pulpotomy on caries-free teeth using enamel matrix derivative or calcium hydroxide: a randomized controlled trial. *International Endodontic Journal* **42**, 584-92. | 24 | 29 | 49 | **2.66** |
| 80 | Del Fabbro M, Taschieri S, Weinstein R (2009) Quality of life after microscopic periradicular surgery using two different incision techniques: a randomized clinical study. *International Endodontic Journal* **42**, 360-7. | 24 | 22 | 34 | **2.66** |
| 81 | Lindeboom JA, Frenken JW, Valkenburg P, van den Akker HP (2005) The role of preoperative prophylactic antibiotic administration in periapical endodontic surgery: a randomized, prospective double-blind placebo-controlled | 24 | 29 | 48 | **1.84** |

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| | study. *International Endodontic Journal* **38**, 877-81. | | | | |
| 82 | Azuma MM, Samuel RO, Gomes-Filho JE, Dezan-Junior E, Cintra LT (2014) The role of IL-6 on apical periodontitis: a systematic review. *International Endodontic Journal* **47**, 615-21. | 24 | 25 | 45 | **6.00** |
| 83 | Malkhassian G, Manzur AJ, Legner M, Fillery ED, Manek S, Basrani BR, Friedman S (2009) Antibacterial efficacy of MTAD final rinse and two percent chlorhexidine gel medication in teeth with apical periodontitis: a randomized double-blinded clinical trial. *Journal of Endodontics* **35**, 1483-90. | 24 | 28 | 63 | **2.66** |
| 84 | Torabinejad M, Shabahang S, Bahjri K (2005) Effect of MTAD on postoperative discomfort: a randomized clinical trial. *Journal of Endodontics* **31**, 171-6. | 24 | 27 | 44 | **1.84** |
| 85 | Leonardi Dutra K, Haas L, Porporatti AL, Flores-Mir C, Nascimento Santos J, Mezzomo LA, Corrêa M, De Luca Canto G (2016) Diagnostic Accuracy of Cone-beam Computed Tomography and Conventional Radiography on Apical Periodontitis: A Systematic Review and | 23 | 30 | 54 | **11.50** |

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| | Meta-analysis. *Journal of Endodontics* **42**, 356-64. | | | | |
| 86 | Silva EJ, Menaged K, Ajuz N, Monteiro MR, Coutinho-Filho Tde S (2013) Postoperative pain after foraminal enlargement in anterior teeth with necrosis and apical periodontitis: a prospective and randomized clinical trial. *Journal of Endodontics* **39**, 173-6. | 23 | 26 | 40 | **4.60** |
| 87 | Jalalzadeh SM, Mamavi A, Shahriari S, Santos FA, Pochapski MT (2010) Effect of pretreatment prednisolone on postendodontic pain: a double-blind parallel-randomized clinical trial. *Journal of Endodontics* **36**, 978-81. | 23 | 33 | 54 | **2.87** |
| 88 | Marín-Botero ML, Domínguez-Mejía JS, Arismendi-Echavarría JA, Mesa-Jaramillo AL, Flórez-Moreno GA, Tobón-Arroyave SI (2006) Healing response of apicomarginal defects to two guided tissue regeneration techniques in periradicular surgery: a double-blind, randomized-clinical trial. *International Endodontic Journal* **39**, 368-77. | 23 | 25 | 42 | **1.91** |
| 89 | Yassen GH, Platt JA (2013) The effect of nonsetting calcium hydroxide on root fracture and mechanical properties of radicular dentine: | 22 | 28 | 52 | **4.40** |

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|---|---|---|---|---|---|
| | a systematic review. *International Endodontic Journal* **46**, 112-8. | | | | |
| 90 | Kherlakian D, Cunha RS, Ehrhardt IC, Zuolo ML, Kishen A, da Silveira Bueno CE (2016) Comparison of the Incidence of Postoperative Pain after Using 2 Reciprocating Systems and a Continuous Rotary System: A Prospective Randomized Clinical Trial. *Journal of Endodontics* **42**, 171-6. | 22 | 29 | 45 | **11.00** |
| 91 | Rogers BS, Botero TM, McDonald NJ, Gardner RJ, Peters MC (2014) Efficacy of articaine versus lidocaine as a supplemental buccal infiltration in mandibular molars with irreversible pulpitis: a prospective, randomized, double-blind study. *Journal of Endodontics* **40**, 753-8. | 22 | 23 | 42 | **5.50** |
| 92 | Caviedes-Bucheli J, Castellanos F, Vasquez N, Ulate E, Munoz HR (2016) The influence of two reciprocating single-file and two rotary-file systems on the apical extrusion of debris and its biological relationship with symptomatic apical periodontitis. A systematic review and meta-analysis. *International Endodontic Journal* **49**, 255-70. | 21 | 24 | 35 | **10.50** |

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|---|---|---|---|---|---|
| 93 | Rôças IN, Provenzano JC, Neves MA, Siqueira JF, Jr. (2016) Disinfecting Effects of Rotary Instrumentation with Either 2.5% Sodium Hypochlorite or 2% Chlorhexidine as the Main Irrigant: A Randomized Clinical Study. *Journal of Endodontics* **42**, 943-7. | 21 | 25 | 34 | **10.50** |
| 94 | Shahi S, Mokhtari H, Rahimi S, Yavari HR, Narimani S, Abdolrahimi M, Nezafati S (2013) Effect of premedication with ibuprofen and dexamethasone on success rate of inferior alveolar nerve block for teeth with asymptomatic irreversible pulpitis: a randomized clinical trial. *Journal of Endodontics* **39**, 160-2. | 21 | 27 | 45 | **4.20** |
| 95 | Berberich G, Reader A, Drum M, Nusstein J, Beck M (2009) A prospective, randomized, double-blind comparison of the anesthetic efficacy of two percent lidocaine with 1: 100,000 and 1: 50,000 epinephrine and three percent mepivacaine in the intraoral, infraorbital nerve block. *Journal of Endodontics* **35**, 1498-504. | 21 | 17 | 29 | **2.33** |
| 96 | Mason R, Drum M, Reader A, Nusstein J, Beck M (2009) A prospective, randomized, double-blind comparison of 2% lidocaine with 1: | 21 | 19 | 34 | **2.33** |

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|---|---|---|---|---|---|
| | 100,000 and 1: 50,000 epinephrine and 3% mepivacaine for maxillary infiltrations. *Journal of Endodontics* **35**, 1173-7. | | | | |
| 97 | von Böhl M, Ren Y, Fudalej PS, Kuijpers-Jagtman AM (2012) Pulpal reactions to orthodontic force application in humans: a systematic review. *Journal of Endodontics* **38**, 1463-9. | 20 | 19 | 31 | **3.33** |
| 98 | Kruse C, Spin-Neto R, Wenzel A, Kirkevang LL (2015) Cone beam computed tomography and periapical lesions: a systematic review analysing studies on diagnostic efficacy by a hierarchical model. *International Endodontic Journal* **48**, 815-28.99. | 20 | 19 | 34 | **6.66** |
| 99 | Boutsioukis C, Psimma Z, van der Sluis LW (2013) Factors affecting irrigant extrusion during root canal irrigation: a systematic review. *International Endodontic Journal* **46**, 599-618. | 20 | 25 | 55 | **4.00** |
| 100 | Talwar S, Utneja S, Nawal RR, Kaushik A, Srivastava D, Oberoy SS (2016) Role of Cone-beam Computed Tomography in Diagnosis of Vertical Root Fractures: A Systematic Review and Meta-analysis. *Journal of Endodontics* **42**, 12-24. | 20 | 19 | 42 | **10.00** |

**Table 2** Number of articles an author appeared as the first author, as the corresponding author, as the first and the corresponding author, and as the co-author

| Serial number | Name of authors | As first author | As corresponding author | As first & corresponding author | A |
|---|---|---|---|---|---|
| 1 | Reader A | - | - | - | |
| 2 | Beck M | - | - | - | |
| 3 | Kvist T | 1 | - | 1 | |
| 4 | Rosen E | - | - | - | |
| 5 | Tsesis I | - | - | 4 | |
| 6 | Nusstein J | - | 1 | 3 | |
| 7 | Gulabivala K | - | - | - | |
| 8 | Taschieri S | - | - | - | |
| 9 | Mann V | - | - | - | |
| 10 | Ng YL | - | - | - | |
| 11 | Sathorn C | 1 | - | 2 | |
| 12 | Setzer CF | - | 1 | 2 | |
| 13 | Messer H | - | 1 | - | |
| 14 | Kanaa D | 2 | - | - | |
| 15 | Fabbro MD | - | - | 1 | |
| 16 | Drum M | - | 3 | - | |
| 17 | Kim S | - | - | - | |
| 18 | Parashos P | - | - | - | |

**Table 3** List of institutions that contributed to the top 100 most-cited articles

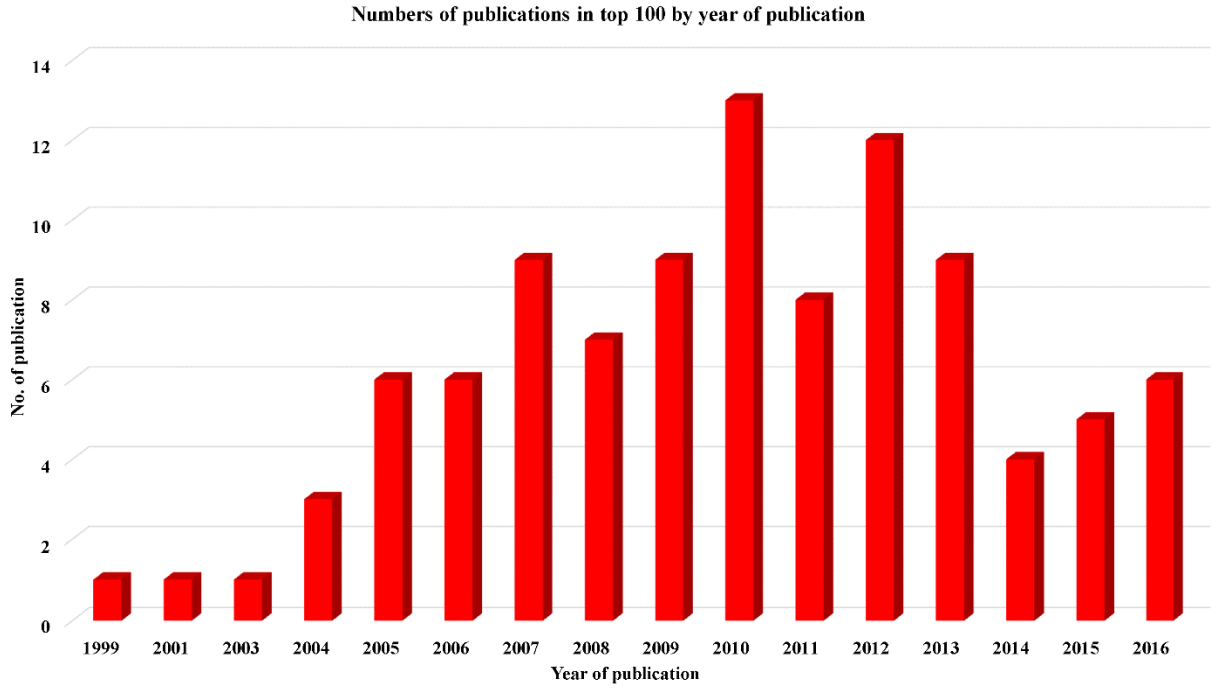
| Rank | Institutions | Numbers of articles |
|---|---|---|
| 1 | College of Dentistry, The Ohio State University, USA | 5 |
| 2 | UCL Eastman Dental Institute, UK | 4 |
| 3 | School of Dental Science, University of Newcastle Upon Tyne, UK | 4 |
| 4 | Maurice and Gabriela Goldschleger School of Dental Medicine, Tel Aviv University, Israel | 4 |
| 5 | School of Dental Sciences, The University of Melbourne, Australia | 3 |
| 6 | West China School of Stomatology, Sichuan University, China | 3 |
| 7 | School of Dental Medicine, University of Milan, Italy | 3 |
| 8 | Faculty of Dentistry, University of Toronto, Canada | 3 |
| 9 | School of Dental Medicine, University of Pennsylvania, USA | 3 |
| 10 | Faculty of Odontology, Malmö University, Sweden | 3 |
| 11 | School of Dentistry, Loma Linda University, USA | 2 |
| 12 | University School of Dental Medicine, The Charité – Universitätsmedizin, Germany | 2 |
| 13 | Faculty of Dentistry, Chulalongkorn University, Thailand | 2 |
| 14 | Faculty of Odontology, The University of Gothenberg, Sweden | 2 |
| 15 | School of Dentistry, The Federal University of Rio Grande do Sul, Brazil | 2 |
| 16 | Department of Dentistry, Aarhus University, Denmark | 2 |
| 17 | Academic Centre for Dentistry Amsterdam (ACTA), University of Amsterdam, The Netherlands | 2 |
| 18 | UCLA School of Dentistry, The University of California, USA | 2 |
| 19 | School of Dentistry, University of Minnesota, USA | 2 |

**Table 4** Study type and topics covered by the top 100 most-cited papers

| Topic | Randomized controlled trial | Systematic Review | Meta-analysis | Systematic review and meta-analysis | Total |
|---|---|---|---|---|---|
| Endodontic microbiology | 3 | 1 | - | - | **4** |
| Outcome studies | 12 | 12 | 6 | 5 | **35** |
| Mineral trioxide aggregate (MTA) | 6 | - | - | - | **6** |
| Radiology | 3 | 5 | - | 2 | **10** |
| Intracanal medicaments | 1 | 1 | 1 | 2 | **5** |
| Irrigants | 3 | 2 | - | - | **5** |
| Canal instrumentations | 3 | 1 | 1 | 1 | **7** |
| Root canal anatomy | - | 1 | - | 1 | **2** |
| Smear layer | - | - | - | 1 | **1** |
| Traumatic dental injuries | - | 1 | - | - | **1** |
| Restorations | - | - | - | 1 | **1** |
| Pulp capping | - | 2 | - | 1 | **3** |
| Canal filling | - | 1 | 2 | - | **3** |
| Local anaesthesia | 14 | - | - | - | **14** |
| Lasers in endodontic therapy | - | 1 | - | - | **1** |
| Inflammatory markers in endodontics | - | 2 | - | 1 | **3** |
| **Total** | **45** | **30** | **10** | **15** | **100** |

**Table 5** The most frequently used keywords of the top 100 most-cited articles

| Serial number | Keywords |
|---|---|
| 1 | Meta-analysis |
| 2 | Systematic review |
| 3 | Success |
| 4 | Lidocaine |
| 5 | Outcome |
| 6 | Apical periodontitis |
| 7 | Post-operative pain |
| 8 | Root canal treatment |
| 9 | Calcium hydroxide |
| 10 | Irreversible pulpitis |


Numbers of publications in top 100 by year of publication
No. of publication
0
2
4
6
8
10
12
14
1999
2001
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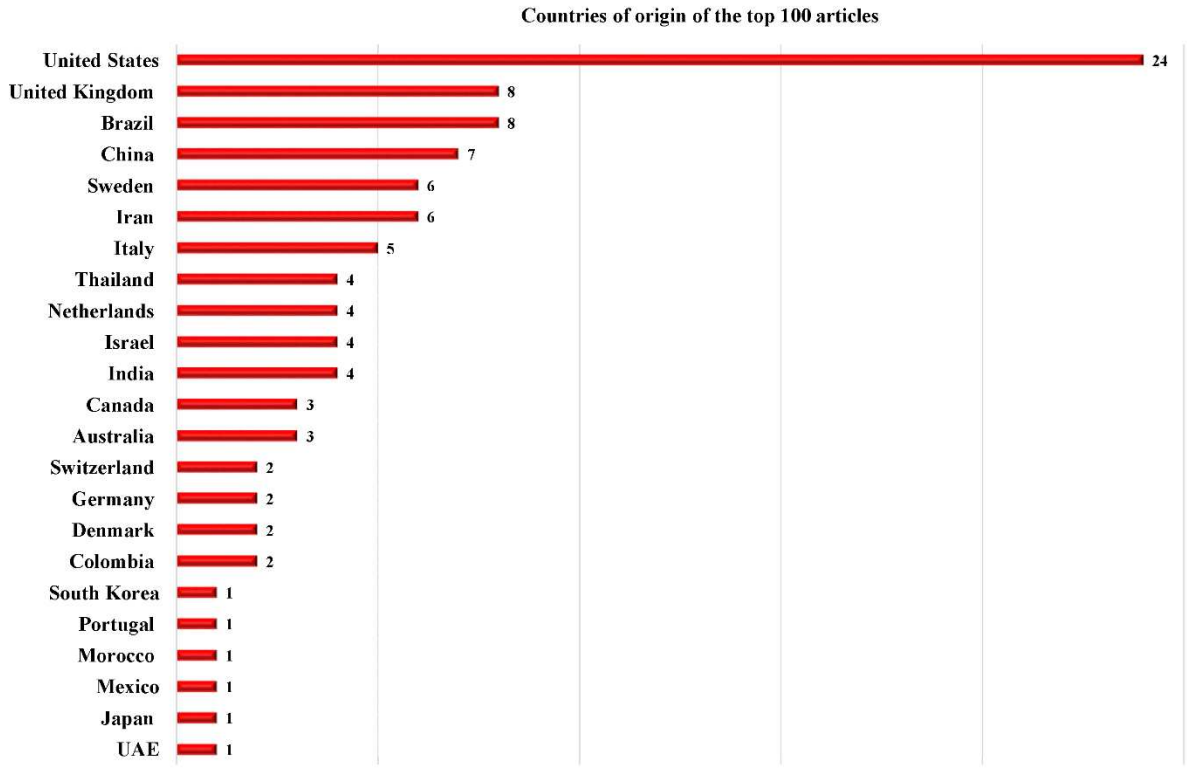
Year of publication


Countries of origin of the top 100 articles
United States 24
United Kingdom 8
Brazil 8
China 7
Sweden 6
Iran 6
Italy 5
Thailand 4
Netherlands 4
Israel 4
India 4
Canada 3
Australia 3
Switzerland 2
Germany 2
Denmark 2
Colombia 2
South Korea 1
Portugal 1
Morocco 1
Mexico 1
Japan 1
UAE 1