

The Scientific Contribution of Malaysia's Researchers in the Field of Endodontics Based on Scopus Database: A Bibliometric Analysis

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ABSTRAK

Analisis bibliometrik akademik adalah kritikal dalam menilai prestasi saintifik sesebuah negara dan telah menyalakan minat yang ketara sejak kebelakangan ini. Walau bagaimanapun, tiada kajian sedemikian dijalankan dalam bidang pergigian, khususnya endodontik, dalam kalangan penyelidik Malaysia. Justeru, kajian ini bertujuan menilai keluaran penerbitan dalam kalangan penyelidik di Malaysia yang berdedikasi dalam bidang endodontik berdasarkan pangkalan data Scopus® dan menganalisis ciri-ciri artikel terpilih serta corak penerbitan. Carian elektronik berdasarkan pangkalan Scopus® telah dilakukan dari Januari 2001 hingga Februari 2021. Hanya artikel Bahasa Inggeris dengan gabungan penulis pertama dari Malaysia dipilih dan parameter yang diekstrak ialah; tajuk, penulis, bilangan pengarang, affiliasi, jurnal, tahun penerbitan, jenis artikel, sumber, kategori tema, kata kunci, dan bilangan sitasi. Data dianalisis menggunakan perisian Microsoft Excel dilengkapi dengan ujian Pearson's Chi-square dan Pearson's Correlation pada tahap kepentingan 0.05. Terdapat 119 artikel yang dipilih dengan artikel yang menerima jumlah sitasi tertinggi adalah 69 sitasi. Seramai 15 penulis mempunyai 2 atau lebih artikel yang diterbitkan dengan "International Endodontic Journal" menerima terbitan yang paling banyak. Tambahan pula, lebih separuh daripada artikel diterbitkan dalam jurnal Q1 dan Q2. Sejak dua dekad yang lalu, terdapat peningkatan yang ketara ($P < 0.05$) dalam bilangan artikel dan sitasi kumulatif,

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dengan korelasi yang ketara ($P=0.038$) antara mereka. Selain itu, Jabatan Pergigian Konservatif dan Universiti Sains Malaysia menerbitkan artikel yang paling banyak, dengan sebahagian besarnya adalah penyelidikan asas mengenai bahan-bahan endodontik. Kesimpulannya, peningkatan penerbitan saintifik mencadangkan minat yang semakin meningkat dalam endodontik di kalangan penyelidik Malaysia.

Kata kunci: analisis bibliometrik, endodontik, penyelidik, scientometrik, Scopus

ABSTRACT

Bibliometric analyses of academic output are critical in assessing a country's scientific performance and have ignited significant interest in recent days. However, no such study has been conducted in the field of dentistry, specifically endodontics, among Malaysia's researchers. Hence, this study aimed to assess the publication output among researchers in Malaysia dedicating to endodontics based on the Scopus database and analyse the characteristics of selected articles as well as the publishing patterns. An electronic search based on the Scopus® database was performed from January 2001 to February 2021. Only English language articles with the first author's affiliation from Malaysia were selected and the following parameters were extracted: title, authors, number of authors, affiliation, journal, year of publication, type of article, source, thematic categories, keywords, and number of citations. Data was analysed using Microsoft Excel software complemented by Pearson's Chi-square and Pearson Correlation tests at 0.05 significance level. There were 119 articles included with the top-cited article received 69 citations. A total of 15 authors have 2 or more articles published, with the International Endodontic Journal published the most. Furthermore, more than half of the articles were published in Q1 and Q2 journals. Over the last two decades, there has been a substantial growth ($P<0.05$) in the number of articles and cumulative citations, with a significant correlation ($P=0.038$) between them. Besides, the Department of Conservative Dentistry and Universiti Sains Malaysia published the most articles, with the bulk of them being basic research on endodontic materials. In conclusion, the rise in scientific publications suggests an increasing interest in endodontics among Malaysia's researchers.

Keywords: bibliometric analysis, endodontics, researcher, scientometrics, Scopus

INTRODUCTION

Endodontics is the study of the basic and clinical sciences of the dental pulp, as well as the aetiology, diagnosis,

prevention, and treatment of pulpal diseases and injuries (European Society of Endodontology 2006). Endodontics has progressed enormously in recent years, as shown by a surge in the

number of articles in the endodontic literature (Fardi et al. 2011; Yilmaz et al. 2019). The consequence of this evolution is a growing number of publications in each issue of dental journals, as well as a rise in articles, published ahead of print. Scientific fundamental and clinical research are an important keystone of clinical practice and a necessity for a high quality of delivered oral health care in the era of evidence-based dentistry (Brignardello-Petersen et al. 2014). Original scientific papers published in peer-reviewed journals are the most common method of evaluating the quality of science in any scientific area (Triaridis & Kyrgidis 2010).

Bibliometric analyses of academic output are critical in assessing a country's scientific performance and have ignited significant interest in recent days (Tzanetakis et al. 2015; Fardi et al. 2011). Bibliometric analysis helps research stakeholders to evaluate and filter published articles, allowing them to identify the most relevant published studies, the most active research aspects and topics, and their evolution over time. Scientometrics is a tool for assessing the progress of science, allowing us to evaluate the output of authors, institutions, countries, or specific thematic areas (Bueno-Aguilera et al. 2016). Such analysis offers useful and comprehensive evidence for designing research and development projects. There have been several bibliometric reviews on endodontics published in the literature (Fardi et al. 2011; Tzanetakis et al. 2015; Yilmaz et al. 2019), but none of them specifically focused on articles

published from Malaysia. Hence, this attracted the authors' interest in the exploration of previously published manuscripts from scholars affiliated with Malaysia.

Scopus (Elsevier's) prominence has escalated in recent years as a result of its increased inclusivity and representativeness (de Moya-Anegón et al. 2007). It was first introduced in November 2004 by Elsevier Science, which soon became the main competitor in dominating the international market for scientific databases. Scopus is recognised as the world's largest abstract and citation database of peer-reviewed literature covering a broad range of topics (Md Khudzari et al. 2018). According to SCImago Journal & Country Rank, which is driven by the Scopus database, Malaysia is the eighth country in the Asiatic region with the most dental articles published annually since 1996 (SCImago Journal & Country Rank). In 2019, Malaysia climbed to the sixth position with a total of 227 articles published by authors affiliated with Malaysia. These articles earned 71 citations (28 self-citations), culminating a citation rate of 0.31 per paper (SCImago Journal & Country Rank). The rise in international scientific output from Malaysia in recent years has been accompanied by the increased demand for dental research.

A paramount scientific literature explicitly on endodontics has been published and these studies should be reviewed and analysed to ascertain their impact on current and future development in the field of

endodontics (Yilmaz et al. 2019). To the best of the authors' knowledge, no comprehensive study is available on the scientific production in endodontics among dental researchers in Malaysia. Hence, the purpose of this study was to perform a bibliometric analysis of the scientific research output among researchers in Malaysia dedicating to endodontology from 2001 to 2021 based on Scopus database. This study also aimed to identify the characteristics of selected articles and provide insight into current and historical publishing patterns in the field of endodontics.

MATERIALS AND METHODS

Search Strategy

An electronic search based on the Scopus® database was performed by 2 investigators in the first week of March 2021 to identify the published articles. The following search equation was applied: TITLE-ABS-KEY (endodontic OR endodontics OR endodontology OR root AND canal OR roots AND canals) AND (LIMIT-TO [AFFILCOUNTRY, "Malaysia"]). The search was performed from January 2001 to February 2021. The inclusion and exclusion criteria for the study

selection are shown in Table 1. Only articles written in English and the first author's affiliation from Malaysia were selected. If the first author has more than one affiliation, only the first affiliation was counted. Editorials, letters to the editor, conference abstracts and opinion pieces were not included. However, there was no constraint on the number of publications and journals that could be included. Any disputes regarding articles that could be included or omitted during the search were discussed with the assistance of the third and fourth investigators. The SCImago Journal & Country Rank (SJR) database was used to determine the journal impact and ranking of each selected article.

Data Collection

The following parameters were extracted from each article: title of the articles, authors' name(s), number of author(s), institution(s) or affiliation(s), name of journal, year of publication, type of publication, source of the article, keywords, and number of citations. The authors were subsequently refined and normalised manually to eliminate typographical, transcription, and/or indexing errors,

Table 1: Inclusion and exclusion criteria for study selection

Inclusion	Exclusion
First author is affiliated with Malaysia	First author is not affiliated with Malaysia
Randomised or non-randomised trials, cohort, case-control, cross-sectional, in-vitro, in-vivo, ex-vivo experimental studies, case reports and case series, literature review, systematic review	Editorials, letter to editor, conference abstracts, opinion pieces
Related to endodontics	Related to dental specialties other than endodontics
Published in English language	Not published in English language

as well as to unify the terminology. If multiple entries for a single author were discovered, the authors' institutional affiliations were reviewed to see if the entries belonged to the same author. The selected articles were ranked according to the number of citations in descending order. If more than one article had the same citation number, the article published more recently was ranked higher. The first author's affiliation was used to evaluate the 'source of the article' (Tzanetakakis et al. 2015), whereby articles were classified based on the first author's affiliation department, such as 'endo' for the department of endodontics, 'cons' for the department of conservative dentistry or 'resto' for the department of restorative dentistry. They were also split into two subcategories i.e. 'Academic' for scholarly papers from universities and 'Non-academic' for articles from professional private practices or private organisations.

Each article was further analysed to include the article type and thematic categories. For article type, it was divided into research, review, case reports and case series, whereas research articles were subdivided into basic research, clinical research, or others. If the study involved *in-vitro* experimental works on extracted teeth or cell tissue culture, it was considered basic research. On the other hand, study involved an *in-vivo* approach or study involved microbiological samples from living human's root canals, the study was then considered a clinical article (Fardi et al. 2011). Articles that do not fall in these two groups were categorised as

others. The selected articles were also classified into 12 thematic categories including microbiology, pulp biology or pathology, root canal morphology, chemical preparation, mechanical preparation and instrumentation, working length determination, obturation, endodontic materials, restoration, endodontic surgery, epidemiological studies, and clinical or radiographic outcomes (Tzanetakakis et al. 2015). Articles that did not fit into either of these groups were listed as others. The classification of thematic categories was calibrated for all four investigators, and any disagreements were addressed with an experienced endodontist. Kappa test was performed to assess the inter-examiner agreement among all investigators.

Data Analysis

Descriptive analyses were performed using SPSS version 24.0 (IBM, Corp, Armonk, NY, USA) and Microsoft Excel software (Redmond, WA, USA). Comparison of the number of articles published and total citation counts between the period of (2001-2010) to (2011-Feb 2021) were analysed using Pearson's Chi-square test, whereas the association between number of publications and citation counts were analysed using Pearson's Correlation test. The significance level was set at $P=0.05$. The keywords and collaboration network among the authors were analysed using VOSviewer software version 1.6.16 (Centre for Science and Technology Studies, Leiden University, The Netherlands).

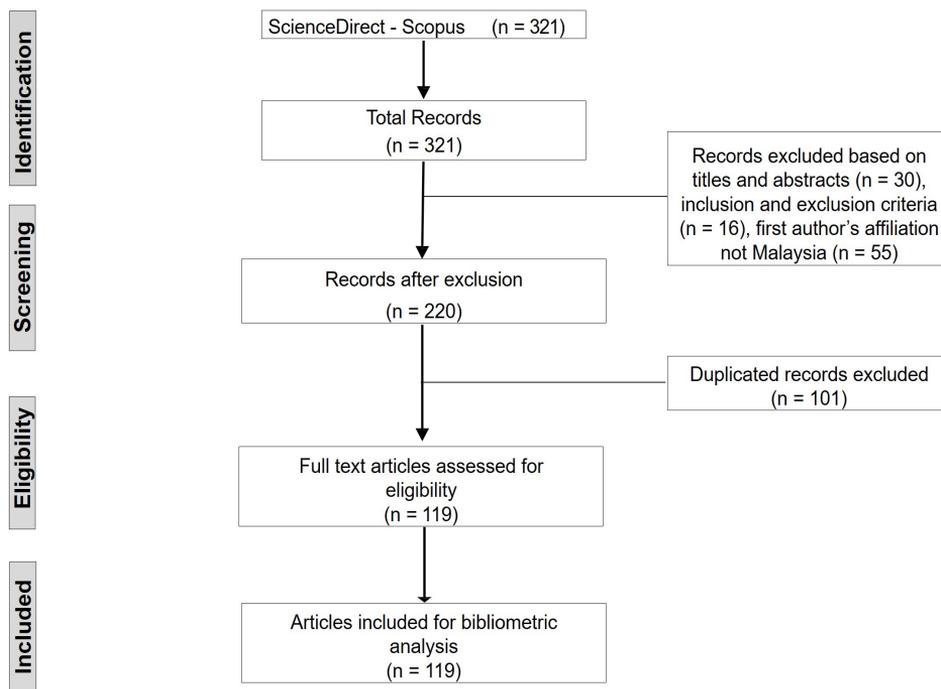


Figure 1: Flowchart of the study selection process.

RESULTS

From the search, a total of 220 articles were remained after preliminary screening based on titles and abstracts, followed by removing the duplicated articles. However, only 119 articles of which the first author affiliated with Malaysia were included (Figure 1). The Kappa test was score 8 among all investigators. The selected articles were ranked in descending order based on their citation counts as listed in Table 2. The top-cited article was cited 69 times, while 11 articles were found to have a citation count of 20 or greater, making them the top 9% among the selected articles. However, 43 articles were noted with no citation count.

Authors

A total of 72 researchers from Malaysia who had contributed to the scientific publication in endodontics as the first authors. The first author with the greatest number of publications was Hany Mohamed Aly Ahmed with 12 articles, followed by Nagendrababu Venkateshbabu and Afaf Yahya Al-Haddad with 8 and 7 articles, respectively. Meanwhile, only 15 authors with 2 or more articles published in Scopus database were found (Figure 2a). The mean number of authors was 3.97, median of 4, and a range of 1 to 15 authors (Figure 2b).

The state-wise distribution of publications revealed the maximum number of authors were 4 (24.4%), followed by 5 authors (21.8%) and 3 authors (19.3%). After an exhaustive analysis of all the first contributing

Table 2: Selected articles contributed by Malaysia's researchers in endodontics based on Scopus database.

Rank	Articles	No. of Citations
1.	Al-Haddad A, Aziz ZACA. Bioceramic-Based Root Canal Sealers: A Review. <i>Int J Biomater</i> 2016;2016.	69
2.	Ahmed HMA, Versiani MA, De-Deus G, Dummer PMH. A new system for classifying root and root canal morphology. <i>Int Endod J</i> 2017;50(8):761-770.	67
3.	Ahmed HMA, Abbott PV. Discolouration potential of endodontic procedures and materials: A review. <i>Int Endod J</i> 2012;45(10):883-897.	56
4.	Ahmed HMA. Anatomical challenges, electronic working length determination and current developments in root canal preparation of primary molar teeth. <i>Int Endod J</i> 2013;46(11):1011-1022.	47
5.	Chai WL, Hamimah H, Cheng SC, Sallam AA, Abdullah M. Susceptibility of <i>Enterococcus faecalis</i> biofilm to antibiotics and calcium hydroxide. <i>J Oral Sci</i> 2007;49(2):161-166.	36
6.	Luddin N, Aly Ahmed HM. The antibacterial activity of sodium hypochlorite and chlorhexidine against <i>Enterococcus faecalis</i> : A review on agar diffusion and direct contact methods. <i>J Conserv Dent</i> 2013;16(1):9-16.	34
7.	Chai WL, Thong YL. Cross-sectional morphology and minimum canal wall widths in C-shaped roots of mandibular molars. <i>J Endod</i> 2004;30(7):509-512.	33
8.	Nagendrababu V, Gutmann JL. Factors associated with postobturation pain following single-visit nonsurgical root canal treatment: A systematic review. <i>Quintessence Int</i> 2017;48(3):193-208.	24
9.	Soo WKM, Thong YL, Gutmann JL. A comparison of four gutta-percha filling techniques in simulated C-shaped canals. <i>Int Endod J</i> 2015;48(8):736-746.	21
10.	Al-Haddad A, Abu Kasim NH, Che Ab Aziz ZA. Interfacial adaptation and thickness of bioceramic-based root canal sealers. <i>Dent Mater J</i> 2015;34(4):516-521.	21
11.	Ahmed HMA, Neelakantan P, Dummer PMH. A new system for classifying accessory canal morphology. <i>Int Endod J</i> 2018;51(2):164-176.	20
12.	Ahmed HMA, Hashem AA. Accessory roots and root canals in human anterior teeth: a review and clinical considerations. <i>Int Endod J</i> 2016;49(8):724-736.	19
13.	Ahmed HMA, Abbott PV. Accessory roots in maxillary molar teeth: A review and endodontic considerations. <i>Aust Dent J</i> 2012;57(2):123-131.	19
14.	Pan JYY, Parolia A, Chuah SR, Bhatia S, Mutalik S, Pau A. Root canal morphology of permanent teeth in a Malaysian subpopulation using cone-beam computed tomography. <i>BMC Oral Health</i> 2019;19(1).	17
15.	Ahmed HMA, Dummer PMH. A new system for classifying tooth, root and canal anomalies. <i>Int Endod J</i> 2018;51(4):389-404.	17
16.	Ahmad P, Dummer PMH, Noorani TY, Asif JA. The top 50 most-cited articles published in the <i>International Endodontic Journal</i> . <i>Int Endod J</i> 2019;52(6):803-818.	16
17.	Nagendrababu V, Jayaraman J, Suresh A, Kalyanasundaram S, Neelakantan P. Effectiveness of ultrasonically activated irrigation on root canal disinfection: a systematic review of in vitro studies. <i>Clin Oral Invest</i> 2018;22(2):655-670.	16
18.	Seow LL, Toh CG, Wilson NHF. Strain measurements and fracture resistance of endodontically treated premolars restored with all-ceramic restorations. <i>J Dent</i> 2015;43(1):126-132.	15
19.	Chua EG, Parolia A, Ahlawat P, Pau A, Amalraj FD. Antifungal effectiveness of various intracanal medicaments against <i>Candida albicans</i> : An ex-vivo study. <i>BMC Oral Health</i> 2014;14(1).	15

Rank	Articles	No. of Citations
20.	Ishak MI, Ahmad Shafi A, Abdul Kadir MR, Sulaiman E. Effect of Ferrule Height and Post Length on Mechanical Stress and Displacement of Endodontically Treated Maxillary Central Incisor: A Finite Element Analysis. <i>J Med Biol Eng</i> 2017;37(3):336-344.	14
21.	Ahmed HMA, Luddin N, Kannan TP, Mokhtar KI, Ahmad A. Cell attachment properties of portland cement-based endodontic materials: Biological and methodological considerations. <i>J Endod</i> 2014;40(10):1517-1523.	14
22.	Farea M, Masudi S, Bakar WZW. Apical microleakage evaluation of system B compared with cold lateral technique: In vitro study. <i>Aust Endod J</i> 2010;36(2):48-53.	14
23.	Nagendrababu V, Pulikkotil SJ, Suresh A, Veetil SK, Bhatia S, Setzer FC. Efficacy of local anaesthetic solutions on the success of inferior alveolar nerve block in patients with irreversible pulpitis: a systematic review and network meta-analysis of randomized clinical trials. <i>Int Endod J</i> 2019;52(6):779-789.	12
24.	Nagendrababu V, Pulikkotil SJ, Jinatongthai P, Veetil SK, Teerawattanapong N, Gutmann JL. Efficacy and Safety of Oral Premedication on Pain after Nonsurgical Root Canal Treatment: A Systematic Review and Network Meta-analysis of Randomized Controlled Trials. <i>J Endod</i> 2019;45(4):364-371.	12
25.	Ahmad P, Dummer PMH, Chaudhry A, Rashid U, Saif S, Asif JA. A bibliometric study of the top 100 most-cited randomized controlled trials, systematic reviews and meta-analyses published in endodontic journals. <i>Int Endod J</i> 2019;52(9):1297-1316.	9
26.	Tiong TJ, Price GJ, Kanagasigam S. A computational simulation study on the acoustic pressure generated by a dental endosonic file: Effects of intensity, file shape and volume. <i>Ultrason Sonochem</i> 2014;21(5):1858-1865.	9
27.	Yap WY, Che Ab Aziz ZA, Azami NH, Al-Haddad AY, Khan AA. An in vitro Comparison of Bond Strength of Different Sealers/Obturation Systems to Root Dentin Using the Push-Out Test at 2 Weeks and 3 Months after Obturation. <i>Med Princ Pract</i> 2017;26(5):464-469.	8
28.	Venkateshbabu N, Anand S, Abarajithan M, Sheriff SO, Jacob PS, Sonia N. Natural therapeutic options in endodontics - A review. <i>Open Dent J</i> 2016;10(Suppl-1, M9):214-226.	7
29.	Tey KC, Lui JL. The effect of glass fiber-reinforced epoxy resin dowel diameter on the fracture resistance of endodontically treated teeth. <i>J Prosthodontics</i> 2014;23(7):572-581.	7
30.	Tan JME, Parolia A, Pau AKH. Intracanal placement of calcium hydroxide: A comparison of specially designed paste carrier technique with other techniques. <i>BMC Oral Health</i> 2013;13(1).	7
31.	Nagendrababu V, Segura-Egea JJ, Fouad AF, Pulikkotil SJ, Dummer PMH. Association between diabetes and the outcome of root canal treatment in adults: an umbrella review. <i>Int Endod J</i> 2020;53(4):455-466.	6
32.	Deng PU, Halim MS, Masudi SM, Al-Shehadat S, Ahmad B. Cone-beam computed tomography analysis on root and canal morphology of mandibular first permanent molar among multiracial population in East Coast Malaysian population. <i>Eur J Dent</i> 2018;12(3):410-416.	6
33.	Aal-Saraj AB, Ariffin Z, Masudi SM. An agar diffusion study comparing the antimicrobial activity of Nanoseal with some other endodontic sealers. <i>Aust Endod J</i> 2012;38(2):60-63.	6
34.	Daood U, Parolia A, Elkezza A, Yiu CK, Abbott P, Matinlinna JP, et al. An in vitro study of a novel quaternary ammonium silane endodontic irrigant. <i>Dent Mater</i> 2019;35(9):1264-1278.	5
35.	Sulaiman E, Alarami N, Wong YI, Lee WH, Al-Haddad A. The effect of fiber post location on fracture resistance of endodontically treated maxillary premolars. <i>Dent Med Probl</i> 2018;55(3):275-279.	5

Rank	Articles	No. of Citations
36.	Al-Haddad AY, Kutty MG, Che Ab Aziz ZA. Push-Out Bond Strength of Experimental Apatite Calcium Phosphate Based Coated Gutta-Percha. <i>Int J Biomater</i> 2018;2018.	5
37.	Sidhu P, Shankargouda S, Dicksit DD, Mahdey HM, Muzaffar D, Arora S. Evaluation of interference of cellular phones on electronic apex locators: An in vitro study. <i>J Endod</i> 2016;42(4):622-625.	5
38.	Chakravarthy Pishipati KV. An in vitro comparison of propex II apex locator to standard radiographic method. <i>Iran Endod J</i> 2013;8(3):114-117.	5
39.	Ong RM, Luddin N, Ahmed HM, Omar NS. Cytotoxicity of accelerated white MTA and Malaysian white Portland cement on stem cells from human exfoliated deciduous teeth (SHED): An in vitro study. <i>Singapore Dent J</i> 2012;33(1):19-23.	5
40.	Singbal K, Jain D, Raja K, Hoe TM. Comparative evaluation of apically extruded debris during root canal instrumentation using two Ni-Ti single file rotary systems: An in vitro study. <i>J Conserv Dent</i> 2017;20(2):64-67.	4
41.	Muttlib NAA, Azman ANP, Seng YT, Alawi R, Ariffin Z. Intracanal adaptation of a fiber reinforced post system as compared to a cast post-and-core. <i>Acta Stomatol Croatica</i> 2016;50(4):329-336.	4
42.	Al-Haddad A, Kutty MG, Abu Kasim NH, Che Ab Aziz ZA. Physicochemical Properties of Calcium Phosphate Based Coating on Gutta-Percha Root Canal Filling. <i>Int J Polym Sci</i> 2015;2015.	4
43.	Ahmed HMA, Che Ab Aziz ZA, Azami NH, Farook MS, Khan AA, Mohd Noor NS, et al. Application of a new system for classifying root canal morphology in undergraduate teaching and clinical practice: a national survey in Malaysia. <i>Int Endod J</i> 2020;53(6):871-879.	3
44.	Ahmed HMA, Musale PK, El Shahawy OI, Dummer PMH. Application of a new system for classifying tooth, root and canal morphology in the primary dentition. <i>Int Endod J</i> 2020;53(1):27-35.	3
45.	Nagendrababu V, Ahmed HMA. Shaping properties and outcomes of nickel-titanium rotary and reciprocation systems using micro-computed tomography: A systematic review. <i>Quintessence Int</i> 2019;50(3):186-195.	3
46.	Al-Kadhim AH, Rajion ZA, Malik NAB, Jaafar AB. Morphology of maxillary first molars analyzed by cone-beam computed tomography among Malaysian: Variations in the number of roots and canals and the incidence of fusion. <i>Int Med J Malaysia</i> 2017;16(2):33-39.	3
47.	Al-Haddad AY, Kutty MG, Abu Kasim NH, Che Ab Aziz ZA. The effect of moisture conditions on the constitution of two bioceramic-based root canal sealers. <i>J Dent Sci</i> 2017;12(4):340-346.	3
48.	Shanmugam CAL, Purmal K, Alam MK, Aziz ZABCA. The comparison of ProTaper® and K-flexfiles in preparation of curved canals: In vitro study. <i>Int Med J</i> 2013;20(4):507-512.	3
49.	Al-Maqtari AAA, Lui JL. Effect of Aging on Coronal Microleakage in Access Cavities through Metal Ceramic Crowns Restored with Resin Composites. <i>J Prosthodontics</i> 2010;19(5):347-356.	3
50.	Ahmad M, Pitt Ford TR, Crum LA, Walton AJ. Ultrasonic debridement of root canals: Acoustic cavitation and its relevance. <i>Int Endod J</i> 2009;42(5):391-398.	3
51.	Lin G--, Ghani N---, Ismail N-, Singbal K, Murugesappa D-, Mamat N. Fracture strength of endodontically treated lateral incisors restored with new zirconia reinforced rice husk nanohybrid composite. <i>J Clin Exp Dent</i> 2020;12(8):e762-e770.	2
52.	Lin GSS, Ghani NRNA, Noorani TY, Kamarudin A. Apical sealing ability of different endodontic sealers using glucose penetration test: A standardized methodological approach. <i>Cumhuriyet Dent J</i> 2020;23(2):79-87.	2

Rank	Articles	No. of Citations
53.	Ooi HY, Tee WY, Davamani F, Nagendrababu V. Comparing the antimicrobial efficacy of pediocin with chlorhexidine and calcium hydroxide as intracanal medicaments against persistent root canal infections. <i>J Conserv Dent</i> 2019;22(3):241-244.	2
54.	Dabbagh A, Madfa A, Naderi S, Talaeizadeh M, Abdullah H, Abdulmunem M, et al. Thermomechanical advantages of functionally graded dental posts: A finite element analysis. <i>Mech Adv Mater Struct</i> 2019;26(8):700-709.	2
55.	Kacharaju K, Hari P, Yee A, Ngo J, Ismail M. Analysis of Mandibular Premolars Root Canal Morphology Using Radiographic and Cross-Sectional Techniques in Malaysian Population. <i>Dent Hypotheses</i> 2019;10(1):14-19.	2
56.	Abdullah D, Eziana Hussein F, Abd Ghani H. Management of perforating idiopathic internal root resorption. <i>Iran Endod J</i> 2017;12(2):257-260.	2
57.	Al-Afifi NA, Abdullah M, Al-Amery SM, Abdulmunem M. Comparison between gutta-percha and resin-coated gutta-percha using different obturation techniques. <i>J Appl Biomater Funct Mater</i> 2016;14(3):e307-e313.	2
58.	Pallivathukal RG, Misra A, Nagraj SK, Donald PM. Dens invaginatus in a geminated maxillary lateral incisor. <i>BMJ Case Rep</i> 2015;2015.	2
59.	Thauk M, Masudi SM, Oo MMT, Ariffin Z, Alam MK. Assessment of the auxiliary effect of irrigation methods on obturation of simulated lateral canals. <i>Int Med J</i> 2014;21(2):188-192.	2
60.	Masudi SM, Azhar L, Awang RAR, Alam MK. Removal efficiency of calcium hydroxide intracanal medicament using two irrigation solutions. <i>Int Med J</i> 2014;21(1):106-109.	2
61.	Hui SHH, Ariffin Z, Alam MK. In vitro study of antibacterial properties of endodontic sealers and medications towards streptococcus mutans and enterococcus faecalis. <i>Int Med J</i> 2013;20(4):493-495.	2
62.	Nie YK, Bakar WZW, Alam MK. The occurrence of C-shaped root canal in Malaysian population. <i>Bangladesh J Med Sci</i> 2013;12(3):286-290.	2
63.	Nagendrababu V, Duncan HF, Whitworth J, Nekoofar MH, Pulikkotil SJ, Veettil SK, et al. Is articaine more effective than lidocaine in patients with irreversible pulpitis? An umbrella review. <i>Int Endod J</i> 2020;53(2):200-213.	1
64.	Soh JA, Sheriff SO, Ramar NAP, Pulikkotil SJ, Nagendrababu V, Neelakantan P, et al. Effect of root canal debridement on inflammatory cytokine levels. <i>Aust Endod J</i> 2019;45(2):171-176.	1
65.	Thomas AR, Mani R, Reddy TVK, Ravichandran A, Sivakumar M, Krishnakumar S. Evaluation of the antibacterial efficiency of a combination of 1% alexidine and sodium hypochlorite on enterococcus faecalis biofilm models: An in vitro study. <i>J Contemp Dental Pract</i> 2019;20(9):1090-1094.	1
66.	Fong JYM, Tan VJH, Lee JR, Tong ZGM, Foong YK, Tan JME, et al. Clinical audit training improves undergraduates' performance in root canal therapy. <i>Eur J Dent Educ</i> 2018;22(3):160-166.	1
67.	Noorani TY, Ghani NRNA, Asif JA, Rahim IA. Surgical endodontics to manage a separated instrument: A case report. <i>Dent Update</i> 2017;44(10):993-997.	1
68.	Bindal P, Kasim NHA, Ramasamy TS, Dabbagh A, Moharamzadeh K, Chai WL. Dental pulp tissue engineering and regenerative endodontic therapy. <i>Biomaterials for Oral and Dental Tissue Engineering</i> ; 2017. p. 297-318.	1
69.	Yacob N, Ramli H, Majid MNA, Fatah FA, Zahid DM. The application of Maqasid Shariah and legal maxims in aesthetic dentistry involving malocclusion and root canal treatment: Case discussion. <i>Adv Sci Lett</i> 2017;23(5):4550-4553.	1

Rank	Articles	No. of Citations
70.	Ahmed H. Endodontics and forensic personal identification: An update. <i>European J Gen Dent</i> 2017;6(1):5-8.	1
71.	Wong CY, Liaw YX, Wong JZ, Chen LC, Parolia A, Pau A. Factors associated with the technical quality of root canal fillings performed by undergraduate dental students in a Malaysian Dental School. <i>Braz J Oral Sci</i> 2016;15(1):45-50.	1
72.	Amith HV, Indushekar KR, Gujjar KR, Sharma R, Amith S. Apical plug technique in a calcified immature tooth: A case report. <i>Gen Dent</i> 2015;63(1):e12-e15.	1
73.	Abou-Alkheir AS, Masudi SM, Wan Bakar WZ, Alam MK. An in vitro study on the cleaning ability of various irrigation techniques using different rotary niti systems. <i>Int J Pharma Bio Sci</i> 2015;6(3):B1166-B1179.	1
74.	Alomari SMA, Ab-Ghani Z, Masudi SM, Husein A, Alam MK. Effect of smear layer on coronal sealing of a nano hydroxyapatite root canal sealer: An in vitro study. <i>Int Med J</i> 2014;21(1):120-122.	1
75.	Abdo SB, Masudi SM, Luddin N, Husien A, Khamis MF. Fracture resistance of over-flared root canals filled with MTA and resin-based material: An in vitro study. <i>Braz J Oral Sci</i> 2012;11(4):451-457.	1
76.	Farea M, Rani A, Husein A, Masudi S, Pameijer CH. Evaluation of gutta-percha-filled areas in root canals after filling by two different obturation techniques. <i>Aust J Basic Appl Sci</i> 2011;5(8):631-636.	1
77.	Baharin SA, Omar SH. Undergraduate endodontic clinical training in Malaysia: A National survey. <i>Eur J Dent Educ</i> 2021;25(1):168-174.	0
78.	Lin GSS, Ghani NRNA, Noorani TY, Ismail NH, Mamat N. Dislodgement resistance and adhesive pattern of different endodontic sealers to dentine wall after artificial ageing: an in-vitro study. <i>Odontology</i> 2021;109(1):149-156.	0
79.	AL-Oulabi A, Hin BY, Ariffin Z, Johari Y. Individually formed glass fibre reinforced composite posts for compromised teeth with oval and flared endodontic canals. <i>Dent Update</i> 2021;48(1):62-67.	0
80.	Lin GSS, Ghani NRNA, Noorani TY. The existence of butterfly effect and its impact on the dentinal microhardness and crack formation after root canal instrumentation. <i>Odontology</i> 2021.	0
81.	Mustaffa M, Nordin N, SNH E, MS MI. Guttaflow Bioseal as Monocone Obturation Technique: A Scanning Electron Microscopy Study. <i>Int Med J Malaysia</i> 2021;20(1):17-25.	0
82.	Daood U, Parolia A, Matinlinna J, Yiu C, Ahmed HMA, Fawzy A. Properties of a modified quaternary ammonium silane formulation as a potential root canal irrigant in endodontics. <i>Dent Mater</i> 2020;36(12):e386-e402.	0
83.	Parolia A, Kumar H, Ramamurthy S, Davamani F, Pau A. Effectiveness of chitosan-propolis nanoparticle against <i>Enterococcus faecalis</i> biofilms in the root canal. <i>BMC Oral Health</i> 2020;20(1).	0
84.	Al-Haddad AY, Kacharaju KR, Haw LY, Yee TC, Rajantheran K, Mun CS, et al. Effect of Intracanal Medicaments on the Bond Strength of Bioceramic Root Filling Materials to Oval Canals. <i>J Contemp Dental Pract</i> 2020;21(11):1218-1221.	0
85.	Parolia A, Nikolopoulou D, Lim BSH, Kanagasingam S. Comparison of antibacterial effectiveness between Sealapex and AH-plus sealer against <i>Enterococcus faecalis</i> : A systematic review of in vitro studies. <i>G Ital Endodonzia</i> 2020;34(2):119-134.	0
86.	Maqbool M, Noorani TY, Asif JA, Makandar SD, Jamayet NB. Controversies in endodontic access cavity design: A literature review. <i>Dent Update</i> 2020;47(9):747-754.	0
87.	Nik Abdul Ghani NR, Abdul Hamid NF, Karobari MI. Tunnel' radicular cyst and its management with root canal treatment and periapical surgery: A case report. <i>Clin Case Rep</i> 2020;8(8):1387-1391.	0

Rank	Articles	No. of Citations
88.	Mavani HAK, Tew IM, Wong L, Yew HZ, Mahyuddin A, Ghazali RA, et al. Antimicrobial efficacy of fruit peels eco-enzyme against <i>Enterococcus faecalis</i> : An in vitro study. <i>Int J Environ Res Public Health</i> 2020;17(14):1-12.	0
89.	Rahman NA, Halim MS, Khamis MF, Ghani HA. Analysis of root and canal morphology of maxillary first and second molars among Malay ethnic in the Malaysian population with the aid of cone-beam computed tomography: A retrospective study. <i>European J Gen Dent</i> 2020;9(2):84-89.	0
90.	Makandar SD, Noorani TY. Triple antibiotic paste - Challenging intracanal medicament: A systematic review. <i>J Int Oral Health</i> 2020;12(3):189-196.	0
91.	Rozainah NAGN, Farah AN, Karobari MI. Management of Discolored Failure Root Canal-Treated Upper Lateral Incisor. <i>Case Rep Dent</i> 2020;2020.	0
92.	Karobari MI, Noorani TY, Halim MS, Ahmed HMA. Root and canal morphology of the anterior permanent dentition in Malaysian population using two classification systems: A CBCT clinical study. <i>Aust Endod J</i> 2020.	0
93.	Alhaji MN, Salim NS, Johari Y, Syahrizal M, Abdul-Muttlib NA, Ariffin Z. Push-out bond strength of two types of dental post luted with two types of cement at two different root levels. <i>Acta Stomatol Croatica</i> 2020;54(3):263-272.	0
94.	Riaz S, Htun AT, Azlina A. Effect of double antibiotic paste and calcium hydroxide on the viability of the stem cells and their attachment to the irrigated dentin; an in-vitro study. <i>Malaysian Journal of Microscopy</i> 2020;16(1):75-82.	0
95.	Lin GSS, Ghani NRNA, Mokhtar K, Halim MS. Endodontic management of a mature mandibular first permanent molar that survived for 20 years after complete pulpotomy: A case report. <i>Arch Orofac Sci</i> 2019;14(2):169-175.	0
96.	Ghani NRNA, Ibrahim R, Luddin N, Masudi SM, Karobari MI. Effect of calcium hydroxide intracanal medicament on the push-out bond strength of RelyX Unicem self-Adhesive cement. <i>Saudi Endod J</i> 2019;9(3):174-180.	0
97.	Baharin S, Razali M. A combined management of a rare case of a maxillary lateral incisor with accessory root and deep mesio-radicular groove. <i>Saudi Endod J</i> 2019;9(1):61-65.	0
98.	Leneena G, Jeevan MB, Mynampati P, Vankayala B, Veerabhadrappe SK. Trauma induced external inflammatory root resorption - A case report. <i>J Young Pharm</i> 2018;10(4):494-496.	0
99.	Salim NA, Muttlib NAA, Alawi R, Rahman NA, Ariffin Z. Evaluation of microleakage between different post and core systems under gradual loading: An in-vitro study. <i>Acta Stomatol Croatica</i> 2018;52(3):218-226.	0
100.	Sakkir N, Asifulla M, Thaha KA, Francis T. Combined endodontic-surgical management of a palato-gingival groove in a maxillary lateral incisor with two canals. <i>Dent Update</i> 2018;45(7):634-640.	0
101.	Lishen W, In Meei T, Marny Mohamed A, Abdullah D. An interdisciplinary approach for management of an extensive carious premolar. <i>Iran Endod J</i> 2018;13(3):403-406.	0
102.	Aly Ahmed H, Kottoor J, Rahman Hashem A. Supernumerary teeth: A review on a critical endodontic challenge. <i>European J Gen Dent</i> 2018;7(1):1-6.	0
103.	Sockalingam SNMP, Talip MSAAA, Zakaria ASI. Maturogenesis of an immature dens evaginatus nonvital premolar with an apically placed bioceramic material (EndoSequence Root Repair Material®): An unexpected finding. <i>Case Rep Dent</i> 2018;2018.	0
104.	Mohd-Said S, Kweh WW, Than CY, Zainal-Abidin Z, Adnan SNA, Baharin SA, et al. In vitro inhibitory and biofilm disruptive activities of ginger oil against <i>enterococcus faecalis</i> [version 1; peer review: 1 approved with reservations, 1 not approved]. <i>F1000 Res</i> 2018;7.	0

Rank	Articles	No. of Citations
105.	Dabbour H, Liew AKC, Soo E, Abdullah D. Efficacy of two different views of video demonstration in teaching access cavity preparation to third year dental students. <i>Iran Endod J</i> 2018;13(4):474-480.	0
106.	Raja KK, Al-Haddad A, Hari P, Singbal KP. Comparison of adaptability of three different root canal obturation materials. <i>World J Dent</i> 2017;8(6):452-456.	0
107.	Ong TK. Disappearance of intracanal medication: A preliminary clinical finding from retrospective review of teeth with vertical root fracture. <i>Eur Endod J</i> 2017;2(1).	0
108.	Rathi R, Saroha P. Endodontic management of a macrodont: A rare tooth anomaly. <i>Int J Clin Dent</i> 2016;9(1):23-28.	0
109.	Ariffin AF, Harudin MH, Kanagasingam S, Rahman MM, Wan Noorina WA. Apical extrusion of sodium hypochlorite irrigation during root canal treatment using monoject or hypodermic irrigation needle. <i>Bangladesh J Med Sci</i> 2016;15(4):575-578.	0
110.	Kusumawardani A, Ardini YD, Hasan TH. The Islamic perspective of lingual dens evaginatus in a mandibular left second premolar: A case report. <i>Int Med J Malaysia</i> 2016;17(Specialissue2):333-336.	0
111.	Wan Noorina WA, Wayen L, Ann TL, Kanagasingam S, Abdullah S, Rahman MM. Irrigant flow in micro-computed tomography scanned root canals using computational fluid dynamics model. <i>J Med Sci</i> 2015;15(4):192-197.	0
112.	Kamruddin K, Tat TE, Abdul Muttlib NA, Alawi R, Rahman NA, Jamayet NB. A 7-year study on survival rate of fixed partial denture and post & core done by 5th year dental students of School of Dental Sciences, Universiti Sains Malaysia. <i>Int J Pharma Bio Sci</i> 2015;6(3):B914-B919.	0
113.	Alawi R, Saunders WP. The link between the restoration of the root filled tooth and post-root canal treatment failure: A narrative literature review. <i>Int Med J</i> 2014;21(2):239-241.	0
114.	Thauk M, Masudi SM, Oo MMT, Ariffin Z, Alam MK. Obturation on the simulated lateral canals of root canal system using heat only and heat with vibration technique: An in vitro study. <i>Int Med J</i> 2014;21(3):367-370.	0
115.	Razali NA, Masudi SM, Ariffin Z, Alam MK. Scanning electron microscope (SEM) study of two lubrication agent in removing smear layer on human dentine. <i>Int Med J</i> 2013;20(4):513-517.	0
116.	Ahmad AM, Bakar WZW, Husein A, Alam MK. An in vitro study of fracture resistance of weakened tooth roots reinforced with two types of adhesive restorative materials. <i>Bangladesh J Med Sci</i> 2013;12(1):63-67.	0
117.	Baharin SA, Ahmad DH, Mohamad Anuar FNA. Evaluation of apical seal between single cone and cold lateral condensation techniques after post space preparation at different timing. <i>Sains Malays</i> 2013;42(1):93-98.	0
118.	Abdo SB, Darrat AA, Masudi SM, Luddin N, Husien A. Sealing ability of gutta-percha/nano HA versus resilon/epiphany after 20 months using an electrochemical model - an in vitro study. <i>Braz J Oral Sci</i> 2012;11(3):387-391.	0
119.	al-Haddad AY, Aziz ZACA, Sulaiman E. Efficacy of R-endo® and protaper® Re-treatment systems in removal of realseal™. <i>Aust J Basic Appl Sci</i> 2011;5(3):108-113.	0

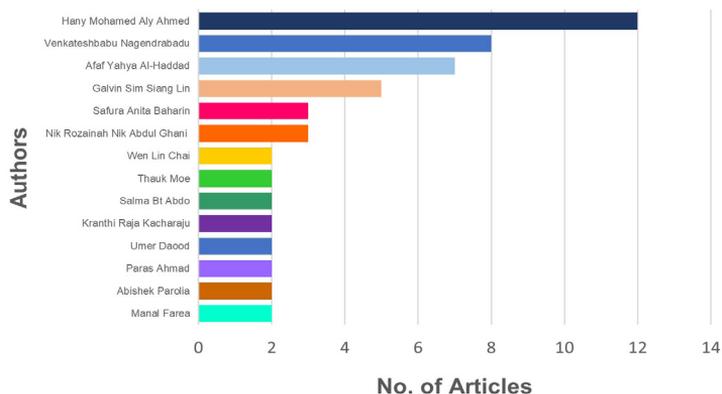


Figure 2(a): First authors with 2 or more articles published in Scopus database

authors, it was discovered that they had also appeared as second, third, fourth, and fifth authors in other articles. For coauthors who contributed to three or more papers from the chosen article list, a collaboration network was developed (Figure 3). The number of articles published by each author is represented by the node size, and the strength of collaborations among the authors is represented by the joining lines.

Journals, Year of Publication and SJR Score

Table 3 shows the lists of top-5-journal in which the articles were published in descending order. Journal with similar number of articles published were ranked based on their score according to the SJR. The International Endodontic Journal published the greatest number of articles, followed by International Medical Journal, Australian Endodontic Journal, Journal of Endodontics, and lastly BMC Oral Health. Based on Figure 4a, 32 out of 119 selected articles (26.89%) were published in endodontic related journal. Among them, 15

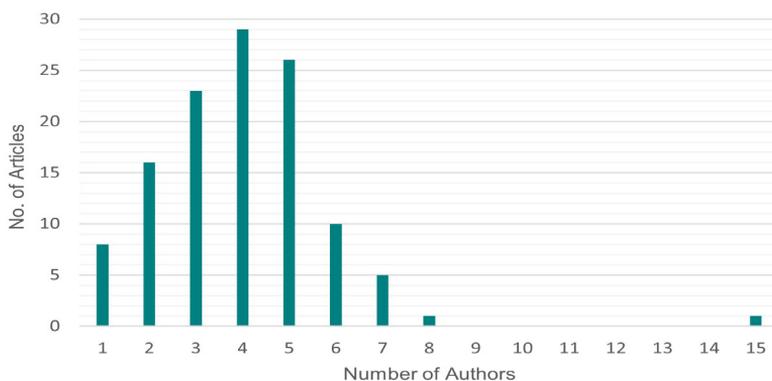


Figure 2(b): Total number of authorships in the selected articles

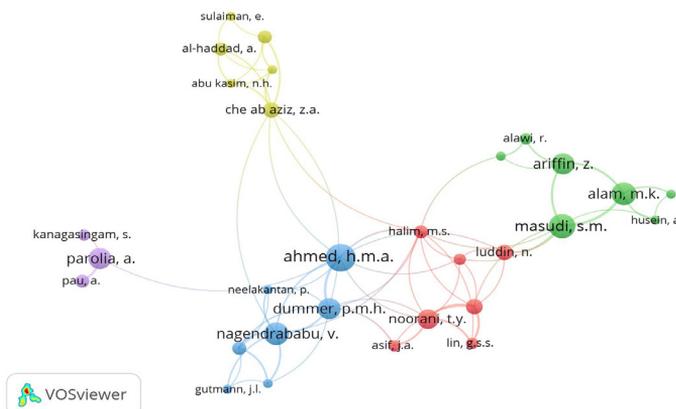


Figure 3: Graphical mapping of co-authorships with at least 3 documents co-occurrence using the VOSviewer Software in the field of Endodontics. The node sizes of the authors reflect the number of scientific articles they contributed. The links between each author represents the number of co-authorships. Four well-differentiated clusters can be observed including Ahmed, H.M.A. (blue), Masudi, S.M. (green), Noorani, T.Y. (red), Parolia, A (purple), and Che Ab Aziz, Z.A. (yellow).

articles (46.88%) were published in International Endodontic Journal which accounted for the greatest number of publications, followed by 5 articles (15.63%) published in Australian Endodontic Journal, and 4 articles (12.5%) each published in Journal of Endodontics and Iranian Endodontic Journal, respectively.

Based on the SJR (Figure 4b), 39 of the selected articles (32.77%) were presented in Quartile 1, followed by 22 articles (18.49%) in Quartile 2, 31 articles (26.05%) in Quartile 3, and 22 articles (18.49%) in Quartile 4. There

Table 3: Top 5 journals in which the selected articles were published

Journals	No. of Articles
International Endodontic Journal	15
International Medical Journal	8
Australian Endodontic Journal	5
Journal of Endodontics	4
BMC Oral Health	4

were 3 articles (2.52%) published in journals that are not assigned in any quartile yet, while 2 articles (1.68%) published in journals that could not be found from the SCImago Journal Rank. From Table 4 and Figure 4c, the greatest number of articles published was found in the year 2020, while the highest number of total citations was noted in the year 2017. A drastic increase ($P < 0.05$) of articles published, and total citation counts were noted when comparing the first decade (year 2001 to 2010) to the second decade (2011 to Feb 2021). Besides, a significant association ($P = 0.038$) was also found between number of articles published and total citations.

Institutions, Source and Origin

A total of 118 articles (99.16%) were academic-based which distributed across 13 institutions in Malaysia, while only one article was non-academic-

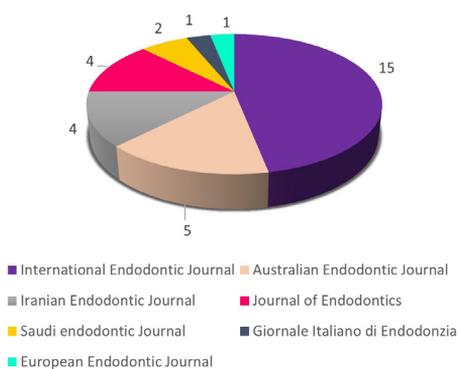


Figure 4(a): Number of selected articles published in endodontic related journals.

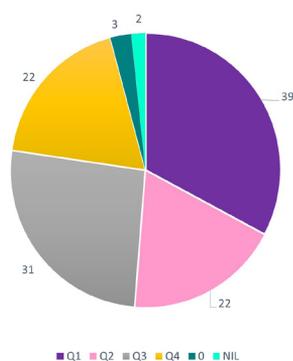


Figure 4(b): Classification of the selected articles based of SJR in quartiles

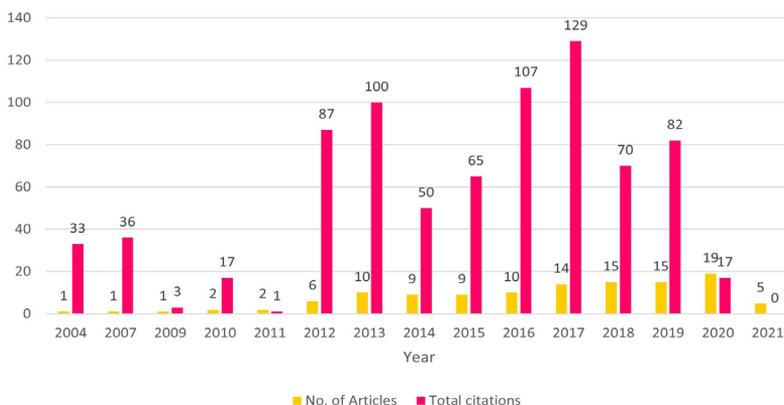


Figure 4(c): Number of articles and total citation counts with regards to the year of publication

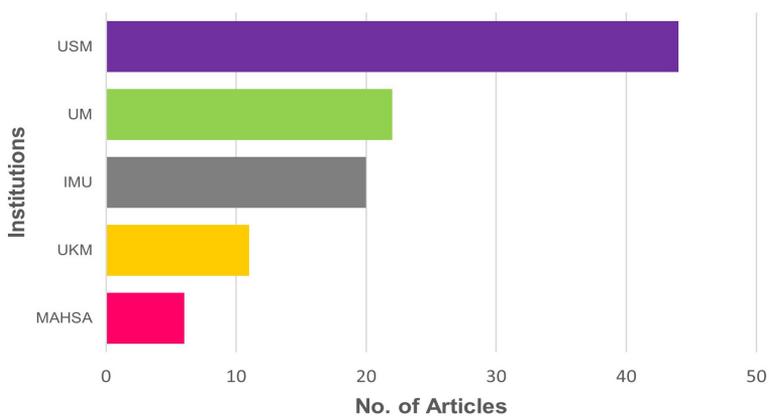


Figure 4(d): Top 5 Malaysia's institutions contributing to the field of endodontics.

Table 4: Number of articles and total citation counts with regards to the year of publication

Period	Year	No. of Articles	P-value	Total citations	P-value
2001-2010	2004	1	0.001*	33	0.001*
	2007	1		36	
	2009	1		3	
	2010	2		17	
2011-Feb 2021	2011	2		1	
	2012	6		87	
	2013	10		100	
	2014	9		50	
	2015	9		65	
	2016	10		107	
	2017	14		129	
	2018	15		70	
	2019	15		82	
	2020	19		17	
	2021	5		0	

Significant at 0.05*

based from a private practice. Among the 118 academic-based articles, the Universiti Sains Malaysia (USM) produced the highest number of publications (37.3%), followed by Universiti Malaya (UM) (18.6%), International Medical University (IMU) (16.9%), Universiti Kebangsaan Malaysia (UKM) (9.3%) and Malaysia

Allied Health Sciences Academy (MAHSA) University (5.1%) (Figure 4d). The source of each article was analysed based on the department where the studies were produced.

Table 5 shows that the Department of Conservative Dentistry was the most prolific, producing the highest number of articles with 29 articles

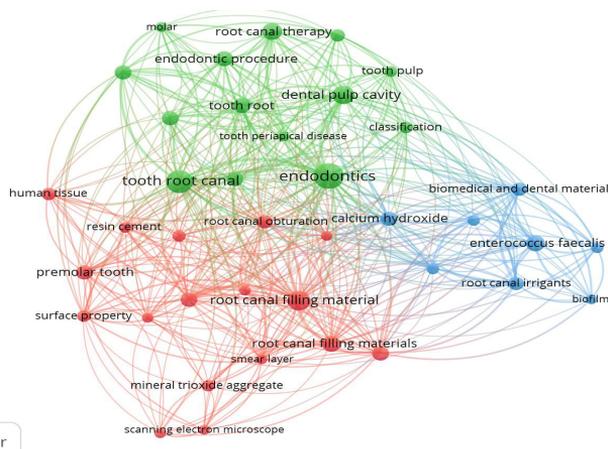


Figure 5: Graphical mapping of keywords using VOS viewer software with at least 5 documents co-occurrence. Larger nodes represent keywords with more frequent appearance of which tooth root canal and endodontics are the central nodes. The small distance between two terms represents that a large number of co-occurrences of the terms. Well-differentiated clusters can be observed including endodontics (green), root canal filling material (red), and *Enterococcus faecalis* (blue).

Table 5: Sources based on institutional departments, thematic categories, and the types of selected articles.

Source	No. of Articles	Thematic Categories	No. of Articles	Origin	No. of Articles	Type of Articles	No. of Articles
Conservative	29	Endodontic materials	19	Journal	118	Research (basic)	62
Restorative	28	Root canal morphology	17	Book	1	Review	27
Clinical Dentistry	13	Restoration	10			Case Report	16
Dentistry	5	Clinical or radiographic outcome	10			Research (others)	8
Oral Medicine	2	Microbiology	10			Research (clinical)	5
Prosthodontics	2	Obturation	9				
Dental Materials	2	Chemical preparation	7				
Operative Dentistry	2	Mechanical preparation and instrumentation	7				
Pedodontics	1	Endodontic surgery	4				
Oral Biology	1	Working length determination	3				
Dental Sciences	1	Pulp biology or pathology	3				
Oral Pathology	1	Epidemiological studies	1				
Oral Pathology	1	Others	19				
Family Oral Health	1						
Mechanical Engineering Technology	1						
Others	29						

each, followed by department of restorative dentistry which produced 28 articles and department of clinical dentistry with 13 articles. Amongst all the articles, the origin of 118 articles was from journals. Only 1 of them was originated from a book chapter (Bindal et al. 2017).

Article Type, Thematic Category and Keywords

Of all the selected articles, 75 articles (63.03%) were research, in which 62 articles (52.1%) were basic research, 5 articles (4.2%) were clinical research,

and 8 articles (6.72%) were classified as others. 27 articles (22.69%) were reviews, followed by 16 (13.45%) case reports (Table 5). Of the total publications, thematic categories of endodontic materials and others had the most number of articles which were 19 each (16%), followed by 17 articles (14.3%) themed as root canal morphology, 10 articles (8.4%) each for restoration, clinical or radiographic outcomes and microbiology. However, only 1 article (0.8%) was about epidemiological studies (Nie et al. 2013). A total of 954 unique keywords were identified. However, after setting

the minimum number of occurrences of a keyword to 5, only 74 keywords met the threshold, and they are provided in Figure 5. The top three most frequently used keywords were 'endodontics', 'tooth root canal' and 'root canal filing material'.

DISCUSSION

The present bibliometric study is the first of its kind to assess the scientific contribution of researchers in Malaysia in the field of endodontics. Nation-based bibliometric analysis in areas of dentistry, especially endodontics, may provide readers with current literature or discoveries in endodontics on a national level, as well as assist in determining future research direction (Abraham et al. 2018). Such analysis often helps researchers to determine the status of national research and equate it to global research performance. Even though it is beyond the scope of this bibliometric review to include and address all the research contents of the selected articles, the present review has managed to extract and outline some pertinent aspects related to the main objectives. According to our findings, the bulk of the publications have more than three authors. The emergence of interest across different institutes in Malaysia and among different researchers could explain the increase in the number of coauthors over the years. Hence, more collaboration among researchers can be expected in the future.

Most of the articles were published in the International Endodontic Journal (Q1 journal), which is regarded as one

of the most reputable publications in the field of endodontic research and clinical practice. This journal has, understandably, published the greatest number of articles (12.7%) in endodontics. However, this contradicts previous bibliometric studies which revealed that Journal of Endodontics was the journal with the highest number of research publications (Fardi et al. 2011; Adnan & Ullah 2018). UM and USM were the two institutions that contributed to the most number of articles in this esteemed journal with 6 articles published each. The high impact factor also reflects the journal's importance as a source of knowledge for researchers interested in advanced and groundbreaking approaches in the field of endodontics (Abraham et al. 2018). A noteworthy finding is that the International Medical Journal (Q4), which contributed 8 articles to the list of selected articles, was ranked as the second most-published journal. Seven of the eight publications were published by the first authors from USM. Several factors, including open access, fast track review, acceptance rate, and a reasonable article processing fee, may have affected the submission of papers to the stated journal considering its low impact factor (Gaston et al. 2020; Calcagno et al. 2012).

In the present review, we evaluated the number of articles published in endodontic related journals. The top three journals with the most publications were International Endodontic Journal, Australian Endodontic Journal, and Journal of Endodontics. The comparatively lower number of publications published

in European Endodontic Journal and *Giornale Italiano di Endodonzia*, may be attributed to author preference and recent Scopus coverage in European Endodontic Journal as this journal being recent and still in its infancy. Since endodontics has attracted a great amount of attention over the years, it is expected that a vast number of related articles will be published in these two journals in due time.

An important distinction of this analysis was that the largest number of publications were published in 2020, while the highest number of citations were reported in 2017. This reflects recent trends among researchers in Malaysia, who are developing a greater interest in endodontics research. Studies released after 2020 have earned no citation, but it is too early to conclude if these papers would gain more citations over time and suggest a different pattern from the one seen in this report. The dramatic spike in publication from the second decade (2011-Feb 2021) may also be attributed to an increase in the quantity and efficiency of conservative dentistry and endodontics researchers, improvements in advanced laboratory technologies that allow for more well-standardised testing, and widespread interest in improving endodontic materials (Krishnan et al. 2020; Abraham et al. 2018; Yilmaz et al. 2019). The SJR indicator assesses both the number of citations per journal and the relevance of journals that have external citations. The SJR metric is based on an average estimation of weighted citations the journal gets over the preceding three years, and the

journals are divided into four quartiles (Falagas et al. 2008). More than half of the articles chosen were published in Q1 and Q2 journals, showing the high quality of study performed by researchers in Malaysia.

The USM was ranked first among the institutes where the bulk of the first authors were affiliated. A large amount of *in-vitro* basic research experiments has been discovered in this institution (Farea et al. 2011; Abdo et al. 2012; Aal-Saraj et al. 2012; Abdo et al. 2012; Ong et al. 2012; Razali et al. 2013; Hui Hui et al. 2013; Masudi et al. 2014; Thauk et al. 2014; Muttlib et al. 2016; Salim et al. 2018; Abdul Ghani et al. 2019; Alhaji et al. 2020; Lin et al. 2018; Lin et al. 2020; Lin et al. 2020; Lin et al. 2021). UM has the second-highest number of endodontic publications, but it pales in contrast to the vast amount of research generated by the first authors associated with USM. The frequent collaboration between academic institutions in Malaysia, as seen in the graphical mapping of co-authorships, may account for the rise in endodontics publications from researchers associated with these two universities. An interesting fact is that one private practitioner in Malaysia (Tan Endodontic Dental Specialist Centre Private Practice) has also contributed to the literature on endodontic (Ong 2017). This is a positive aspect because private practitioners may see a lot of unusual cases, and their participation in the research literature can offer a thought-provoking insight into various endodontic treatment procedures and outcomes. Another interesting discovery was that conservative and

restorative dentistry departments tended to produce a considerable number of articles. This can be explained as most institutions incorporate endodontics into 'conservative' or 'restorative' departments and the term 'endodontic' or 'endodontology' were not used. Such a phenomenon was also found to be more prominent in European countries according to a previous study (Tzanetakis et al. 2015).

Although *in-vitro* study designs are not regarded at the top of the evidence ladder, they have been seen in the majority of published studies (Burns et al. 2011). The second most popular category of article published is a review, followed by case reports. Clinical research using an *in-vivo* methodology is still limited according to the current review (Kim et al. 2012; Deng et al. 2018; Soh et al. 2019; Pan et al. 2019; Karobari et al. 2020), and only one paper derived from a book chapter (Bindal et al. 2017). As a result, prospective experiments should concentrate on clinical settings and follow-ups, as these studies will provide more predictable and reliable outcomes, as well as reinforce the clinical validity of *in-vitro* studies.

The two major focuses of studies included in the list were related to endodontic materials and root canal morphology which corroborates with a previous study (Tzanetakis et al. 2015). This is a major predictor of Malaysia's researchers to success in dealing with a large spectrum of endodontic studies, as endodontic materials cover not only dental knowledge but also material sciences and chemical engineering viewpoints. Root canal morphology

research is also essential in ensuring the safety and efficacy of endodontic treatments and offers clinicians a greater understanding during root canal cleaning and shaping (Chai & Thong 2004; Ahmed & Abbott 2012; Pallivathukal et al. 2015; Ahmed & Hashem 2016; Ahmed et al. 2017; Kacharaju et al. 2019; Pan et al. 2019; Karobari et al. 2020; Abdul Rahman et al. 2020). These study results can also be extrapolated and validated in clinical trials, enabling clinical decisions to be made in light of them. On the other hand, only one epidemiological study was reported related to the occurrence of C-shaped canals in Malaysian population (Nie et al. 2013). Therefore, highlight should be made for future researchers to explore more in this theme of endodontics to provide more in-depth information on the distribution of pulp and periapical diseases and factors affecting them among Malaysian population.

One of the potential limitations of bibliometric analysis is that older articles have more time to receive citations (Adnan & Ullah 2018). Therefore, prejudice may emerge when the articles were also tabulated according to the citation counts. Since new research may be a continuation of this current literature or novel research, subsequent publications could supersede current data and obtain even more citations. Despite this, there is no system in place to distinguish publications with a higher number of citations because of self-citation. Another drawback may be the inclusion of publications with only the first author affiliated with Malaysia.

Furthermore, the current study relied entirely on the Scopus database to evaluate the scientific contribution of Malaysia's researchers in endodontics. Significant evidence could also be lost since published papers in other languages, opinions, or conference proceedings were not included.

CONCLUSION

This is the first bibliometric analysis that portrayed an original and comprehensive review of the scientific contribution of Malaysia's researcher in the field of endodontics. Despite certain shortcomings, it provides a thorough review of endodontic studies over the last two decades. Ignoring the fact that only about 10% of the articles had 20 or more citations, more than half of the articles were published in journals ranked in the first and second quartiles by SCImago. In the Scopus database, 15 of the 72 authors had two or more publications. Moreover, there has been a rise in the number of publications and citations in recent years, suggesting an increasing interest in endodontics among researchers in Malaysia. The USM ranked first with the highest number of publications, whereas International Endodontic Journal was the journal with the most articles published. The majority of the publications came from the department of conservative dentistry. The primary theme of endodontic research was basic research experiments on endodontic materials, indicating that researchers prefer *in-vitro* laboratory studies focusing on developing or enhancing the properties

of endodontic materials. Nevertheless, a more detailed analysis of the validity of evidence in the articles used in this analysis is warranted.

REFERENCES

- Aal-Saraj, A.B., Ariffin, Z., Masudi, S.M. 2012. An agar diffusion study comparing the antimicrobial activity of Nanoseal with some other endodontic sealers. *Aust Endod J* 38(2): 60-3.
- Abdo, S.B., Darrat, A.A., Masudi, S.M., Luddin, N., Husein, A. 2012. Sealing ability of gutta-percha/ Nano HA versus Resilon/Epiphany after 20 months using an electrochemical model – an in vitro study. *Braz J Oral Sci* 11(3): 387-91.
- Abdo, S.B., Masadi, S.M., Luddin, N., Husein, A., Khamis, M.F. 2012. Fracture resistance of over-flared root canals filled with MTA and resin-based material: An in vitro study. *Braz J Oral Sci* 11(4): 451-7.
- Abdul Ghani, N.R. Ibrahim, R., Luddin, N., Masudi, S.M., Karobari, M.I. 2019. Effect of calcium hydroxide intracanal medication on the push-out bond strength of RelyX Unicem self-Adhesive cement. *Saudi Endod J* 9(3): 174-80.
- Abdul Rahman, N., Halim, M.S., Khamis, M.F., Abd Ghani, H. 2020. Analysis of root and canal morphology of maxillary first and second molars among Malay ethnic in the Malaysian population with the aid of cone-beam computed tomography: A retrospective study. *Eur J Gen Dent* 9(2): 84-9.
- Abraham, S., Mehta, D.L., Bellad, S.C., Patil, S., Kamble, A.B., Chaudhari, S. 2018. The Contribution of Indian Endodontists in Rotary Endodontics to Pubmed Database, from 2000-2017. *Open Access Maced J Med Sci* 6(10): 1878-81.
- Adnan, S., Ullah, R. 2018. Top-cited Articles in Regenerative Endodontics: A Bibliometric Analysis. *J Endod* 44(11): 1650-64.
- Ahmed, H.M., Abbott, P.V. 2012. Accessory roots in maxillary molar teeth: a review and endodontic considerations. *Aust Dent J* 57(2): 123-31; quiz 248.
- Ahmed, H.M., Hashem, A.A. 2016. Accessory roots and root canals in human anterior teeth: a review and clinical considerations. *Int Endod J* 49(8): 724-36.
- Ahmed, H.M.A., Versiani, M.A., De-Deus, G., Dummer, P.M.H. 2017. A new system for classifying root and root canal morphology. *Int Endod J* 50(8): 761-70.
- Alhaji, M.N., Salim, N.S., Johari, Y., Syahrizal, M., Abdul-Mutlib, N.A., Ariffin, Z. 2020. Push-out

- bond strength of two types of dental post luted with two types of cement at two different root levels. *Acta Stomatol Croat* 54(3): 263-72.
- Bindal, P., Kasim, N.H.A., Ramasamy, T.S., Dabbagh, A., Moharamzadeh, K., Chai, W.L. 2017. Dental pulp tissue engineering and regenerative endodontic therapy. In *Biomaterials for Oral and Dental Tissue Engineering*, 297-318.
- Brignardello-Petersen, R., Carrasco-Labra, A., Glick, M., Guyatt, G.H., Azarpazhooh, A. 2014. A practical approach to evidence-based dentistry: understanding and applying the principles of EBD. *J Am Dent Assoc* 145(11): 1105-7.
- Bueno-Aguilera, F., Jimenez-Contreras, E., Lucena-Martin, C., Pulgar-Encinas, R. 2016. Dental research in Spain. A bibliometric analysis on subjects, authors and institutions (1993-2012). *Med Oral Patol Oral Cir Bucal* 21(2): e142-50.
- Burns, P.B., Rohrich, R.J., Chung, K.C. 2011. The levels of evidence and their role in evidence-based medicine. *Plast Reconstr Surg* 128(1): 305-10.
- Calcagno, V., Demoinet, E., Gollner, K., Guidi, L., Ruths, D., de Mazancourt, C. 2012. Flows of research manuscripts among scientific journals reveal hidden submission patterns. *Science* 338(6110): 1065-9.
- Chai, W.L., Thong, Y.L. 2004. Cross-sectional morphology and minimum canal wall widths in C-shaped roots of mandibular molars. *J Endod* 30(7): 509-12.
- de Moya-Anegón, F., Chinchilla-Rodríguez, Z., Vargas-Quesada, B., Corera-Álvarez, E., Muñoz-Fernández, F.J., González-Molina, A., Herrero-Solana, V. 2007. Coverage analysis of Scopus: A journal metric approach. *Scientometrics* 73(1): 53-78.
- Deng, P.U., Halim, M.S., Masudi, S.M., Al-Shehadat, S., Ahmad, B. 2018. Cone-beam computed tomography analysis on root and canal morphology of mandibular first permanent molar among multiracial population in East Coast Malaysian population. *Eur J Dent* 12(3): 410-6.
- European Society of Endodontology. 2006. Quality guidelines for endodontic treatment: consensus report of the European Society of Endodontology. *Int Endod J* 39(12): 921-30.
- Falagas, M.E., Kouranos, V.D., Arencibia-Jorge, R., Karageorgopoulos, D.E. 2008. Comparison of SCImago journal rank indicator with journal impact factor. *FASEB J* 22(8): 2623-8.
- Fardi, A., Kodonas, K., Gogos, C., Economides, N. 2011. Top-cited articles in endodontic journals. *J Endod* 37(9): 1183-90.
- Farea, M., Rani, A., Husein, A., Masudi, S., Pameijer, C.H. 2011. Evaluation of gutta-percha-filled areas in root canals after filling by two different obturation techniques. *Aust J Basic Appl Sci* 5(8): 631-6.
- Gaston, T.E., Ounsworth, F., Senders, T., Ritchie, S., Jones, E. 2020. Factors affecting journal submission numbers: Impact factor and peer review reputation. *Learned Publishing* 33(2): 154-62.
- Hui Hui, S.H., Ariffin, Z., Alam, M.K. 2013. In vitro study of antibacterial properties of endodontic sealers and medications towards streptococcus mutans and enterococcus faecalis. *Int Medical J* 20(4): 493-5.
- Kacharaju, K.R., Hari, P., Yee, A., Ngo, J., Ismail, M.F. 2019. Analysis of mandibular premolars root canal morphology using radiographic and cross-sectional techniques in Malaysian population. *Dent Hypotheses* 10(1): 14-9.
- Karobari, M.I., Noorani, T.Y., Halim, M.S., Ahmed, H.M.A. 2020. Root and canal morphology of the anterior permanent dentition in Malaysian population using two classification systems: A CBCT clinical study. *Aust Endod J* 47(2): 202-16.
- Kim, Y., Lee, S.J., Woo, J. 2012. Morphology of maxillary first and second molars analyzed by cone-beam computed tomography in a Korean population: variations in the number of roots and canals and the incidence of fusion. *J Endod* 38(8): 1063-8.
- Krishnan, A., Saini, A., Sharma, S., Kumar, V., Chawla, A., Logani, A. 2020. India's contribution to regenerative endodontics: A bibliometric analysis. *J Conserv Dent* 23(4): 325-9.
- Lin, G.S., Ghani, N.R., Ismail, N.H., Singbal, K., Murugesappa, D.G., Mamat, N. 2020. Fracture strength of endodontically treated lateral incisors restored with new zirconia reinforced rice husk nanohybrid composite. *J Clin Exp Dent* 12(8): e762-70.
- Lin, G.S., Ghani, N.R., Noorani, T.Y., Ismail, N.H. 2018. Fracture resistance of the permanent restorations for endodontically treated premolars. *Euro J Gen Dent* 7(3): 56-60.
- Lin, G.S.S., Abdul Ghani, N.R.N.A., Noorani, T.Y., Ismail, N.H., Mamat, N. 2021. Dislodgement resistance and adhesive pattern of different endodontic sealers to dentine wall after artificial ageing: an in-vitro study. *Odontology* 109(1): 149-56.
- Lin, G.S.S., Abdul Ghani, N.R.N., Noorani, T.Y., Kamarudin, A. 2020. Apical sealing ability of different endodontic sealers using glucose penetration test: a standardized methodological approach. *Cumhuriyet Dent J* 23(2): 79-87.
- Masudi, S.M., Azhar, L., Awang, R.A.R., Alam, M.K. 2014. Removal efficiency of calcium hydroxide intracanal medicament using two irrigation solutions. *Int Medical J* 21(1): 106-9.
- Md Khudzari, J., Kurian, J., Tartakovsky, B., Raghavan, G.S.V. 2018. Bibliometric analysis of global research trends on microbial fuel cells using Scopus database. *Biochem Eng J* 136: 51-60.

- Muttlib, N.A., Azman, A.N., Seng, Y.T., Alawi, R., Ariffin, Z. 2016. Intracanal adaptation of a fiber reinforced post system as compared to a cast post-and-core. *Acta Stomatol Croat* 50(4): 329-36.
- Nie, Y.K., Bakar, W.Z.W., Alam, M.K. 2013. The occurrence of C-shaped root canal in Malaysian population. *Bangladesh J Med Sci* 12(3): 286-90.
- Ong, R.M., Luddin, N., Ahmed, H.M., Omar, N.S. 2012. Cytotoxicity of accelerated white MTA and Malaysian white Portland cement on stem cells from human exfoliated deciduous teeth (SHED): An in vitro study. *Singapore Dent J* 33(1): 19-23.
- Ong, T.K. 2017. Disappearance of Intracanal Medication: A Preliminary Clinical Finding from Retrospective Review of Teeth with Vertical Root Fracture. *Eur Endod J* 2(1): 1-6.
- Pallivathukal, R.G., Misra, A., Nagraj, S.K., Donald, P.M. 2015. Dens invaginatus in a geminated maxillary lateral incisor. *BMJ Case Rep* 2015: bcr2015209672
- Pan, J.Y.Y., Parolia, A., Chuah, S.R., Bhatia, S., Mutalik, S., Pau, A. 2019. Root canal morphology of permanent teeth in a Malaysian subpopulation using cone-beam computed tomography. *BMC Oral Health* 19(1): 14.
- Razali, N.A., Masudi, S.M., Ariffin, Z., Alam, M.K. 2013. Scanning electron microscope (SEM) study of two lubrication agent in removing smear layer on human dentine. *Int Medical J* 20(4): 513-7.
- Salim, N.A., Muttlib, N.A.A., Alawi, R., Rahman, N.A., Ariffin, Z. 2018. Evaluation of microleakage between different post and core systems under gradual loading: an in-vitro study. *Acta Stomatol Croat* 52(3): 218-26.
- Scimago Journal & Country Rank. Available from <http://www.scimagojr.com/>. [03 March 2021].
- Soh, J.A., Sheriff, S.O., Ramar, N. A., Pulikkotil, S.J., Nagendrababu, V., Neelakantan, P., Amalraj, F.D. 2019. Effect of root canal debridement on inflammatory cytokine levels. *Aust Endod J* 45(2): 171-6.
- Thauk, M., Masudi, S.M., Oo, M.M.T., Ariffin, Z., Alam, M.K. 2014. Obturation on the simulated lateral canals of root canal system using heat only and heat with vibration technique: An in vitro study. *Int Medical J* 21(3): 367-70.
- Triaridis, S., Kyrgidis, A. 2010. Peer review and journal impact factor: the two pillars of contemporary medical publishing. *Hippokratia* 14(Suppl 1): 5-12.
- Tzanetakis, G.N., Stefopoulos, S., Loizides, A.L., Kakavetsos, V.D., Kontakiotis, E.G. 2015. Evolving Trends in Endodontic Research: An Assessment of Published Articles in 2 Leading Endodontic Journals. *J Endod* 41(12): 1962-8.
- Yilmaz, B., Dincol, M.E., Yalcin, T.Y. 2019. A bibliometric analysis of the 103 top-cited articles in endodontics. *Acta Odontol Scand* 77(8): 574-83.

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