

ORIGINAL ARTICLE

A bibliometric analysis of current trends, hotspots, and future aspects of endodontic-periodontal lesions

ABSTRACT

Aim: This study aims to examine the present findings, contemporary developments, and productivity of endodontic-periodontal (endo-perio) lesions based on the top 50 most-cited articles between 1990 and 2022.

Methodology: An electronic search was carried out in the “Clarivate Analytics Web of Science, All Databases”. After ranking the articles in descending order based on their citation counts, the first 50 relevant articles were selected. Parameters such as citation density, publication year, journal, country, institution, author, study design, evidence level, and keywords were analyzed. Spearman’s correlation was used to determine associations between the number of citations and citation density.

Results: There was a significant positive correlation between citation number and the age of publication ($p < 0.05$). Articles were mostly published between 2011 and 2022. The Journal of Endodontics had the largest number of publications. The United States and The University of Southern California made the highest contribution. The majority of the articles were case reports. Ilan Rotstein, Se-Lim Oh, and Maryam Pourhajibagher were the most frequent first authors. Studies were frequently designed as case reports with evidence level V. “Endo-perio lesions” followed by “guided tissue regeneration” were mostly-used keywords.

Conclusion: Regenerative procedures along with endodontic treatments have been utilized in the last decade to manage endo-perio lesions due to the developments in materials and techniques. Case reports could guide dental practitioners by demonstrating updated information in this field.

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Received 2023, April 24

Accepted 2023, May 26

KEYWORDS Bibliometrics, citation analysis, endodontics, endodontic-periodontal lesion, periodontology.

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Peer review under responsibility of Società Italiana di Endodonzia

10.32067/GIE.2023.37.01.16

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Introduction

The relationships between dental pulp and periodontium occur through anatomic, vascular, and pathological connections such as the apical foramina, lateral and accessory canals, exposed dentinal tubules, palatal grooves, root canal perforations, and root fractures (1). These pathways simultaneously affect the periodontal and pulpal tissues by forming endodontic and periodontal (endo-perio) lesions (2). Endo-perio lesions were classified by Simon et al. (3) as follows: “primary endodontic lesions, primary endodontic lesions with secondary periodontal involvement, primary periodontal lesions, primary periodontal lesions with secondary endodontic involvement, and true combined lesions.” Since these diseases can mimic others’ clinical features (4), diagnosing the endo-perio lesions as of pulpal or periodontal origin can be challenging, and it requires more profound knowledge and perspective in the field (2). The success of the treatment of endo-perio lesions depends on assessing endodontic and periodontal contribution correctly to utilize the best treatment option (4). The lesions that mainly originate from pulpal pathosis usually heal after properly cleaning, shaping, and obturation procedures of the root canal system (5, 6). Intracanal medicaments can be preferred to enhance antibacterial activity and thus prevent the transfer of microorganisms in the root canal system to the periodontium (5). Additionally, contemporary irrigation activation systems and antibacterial materials such as lasers (7), automated root canal irrigation systems (8), silver nanoparticles (9), and natural extracts (10) can be utilized as treatment approaches in order to improve disinfection. If a lesion of endodontic origin is untreated, it damages the hard and soft tissues in the periapical area, leading to the involvement of periodontal disease (11). A better outcome in such cases requires applying adequate periodontal therapy followed by endodontic treatment (12). Furthermore, combined lesions that pulpal and periodontal disease

may occur individually or simultaneously are needed to be treated with periodontal treatment followed by endodontic treatment (13).

Treating endo-perio lesions may pose a challenge, especially when the existence of an excessive loss of periodontal attachment and bone structure (14). In this sense, conventional endodontic and periodontal treatments may be insufficient, and resection or regenerative approaches may be required (15). Several contemporary treatment methods have been recently developed to advance microbial activity and regenerate periodontal tissues, such as guided tissue regeneration with barrier membranes, grafting materials, enamel matrix proteins, and autologous platelet concentrates (16, 17).

The bibliometric analysis aims to statistically evaluate publications within a field of interest by examining the quality of articles and journals, collaboration between authors or institutions, and new trends in the research context (18, 19). Citation analysis, the most frequently used metric, can partially provide the scientific value of publications, reflect the past, current, and future research trends, and guide the researchers to follow developments in particular fields (20, 21). As well as in other specialties in the dentistry field (22, 23), several bibliometric analyses have also been conducted to address specific topics in endodontics (24, 25).

Although many studies in the literature investigate the aetiology, diagnosis, classification, and treatment of endo-perio lesions, these lesions are still a dilemma for clinicians. Due to the rapid growth rate in the development of the materials and techniques used in treating endo-perio lesions, it has become important to evaluate the scientific impact of such studies on research and clinical applications.

To our knowledge, the most cited articles have not been identified to date in this field. Therefore, this study aims to examine the current knowledge, innovations, and productivity of endo-perio lesions based on the top 50 most-cited articles from 1990 to 2022.



Materials and Methods

This bibliometric analysis was performed to determine the articles about the management of endo-perio lesions with the highest citation counts from 01.01.1990 to 01.01.2022. Clarivate Analytics Web of Science (WoS) (<http://www.webofknowledge.com>) was accessed to search and determine the most cited articles about endo-perio lesions in all databases since WoS contains peer-reviewed, high-quality scientific journals published worldwide (26). Two researchers (SNU and ZUA) with experience in endodontics and/or bibliometrics designed the search strategy. An extensive search was utilized using frequently utilized keywords related to the topic. No restriction was applied during the search process. Firstly, the below-mentioned three search groups were created on 1 May 2022 and articles were obtained:

1. Q1: (((((((ALL=(endod*)) OR ALL=(dental pulp necrosis)) OR ALL=(pulp necrosis)) OR ALL=(endodontic inflammation)) OR ALL=(nonvital teeth)) OR ALL=(nonvital tooth)) OR ALL=(endodontic infection*)) OR ALL=(pulpal disease). 3479 articles were received.
2. Q2: (((((((ALL=(periodont*)) OR ALL=(adult periodontitis)) OR ALL=(chronic periodontitis)) OR ALL=(aggressive periodontitis)) OR ALL=(periodontal pocket)) OR ALL=(apical periodontitis)) OR ALL=(periodontal infection*)) OR ALL=(periodontal disease). 102922 articles were received.
3. Q3: (((((((ALL=(endo-perio lesion*)) OR ALL=(endodontic periodontal lesion*)) OR ALL=(combined lesion*)) OR ALL=(periapical lesion*)) OR ALL=(treatment*)) OR ALL=(therapy)) OR ALL=(surgery)) OR ALL=(management*). 12352168 articles were received.

These three main groups were combined as [(Q1 AND Q2) AND Q3], and 7894 articles were obtained in total. Afterwards, the articles were downloaded for bibliometric analysis and listed in descending order of their citation counts. If more than one article received the same number of

citations, the article with the higher citation density was listed higher (21). Two independent researchers (SNU and ZUA) examined and characterized the articles to determine whether the main focus was endo-perio lesions. Any disagreements were resolved by consulting with the third researcher (MG) until a consensus was reached.

The citation count, citation density, publication year, journal, country, institution, first author, co-authors, study design, evidence level (EL), and keywords were evaluated. Publication years were divided into three main periods to compare metrics: 1990-2000, 2001-2010, and 2011-2022. Study designs were categorized into the following five groups: review (narrative and systematic), *in vitro* (part of dental tissue, tooth section, and cell culture), *ex vivo* (complete teeth and animal study), clinical observational studies (case reports), and clinical experimental studies (clinical trial and randomized clinical trial, RCT).

The VOSviewer (version 1.6.18; Leiden University Center for Science and Technology Studies, Leiden, Netherlands, available at <https://www.vosviewer.com>) was accessed to process the bibliometric data. This software provides a science map for summarizing and visualizing the network between keywords. Used keywords less frequently than two were excluded to improve the map's clarity.

Statistical analysis

All statistical analyses were done using IBM SPSS (SPSS Inc., Chicago, IL, USA) version 26. The level of agreement between two independent researchers was measured with Cronbach's alpha coefficient. The Shapiro-Wilk test was used to determine the normality of the citation number and citation density. The Kruskal-Wallis test was performed to compare these metrics among time periods. The Mann-Whitney U test was performed for pair comparisons. The correlation between citation, citation density and age of publication was evaluated using the square of the Spearman linear coefficient. The significance level was set at $p < 0.05$.

Results

Number of citations, citation density, and publication year

A high level of internal consistency was determined by a Cronbach's alpha of 0.975. The top 50 most-cited studies ranked by their citation counts are shown in Table 1, including their citation density ranks. These 50 most-cited articles received 756 citations, with a mean citation per article of 15.12. The citation range was 3 to 62. The total citation density was 67.11, with a mean citation density per article of 1.34. A significant positive association was observed between the number of citations and the age of publication (correlation coefficient = 0.446, $p < 0.05$). In addition, there was a significant negative association between citation density and age of publication (correlation coefficient = -0.360, $p < 0.05$). Associations are shown in Figure 1.

Between the three periods, the total number of citations had the highest values in 2001-2010 compared to the other periods. There was a significant difference between 1990-2000 and 2001-2010 and 2001-2010 and 2011-2022 ($p < 0.05$). The citation density values only differed between 1990-2000 and 2011-2022 ($p < 0.05$). Metrics of the top 50 most-cited articles about endo-perio lesions in time periods are presented in Table 2. The highest number of articles was published in 2015 ($n=5$), followed by 2002 and 2016 ($n=4$ for each). In 2004, 2009, 2014, and 2017, 3 articles were published.

Journal, country, institution, and authors

The most-cited 50 articles were represented in 24 different journals in total. Among these journals, the *Journal of Endodontics* had the largest number of publications ($n=11$), followed by the *International Endodontic Journal* ($n=5$), *Periodontology 2000* ($n=4$), *Journal of Clinical and Diagnostic Research* ($n=3$) and *Case Reports in Dentistry* ($n=3$), *The Journal of the American Dental Association* ($n=2$), *Journal of Periodontology* ($n=2$), *International Journal of Dentistry* ($n=2$), *Journal of Clinical Periodontology* ($n=2$), and *Photodiagnosis and Photodynamic Therapy* ($n=2$). Ten of the total journals had only 1 article, as presented in Table 3.

According to the affiliation of the first author, 21 countries were achieved. The United States (US) was leading the most-cited list ($n=15$), followed by India ($n=8$). Out of the 42 determined institutions, the University of Southern California was the most productive institution ($n=3$). All countries and institutions that have contributed with at least two publications are shown in Figure 2.

One hundred and sixty authors contributed to the top 50 most-cited articles. Abbas Bahador, Chi-Chou Huang, Chuen-Chyi Tseng, Ilan Rotstein, James H S Simon, Juan Blanco-Carrión, Maryam Pourhajibagher, Pablo Castelo-Baz, Sanjay Tewari, Se-Lim Oh, and Yea-Huey Melody Chen were the most productive authors with two publications for each. However, Ilan Rotstein, Se-Lim Oh, and Maryam Pourhajibagher were the most frequent first authors.

Figure 1

Association between the number of citations and age of publication (A); association between the citation density and age of publication (B).

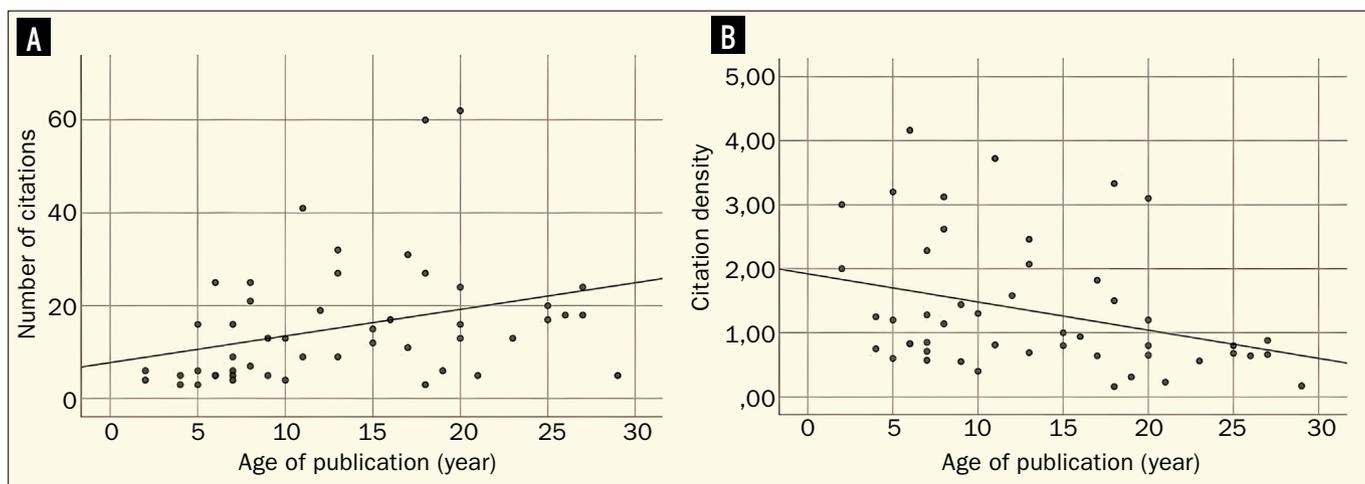


Table 1
The top 50 most-cited articles about endo-perio lesions with the number of citations and citation density from 1990 to 2022.

Citation Rank	Reference	Number of Citation	Citation Density (Rank)
1	Dahlén G. Microbiology and treatment of dental abscesses and periodontal-endodontic lesions. <i>Periodontol 2000</i> . 2002;28:206-239.	62	3.10 (6)
2	Rotstein I, Simon JH. Diagnosis, prognosis and decision-making in the treatment of combined periodontal-endodontic lesions. <i>Periodontol 2000</i> . 2004;34:165-203.	60	3.33 (3)
3	Goyal B, Tewari S, Duhan J, Sehgal PK. Comparative evaluation of platelet-rich plasma and guided tissue regeneration membrane in the healing of apicomarginal defects: a clinical study. <i>J Endod</i> . 2011;37:773-780.	41	3.72 (2)
4	Oh SL, Fouad AF, Park SH. Treatment strategy for guided tissue regeneration in combined endodontic-periodontal lesions: case report and review. <i>J Endod</i> . 2009;35:1331-1336.	32	2.46 (9)
5	Britain SK, Arx T, Schenk RK, Buser D, Nummikoski P, Cochran DL. The use of guided tissue regeneration principles in endodontic surgery for induced chronic periodontic-endodontic lesions: a clinical, radiographic, and histologic evaluation. <i>J Periodontol</i> . 2005;76:450-460.	31	1.82 (13)
6	Abbott PV, Salgado JC. Strategies for the endodontic management of concurrent endodontic and periodontal diseases. <i>Aust Dent J</i> . 2009;54 Suppl 1:S70-85.	27	2.07 (11)
7	Carrotte P. Endodontics: Part 9. Calcium hydroxide, root resorption, endo-perio lesions. <i>Br Dent J</i> . 2004;197:735-743.	27	1.50 (15)
8	Pourhajibagher M, Chiniforush N, Raoofian R, Ghorbanzadeh R, Shahabi S, Bahador A. Effects of sub-lethal doses of photo-activated disinfection against <i>Porphyromonas gingivalis</i> for pharmaceutical treatment of periodontal-endodontic lesions. <i>Photodiagnosis Photodyn Ther</i> . 2016;16:50-53.	25	4.16 (1)
9	Al-Fouzan KS. A new classification of endodontic-periodontal lesions. <i>Int J Dent</i> . 2014;2014:919173.	25	3.12 (5)
10	Harrington GW, Steiner DR, Ammons WF. The periodontal-endodontic controversy. <i>Periodontol 2000</i> . 2002;30:123-130.	24	1.20 (20)
11	Solomon C, Chalfin H, Kellert M, Weseley P. The endodontic-periodontal lesion: a rational approach to treatment. <i>J Am Dent Assoc</i> . 1995;126:473-479.	24	0.88 (25)
12	Schmidt JC, Walter C, Amato M, Weiger R. Treatment of periodontal-endodontic lesions- a systematic review. <i>J Clin Periodontol</i> . 2014;41:779-790.	21	2.62 (8)
13	Chen SY, Wang HL, Glickman GN. The influence of endodontic treatment upon periodontal wound healing. <i>J Clin Periodontol</i> . 1997;24:449-456.	20	0.80 (31)
14	Attam K, Tiwary R, Talwar S, Lamba AK. Palatogingival groove: endodontic-periodontal management-case report. <i>J Endod</i> . 2010;36:1717-1720.	19	1.58 (14)
15	Tseng CC, Chen YH, Huang CC, Bowers GM. Correction of a large periradicular lesion and mucosal defect using combined endodontic and periodontal therapy: a case report. <i>Int J Periodontics Restorative Dent</i> . 1995;15:377-383.	18	0.66 (38)
16	Tseng CC, Harn WM, Chen YH, Huang CC, Yuan K, Huang PH. A new approach to the treatment of true-combined endodontic-periodontic lesions by the guided tissue regeneration technique. <i>J Endod</i> . 1996;22:693-696.	18	0.64 (40)
17	Schwartz SA, Koch MA, Deas DE, Powell CA. Combined endodontic-periodontic treatment of a palatal groove: a case report. <i>J Endod</i> . 2006;32:573-578.	17	0.94 (24)
18	Paul BF, Hutter JW. The endodontic-periodontal continuum revisited: new insights into etiology, diagnosis and treatment. <i>J Am Dent Assoc</i> . 1997;128:1541-1548.	17	0.68 (37)
19	Rotstein I. Interaction between endodontics and periodontics. <i>Periodontol 2000</i> . 2017;74:11-39.	16	3.20 (4)

Table 1
The top 50 most-cited articles about endo-perio lesions with the number of citations and citation density from 1990 to 2022.

Citation Rank	Reference	Number of Citation	Citation Density (Rank)
20	Castelo-Baz P, Ramos-Barbosa I, Martín-Biedma B, Dablanca-Blanco AB, Varela-Patiño P, Blanco-Carrión J. Combined Endodontic-Periodontal Treatment of a Palatogingival Groove. <i>J Endod.</i> 2015;41:1918-1922.	16	2.28 (10)
21	Aryanpour S, Bercy P, Van Nieuwenhuysen JP. Endodontic and periodontal treatments of a geminated mandibular first premolar. <i>Int Endod J.</i> 2002;35:209-214.	16	0.80 (32)
22	Gonzales JR, Rodekirchen H. Endodontic and periodontal treatment of an external cervical resorption. <i>Oral Surg Oral Med Oral Pathol Oral Radiol Endod.</i> 2007;104:e70-77.	15	1 (23)
23	Simon JH, Glick DH, Frank AL. The relationship of endodontic-periodontic lesions. <i>J Endod.</i> 2013;39:e41-46.	13	1.44 (16)
24	Ahmed HMA. Different perspectives in understanding the pulp and periodontal intercommunications with a new proposed classification for endo-perio lesions. <i>Endod Pract.</i> 2012;6:87-104.	13	1.30 (17)
25	Hauelsen H, Heidemann D. Hemisection for treatment of an advanced endodontic-periodontal lesion: a case report. <i>Int Endod J.</i> 2002;35:557-572.	13	0.65 (39)
26	Wei PC, Geivelis M, Chan CP, Ju YR. Successful treatment of pulpal-periodontal combined lesion in a bicroot maxillary lateral incisor with concomitant palato-radicular groove. A case report. <i>J Periodontol.</i> 1999;70:1540-1546.	13	0.56 (44)
27	Ballal NV, Jothi V, Bhat KS, Bhat KM. Salvaging a tooth with a deep palatogingival groove: an endo-perio treatment—a case report. <i>Int Endod J.</i> 2007;40:808-817.	12	0.80 (33)
28	Vakalis SV, Whitworth JM, Ellwood RP, Preshaw PM. A pilot study of treatment of periodontal-endodontic lesions. <i>Int Dent J.</i> 2005;55:313-318.	11	0.64 (41)
29	Varughese V, Mahendra J, Thomas AR, Ambalavanan N. Resection and Regeneration - A Novel Approach in Treating a Perio-endo Lesion. <i>J Clin Diagn Res.</i> 2015;9:Zd08-10.	9	1.28 (18)
30	Gandhi A, Kathuria A, Gandhi T. Endodontic-periodontal management of two rooted maxillary lateral incisor associated with complex radicular lingual groove by using spiral computed tomography as a diagnostic aid: a case report. <i>Int Endod J.</i> 2011;44:574-582.	9	0.81 (30)
31	Karabucak B, Setzer FC. Conventional and surgical retreatment of complex periradicular lesions with periodontal involvement. <i>J Endod.</i> 2009;35:1310-1315.	9	0.69 (36)
32	Kambale S, Aspalli N, Munavalli A, Ajgaonkar N, Babannavar R. A sequential approach in treatment of endo-perio lesion a case report. <i>J Clin Diagn Res.</i> 2014;8:Zd22-24.	7	1.14 (22)
33	Ustaoglu G, Uzunaydin Z, Özelçi F. Comparison of GTR, T-PRF and open-flap debridement in the treatment of intrabony defects with endo-perio lesions: a randomized controlled trial. <i>Med Oral Patol Oral Cir Bucal.</i> 2020;25:e117-e123.	6	3 (7)
34	Pourhajibagher M, Bahador A. Evaluation of the crystal structure of a fimbrillin (FimA) from <i>Porphyromonas gingivalis</i> as a therapeutic target for photo-activated disinfection with toluidine blue O. <i>Photodiagnosis Photodyn Ther.</i> 2017;17:98-102.	6	1.20 (21)
35	Gupta S, Tewari S, Tewari S, Mittal S. Effect of Time Lapse between Endodontic and Periodontal Therapies on the Healing of Concurrent Endodontic-Periodontal Lesions without Communication: A Prospective Randomized Clinical Trial. <i>J Endod.</i> 2015;41:785-790.	6	0.85 (26)
36	Yu L, Xu B, Wu B. Treatment of combined endodontic-periodontic lesions by intentional replantation and application of hydroxyapatites. <i>Dent Traumatol.</i> 2003;19:60-63.	6	0.31 (47)
37	Alquthami H, Almalik AM, Alzahrani FF, Badawi L. Successful Management of Teeth with Different Types of Endodontic-Periodontal Lesions. <i>Case Rep Dent.</i> 2018;2018:7084245.	5	1.25 (19)



Table 1
The top 50 most-cited articles about endo-perio lesions with the number of citations and citation density from 1990 to 2022.

Citation Rank	Reference	Number of Citation	Citation Density (Rank)
38	Pico-Blanco A, Castelo-Baz P, Caneiro-Queija L, Liñares-González A, Martín-Lancharro P, Blanco-Carrión J. Saving Single-rooted Teeth with Combined Endodontic-periodontal Lesions. <i>J Endod.</i> 2016;42:1859-1864.	5	0.83 (27)
39	Nadig PP, Agrawal IS, Agrawal VS, Srinivasan SC. Palato-Radicular Groove: A Rare Entity in Maxillary Central Incisor Leading To Endo-Perio Lesion. <i>J Clin Diagn Res.</i> 2016;10:Zj14-15.	5	0.83 (28)
40	Fahmy MD, Luepke PG, Ibrahim MS, Guentsch A. Treatment of a Periodontic-Endodontic Lesion in a Patient with Aggressive Periodontitis. <i>Case Rep Dent.</i> 2016;2016:7080781.	5	0.83 (29)
41	Miao H, Chen M, Otgonbayar T, Zhang SS, Hou MH, Wu Z, et al. Papillary reconstruction and guided tissue regeneration for combined periodontal-endodontic lesions caused by palatogingival groove and additional root: a case report. <i>Clin Case Rep.</i> 2015;3:1042-1049.	5	0.71 (35)
42	Coraini C, Mascarello T, de Palma CM, Gobbato EA, Costa R, de Micheli L, et al. Endodontic and periodontal treatment of dens invaginatus: Report of 2 clinical cases. <i>G Ital Endod.</i> 2013;27:86-94.	5	0.55 (45)
43	Niemiec BA. Treatment of mandibular first molar teeth with endodontic-periodontal lesions in a dog. <i>J Vet Dent.</i> 2001;18:21-25.	5	0.23 (48)
44	Zubery Y, Kozlovsky A. Two approaches to the treatment of true combined periodontal-endodontal lesions. <i>J Endod.</i> 1993;19:414-416.	5	0.17 (49)
45	Katwal D, Fiorica JK, Bleuel J, Clark SJ. Successful Multidisciplinary Management of an Endodontic-Periodontal Lesion Associated With a Palato-Radicular Groove: A Case Report. <i>Clin Adv Periodontics.</i> 2020;10:88-93.	4	2 (12)
46	Olczak K, Pawlicka H. Mineral trioxide aggregate in treatment of permanent teeth with open apex and endo-perio lesions. A case report. <i>Eur J Paediatr Dent.</i> 2015;16:287-289.	4	0.57 (43)
47	Oh SL. Mesio Buccal root resection in endodontic-periodontal combined lesions. <i>Int Endod J.</i> 2012;45:660-669.	4	0.40 (46)
48	Dhoum S, Laslami K, Rouggani F, El Ouazzani A, Jabri M. Endo-Perio Lesion and Uncontrolled Diabetes. <i>Case Rep Dent.</i> 2018;2018:7478236.	3	0.75 (34)
49	Betancourt P, Elgueta R, Fuentes R. Treatment of endo-periodontal lesion using leukocyte-platelet-rich fibrin. A case report. <i>Colomb Med (Cali).</i> 2017;48:204-207.	3	0.60 (42)
50	Aqrabawi J, Jarbawi MM. The healing potential of periodontal-endodontic lesions. <i>Int Dent J.</i> 2004;54:166-170.	3	0.16 (50)

Study design, evidence level, and keywords
 Clinical observational studies (case reports=29) were found to be the most frequent study design, followed by review (narrative review=12 and systematic review=1), *in vitro* (n=2), *ex vivo* (n=2), and clinical experimental studies (clinical trial=2 and RCT=2).

ELs were categorized into five groups (27): EL I: systematic reviews and meta-analysis, EL II: RCTs, EL III: cohort studies and

clinical trials, EL IV: case-control series, EL V: case series and case reports. Since reviews (except systematic review of RCTs), *in vitro*, and *ex vivo* studies belong to the bottom of the EL pyramid, the frequency of each level was as follows: EL I (n=1), II (n=2), III (n=2), and V (n= 45).

Among the top 50 most-cited articles, the VOSviewer software recovered 109 keywords. After reducing the number of co-occurrences to two, 16 keywords (nodes)

Table 2

The number of citations and citation density values of the top 50 most-cited articles about endo-perio lesions in time periods.

	1990-2000 n=7	2001-2010 n=18	2011-2022 n=25	Comparison p value*
Number of citations	16.42 ¹	21.61 ¹	10.44 ²	<.05
Min-Max	5-24	3-62	3-41	
Total	115	389	261	
Citation density	0.62 ^x	1.29 ^{x,y}	1.57 ^y	<.05
Min-Max	0.17-0.88	0.16-3.33	0.4-4.16	
Total	4.39	23.28	39.44	

*Median. Min-Max: Minimum and Maximum values.

*The Shapiro-Wilk test showed no normality. The Mann-Whitney U test analyzed pair comparisons. Read horizontally; the different superscript numbers and letters indicate a significant difference.

were grouped into five clusters and a maximum of 1000 lines were loaded. The network of keywords is shown in Figure 3. “Endo-perio lesions” (n=10), followed by “guided tissue regeneration” (n=7), “palatogingival groove” (n=4), and “root canal treatment” (n=4) were found to be the most frequent keywords.

Discussion

Diagnosis and treatment of endo-perio lesions present challenges because of the anatomical and functional similarities (28, 29). Integrating multidisciplinary treat-

ment approaches with newly developed materials and appropriate techniques leads to better outcomes (30, 31). Various well-designed studies have been performed in this scope to provide accurate aspects and treatment options for endo-perio lesions (17, 32, 33). Based on the present knowledge, the goal of this bibliometric study is to exhibit the process of endo-perio lesions through changing developments and trends with the aid of the top 50 most-cited articles.

The year of publication significantly impacts the citation count that an article receives. Since the number of citations is

Figure 2
All contributed countries and institutions with at least 2 publications.

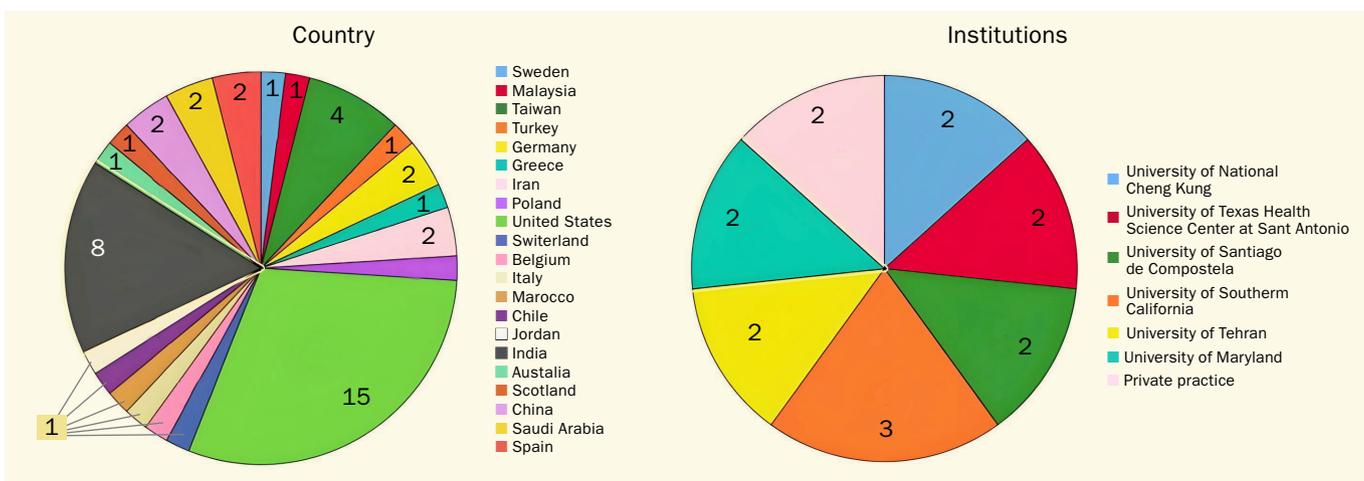




Table 3
Journals with the top 50 most-cited articles

Name of the journal	Number of articles
Journal of Endodontics	11
International Endodontic Journal	5
Periodontology 2000	4
Journal of Clinical and Diagnostic Research	3
Case Reports in Dentistry	3
The Journal of the American Dental Association	2
Journal of Periodontology	2
International Journal of Dentistry	2
Journal of Clinical Periodontology	2
Photodiagnosis and Photodynamic Therapy	2
Australian Dental Journal	1
British Dental Journal	1
Endodontic Practice Today	1
Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology	1
Medicina Oral Patología Oral y Cirugía Bucal	1
Journal of Veterinary Dentistry	1
European Journal of Paediatric Dentistry	1
Dental Traumatology	1
The International Journal of Periodontics & Restorative Dentistry	1
Giornale Italiano di Endodonzia	1
Clinical Case Reports	1
Clinical Advances in Periodontics	1
Colombia Médica	1
International Dental Journal	1

a time-dependent metric (34), older publications are expected to gain more citations than recently published articles (35). There was a significant positive correlation between the number of citations and the age of publication in accordance with the nature of citation analysis. However, interest-

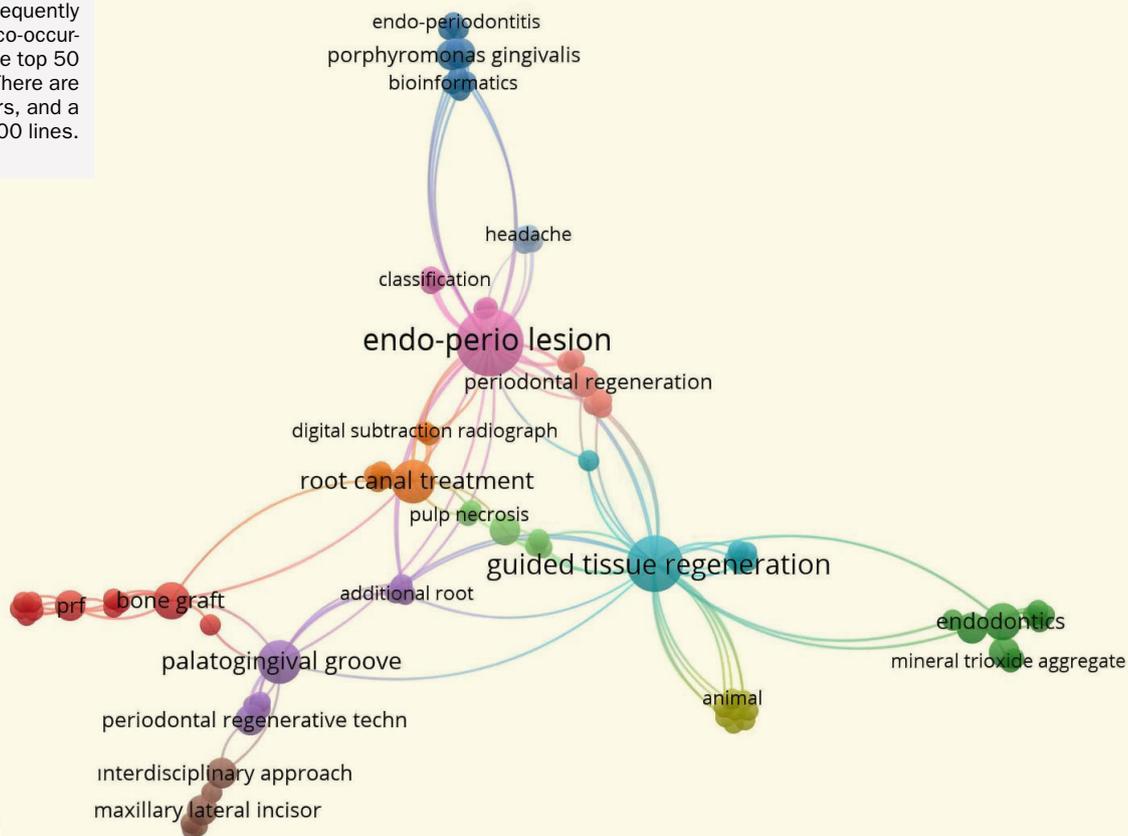
ingly, this metric had the highest counts in the period 2001-2010. It can be explained by the fact that innovations in treatment protocols and materials have led clinicians to follow new trends and publish their knowledge and experiences with high quality and effect, especially in this period (36). However, time is still needed to see if these publications will receive more citations as time goes on. In this aspect, citation density which is the time-normalized metric could be a valid alternative to detect the importance of the new articles to the readership.

In this study, the three most-cited articles aimed to give an aspect about the definition, clinical characterization, treatment of endo-perio lesions, treatment of combined perio-endo lesions, and the evaluation of the efficacy and equivalence of platelet-rich plasma with guided tissue regeneration membrane during the treatment of apicomarginal defects. Among the 50 most-cited articles, it was observed that the developments in techniques and materials were mainly actualized in the field of periodontology. Although novel therapeutic approaches such as photo-activated disinfection (37), using silver nanoparticles (9) and diode lasers (7) were suggested in order to increase the efficiency of endodontic disinfection, there is a lack of information about utilizing these methods for clinical applications. Thus, further studies are needed to determine the impact of different endodontic treatment protocols on the healing process of endo-perio lesions.

The highest number of publications were published mainly in two well-recognized and influential journals in endodontics (38). Prolific journals constitute a significant percentage of all articles in a particular specialty and are then widely cited by subsequent articles (39). However, multidisciplinary journals that publish studies from all fields of dentistry made up the vast majority. The combined nature of endo-perio lesions can explain why this topic cannot be evaluated in a single area. Moreover, the publication of a study related to the subject in the veterinary journal is another striking result. Easier manage-

Figure 2

The network of frequently used two or more co-occurring keywords of the top 50 most-cited articles. There are 16 nodes, 5 clusters, and a maximum of 1,000 lines.



ment of treatment methods and follow-up in animals may have led to animal studies being conducted and published in related journals.

In line with many other studies, the US was the most productive country with 15 most-cited articles (26, 36, 39). A significant amount of funding towards research and the large size of the scientific society is making the US a leading country in terms of innovation in science and technology (40). India contributed to this study with the eight most-cited articles. This result is also understandable since National Science Foundation ranked India as the third-biggest knowledge. During the last two decades, India has been growing daily regarding performing scientific work and obtaining research output (41).

Among the institutes from which most of the first authors were affiliated, 11 of them pertained to the US. The University of

Southern California was the most prolific institution in total. Publications from the University of Southern California have appraised the interrelationship between endo-perio lesions and provided biological and clinical evidence for diagnosis, prognosis, and treatment of these conditions. Interestingly, the highest number of published articles per author was two. Therefore, among these eleven authors, no one contributed more considerably than the others to this bibliometric study. This result can be interpreted as that only a particular group of authors does not tend to work on the management of endo-perio lesions, and various authors have orientations on variable subjects within this field. More than half of the 50 most-cited studies were case reports, followed by reviews, and this is compatible with lower citation counts in total and for each selected article. Although case reports



guide other clinicians by describing treatment approaches in a specific situation, there is a tendency for fewer citations to case reports (42). A possible reason can be that case reports about endo-perio lesions often report rarely-seen complicated cases on a small number of patient groups. However, selected treatment modalities for endo-perio lesions are needed to investigate with RCTs to make a general assessment. Interestingly, there are few clinical trials in the literature about endo-perio lesions (15, 28). It may be considered that the poor coordination between departments and the difficulties in diagnosing and classifying patients within the scope of endo-perio lesions cause an insufficient number of RCTs. On the other hand, reviews tend to be cited more often since these publications give comprehensive information about relevant fields (43). This study, as the first and second most-cited articles are narrative reviews, is consistent with the above-mentioned information.

This bibliometric study has some limitations that should be addressed. Firstly, citation analysis was used in this bibliometric study, and this metric is time-dependent. Therefore, fairly recent articles with good content and quality might have been missed. In addition, the citation count does not distinguish between positive and negative citations. Therefore, an article published on a critical trend may lead to being received more citations (42). Secondly, although the WoS is considered the most beneficial database to find and analyze high-quality publications, particularly in health sciences, it is difficult to be sure whether this database conclusively records all articles published in all journals compared to, i.e., Scopus. Finally, the institutional address of the first authors was selected to list as the primary contributing institution; consequently, only those institutions and countries could be established.

Conclusion

It can be concluded that successfully treating endo-perio lesions depends on accurate diagnosis and proper treatment

strategy involving both endodontics and periodontics. Developments in materials and techniques could improve the outcomes. Future RCTs are needed to observe these methodologies' actual impact on the clinic definitively.

Clinical Relevance

The improved materials and techniques in the management of endo-perio lesions have led to better treatment outcomes. Identifying the contemporary research areas could be beneficial to address new investigations in the near future.

Conflict of Interest

None.

Acknowledgments

None.

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