Review Article

The top 100 most cited articles on composite resin in dentistry: A bibliometric analysis

ABSTRACT

Aim: This study aimed to carry out a bibliometric review of the 100 most cited articles on composite resin in dentistry. The review was carried out in the Clarivate Analytics Web of Science database.
Study design: Review article.
Methodology: The search took place in September 2023, using specific terms. The results were organized in an Excel table, with paired selection. The sample included publications that mentioned composite resin in the title and/or abstract. The most cited articles were analyzed manually, including information such as authors, number of citations and contributing institutions. This study did not require ethical approval.
Results: The initial search identified 20,129 articles. The results revealed a great diversity of studies, with a significant predominance of laboratory research. The prominent presence of author Ferracane and institutions such as Oregon Health & Science University and the University of Munich were highlighted as leaders in scientific production on composite resins. Additionally, a pattern of publications with production peaks in certain years was identified. These findings provide a comprehensive overview of research in this area and highlight the importance of these studies for the advancement of dentistry.
Conclusion: The top 100 articles are fundamental to understanding the development of composite resins, although many recent articles may not have been included in the study because they are not among the most cited articles. This review can inspire new research, guiding the directions of future investigations. These results can guide researchers in identifying crucial information, including relevant articles, important journals, and essential.

keywords: composite resin, dentistry, bibliometric analysis, citations.

1. INTRODUCTION

Composite resins have revolutionized dentistry, allowing for minimally invasive interventions and preserving healthy tooth structure. These compounds play a central role in restoring and enhancing the aesthetic appearance of teeth, significantly transforming the approach of oral health professionals to dental procedures [1]. The essence of composite resins lies in their multiphase composition, comprising a polymer matrix, reinforcing fillers, a silane bonding agent to bind the filler to the matrix, and other chemical components that promote or modulate the polymerization reaction [2]. This complex combination grants composite resins remarkable properties, such as the ability to adhere to dental tissues, conform to replicate the natural anatomy of teeth, and offer a variety of shades to achieve desired aesthetics. Thus, these materials have evolved from being mere limited options for dental restorations to highly versatile, aesthetic, and long-lasting solutions [2,3].

Composite resin has varied applications in dentistry, with its use becoming more and more frequent due to its versatility [2,3]. This expansion can be attributed to the enhancement of various properties of dental composites, such as the development of nano-sized particles, resulting in smoother surfaces and increased strength, contributing to aesthetically appealing and durable dental restorations [4]. With the continuous advancement of technology and research, it is likely that composite resins will continue to evolve, offering even better options for patients and dentists in the future [2].

To keep pace with this evolution and the vast volume of scientific information generated in the healthcare field, there is a need for syntheses that facilitate access to this information, enabling conclusions based on the combination of results from multiple sources [5]. One mechanism that fulfills this role is bibliometric review, which analyzes the most frequently cited articles on a particular topic, as citation count is considered an indicator to assess the impact of an article. Thus, this approach allows for the identification of which articles in the field of composite resins have had the most significant impact and are considered references in the formulation of new works, lending them greater credibility [6].

Additionally, bibliometric analysis provides an overview of the current state of composite resins, encompassing countries, authors, institutions, and journals. This assists professionals and researchers in making clinically relevant decisions and partnerships. Furthermore, highly cited articles may indicate trends in clinical practice and are therefore recognized as sources of greater research and clinical interest in the respective areas [7,8].

With this in mind, this study aimed to expose the 100 most cited articles in the field of composite resins. Through this analysis, we sought to identify which publications received greater recognition in the area, in addition to mapping trends and advances, highlighting the most active areas of research. Furthermore, this work aims to recognize leading authors and institutions in the field of research on composite resins.

2. METHODOLOGY

A bibliometric review on the topic of composite resin was using the Web of Science database from Clarivate Analytics. As this study is a review, it is exempt from approval by the research ethics committee. The search was performed on September, 2023. A search was conducted using the terms (Composite Resin OR Resin, Composite OR Resins, Composite) AND (Dentistry) in the title and/or abstract. The results were extracted into a table in Microsoft Excel software and organized in descending order of citation count. Manuscripts were pair-selected by two researchers, AST and OBLM, independently and previously calibrated.

The study sample included publications that mentioned composite resin in the title and/or abstract, while publications that did not relate to the studied theme or used composite resins as a secondary subject were excluded. There were no restrictions on study design, year of publication, language, or journal impact factor of the manuscripts.

The most cited articles were manually stratified based on information retrieved from the Clarivate Analytics Web of Science database, such as publication year, authors, citation count, journals, keywords, contributing institution, country, among others. The address provided to the first author was used to determine the country of origin and the contributing institution of the article.

The relationship between authors was determined based on the number of times they cited each other, using network visualization conducted with VOSviewer software (University of Leiden, Netherlands).

3. RESULTS

The initial search identified 20,129 articles in the Web of Science database. After comparing titles and abstracts, the 100 most cited manuscripts involving Composite Resins in dentistry are listed in order of ranking based on the number of citations in Table 1. The study selection process, including the search strategy used in the database, is summarized in a flowchart as depicted in Fig 1.

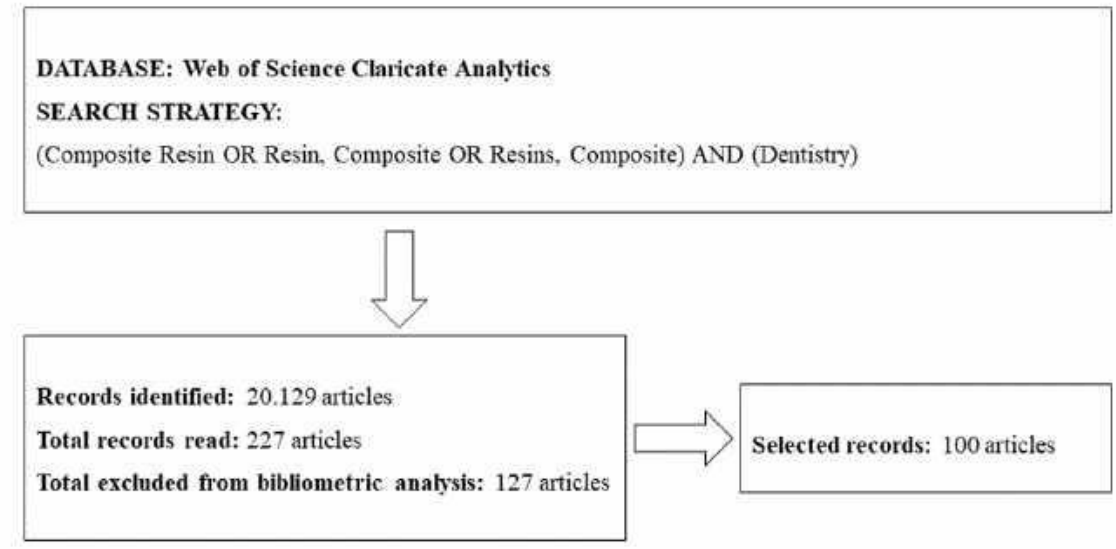

Fig. 1. Flowchart of the study selection process and search strategy for the top 100 in composite resin

Table 1. Top 100 most cited articles on composite resin

Rank	Author	Title	Publication year	Journal	Institution	Citations	Average citations/Year	Types of Studies
1	Ferracane, JL	Resin composite-State of the art	2011	DM	Oregon Health & Science University	1143	87,92	Literature review
2	Bollen, CML *et al.*	Comparison of surface roughness of oral hard materials to the threshold surface roughness for bacterial plaque retention: A review of the literature	1997	DM	Universite Catholique Louvain	960	35,56	Literature review
3	Ferracane, JL	Hygroscopic and hydrolytic effects in dental polymer networks	2006	DM	Oregon Health & Science University	850	47,22	Literature review
4	Peutzfeldt, A	Resin composites in dentistry: The monomer systems	1997	EJOS	University of Copenhagen	638	23,63	Literature review
5	Demarco, FF *et al.*	Longevity of posterior composite restorations: Not only a matter of materials	2012	DM	Federal University of Pelotas	603	50,25	Systematic review
6	Wiegand, A *et al.*	Review on fluoride-releasing restorative materials - Fluoride release and uptake characteristics, antibacterial activity and influence on caries formation	2007	DM	University of Gottingen	550	32,35	Literature review
7	Manhart, J *et al.*	Review of the clinical survival of direct and indirect restorations in posterior teeth of the permanent dentition	2004	OP	University of Munich	548	27,40	Literature review

8	Mitra, SB *et al.*	An application of nanotechnology in advanced dental materials	2003	JADA	3M	544	25,90	Laboratory Studies
9	Davidson, CL; Feilzer, AJ	Polymerization shrinkage and polymerization shrinkage stress in polymer-based restoratives	1997	JD	Vrije Universiteit Amsterdam	508	18,81	Literature review
10	Ruyter, IE *et al.*	Color stability of dental composite resin materials for crown and bridge veneers	1987	DM	NIOM, Scandinavian Institute of Dental Materials	507	13,70	Laboratory Studies
11	Braga, RR *et al.*	Factors involved in the development of polymerization shrinkage stress in resin-composites: A systematic review	2005	DM	University of Sao Paulo	442	23,26	Systematic review
12	Opdam, NJM *et al*.	Longevity of Posterior Composite Restorations: A Systematic Review and Meta-analysis	2014	JDR	Radboud University Nijmegen	428	42,80	Systematic review e Meta-analysis
13	Cramer, NB *et al.*	Recent Advances and Developments in Composite Dental Restorative Materials	2011	JDR	University of Colorado	426	32,77	Literature review
14	Bayne, SC et al.	A characterization of first-generation flowable composites	1998	JADA	University of North Carolina	416	16,00	Laboratory Studies
15	Labella, R *et al.*	Polymerization shrinkage and elasticity of flowable composites and filled adhesives	1999	DM	Universite Catholique Louvain	412	16,48	Laboratory Studies

16	Stansbury, JW; Dickens, SH	Determination of double bond conversion in dental resins by near infrared spectroscopy	2001	DM	National Institute of Standards & Technology (NIST)	401	17,43	Laboratory Studies
17	Geurtsen, W *et al.*	Cytotoxicity of 35 dental resin composite monomers/additives in permanent 3T3 and three human primary fibroblast cultures	1998	JBMR	Leibniz University Hannover	398	15,31	Laboratory Studies
18	Drummond, JL	Degradation, fatigue, and failure of resin dental composite materials	2008	JDR	University of Illinois Chicago	374	23,38	Literature review
19	Rueggeberg, FA *et al.*	Effect of light-intensity and exposure duration on cure of resin composite	1994	OD	Medical College of Georgia	372	12,40	Laboratory Studies
20	Bernardo, M *et al.*	Survival and reasons for failure of amalgam versus composite posterior restorations placed in a randomized clinical trial	2007	JADA	University of Lisbon	364	21,41	Clinical trials
21	Kleverlaan, CJ; Feilzer, AJ	Polymerization shrinkage and contraction stress of dental resin composites	2005	DM	Universiteit van Amsterdam and Vrije Universiteit	363	19,11	Laboratory Studies
22	Beyth, N *et al.*	Antibacterial activity of dental composites containing quaternary ammonium polyethylenimine nanoparticles against Streptococcus mutans	2006	BM	The Hebrew University of Jerusalem	358	19,89	Laboratory Studies

23	Opdam, NJM *et al.*	12-year Survival of Composite vs. Amalgam Restorations	2010	JDR	Radboud University Nijmegen	349	24,93	Clinical trials
24	Imazato, S	Antibacterial properties of resin composites and dentin bonding systems	2003	DM	Osaka University	333	15,86	Literature review
25	Asmussen, E; Peutzfeldt, A	Influence of UEDMA, BisGMA and TEGDMA on selected mechanical properties of experimental resin composites	1998	DM	University of Copenhagen	333	12,81	Laboratory Studies
26	Leprince, JG *et al*.	Progress in dimethacrylate-based dental composite technology and curing efficiency	2013	DM	Universite Catholique Louvain	328	29,82	Literature review
27	Hanks, CT *et al.*	Cytotoxic effects of resin components on cultured mammalian fibroblasts	1991	JDR	University of Michigan	328	9,94	Laboratory Studies
28	Silikas, N *et al.*	Light intensity effects on resin-composite degree of conversion and shrinkage strain	2000	DM	University of Manchester	322	13,42	Laboratory Studies
29	Busscher, HJ *et al.*	Biofilm Formation on Dental Restorative and Implant Materials	2010	JDR	University of Groningen	315	22,50	Literature review
30	Kim, KH *et al.*	The effect of filler loading and morphology on the mechanical properties of contemporary composites	2002	JPD	Kyungpook National University	315	14,32	Laboratory Studies
31	Spencer, P *et al.*	Adhesive/Dentin Interface: The Weak Link in the Composite Restoration	2010	ABE	University of Kansas	314	22,43	Literature review

32	Santerre, JP *et al.*	Relation of dental composite formulations to their degradation and the release of hydrolyzed polymeric-resin-derived products	2001	CROBM	University of Toronto	306	13,30	Literature review
33	Awada, A; Nathanson, D	Mechanical properties of resin-ceramic CAD/CAM restorative materials	2015	JPD	Louisiana State University System	302	33,56	Laboratory Studies
34	Van Landuyt, KL *et al.*	How much do resin-based dental materials release? A meta-analytical approach	2011	DM	Universite Catholique Louvain	298	22,92	Systematic review and Meta-analysis
35	Ruse, ND; Sadoun, MJ	Resin-composite Blocks for Dental CAD/CAM Applications	2014	JDR	University of British Columbia	290	29,00	Literature review
36	Geurtsen, W	Biocompatibility of resin-modified filling materials	2000	CROBM	Hannover Medical School	290	12,08	Literature review
37	Ferracane, JL	Developing a more complete understanding of stresses produced in dental composites during polymerization	2005	DM	Oregon Health & Science University	286	15,05	Literature review
38	Spahl, W *et al.*	Determination of leachable components from four commercial dental composites by gas and liquid chromatography mass spectrometry	1998	JD	University of Munich	286	11,00	Laboratory Studies
39	Carvalho, RM *et al.*	A review of polymerization contraction: The influence of stress	1996	OD	University of Georgia	286	10,21	Literature review

		development versus stress relief						
40	Goldberg, M	In vitro and in vivo studies on the toxicity of dental resin components: a review	2008	COI	University Paris 5	279	17,44	Literature review
41	Versluis, A *et al.*	Does an incremental filling technique reduce polymerization shrinkage stresses?	1996	JDR	University of Minnesota	279	9,96	Numerical analysis
42	Mair, LH *et al.*	Wear: Mechanisms, manifestations and measurement. Report of a workshop	1996	JD	University of Liverpool	274	9,79	Report
43	Bagheri, R; Burrow, MF; Tyas, M	Influence of food-simulating solutions and surface finish on susceptibility to staining of aesthetic restorative materials	2005	JD	University of Melbourne	270	14,21	Laboratory Studies
44	Dickens, SH *et al.*	Photopolymerization kinetics of methacrylate dental resins	2003	MM	National Institute of Standards & Technology (NIST) - USA	262	12,48	Laboratory Studies
45	Dietschi, D *et al.*	Biomechanical considerations for the restoration of endodontically treated teeth: A systematic review of the literature, Part II (Evaluation of fatigue behavior, interfaces, and in vivo studies)	2008	QI	University of Geneva	261	16,31	Systematic review
46	Beun, S *et al.*	Characterization of nanofilled compared to	2007	DM	Universite Catholique Louvain	261	15,35	Laboratory Studies

		universal and microfilled composites						
47	Geurtsen, W	Substances released from dental resin composites and glass ionomer cements	1998	EJOS	Medical University Hannover	261	10,04	Literature review
48	Imazato, S *et al.*	Incorporation of bacterial inhibitor into resin composite	1994	JDR	Osaka University Faculty of Dentistry	261	8,70	Laboratory Studies
49	Lovell, LG *et al.*	The effect of cure rate on the mechanical properties of dental resins	2001	DM	University of Colorado	259	11,26	Laboratory Studies
50	Willems, G *et al.*	A classification of dental composites according to their morphological and mechanical characteristics	1992	DM	Universite Catholique Louvain	251	7,84	Laboratory Studies
51	Ilie, N *et al.*	Bulk-fill Resin-based Composites: An In Vitro Assessment of Their Mechanical Performance	2013	OD	University of Munich	250	22,73	Laboratory Studies
52	Cheng, L *et al.*	Antibacterial amorphous calcium phosphate nanocomposites with a quaternary ammonium dimethacrylate and silver nanoparticles	2012	DM	University of Maryland Dental School	249	20,75	Laboratory Studies
53	Ferracane, JL	Resin-based composite performance: Are there some things we can't predict?	2013	DM	Oregon Health & Science University	245	22,27	Literature review
54	Mehl, A *et al.*	Physical properties and gap formation of light-	1997	JD	University of Munich	245	9,07	Laboratory Studies

		cured composites with and without 'softstart-polymerization'						
55	Hickel, R *et al.*	Recommendations for conducting controlled clinical studies of dental restorative materials	2007	COI	University of Munich	243	14,29	Literature review
56	Heintze, SD; Rousson, V	Clinical Effectiveness of Direct Class II Restorations - A Meta-Analysis	2012	JAD	Ivoclar Vivadent	242	20,17	Systematic review and Meta-analysis
57	Chen, MH	Update on Dental Nanocomposites	2010	JDR	National Taiwan University	242	17,29	Literature review
58	Ilie, N; Hickel, R	Investigations on mechanical behaviour of dental composites	2009	COI	University of Munich	238	15,87	Laboratory Studies
59	Rueggeberg, FA et al.	Calibration of ftir conversion analysis of contemporary dental resin composites	1990	DM	University of Georgia	237	6,97	Laboratory Studies
60	Uno, S; Asmussen, E	Marginal adaptation of a restorative resin polymerized at reduced rate	1991	SJDR	Hokkaido University	235	7,12	Laboratory Studies
61	Ertas, E *et al*.	Color stability of resin composites after immersion in different drinks	2006	DMJ	Ondokuz Mayis University	232	12,89	Laboratory Studies
62	Ortengren, U *et al.*	Water sorption and solubility of dental composites and identification of monomers released in an aqueous environment	2001	JOR	University of Gothenburg	229	9,96	Laboratory Studies
63	Manhart, J *et al.*	Mechanical properties and wear behavior of	2000	DM	University of Munich	229	9,54	Laboratory Studies

		light-cured packable composite resins						
64	Ausiello, P *et al.*	Effect of adhesive layer properties on stress distribution in composite restorations - a 3D finite element analysis	2002	DM	University of Naples Federico II	228	10,36	Numerical analysis
65	Gladys, S *et al.*	Comparative physico-mechanical characterization of new hybrid restorative materials with conventional glass-ionomer and resin composite restorative materials	1997	JDR	Universite Catholique Louvain	222	8,22	Laboratory Studies
66	Watts, DC; Cash, AJ	Determination of polymerization shrinkage kinetics in visible-light-cured materials - methods development	1991	DM	University of Manchester	222	6,73	Laboratory Studies
67	Leprince, JG *et al.*	Physico-mechanical characteristics of commercially available bulk-fill composites	2014	JD	Universite Catholique Louvain	219	21,90	Laboratory Studies
68	Sanares, AME *et al.*	Adverse surface interactions between one-bottle light-cured adhesives and chemical-cured composites	2001	DM	University of Hong Kong	218	9,48	Laboratory Studies
69	Bucuta, S; Ilie, N	Light transmittance and micro-mechanical properties of bulk fill vs. conventional resin based composites	2014	COI	University of Munich	216	21,60	Laboratory Studies

70	Choi, KK *et al.*	The effects of adhesive thickness on polymerization contraction stress of composite	2000	JDR	Kyung Hee University	215	8,96	Laboratory Studies
71	Turssi, CP *et al.*	Filler features and their effects on wear and degree of conversion of particulate dental resin composites	2005	BM	Oregon Health & Science University	214	11,26	Laboratory Studies
72	Xu, HHK *et al.*	Nanocomposite containing amorphous calcium phosphate nanoparticles for caries inhibition	2011	DM	University of Maryland	213	16,38	Laboratory Studies
73	Dietschi, D *et al.*	Comparison of the color stability of 10 new-generation composites - an in-vitro study	1994	DM	University of Geneva	213	7,10	Laboratory Studies
74	Krifka, S *et al.*	A review of adaptive mechanisms in cell responses towards oxidative stress caused by dental resin monomers	2013	BM	University of Regensburg	211	19,18	Literature review
75	Rodolpho, PAD *et al.*	22-Year clinical evaluation of the performance of two posterior composites with different filler characteristics	2011	DM	Private Dental Practitioner	211	16,23	Clinical trials
76	Halvorson, RH *et al.*	Energy dependent polymerization of resin-based composite	2002	DM	3M	211	9,59	Laboratory Studies
77	Lawson, NC *et al.*	Wear, strength, modulus and hardness	2016	DM	University of Alabama	209	26,13	Laboratory Studies

		of CAD/CAM restorative materials						
78	Kempscholte, CM; Davidson, CL	Marginal integrity related to bond strength and strain capacity of composite resin restorative systems	1990	JPD	University of Amsterdam	208	6,12	Laboratory Studies
79	Nedeljkovic, I *et al.*	Is secondary caries with composites a material-based problem?	2015	DM	University of Leuven	207	23,00	Systematic review
80	Floyd, CJE; Dickens, SH	Network structure of bis-GMA- and UDMA-based resin systems	2006	DM	National Institute of Standards & Technology (NIST) - USA	207	11,50	Laboratory Studies
81	Van Nieuwenhuysen, JP *et al.*	Long-term evaluation of extensive restorations in permanent teeth	2003	JD	Universite Catholique Louvain	206	9,81	Clinical trials
82	Sakaguchi, RL; Berge, HX	Reduced light energy density decreases post-gel contraction while maintaining degree of conversion in composites	1998	JD	Oregon Health & Science University	205	7,88	Laboratory Studies
83	Park, J *et al.*	How should composite be layered to reduce shrinkage stress: Incremental or bulk filling?	2008	DM	Seoul National University (S	203	12,69	Laboratory Studies
84	Shortall, AC *et al.*	Refractive index mismatch and monomer reactivity influence composite curing depth	2008	JDR	University of Birmingham	203	12,69	Laboratory Studies
85	Lassila, LVJ *et al.*	The influence of short-term water storage on the flexural properties	2002	BM	University of Turku	203	9,23	Laboratory Studies

		of unidirectional glass fiber-reinforced composites						
86	Lauvanutanon, S *et al.*	Mechanical properties of composite resin blocks for CAD/CAM	2014	DMJ	Tokyo Medical & Dental University	202	20,20	Laboratory Studies
87	Beyth, N et al.	An in vitro quantitative antibacterial analysis of amalgam and composite resins	2007	JD	Hebrew University of Jerusalem	202	11,88	Laboratory Studies
88	Ilie, N; Hickel, R	Investigations on a methacrylate-based flowable composite based on the SDR (TM) technology	2011	DM	University of Munich	201	15,46	Laboratory Studies
89	Guler, AU *et al.*	Effects of different drinks on stainability of resin composite provisional restorative materials	2005	JPD	Ondokuz Mayis University	201	10,58	Laboratory Studies
90	Hansel, C *et al.*	Effects of various resin composite (co)monomers and extracts on two caries-associated micro-organisms in vitro	1998	JDR	Medical University Hannover	201	7,73	Laboratory Studies
91	Lu, H *et al.*	Investigations of step-growth thiol-ene polymerizations for novel dental restoratives	2005	DM	University of Colorado	200	10,53	Laboratory Studies
92	Yoshikawa, T *et al.*	Effects of dentin depth and cavity configuration on bond strength	1999	JDR	Tokyo Medical and Dental University	200	8,00	Laboratory Studies
93	Villalta, P *et al.*	Effects of staining and bleaching on color change of dental composite resins	2006	JPD	Nova Southeastern University	195	10,83	Laboratory Studies

94	Vichi, A *et al.*	Color and opacity variations in three different resin-based composite products after water aging	2004	DM	University of Siena	194	9,70	Laboratory Studies
95	Watts, DC et al.	Photo-polymerization shrinkage-stress kinetics in resin-composites: methods development	2003	DM	University of Manchester	194	9,24	Laboratory Studies
96	Unterbrink, GL; Mussner, R	Influence of light-intensity on 2 restorative systems	1995	JD	Ivoclar Vivadent	192	6,62	Laboratory Studies
97	Soncini, JA et al.	The. longevity of amalgam versus compomer/composite restorations in posterior primary and permanent teeth - Findings from the new England children's amalgam trial	2007	JADA	Boston University	190	11,18	Clinical trials
98	Urcan, E *et al.*	Real-time xCELLigence impedance analysis of the cytotoxicity of dental composite components on human gingival fibroblasts	2010	DM	University of Munich	188	13,43	Laboratory Studies
99	Condon, JR; Ferracane, JL	In vitro wear of composite with varied cure, filler level, and filler treatment	1997	JDR	Oregon Health & Science University	187	6,93	Laboratory Studies
100	Stansbury, JW *et al.*	Conversion-dependent shrinkage stress and strain in dental resins and composites	2005	DM	University of Colorado	186	9,79	Literature review

3.1 Types of studies, publications, and author citations

Among the top 100 most cited articles in the field of composite resin in dentistry, 60% of these manuscripts are laboratory studies, 25% are literature reviews, and only 5% are clinical studies. The remaining studies are divided among systematic reviews, systematic reviews and meta-analyses, numerical analysis, and reports, as shown in Fig 2.

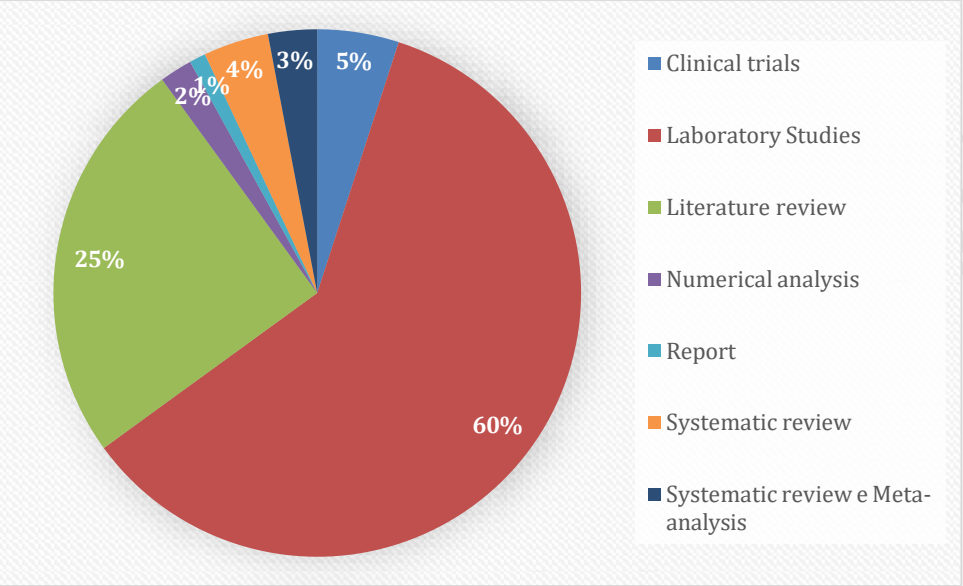

Fig. 2. Types of studies among the TOP 100 most cited in the field of composite resin in dentistry

The number of authors in the articles ranged from 1 to 13 (mean 3.73 ± 2.18), totaling 282 authors and co-authors in the top 100 most cited articles on "Composite Resin in Dentistry." The authors and co-authors with the highest number of publications, followed by their respective scores, are as follows: Ferracane JL appeared in (9 articles), Hickel R (7 articles), Stansbury JW (7 articles), Davidson CL (5 articles), Geurtsen W (5 articles). Approximately 232 authors and co-authors appeared in only one article. Fig 3 shows a graphical representation of the network among the authors and co-authors in the articles, with few lines connecting them, indicating little relationship among them.

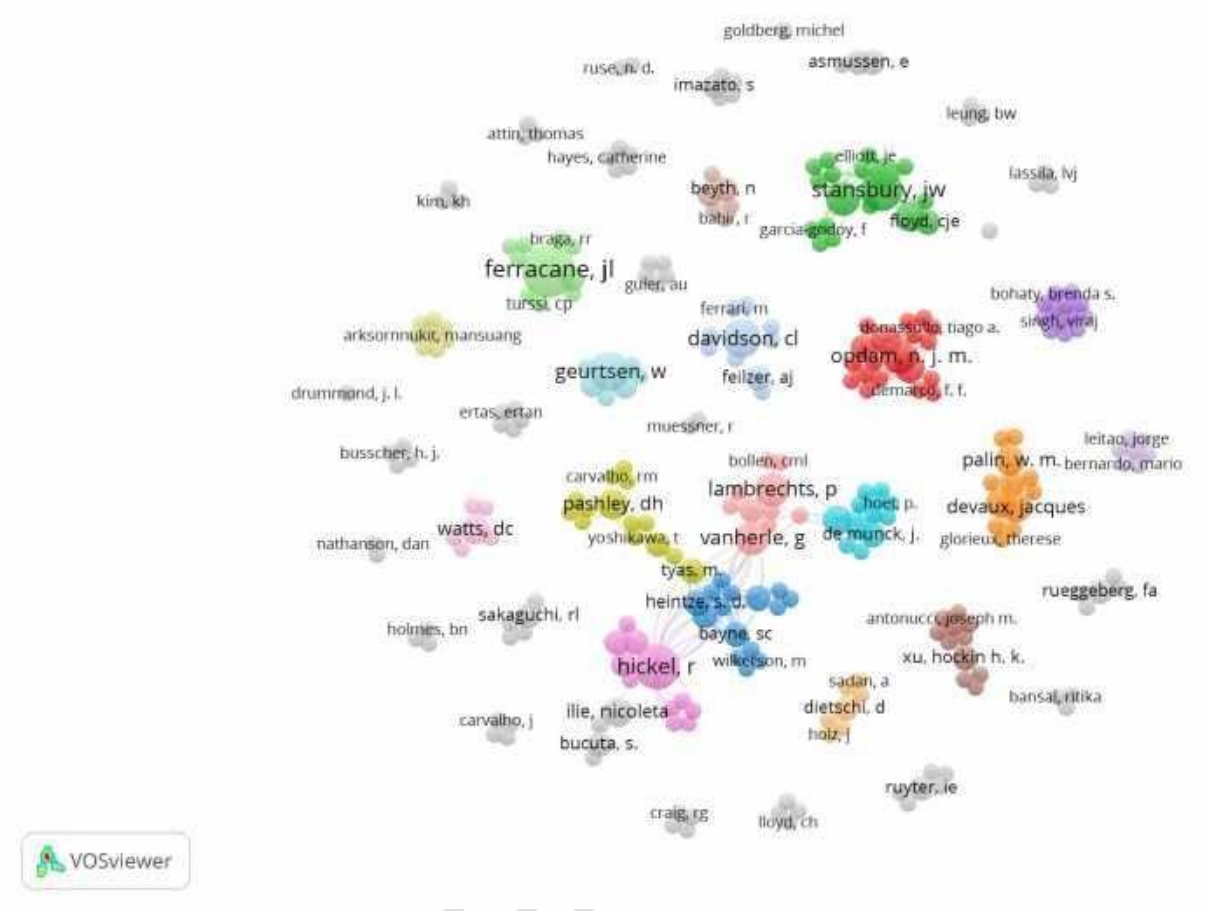

Fig. 3. Network of authors and co-authors in bibliometric research on composite resin in dentistry

The most cited articles in the top 100 were in the first position by Ferracane, JL in 2011 with a total of 1143 citations, followed by Bollen, CM et al. in 1997 with 960 citations, again Ferracane, JL in 2006 with 850 citations, and Peutzfeldt, A in 1997 with 638 citations. The number of citations ranged from 186 to 1143 (mean 305.17 ± 157.23). About 10 articles reached 500 or more citations (Table 1).

Two manuscripts were the oldest in this bibliometric analysis, published in 1990 by Rueggeberg, FA et al. in Dental Materials (DM) and was cited 237 times and by Kempscholte, CM and Davidson, CL in the Journal of Prosthetic Dentistry (JPD) and was cited 208 times. While the most recent ones were published in Lawson, NC et al. in Dental Materials in 2016 and were cited 209 times.

Fig 4 shows the correlation between the number of citations and the year of publication of the studies among the top 100 most cited articles in the field of composite resin. The citation distribution line presents high peaks in the years 1997 and 2011, with the highest citations summed to the top 100 studies, with 2760 and 2492 respectively.

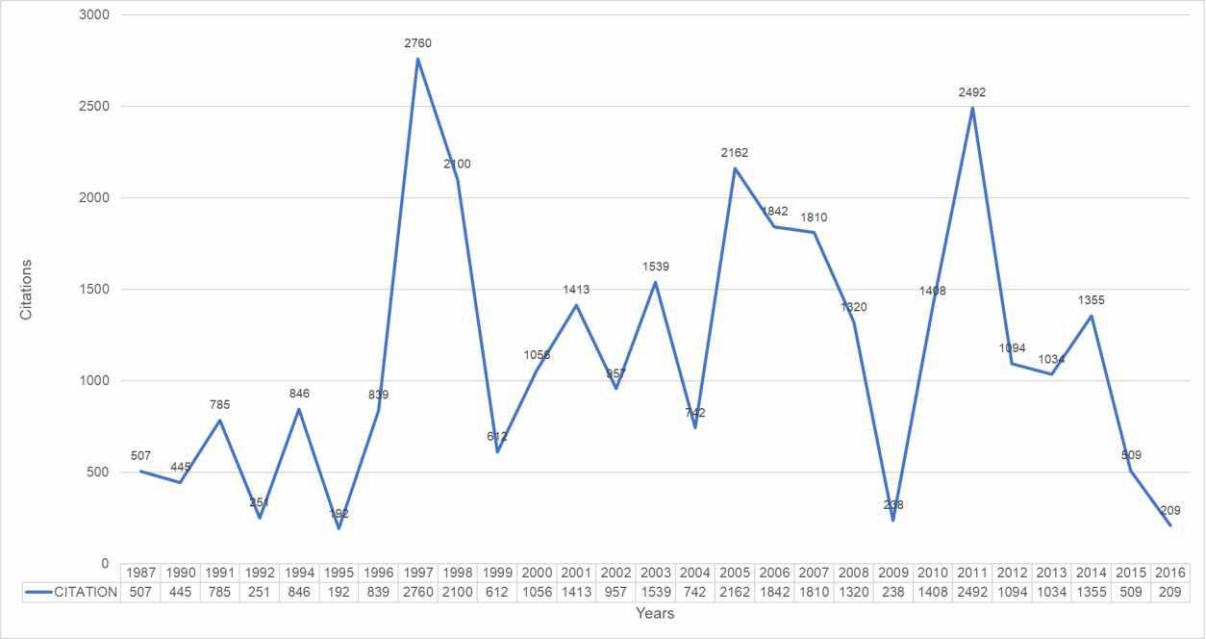

Fig. 4. Correlation between the number of citations and the year of publication of the top 100 studies in the field of composite resin

3.2 Institutions and countries

A total of 102 different institutions are associated with these studies. Oregon Health & Science University and the University of Munich topped the list, with 10 published manuscripts each among the top 100 most cited; followed by Universite Catholique Louvain with 8 articles, Ivoclar Vivadente with 4 articles, as shown in Fig 5. When considering only the institutions of the first author, this number drops to 60 institutions, as seen in Table 2. Universite Catholique Louvain (3,157 citations) and the University of Munich (2,399 citations) led the list, with 9 published manuscripts each among the top 100 most cited; followed by Oregon Health & Science University (3,130 citations) with 7 articles and the University of Colorado (1,071 citations) with 4 articles.

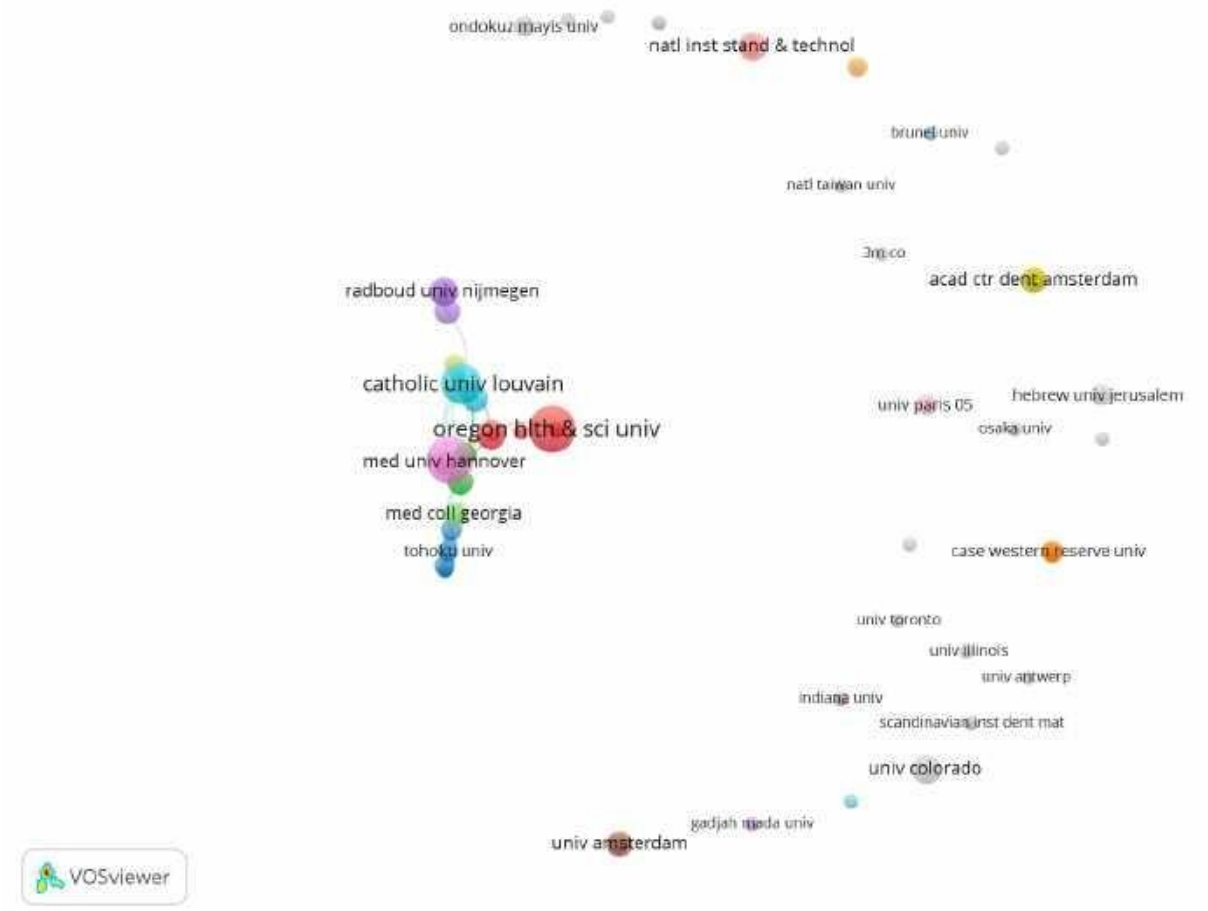

Fig. 5. Correlation between the institutions of all authors and co-authors. The larger the number of publications from these institutions, the larger the circles.

Table 2 Correlation between the institutions of the first author, number of publications, and citations in the top 100 most cited articles on composite resin

First Author's Institutions	Number of articles	Total Citations
Universite Catholique Louvain	9	3.157
University of Munich	9	2.399
Oregon Health & Science University	7	3.130
University of Colorado	4	1.071
University of Manchester	3	738
National Institute of Standards & Technology (NIST)	3	870
Osaka University	2	594
University of Geneva	2	474
Radboud University Nijmegen	2	777
Medical University Hannover	2	462
University of Georgia	2	523
Ondokuz Mayis University	2	433
University of Maryland	2	462
Ivoclar Vivadent	2	434
3M	2	755
Tokyo Medical and Dental University	2	402
University of Copenhagen	2	971
University of Regensburg	1	211
Hokkaido University	1	235

University of Illinois Chicago	1	374
Kyungpook National University	1	315
Hannover Medical School	1	290
Seoul National University (S	1	203
University Paris 5	1	279
The Hebrew University of Jerusalem	1	358
Private Dental Practitioner	1	211
Leibniz University Hannover	1	398
University of Michigan	1	328
Louisiana State University System	1	302
University of Naples Federico II	1	228
Universiteit van Amsterdam and Vrije Universiteit	1	363
University of Toronto	1	306
University of Alabama	1	209
Kyung Hee University	1	215
University of Amsterdam	1	208
University of Sao Paulo	1	442
University of Birmingham	1	203
Nova Southeastern University	1	195
University of British Columbia	1	290
University of Melbourne	1	270
Medical College of Georgia	1	372
University of Minnesota	1	279
Hebrew University of Jerusalem	1	202
University of Munich	1	245
National Taiwan University	1	242
University of North Carolina	1	416
NIOM, Scandinavian Institute of Dental Materials	1	507
University of Siena	1	194
University of Gothenburg	1	229
University of Turku	1	203
University of Gottingen	1	550
Vrije Universiteit Amsterdam	1	508
University of Groningen	1	315
Boston University	1	190
University of Hong Kong	1	218
University of Lisbon	1	364
University of Kansas	1	314
Federal University of Pelotas	1	603
University of Leuven	1	207
University of Liverpool	1	274
Total	100	30517

The studies originated from 23 different countries when considering only the location of the first author, with the total number of citations from all countries reaching 30,517 citations, of which the United States alone accounted for 9,790 citations, as evidenced in Table 3. The leading countries were the United States with 30 articles, Germany with 16 articles, and Belgium with 10 articles published among the top 100 articles on composite resin. Fig 6 shows the world map with the countries of the first authors highlighted in blue. When considering the country of all authors and co-authors, the number of countries of origin increases to 30, with the United States remaining in first place, with 37 manuscripts, followed by Germany with 16 manuscripts, Belgium with 12 manuscripts in third place, and the Netherlands with 11 manuscripts published, as shown in Fig 7.

Table 3. Number of articles published and number of citations from each country of origin among the top 100 most cited articles on composite resin

Country Of the First Author	Number of Articles	Number of Citations
Estados Unidos	30	9.790
Alemanha	16	4.555
Bélgica	10	3.364
Holanda	6	2.171
Brasil	3	1.256
Japão	5	1.231
Reino Unido	5	1.215
Dinamarca	2	971
Coréia	3	733
Canadá	2	596
Israel	2	560
Noruega	1	507
Suíça	2	474
Liechtenstein	2	434
Turquia	2	433
Itália	2	422
Portugal	1	364
França	1	279
Austrália	1	270
Taiwan	1	242
Suécia	1	229
China	1	218
Finlândia	1	203
Total Geral	**100**	**30.517**

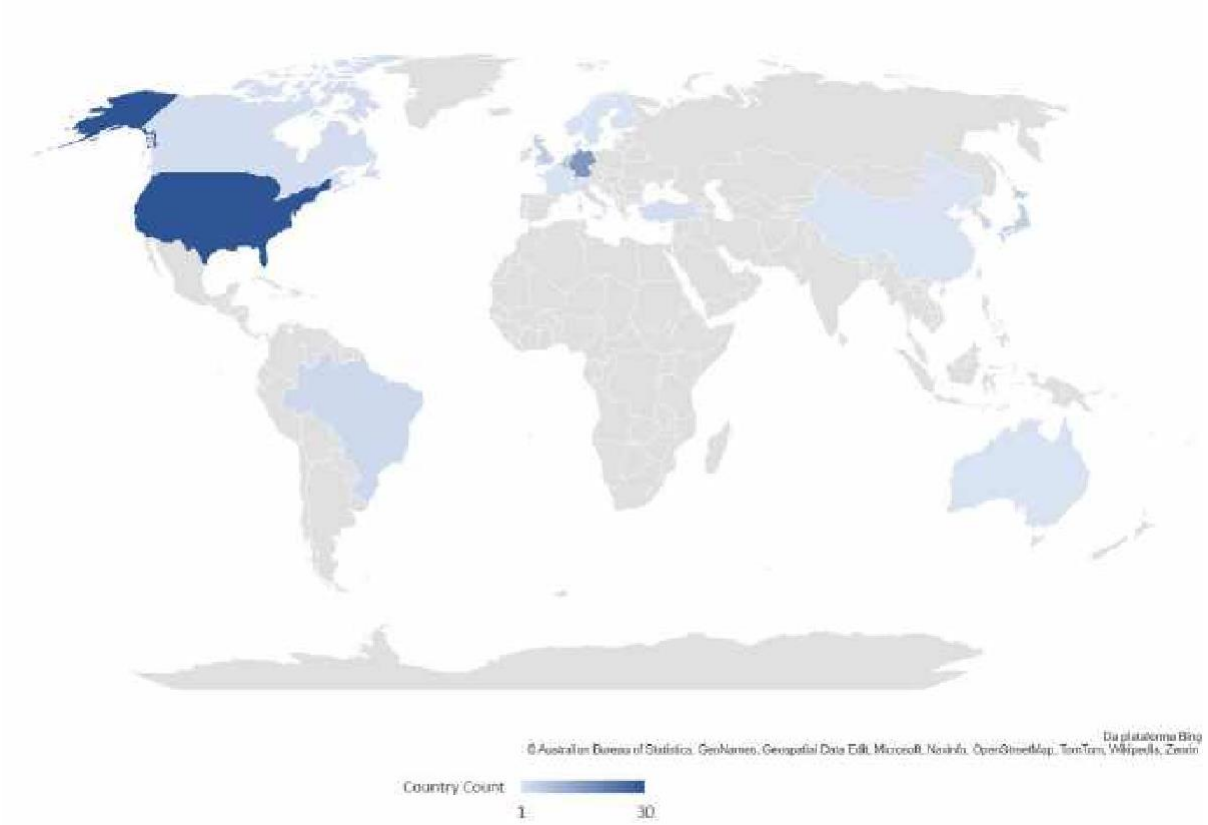

Fig. 6. World Map, highlighting the countries of origin of the top 100 most cited articles on composite resin. The more publications from a country, the bluer it becomes

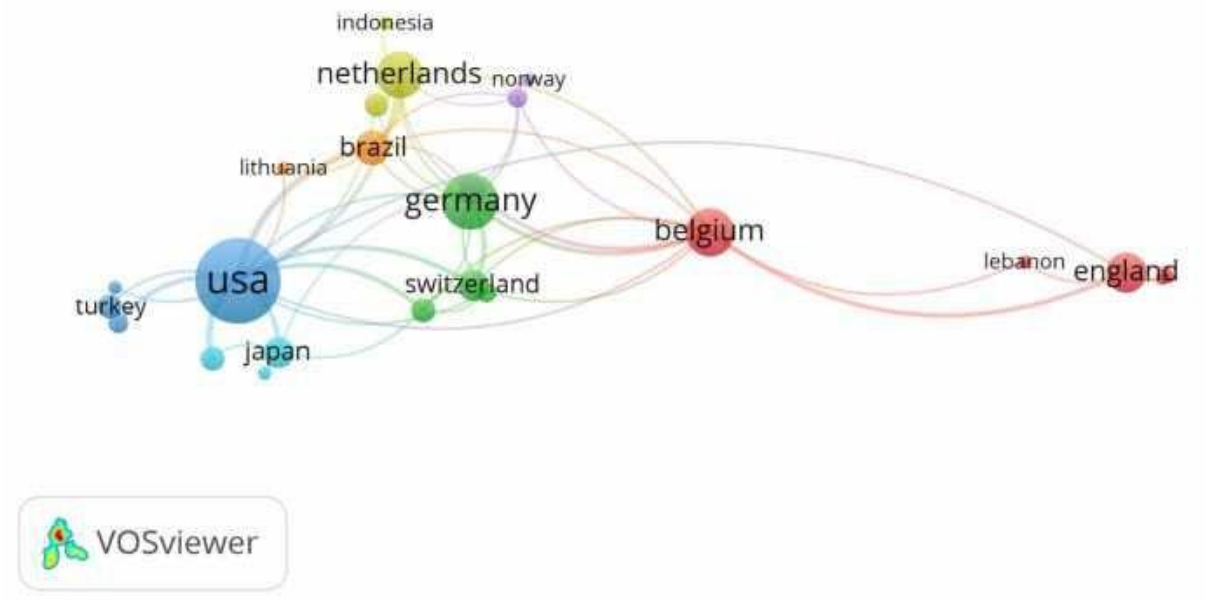

Fig. 7. Analysis of the country network from the bibliometric research "Composite Resin in Dentistry". The sizes of the circles are related to the countries and their number of publications

3.3 Journals

The 100 most cited articles involving composite resins in dentistry were published in 18 different journals. Among the top ones, Dental Materials (DM) leads the ranking with 40 articles, followed by the Journal of Dental Research (JDR) with 16 articles, Journal of Dentistry (JD) with 10 articles, and Journal

of Prosthetic Dentistry (JPD) with 5 articles published, as shown in Fig 8. Table 4 shows the list of newspaper abbreviations.

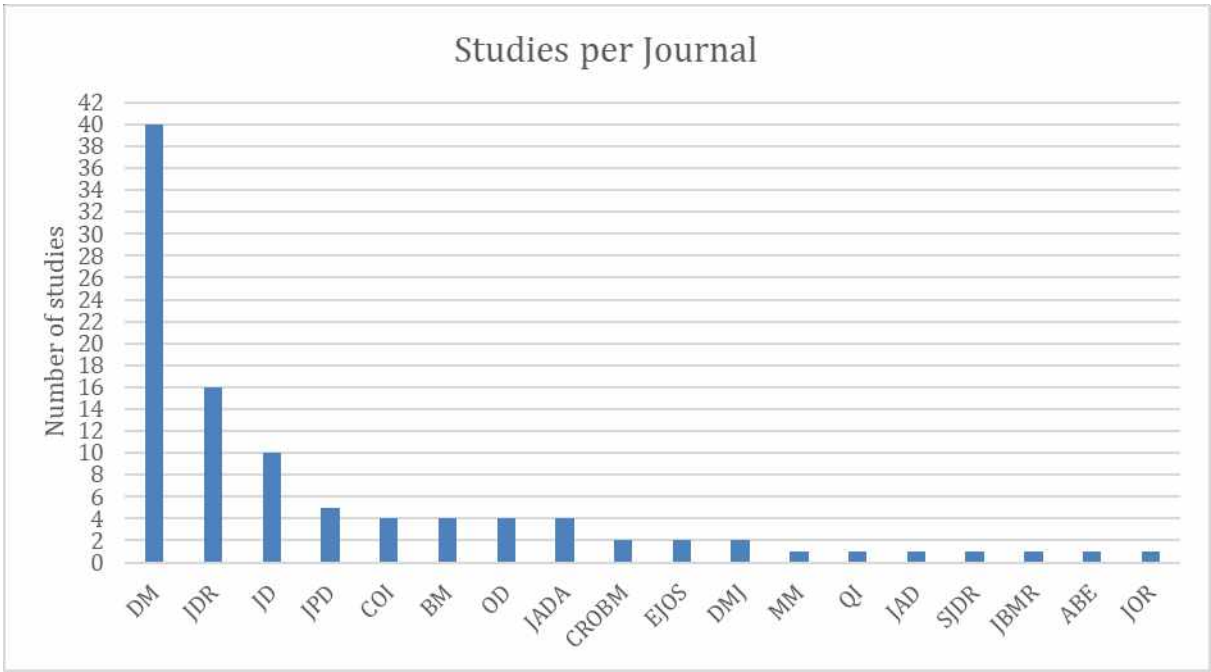

Fig. 8. Number of articles published per Journals

Table 4. List of journal abbreviations

Journal	Abbreviations
Dental Materials	DM
Journal of Prosthetic Dentistry	JPD
Journal of Dentistry	JD
Journal of The American Dental Association	JADA
Biomaterials	BM
Clinical Oral Investigations	COI
Journal of Dental Research	JDR
Operative Dentistry	OD
Macromolecules	MM
Quintessence International	QI
Dental Materials Journal	DMJ
Critical Reviews in Oral Biology & Medicine	CROBM
European Journal of Oral Sciences	EJOS
Journal of Biomedical Materials Research	JBMR
Journal of Adhesive Dentistry	JAD
Journal of Oral Rehabilitation	JOR
Annals of Biomedical Engineering	ABE
Scandinavian Journal of Dental Research	SJDR

The most represented publishers among the 100 articles were Elsevier SCI LTD (ELS) with 48 articles, Sage Publications Inc (SPINC) with 11 articles, Acad. Dental Materials (ADM) with 5 articles, and Amer. Assoc. Dental Research (AADR) also with 5 articles published as shown in Fig 9. Table 5 shows the list of publisher abbreviations

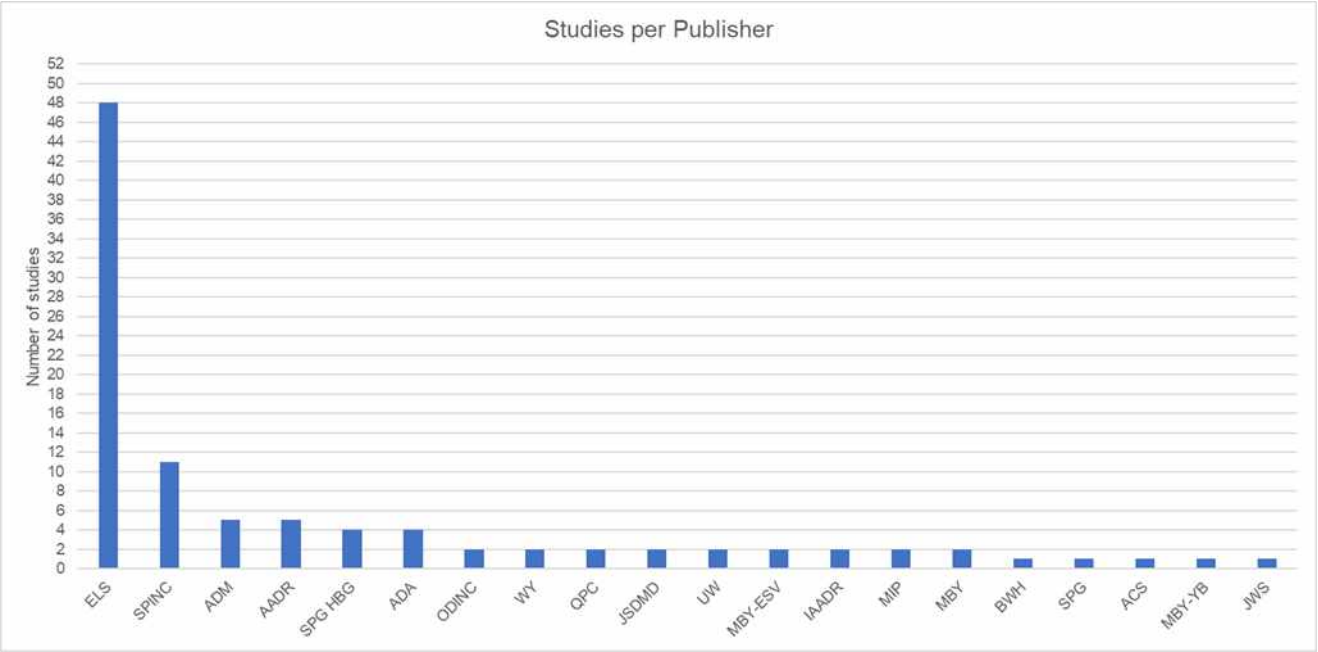

Fig. 9. Number of studies published by Publishers of the top 100 most cited articles in the field of composite resin

Table 5 - List of publisher abbreviations

Publisher	Abbreviations
Elsevier Sci Ltd	ELS
Mosby-Elsevier	MBY-ESV
Amer Dental Assoc	ADA
Elsevier Sci Ltd	ELS
Springer Heidelberg	SPG HBG
Sage Publications Inc	SPINC
Univ Washington	UW
Amer Assoc Dental Research	AADR
Amer Chemical Soc	ACS
Acad Dental Materials	ADM
Quintessence Publishing Co Inc	QPC
Japanese Soc Dental Materials Devices	JSDMD
Int Amer Assoc Dental Researchi A D R/A A D R	IAADR
Munksgaard Int Publ Ltd	MIP
John Wiley & Sons Inc	JWS
Operative Dentistry Inc	ODINC
Amer Dental Assoc	ADA
Wiley	WY
Butterworth-Heinemann Ltd	BWH
Mosby-Year Book Inc	MBY-YB

3.4 Keywords

In total, 626 keywords were used in the top 100 most cited articles. The most commonly used keywords in this article list were: Restorative Materials (19 times), Dental Composites (19 times), Conversion (17 times), Mechanical-properties (15 times), Polymerization (13 times), Resin Composites (12 times), and Shrinkage (12 times). The most used keyword was repeated in 19 studies, and the

frequency of keyword usage varied from 1 to 19 repetitions. Fig 10 shows a graphical representation in the form of a keyword network.

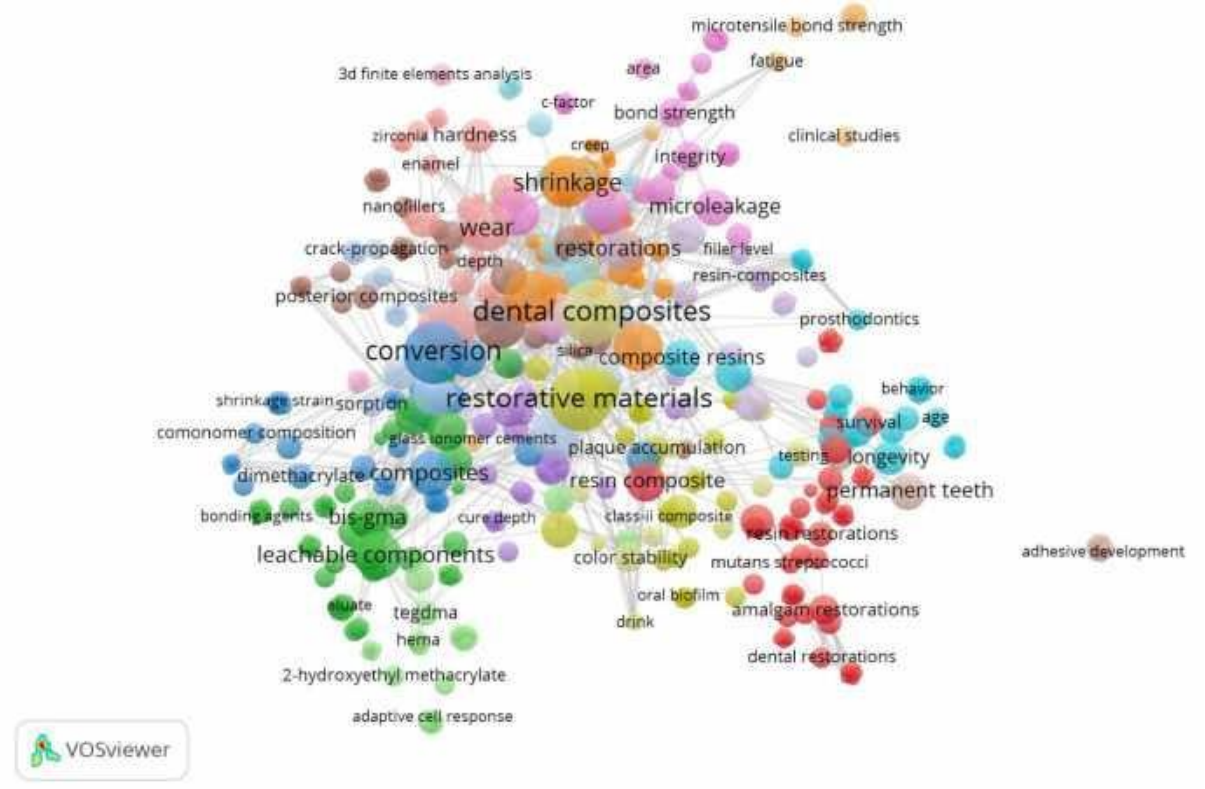

Fig. 10. Keyword network analysis from the bibliometric research "Composite Resin in Dentistry". The sizes of the circles are related to the frequency of each keyword used

3.5 Temporal pattern of publications

Based on the distribution of the top 100 most cited articles and the year of their publication, the period from 2005 to 1998 had the highest concentration of publications and was the most productive, with 8 and 7 studies respectively as shown in Fig 11.

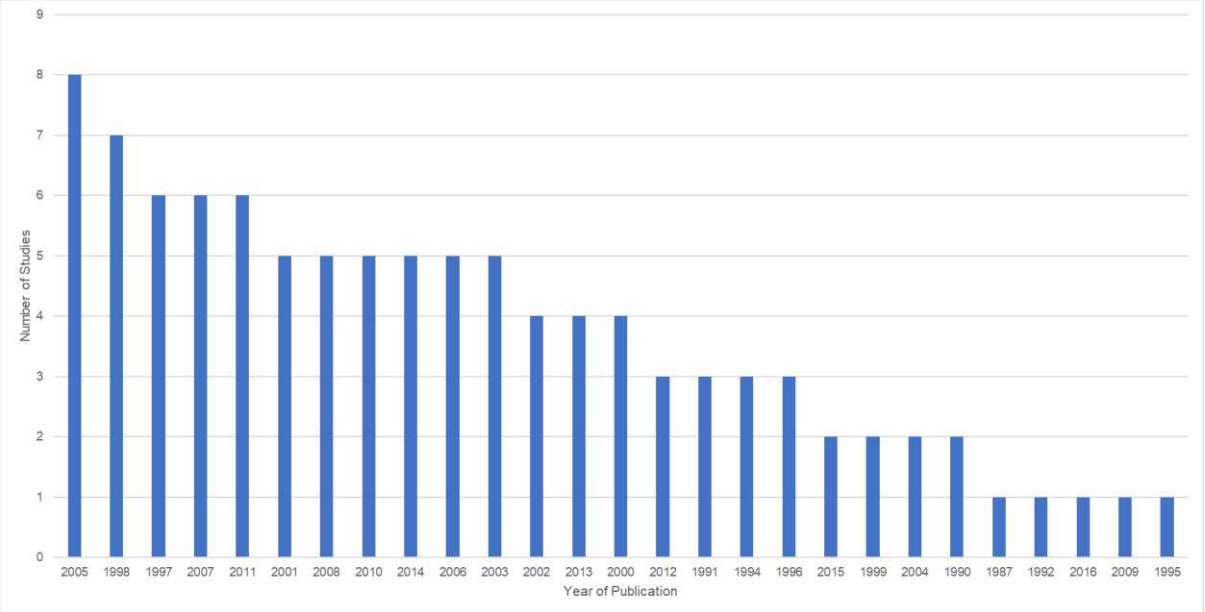

Fig. 11. Temporal distribution of the top 100 most cited studies on "Composite Resin in Dentistry!" by year of publication

4. DISCUSSION

Composite resins are constantly evolving, and research and development of these dental materials have gradually expanded to include direct restoration in both anterior and posterior teeth. This is due to the excellent mechanical and physical characteristics of these materials, along with their great potential to provide additional functionalities, such as antibacterial and therapeutic action [9]. The present study analyzed the100 most cited articles in the literature on composite resins, and in general, when a scientific article is among the most cited in its field, it indicates that it has achieved a significant milestone. Theoretically, the recognition of research within the scientific field, expressed by citation counts, and its impact on the understanding and treatment of a disease, reflect its quality (10,11). Additionally, it is noted that all of the top 100 most cited articles reach at least 100 citations and are considered classics in the literature [12]. Therefore, when a publication secures its position in the list of "classic" works in a specific area, it indicates that both the research and the journal have been recognized by global clinical and scientific communities as significant contributions to the field [10,13,14]. Thus, the results of this study not only offer a historical insight into the scientific advancement of composite resins but also highlight key trends in research and clinical practice.

It is observed that 60% of the most cited articles are laboratory studies. These studies constitute the base of the evidence pyramid and represent the starting point in the research process, providing insights and exploring properties and characteristics [15]. A more in-depth analysis revealed that 70% of these studies investigated the components present in the formulation of composite resins, as well as their mechanical properties. This aspect confirms the wide evolution of composite resins with innovative transformations of such restorative material through constant modification of its formulation. Among these, the predominant articles address properties related to the polymerization process of composite resins. One of the oldest articles among the most cited list, authored by Watts (1991) and having 222 citations, discusses the adverse effects of polymerization shrinkage on the bond between composite resins and dental tissues, a topic widely debated since the 1970s in the literature [16). Shrinkage occurs during the polymerization process, when monomer molecules convert into a polymeric network, generating stress in a confined structure, such as a dental cavity [17].

Various strategies have been developed to reduce polymerization shrinkage, as mentioned in the study by Choi [2000), with 200 citations, which includes controlling the composite components, resin type and quantity, filler level, as well as adapted application methods such as incremental resin placement. However, despite these measures, achieving reliable and well-bonded margins is still a challenge in the use of dental composites [18]. Therefore, investigating polymerization shrinkage, shrinkage stress, elastic modulus, and flow plays a crucial role in determining the final properties of composite resin, as stated by Kleverlaan (2005), whose study accumulates 363 citations [19]. Additionally, several studies among the most cited have explored alternative approaches to compensate for deficiencies in the curing process. For example, the study by Silikas (2000), with 322 citations, investigated irradiation at two levels of light intensity for different periods of time, demonstrating its effectiveness in reducing resin shrinkage [20]. Thus, these studies, along with many others, have contributed to a deeper understanding and improvement of the properties of composite resins.

The finding that the majority of examined articles deal with properties related to the polymerization process of composite resins is corroborated by the fact that the most frequent keywords are related to this area, such as "Restorative Materials" (19 times), "Dental Composites" (19 times), "Conversion" (17 times), "Mechanical Properties" (15 times), "Polymerization" (13 times), "Composite Resins" (12 times), and "Shrinkage" (12 times). Keywords play an important role in the identification and classification of an article in academic databases and search engines [21], and their frequency among the top 100 most cited articles suggests the main themes addressed. The remaining laboratory studies focus on investigating the optical properties of composite resins, the development of modified resins, and the methods used to measure their properties.

Several laboratory studies have been dedicated to improving composite resins through the production of modified resins, driving technologies that expand the possibilities of using these materials. A notable advancement in this field was made by Mitra (2003), whose study, with 544 citations, resulted in the creation of nanocomposites that meet both aesthetic and functional requirements for both posterior and anterior restorations. These nanocomposites have demonstrated to possess physical properties equivalent to or even superior to conventional resins available at the time [22]. Another significant innovation was achieved in the work of Beyth (2006), cited 358 times, which involved the incorporation of nanoparticles with bactericidal properties into dental composite resins. Studies have

shown that the addition of quaternary ammonium polyethylenimine nanoparticles conferred bactericidal activity without compromising mechanical properties [23]. In 2012, Cheng et al., with 249 citations, developed a nanocomposite with mineralizing and bactericidal action, containing quaternary ammonium dimethacrylate, silver nanoparticles, and amorphous calcium phosphate nanoparticles. These nanocomposites provided dual benefits without compromising their physical properties [24]. These are just three examples of studies that have contributed significantly to the advancement of composite resins, highlighting that 10% of the most cited laboratory studies address the development of modified composites.

In addition to the total number of citations, citation density is a measure that evaluates the scientific strength and impact of an article over time, considering the number of citations per year of publication. This allows for the comparison of both recent and older articles based on similar classification criteria. The article titled "Resin composite - State of the art," authored by Ferracane, leads the list with an annual citation density of 87.92 and 1143 total citations. This article discusses the current state of development of composite resins, analyzing their composition, potential for future advancements, characteristics, and limitations of products available in the market, as well as crucial aspects for their clinical application [2]. In second place is the article "Longevity of posterior composite restorations: Not only a matter of materials," authored by Demarco, with an annual citation density of 50.25 and 603 total citations. The study examines dental literature for clinical trials addressing the longevity of composite restorations in posterior teeth, with a minimum follow-up period of 5 years [25].

The first most cited work is a literature review and represents the second most predominant study design among the most cited articles. These studies are fundamental as they examine relevant literature to compare and contrast findings from previous studies in a specific field. They contribute to a more comprehensive understanding of the current state of research, identify areas that need further study, and point to future research directions [26]. On the other hand, the second is a systematic review that seeks to provide a comprehensive and unbiased synthesis of various relevant studies in a single document. Although it shares many characteristics with a literature review, a systematic review differs by attempting to identify "all" relevant evidence for a question and by focusing on research that presents data rather than concepts or theories [27].

In the context of assessing an author's impact on publications on the topic, two aspects are relevant: the volume of published articles and the influence of these publications, measured by the number of citations they receive. From this perspective, Ferracane stands out not only as the most prolific author, with nine articles among the 100 most cited, but also due to the significant number of citations, including the most cited article. These data highlight Ferracane's prominent position in composite resin research, underscoring his substantial contribution to the development of these materials. Furthermore, the analysis of co-citation networks among authors revealed limited collaboration among different researchers, institutions, and countries of origin. A more robust co-citation network, involving potential collaborators and author groups, is crucial for driving research forward, facilitating the exchange of knowledge and perspectives. However, this collaboration seems to be underexplored in the examined studies.

The publications originate from 22 different countries, with the United States leading the ranking, contributing 30 publications, followed by Germany with 16, and Belgium with 10. These countries account for 56% of the total articles, highlighting their influence on composite resin research. Additionally, the variety of countries involved in these publications underscores the global relevance of composite resins, allowing contributions from diverse perspectives and distinct methodologies.

Another important aspect to consider is the most prolific institutions. Oregon Health & Science University and the University of Munich lead the list, with 10 articles published each, followed by Universite Catholique Louvain, with 8. These data indicate the most active and engaged research centers in the study of composite resins. However, it is important to note that these institutions do not encompass all available information on composite resins, as each publication employs different methods, which can result in diverse but complementary findings and understandings.

Furthermore, the 19 journals examined in this study were evaluated, revealing an average impact factor of the journals over the past two years of 4.3, with a range between 0.0 and 14.0. These results provide us with important data, such as the finding that there is a journal that, despite having a classic article in its collection, is no longer in circulation. Additionally, it is observed that the journal with the highest impact factor is not the one with the highest number of publications on composite resin, indicating that, although highly influential, it is not the most sought after for this specific topic. The most prominent journal is Dental Materials, with 40 articles published, an impact factor of 5, and a citation score of 9.2, highlighting its considerable influence and credibility in research related to composite resin. Furthermore, the presence of 20 different publishers suggests a wide variety of approaches on the

subject. Elsevier leads the ranking with the highest number of publications, which is understandable since the Dental Materials journal is affiliated with this publisher. In light of these results, it is crucial to promote dialogue and collaboration among various publishers and publications, facilitating an interdisciplinary approach.

However, this study has some limitations. The constraints of this research are associated with the selection of the dataset used, as the database employed was the Web of Science from Clarivate Analytics. Although some articles on composite resin may have been excluded, all major dental works and materials research were listed in WoSCA, which was reported to have broader coverage than other important databases [28]. Additionally, there are works that are difficult to access for the academic community, which also limits the collection of data that could be used. Another important consideration is related to the number of citations of a specific study, taking into account the possibility of self-citation, which may influence the total number of citations of a publication.

The production of the most cited articles covered the period from 1990 to 2016, reflecting changes in the most addressed topics over time. The two oldest articles are laboratory studies, one of which addressed methods for determining monomer conversion using infrared spectroscopy, with 237 citations [29], and the other focused on the shear bond strength of composite resin restoration systems, cited 208 times [30]. The most recent article, published in 2016, examined the mechanical properties of CAD/CAM materials and received 209 citations [31].

The years 1997 and 2011 stood out for article production, primarily addressing polymerization shrinkage and reviews on composite resin, respectively. However, no recent studies (within the last 5 years) were found among the top 100 most cited articles, raising questions about the evolution of research on composite resins in dentistry. The lack of more recent studies may indicate a decline in interest or research activities in this area, or perhaps these studies have not yet had enough time to achieve the same recognition as older studies.

This analysis provides valuable insights for researchers seeking to guide their research or identify knowledge gaps about composite resins. By examining the most cited articles, it is possible to understand the trends and impact of research in this field, assisting researchers, professionals, and academic institutions in identifying promising areas for future investigations and understanding the relevance of research already conducted.

The top 100 most cited articles on composite resin play a fundamental role in the development and evolution of these materials to the present day. Analyzing these studies provides a comprehensive view of research in this field, highlighting the most active areas and key scientific contributors. However, it is crucial to recognize the importance of closer collaboration among these leaders to further drive the advancement of knowledge. It is noteworthy that there are no articles from the last five years among the most cited articles, suggesting that none of them had a significant impact or have not had enough time to establish themselves as references. Therefore, it is challenging through this analysis to gain an understanding of recent developments in composite resins or identify areas of major investment in recent years. However, these results can serve as a valuable starting point for researchers, allowing not only the identification of important articles, journals, and contributors but also gaining inspiration from research trends to guide future investigations.

5 REFERENCES

1. Cho K, Rajan G, Farrar P, Prentice L, Prusty BG. Dental resin composites: a review on materials to product realizations. Composites Part B: Engineering 2022; 230:109495. https://doi.org/10.1016/j.compositesb.2021.109495

2. Ferracane JL. Resin composite—state of the art. Dental materials 2011; 27:29-38. https://doi.org/10.1016/j.dental.2010.10.020

3. García AH, Lozano MAM, Vila JC, Escribano AB, Galve PF. Composite resins. A review of the materials and clinical indications. Med Oral Patol Oral Cir Bucal 2006; 11:215-220.

4. Klapdohr S, Moszner N. New inorganic components for dental filling composites. Monatshefte für Chemie/Chemical Monthly 2005; 136:21-45. https://doi.org/10.1007/s00706-004-0254-y

5. Cordeiro AM, Oliveira GMD, Rentería JM, Guimarães CA. Revisão sistemática: uma revisão narrativa. Revista do colégio brasileiro de cirurgiões 2007; *34:*428-431. https://doi.org/10.1590/S0100-69912007000600012

6. He L, Fang H, Wang X, Wang Y, Ge H, Li C, He H. The 100 most-cited articles in urological surgery: A bibliometric analysis. International Journal of Surgery 2020; 75:74-79. https://doi.org/10.1016/j.ijsu.2019.12.030

7. Alam BF, Najmi MA, Qasim SB, Almulhim KS, Ali S. A bibliometric analysis of minimally invasive dentistry: A review of the literature from 1994 to 2021. The Journal of Prosthetic Dentistry 2023; 130:179-186. https://doi.org/10.1016/j.prosdent.2021.09.023

8. Ahmad P, Arshad AI, Della Bella E, Khurshid Z, Stoddart M. Systemic manifestations of the periodontal disease: a bibliometric review. Molecules 2020; 25:4508. https://doi.org/10.3390/molecules25194508

9. Pratap B, Gupta RK, Bhardwaj B, Nag M. Resin based restorative dental materials: Characteristics and future perspectives. Japanese Dental Science Review 2019; *55*:126-138. https://doi.org/10.1016/j.jdsr.2019.09.004

10. Ahmad P, Della Bella E, Stoddart MJ. Applications of bone morphogenetic proteins in dentistry: A Bibliometric Analysis. BioMed research international. 2020; 24:5971268. https://doi.org/10.1155/2020/5971268

11. Fardi A, Kodonas K, Lillis T, Veis A,. Top-Cited Articles in Implant Dentistry. International Journal of Oral & Maxillofacial Implants 2017; 32:555-564. https://doi.org/10.11607/jomi.5331

12. Feijoo JF, Limeres J, Fernández-Varela M, Ramos I, Diz P. The 100 most cited articles in dentistry. Clinical oral investigations 2014; 18:699-706. https://doi.org/10.1007/s00784-013-1017-0

13. Fardi A, Kodonas K, Gogos C, Economides N. Top-cited articles in endodontic journals. Journal of Endodontics 2011; 37:1183-1190. https://doi.org/10.1016/j.joen.2011.05.037

14. Ahmad P, Dummer PMH, Noorani TY, Asif JA. The top 50 most-cited articles published in the International Endodontic Journal. International Endodontic Journal 2019;52:803-818. https://doi.org/10.1111/iej.13083

15. Gelardi F, Kirienko M, Sollini M. Climbing the steps of the evidence-based medicine pyramid: highlights from Annals of Nuclear Medicine 2019. European Journal of Nuclear Medicine and Molecular Imaging 2021;48:1293-1301. https://doi.org/10.1007/s00259-020-05073-6

16. Watts DC, Cash AJ. Determination of polymerization shrinkage kinetics in visible-light-cured materials: methods development. Dental Materials 1991;7:281-287. https://doi.org/10.1016/S0109-5641(05)80030-2

17. Feilzer AJ, De Gee AJ, Davidson CL. Setting stress in composite resin in relation to configuration of the restoration. Journal of dental research, 1987; 66:1636-1639. https://doi.org/10.1177/00220345870660110601

18. Choi KK, Condon JR, Ferracane JL. The effects of adhesive thickness on polymerization contraction stress of composite. Journal of dental research 2000;79:812-817. https://doi.org/10.1177/002203450007900305

19. Kleverlaan CJ, Feilzer AJ. Polymerization shrinkage and contraction stress of dental resin composites. Dental Materials 2005;21:1150-1157. https://doi.org/10.1016/j.dental.2005.02.004

20. Silikas N, Eliades G, Watts DC. Light intensity effects on resin-composite degree of conversion and shrinkage strain. Dental Materials 2000;16:292-296. https://doi.org/10.1016/S0109-5641(00)00020-8

21. Mondal H, Mondal S, Mondal S. How to choose title and keywords for manuscript according to medical subject headings. Indian Journal of Vascular and Endovascular Surgery 2018;5:141-144. https://doi.org/10.4103/ijves.ijves_15_18

22. Mitra,SB, Wu D, Holmes BN. An application of nanotechnology in advanced dental materials. The Journal of the American Dental Association 2003;134:1382-1390. https://doi.org/10.14219/jada.archive.2003.0054

23. Beyth N, Yudovin-Farber I, Bahir R, Domb AJ, Weiss EI, 2006. Antibacterial activity of dental composites containing quaternary ammonium polyethylenimine nanoparticles against Streptococcus mutans. Biomaterials 2006;27:3995-4002. https://doi.org/10.1016/j.biomaterials.2006.03.003

24. Cheng L, Weir MD, Xu HH, Antonucci JM, Kraigsley AM, Lin NJ et al., 2012. Antibacterial amorphous calcium phosphate nanocomposites with a quaternary ammonium dimethacrylate and silver nanoparticles. Dental Materials 2012;28:561-572. https://doi.org/10.1016/j.dental.2012.01.005

25. Demarco FF, Corrêa MB, Cenci MS, Moraes RR, Opdam NJ. Longevity of posterior composite restorations: not only a matter of materials. Dental materials 2012;*28*:87-101. https://doi.org/10.1016/j.dental.2011.09.003

26. Marabelli M, Newell S. Knowing, power and materiality: A critical review and reconceptualization of absorptive capacity. International journal of management reviews 2014;16:479-499. https://doi.org/10.1111/ijmr.12031

27 Aromataris E, Pearson A. The systematic review: an overview. AJN The American Journal of Nursing 2014;114:53-58. https://doi.org/10.1097/01.NAJ.0000444496.24228.2c

28. Kokol P, Vošner HB. Discrepancies among Scopus, Web of Science, and PubMed coverage of funding information in medical journal articles. Journal of the Medical Library Association: JMLA, 2018;106:81. https://doi.org/10.5195/jmla.2018.181

29. Rueggeberg FA, Hashinger DT, Fairhurst CW. Calibration of FTIR conversion analysis of contemporary dental resin composites. Dental Materials 1990;6:241-249. https://doi.org/10.1016/S0109-5641(05)80005-3

30. Kemp-Scholte CM, Davidson CL. Marginal integrity related to bond strength and strain capacity of composite resin restorative systems. The Journal of Prosthetic Dentistry 1990;64:658-664. https://doi.org/10.1016/0022-3913(90)90291-J

31. Lawson NC, Bansal R, Burgess JO. Wear, strength, modulus and hardness of CAD/CAM restorative materials. Dental materials 2016;32:275-283. https://doi.org/10.1016/j.dental.2016.08.222