Review Article

The 100 most cited articles on glass ionomer cement: A bibliometric analysis

ABSTRACT

Aims: This bibliometric review aimed to rank, examine, and present the 100 most cited publications in the literature on glass ionomer cement, in order to evaluate the progress of scientific production and thus contribute to future studies.
Study design: Bibliometric review.
Methodology: A search using MESH terms was performed in the Clarivate Analytics Web of Science database. Two independent authors selected the 100 most cited articles. There were no restrictions regarding the study design, year of publication, language or journal impact factor of the manuscripts. The year of publication, authors, citation count, periodicals, keywords, contributing institution, country, among other details, were extracted from the articles included.
Results: The initial search identified 5,186 articles. Among the 100 most cited articles selected, the author with the highest number of publications was Frencken JE. The most cited article, by Wiegand A *et al.* in 2007, had a total of 547 citations. The oldest manuscript was published in 1977 by Forsten L. The University of Manchester and Medical College of Georgia led the list of institutions. The country with the highest number of publications was the USA. The top journals were Dental Materials leading the ranking, followed by the Journal of Dental Research and the Journal of Prosthetic Dentistry. The most used keywords in this list were: fluoride release, glass-ionomer cements, glass-ionomer cement. The years with the highest concentration of publications were between 1998 and 2003.
Conclusion: This analysis reinforces the importance of periodic reviews and updates in the literature, promoting the dissemination of knowledge and the continuous advancement in dental materials science.

Keywords - Glass Ionomer Cements; Polyalkenoate Cement; Glass Polyalkenoate Cements; Dentistry.

1. INTRODUCTION

"Since the observation that secondary caries was rarely associated with fluoride-containing silicate cement restorations, increasing attention has been given to the development of various fluoride-releasing products" [1]. In the 1970s, glass ionomer cement (GIC) was developed, named for its setting through an ionic reaction between glass powder and polyacrylic acid [2].

GIC has a fluoride-releasing property that is desirable in clinical practice [3] and is biocompatible, with a low potential to cause pulp injury [4]. Fluoride release is beneficial because it is believed that fluoride from restorative dental materials affects caries formation through various anticariogenic mechanisms, such as increasing remineralization rates over demineralization rates [4].

“Additionally, glass ionomer cements have properties such as adhesion to dental structure. This adhesion occurs at a high speed, initially forming hydrogen bonds between the free carboxyl groups of the cement and the water present on the dental surface” [5]. Once these hydrogen bonds are formed, they are gradually replaced by ionic bonds between the cations of the dental element and the anionic functional groups of the cement. This process leads to the progressive formation of an ionic layer between the dental element and the glass ionomer cement over time [5]. However, their fracture resistance is relatively low, and their ability to withstand wear is limited, making them more suitable for use in low-load bearing areas [6].

Within this context, aiming to enhance these characteristics, resin-modified glass ionomer cements were created, which share the same clinical applications as traditional glass ionomers. However, these materials offer aesthetic improvements, are light-curable, and bubble-free, as they eliminate the need for manipulation during application [7,8]. These adaptations have contributed significantly to improving the material's ability to resist early moisture and dehydration, as well as enhancing its mechanical characteristics, providing greater strength, color stability, and longevity [9].

Bibliometrics is a quantitative method for scientific research analysis. Data compiled through bibliometric studies measure the contribution of scientific knowledge derived from publications in specific areas [10]. Conducting these quantitative analyses is critically important to provide new insights into scientific production and the development of knowledge in each field, offering a more objective and clear view of trends and the impact of these studies on the scientific community and clinical practice. Therefore, having knowledge about what is produced and published is essential for evaluating current progress and guiding future research. This work aimed to rank, examine, and present the 100 most cited publications in the literature on glass ionomer cement to assess the progress of scientific production and contribute to future studies.

2. MATERIALS AND METHODS

A bibliometric review on the topic of glass ionomer cement was conducted using the Web of Science database from Clarivate Analytics. As a review study, ethical approval from a research ethics committee was not required.

The search was conducted in August using the following terms: "Glass Ionomer Cements OR Glass Ionomer Cement OR Cement, Glass Ionomer OR Cements, Glass Ionomer OR Ionomer Cement, Glass OR Polyalkenoate Cement OR Cement, Polyalkenoate OR Cements, Polyalkenoate OR Polyalkenoate Cements OR Glass-Ionomer Cement OR Cement, Glass-Ionomer OR Cements, Glass-Ionomer OR Glass-Ionomer Cements OR Glass Polyalkenoate Cements OR Glass Polyalkenoate Cement OR Cement, Glass Polyalkenoate OR Cements, Glass Polyalkenoate OR Polyalkenoate Cement, Glass) AND (Dentistry) in the title and/or abstract.

“Results were extracted into a table using Microsoft Excel and organized in descending order based on citation count. Manuscripts were independently selected in pairs by two researchers, previously calibrated. The study sample included publications that mentioned glass ionomer cement in the title and/or abstract as the main subject, excluding those that did not relate to the topic. There were no restrictions regarding study design, publication year, language, or journal impact factor”. [113]

The most cited articles were manually categorized based on retrieved information from the Clarivate Analytics Web of Science database, including publication year, authors, citation count, journals, keywords, contributing institution, country, among other details. The first author's affiliation address determined the country of origin and contributing institution of the article.

Author relationships were determined based on citation frequency, visualized using network analysis with VOSviewer software (University of Leiden, Netherlands).

3. RESULTS

“The initial search in the Web of Science database by Clarivate Analytics identified 5,186 articles. After comparing titles and abstracts, the 100 most cited manuscripts involving glass ionomer cements were 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 shown in Figure 1”. [113]

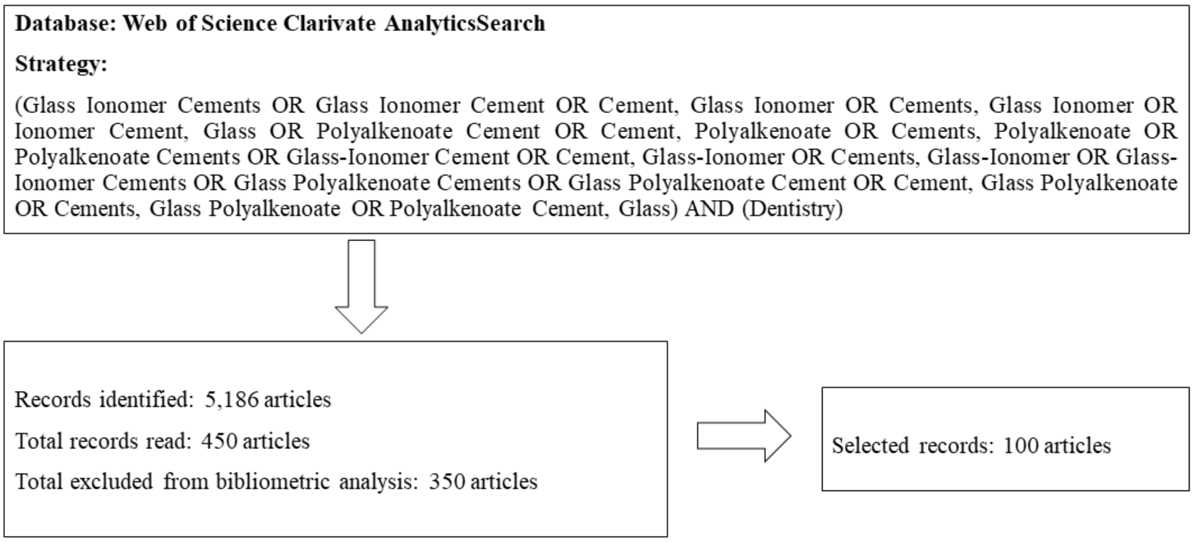

Figure 1. Flowchart of Study Selection Process and Search Strategy

Table 1 - Ranking of the Top 100 Cited Articles on Glass Ionomer Cement

Ranking	Author	Title	Year of Publication	Journal	Institutions	Citations	Citation Density
1	Wiegand A et al. [11]	Review on fluoride-releasing restorative materials - Fluoride release and uptake characteristics, antibacterial activity and influence on caries formation	2007	Dent. Mater.	University of Gottingen	547	32,18
2	Rosenstiel SF et al. [12]	Dental luting agents: A review of the current literature	1998	J. Prosthet. Dent.	The Ohio State University College of Dentistry	330	12,69
3	Yoshida Y et al. [13]	Evidence of chemical bonding at biomaterial-hard tissue interfaces	2000	J. Dent. Res.	Hiroshima University Faculty of Dentistry	329	13,71
4	Busscher HJ et al. [14]	Biofilm Formation on Dental Restorative and Implant Materials	2010	J. Dent. Res.	University Medical Center Groningen and University of Groningen	315	22,50
5	Nicholson JW [15]	Chemistry of glass-ionomer cements: a review	1998	Biomaterials	Kings College School of Medicine and Dentistry	309	11,88
6	Xie, D et al. [16]	Mechanical properties and microstructures of glass-ionomer cements	2000	Dent. Mater.	College of Dentistry, The Ohio State University	303	12,63
7	Beauchamp J et al. [17]	Evidence-based clinical recommendations for the use of pit-and-fissure sealants - A report of the American Dental Association Council on Scientific Affairs	2008	J. Am. Dent. Assoc.	is in private practice in Clarksville	284	17,75

8	Bagheri R et al. [18]	Influence of food-simulating solutions and surface finish on susceptibility to staining of aesthetic restorative materials	2005	J. Dent.	University of Melbourne	268	14,11
9	Geurtsen W [19]	Substances released from dental resin composites and glass ionomer cements	1998	Eur. J. Oral Sci.	Medical University Hannover	261	10,04
10	Powis DR et al. [20]	Improved adhesion of a glass ionomer cement to dentin and enamel	1982	J. Dent. Res.	Laboratory of the Government Chemist, Department of Industry	255	6,07
11	Swartz ML et al. [21]	Long-term f release from glass ionomer cements	1984	J. Dent. Res.	Indiana University School of Dentistry	250	6,25
12	Kenny SM; Buggy M [22]	Bone cements and fillers: A review	2003	J. Mater. Sci.-Mater. Med.	University of Limerick	237	11,29
13	Sidhu SK; Watson TF [23]	Resin-modified glass-ionomer materials - a status-report for the american-journal-of-dentistry	1995	Am. J. Dent.	National University of Singapore	232	8,00
14	Mjor IA [24]	The reasons for replacement and the age of failed restorations in general dental practice	1997	Acta Odontol. Scand.	College of Dentistry, University of Florida	223	8,26
15	Gladys S et al. [25]	Comparative physico-mechanical characterization of new hybrid restorative materials with conventional glass-ionomer and resin composite restorative materials	1997	J. Dent. Res.	Catholic University of Leuven	222	8,22
16	Feilzer AJ et al. [26]	Curing contraction of composites and glass-ionomer cements	1988	J. Prosthet. Dent.	University of Amsterdam, School of Dentistry,	221	6,14

17	Imazato S [27]	Bio-active restorative materials with antibacterial effects: new dimension of innovation in restorative dentistry	2009	Dent. Mater. J.	Osaka University Graduate School of Dentistry	208	13,87
18	Blatz MB et al. [28]	Influence of surface treatment and simulated aging on bond strengths of luting agents to zirconia	2007	Quintessence Int.	University of Pennsylvania School	201	11,82
19	Forsten L [29]	Fluoride release and uptake by glass-ionomers and related materials and its clinical effect	1998	Biomaterials	University of Turku	194	7,46
20	Ahn SJ et al. [30]	Experimental antimicrobial orthodontic adhesives using nanofillers and silver nanoparticles	2009	Dent. Mater.	Seoul National University	190	12,67
21	Atmeh AR et al. [31]	Dentin-cement Interfacial Interaction: Calcium Silicates and Polyalkenoates	2012	J. Dent. Res.	King's College London Dental Institut	174	14,50
22	Ahovuo-Saloranta A et al. [32]	Sealants for preventing dental decay in the permanent teeth	2013	Cochrane Database Syst Rev.	The Cochrane Collaboration	172	15,64
23	Ernst CP et al. [33]	In vitro retentive strength of zirconium oxide ceramic crowns using different luting agents	2005	J. Prosthet. Dent.	University Mainz	170	8,95
24	Xu XM; Burgess JO [34]	Compressive strength, fluoride release and recharge of fluoride-releasing materials	2003	Biomaterials	Louisiana State University Health Science Center	170	8,10
25	Agar JR et al. [35]	Cement removal from restorations luted to titanium abutments with simulated subgingival margins	1997	J. Prosthet. Dent.	University of Connecticut Health Center	169	6,26
26	Kopperud SE et al. [36]	Longevity of posterior dental restorations and reasons for failure	2012	Eur. J. Oral Sci.	University of Oslo	166	13,83

27	Moshaverinia A et al. [37]	Effects of incorporation of hydroxyapatite and fluoroapatite nanobioceramics into conventional glass ionomer cements (GIC)	2008	Acta Biomater.	Queen Mary University of London	166	10,38
28	Piwowarczyk A et al. [38]	In vitro shear bond strength of cementing agents to fixed prosthodontic restorative materials	2004	J. Prosthet. Dent.	Wolfgang Goethe University School of Dentistry	165	8,25
29	Diaz-Arnold AM et al. [39]	Current status of luting agents for fixed prosthodontics	1999	J. Prosthet. Dent.	University of Iowa	157	6,28
30	Geurtsen, W et al. [40]	Residual monomer additive release and variability in cytotoxicity of light-curing glass-ionomer cements and compomers	1998	J. Dent. Res.	Medical University Hannover,	156	6,00
31	Forsten L [41]	Fluoride release from a glass ionomer cement	1977	Scand J Dent Res	University of Turku	154	3,28
32	Attar N, Tam LE, McComb D [42]	Mechanical and physical properties of contemporary dental luting agents	2003	J. Prosthet. Dent.	Hacettepe University	153	7,29
33	Lohbauer U [43]	Dental Glass Ionomer Cements as Permanent Filling Materials? - Properties, Limitations and Future Trends	2010	Materials	University of Erlangen Nuremberg	148	10,57
34	Hatibovickofman S, Koch G [44]	Fluoride release from glass ionomer cement invivo and invitro	1991	Swed. Dent. J.	University of Sarajevo	148	4,48
35	Li ZC, White SN [45]	Mechanical properties of dental luting cements	1999	J. Prosthet. Dent.	University of Southern California	147	5,88
36	Forsten L [46]	Fluoride release and uptake by glass ionomers	1991	Scand J Dent Res	University of Turku	145	4,39
37	Lee, KW et al. [47]	Adhesion of endodontic sealers to dentin and gutta-percha	2002	J. Endod.	University System of Georgia	144	6,55

38	Ahovuo-Saloranta A et al. [48]	Pit and fissure sealants for preventing dental decay in permanent teeth	2017	Cochrane Database Syst Rev.	Tampere University	143	20,43
39	Hickel R et al. [49]	Repair of restorations - Criteria for decision making and clinical recommendations	2013	Dent. Mater.	University of Munich	143	13,00
40	Xie D et al. [50]	Preparation and evaluation of a novel glass-ionomer cement with antibacterial functions	2011	Dent. Mater.	Indiana University System	143	11,00
41	Fujimoto Y et al. [51]	Detection of ions released from S-PRG fillers and their modulation effect	2010	Dent. Mater. J.	Nihon University	141	10,07
42	Inokoshi S et al. [52]	Opacity and color changes of tooth-colored restorative materials	1996	Oper. Dent.	Tokyo Medical & Dental University	141	5,04
43	Meyer JM et al. [53]	Compomers: between glass-ionomer cements and composites	1998	Biomaterials	University of Geneva	140	5,38
44	Forss H [54]	Release of fluoride and other elements from light-cured glass ionomers in neutral and acidic conditions	1993	J. Dent. Res.	University of Eastern Finland	140	4,52
45	Abdullah D et al. [55]	An evaluation of accelerated Portland cement as a restorative material	2002	Biomaterials	University of London	138	6,27
46	van Dijken JWV [56]	Clinical evaluation of three adhesive systems in class V non-carious lesions	2000	Dent. Mater.	Umea University	137	5,71
47	Smith DC [57]	Development of glass-ionomer cement systems	1998	Biomaterials	University of Toronto	137	5,27
48	Elsaka SE et al. [58]	Titanium dioxide nanoparticles addition to a conventional glass-	2011	J. Dent.	Egyptian Knowledge Bank	135	10,38

		ionomer restorative: Influence on physical and antibacterial properties					
49	Takahashi Y et al. [59]	Antibacterial effects and physical properties of glass-ionomer cements containing chlorhexidine for the ART approach	2006	Dent. Mater.	Osaka University	135	7,50
50	Quintas AF et al. [60]	Vertical marginal discrepancy of ceramic copings with different ceramic materials finish lines and luting agents: An in vitro evaluation	2004	J. Prosthet. Dent.	Universidade de Sao Paulo	132	6,60
51	Ngo HC *et al.* [61]	Chemical exchange between glass-ionomer restorations and residual carious dentine in permanent molars: An in vivo study	2006	J. Dent.	University of Adelaide	127	7,06
52	Walls AWG [62]	Glass polyalkenoate (glass-ionomer) cements - a review	1986	J. Dent.	Newcastle University - UK	127	3,34
53	Gorton J, Featherstone JDB [63]	In vivo inhibition of deraineralization around orthodontic brackets	2003	Am. J. Orthod. Dentofac. Orthop.	University of California San Francisco	125	5,95
54	Matsuya S et al. [64]	IR and NMR analyses of hardening and maturation of glass-ionomer cement	1996	J. Dent. Res.	Kyushu University	124	4,43
55	Zhi QH et al. [65]	Randomized clinical trial on effectiveness of silver diamine fluoride and glass ionomer in arresting dentine caries in preschool children	2012	J. Dent.	The University of Hong Kong Faculty of Dentistry	123	10,25

56	Burke FJT et al. [66]	Restoration longevity and analysis of reasons for the placement and replacement of restorations provided by vocational dental practitioners and their trainers in the United Kingdom	1999	Quintessence Int.	University of Glasgow	123	4,92
57	Wasson EA, Nicholson JW [67]	New aspects of the setting of glass-ionomer cements	1993	J. Dent. Res.	University of London	122	3,94
58	Auschill TM et al. [68]	The effect of dental restorative materials on dental biofilm	2002	Eur. J. Oral Sci.	University of Freiburg	121	5,50
59	Mount GJ [69]	Glass-ionomer cements - past, present and future	1994	Oper. Dent.	University of Adelaide	120	4,00
60	Tyas MJ, Burrow MF [70]	Adhesive restorative materials: A review	2004	Aust. Dent. J.	University of Melbourne	119	5,95
61	Maldonado A et al. [71]	Invitro study of certain properties of a glass ionomer cement	1978	J. Am. Dent. Assoc.	University of Central Venezuela	119	2,59
62	Ikemura K *et al.* [72]	A review of chemical-approach and ultramorphological studies on the development of fluoride-releasing dental adhesives comprising new pre-reacted glass ionomer (PRG) fillers	2008	Dent. Mater. J.	University System of Georgia	118	7,38
63	Tam LE et al. [73]	In vitro caries inhibition effects by conventional and resin modified glass ionomer restorations	1997	Oper. Dent.	University of Toronto	118	4,37
64	Dauvillier BS et al. [74]	Visco-elastic parameters of dental restorative materials during setting	2000	J. Dent. Res.	Academic Center for Dentistry Amsterdam	117	4,88

65	Benelli EM et al. [75]	In-situ anticariogenic potential of glass-ionomer cement	1993	Caries Res.	Universidade Estadual de Campinas	117	3,77
66	Hickel R et al. [76]	Longevity of occlusally-stressed restorations in posterior primary teeth	2005	Am. J. Dent.	University of Munich	115	6,05
67	Schafer E, Zandbiglari T [77]	Solubility of root-canal sealers in water and artificial saliva	2003	Int. Endod. J.	University of Munster	114	5,43
68	Attin T et al. [78]	Curing shrinkage and volumetric changes of resin-modifed glass ionomer restorative materials	1995	Dent. Mater.	University of Freiburg	113	3,90
69	Chisini LA et al. [79]	Restorations in primary teeth: a systematic review on survival and reasons for failures	2018	Int. J. Pediatr. Dent.	Universidade Federal de Pelotas	112	18,67
70	de Amorim RG et al. [80]	Survival of atraumatic restorative treatment (ART) sealants and restorations: a meta-analysis	2012	Clin. Oral Investig.	Radboud University Nijmegen	112	9,33
71	Creanor SL et al. [81]	Fluoride uptake and release characteristics of glass-ionomer cements	1994	Caries Res.	University of Glasgow	111	3,70
72	Montanaro L et al. [82]	Evaluation of bacterial adhesion of Streptococcus mutans on dental restorative materials	2004	Biomaterials	IRCCS Istituto Ortopedico Rizzoli	110	5,50
73	Kleverlaan CJ et al. [83]	Mechanical properties of glass ionomer cements affected by curing methods	2004	Dent. Mater.	Academic Center for Dentistry Amsterdam	109	5,45
74	Mejare I *et al*. [84]	Caries-preventive effect of fissure sealants: a systematic review	2003	Acta Odontol. Scand.	Malmo University	109	5,19

75	Friedman S et al. [85]	Evaluation of success and failure after endodontic therapy using a glass-ionomer cement sealer	1995	J. Endod.	Eberhard Karls University of Tubingen	109	3,76
76	Van Meerbeek B et al. [86]	Adhesives and cements to promote preservation dentistry	2001	Oper. Dent.	Universite Catholique Louvain	108	4,70
77	Randall RC, Wilson NHF [87]	Glass-ionomer restoratives: A systematic review of a secondary caries treatment effect	1999	J. Dent. Res.	University of Manchester	108	4,32
78	Moshaverinia A et al. [88]	Modification of conventional glass-ionomer cements with N-vinylpyrrolidone containing polyacids, nano-hydroxy and fluoroapatite to improve mechanical properties	2008	Dent. Mater.	University of London	107	6,69
79	Tyas MJ [89]	Cariostatic effect of glass ionomer cement - a 5-year clinical-study	1991	Aust. Dent. J.	University of Melbourne	107	3,24
80	Opdam NJM et al.[90]	Longevity and reasons for failure of sandwich and total-etch posterior composite resin restorations	2007	J. Adhes. Dent.	Radboud University Nijmegen	106	6,24
81	Retief DH et al. [91]	Enamel and cementum fluoride uptake from a glass ionomer cement	1984	Caries Res.	University of Alabama System	106	2,65
82	Itota T et al. [92]	Fluoride release and recharge in giomer, compomer and resin composite	2004	Dent. Mater.	Newcastle University - UK	105	5,25
83	Kontakiotis EG et al. [93]	Effect of sealer thickness on long-term sealing ability: a 2-year follow-up study	1997	Int. Endod. J.	Academic Center for Dentistry Amsterdam	105	3,89
84	Cattani-Lorente MA et al. [94]	Effect of water on the physical properties of resin-modified glass ionomer cements	1999	Dent. Mater.	University of Geneva	104	4,16

85	DeGee AJ et al. [95]	Early and long term wear of conventional and resin-modified glass ionomers	1996	J. Dent. Res.	Academic Center for Dentistry Amsterdam	104	3,71
86	DeMoor, RJG et al. [96]	Fluoride release profiles of restorative glass ionomer formulations	1996	Dent. Mater.	Ghent University	104	3,71
87	Breeding LC et al. [97]	Use of luting agents with an implant system .1.	1992	J. Prosthet. Dent.	University of Alabama System	104	3,25
88	Toledano M et al. [98]	Sorption and solubility of resin-based restorative dental materials	2003	J. Dent.	University of Granada	103	4,90
89	Frencken JE et al. [99]	ART restorations and glass ionomer sealants in Zimbabwe: survival after 3 years	1998	Community Dentist. Oral Epidemiol.	Radboud University Nijmegen	103	3,96
90	van Dijken JWV, Pallesen U [100]	Long-term dentin retention of etch-and-rinse and self-etch adhesives and a resin-modified glass ionomer cement in non-carious cervical lesions	2008	Dent. Mater.	Umea University	102	6,38
91	Frencken JE et al. [101]	Twenty-five-year atraumatic restorative treatment (ART) approach: a comprehensive overview	2012	Clin. Oral Investig.	Radboud University Nijmegen	101	8,42
92	Massara MLA et al. [102]	Atraumatic restorative treatment: Clinical, ultrastructural and chemical analysis	2002	Caries Res.	Universidade Federal de Minas Gerais	101	4,59
93	Keith S et al. [103]	Marginal discrepancy of screw-retained and cemented metal-ceramic crowns on implant abutments	1999	Int. J. Oral Maxillofac. Implants	Harvard University	100	4,00

94	Zhou HM et al. [104]	In Vitro Cytotoxicity Evaluation of a Novel Root Repair Material	2013	J. Endod.	Harbin Engineering University	99	9,00
95	Bachicha WS et al. [105]	Microleakage of endodontically treated teeth restored with posts	1998	J. Endod.	Northwestern University	99	3,81
96	Mcknighthanes C, Whitford GM [106]	Fluoride release from 3 glass ionomer materials and the effects of varnishing with or without finishing	1992	Caries Res.	University System of Georgia	98	3,06
97	Hauman CHJ, Love RM [107]	Biocompatibility of dental materials used in contemporary endodontic therapy: a review. Part 2. Root-canal-filling materials	2003	Int. Endod. J.	University of Otago	97	4,62
98	Brook IM, Hatton PV [108]	Glass-ionomers: bioactive implant materials	1998	Biomaterials	University of Sheffield	97	3,73
99	Guggenberger R et al. [109]	New trends in glass-ionomer chemistry	1998	Biomaterials	ESPE Dental-Medizin GmbH & Co.KG	97	3,73
100	Watts DC, Cash AJ [110]	Analysis of optical-transmission by 400-500 nm visible-light into aesthetic dental biomaterials	1994	J. Dent.	University of Manchester	97	3,23

3.1 Publications and citations of authors

The number of authors in the articles varied between 1 and 12 (average 3.65 ± 2.05), totalling 313 authors in the top 100 most cited articles on "Glass Ionomer Cement." The authors and co-authors with the highest number of publications, followed by their respective counts, are Frencken JE (4 articles), Lambrechts P (3 articles), Vanherle G (3 articles), Forsten I (3 articles), Feilzer AJ (3 articles), Burrow MF (3 articles), Davidson CL (3 articles), Pashley DH (3 articles), Forss H (3 articles). A total of 33 authors and co-authors appeared in two articles. The vast majority, 271 authors and co-authors, appeared in only one publication. Figure 2 shows a graphical representation of the network among the authors.

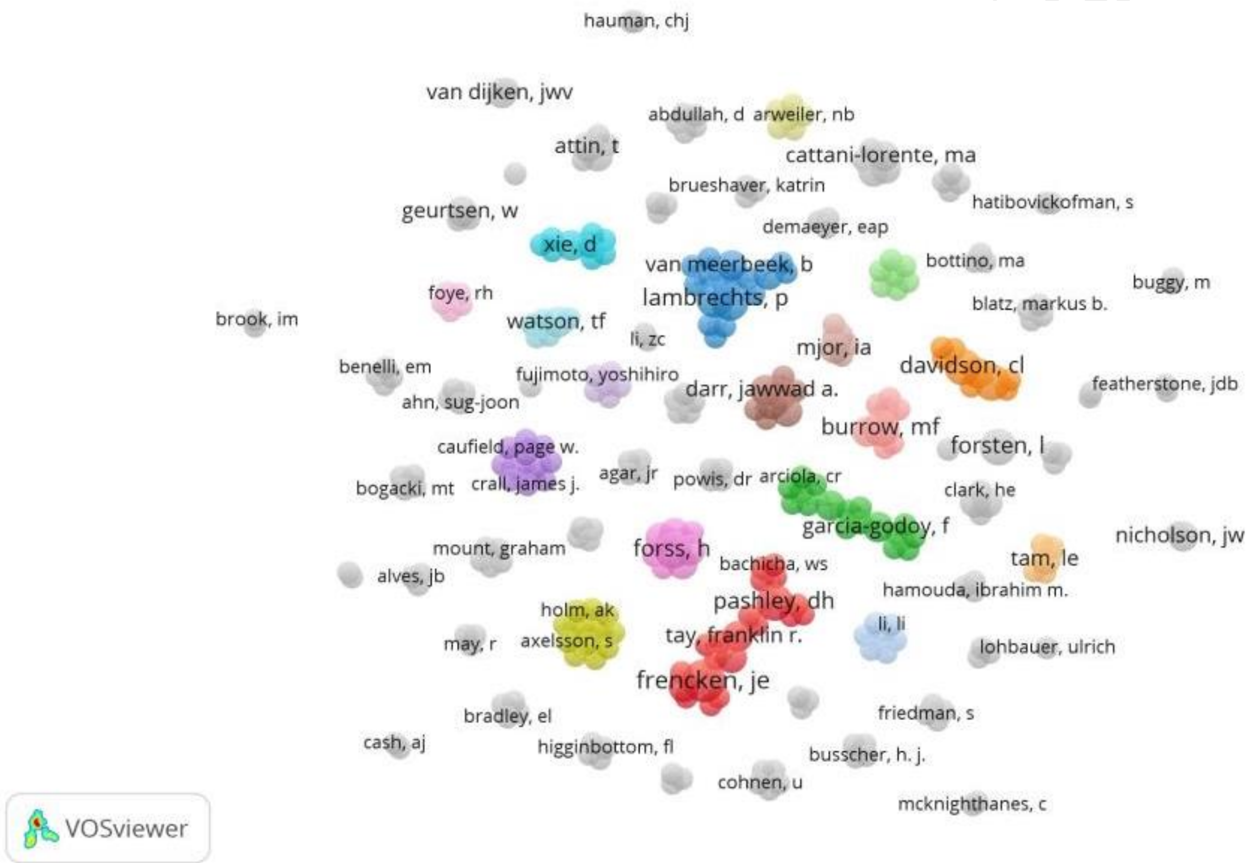

Figure 2. Network of authors and citations in the bibliometric research on "Glass Ionomer Cement". Circle sizes are related to the number of publications of each author and co-author.

"The most cited articles in the top 100 were led by Wiegand A and collaborators in 2007 [11], with a total of 547 citations, followed by Rosenstiel SF and collaborators in 1998 [12] with 330 citations, and Yoshida Y and collaborators in 2000 [13] with 329 citations for their article. The number of citations ranged from 97 to 547 (average 153.84 ± 70.36). Approximately 18 articles reached 201 citations or more (Table 1). The oldest manuscript in this bibliometric analysis was published in 1977 by Forsten, L [41] in the Scandinavian Journal of Dental Research (SJDR) and was cited 154 times, while the most recent was published in 2018 in the International Journal of

Paediatric Dentistry (IJPD) by Chisini LA and collaborators [79] and was cited 112 times.” [113]

Figure 3 shows the correlation between the number of citations and the publication year of the top 100 most cited articles in the area of glass ionomer cement. The citation distribution line peaks notably in 1998, with 1923 citations, representing the highest citations among the top 100 studies.

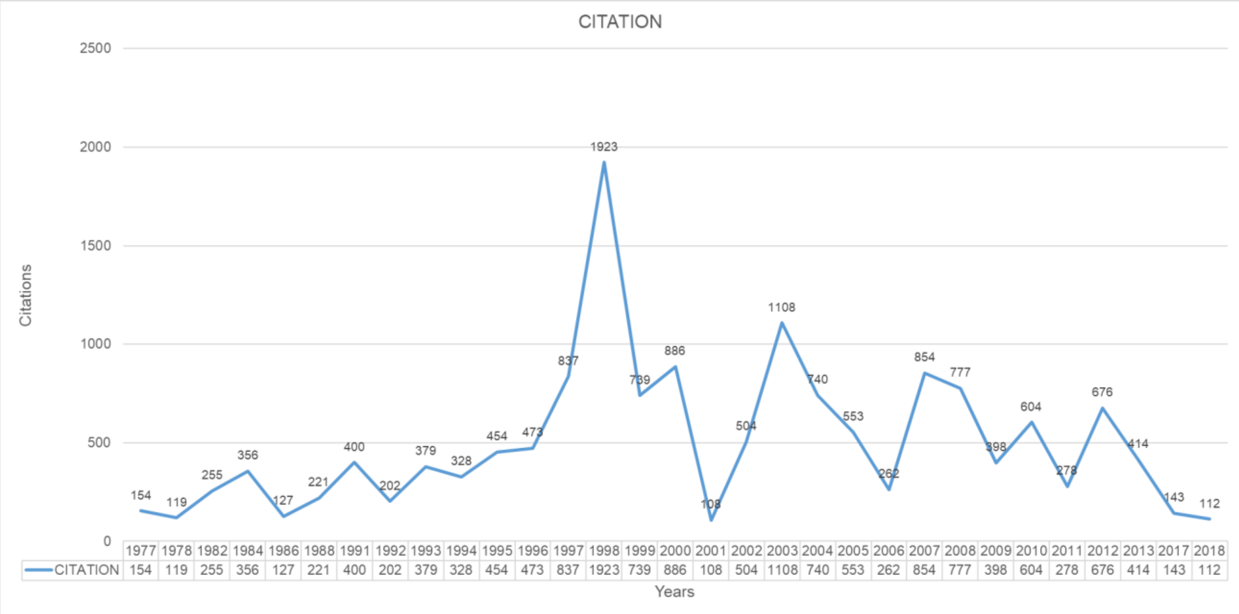

Figure 3. Correlation between the number of citations and the year of publication of the studies.

3.2 Institutions and countries

A total of 131 different institutions are associated with these studies. The University of Manchester and Medical College Georgia led the list with only 4 manuscripts published among the top 100 most cited; followed by Ohio State University, Umea University, University of São Paulo, Radboud University Nijmegen, King's College London, and University of Munich, each with 3 manuscripts. 21 institutions had 2 publications each, and the majority, 102 organizations, had only 1 manuscript published among the top 100 cited articles in the area of glass ionomer cement, as shown in Figure 4.

The studies originated from 25 different countries when considering only the location of the first author. The leading countries were the USA with 16 published manuscripts, followed by Germany and England with 13 articles each, the Netherlands with 10 articles, and Japan with 7 works among the top 100 articles, as evidenced in Figure 5. When considering the country of origin for all authors and co-authors, the number of countries increases to 32. In this case, the USA ranks first with 22 articles, followed by Germany with 14 articles, England with 12 articles, the Netherlands with 10 articles, and Japan with 7 articles published, as shown in Figure 6.

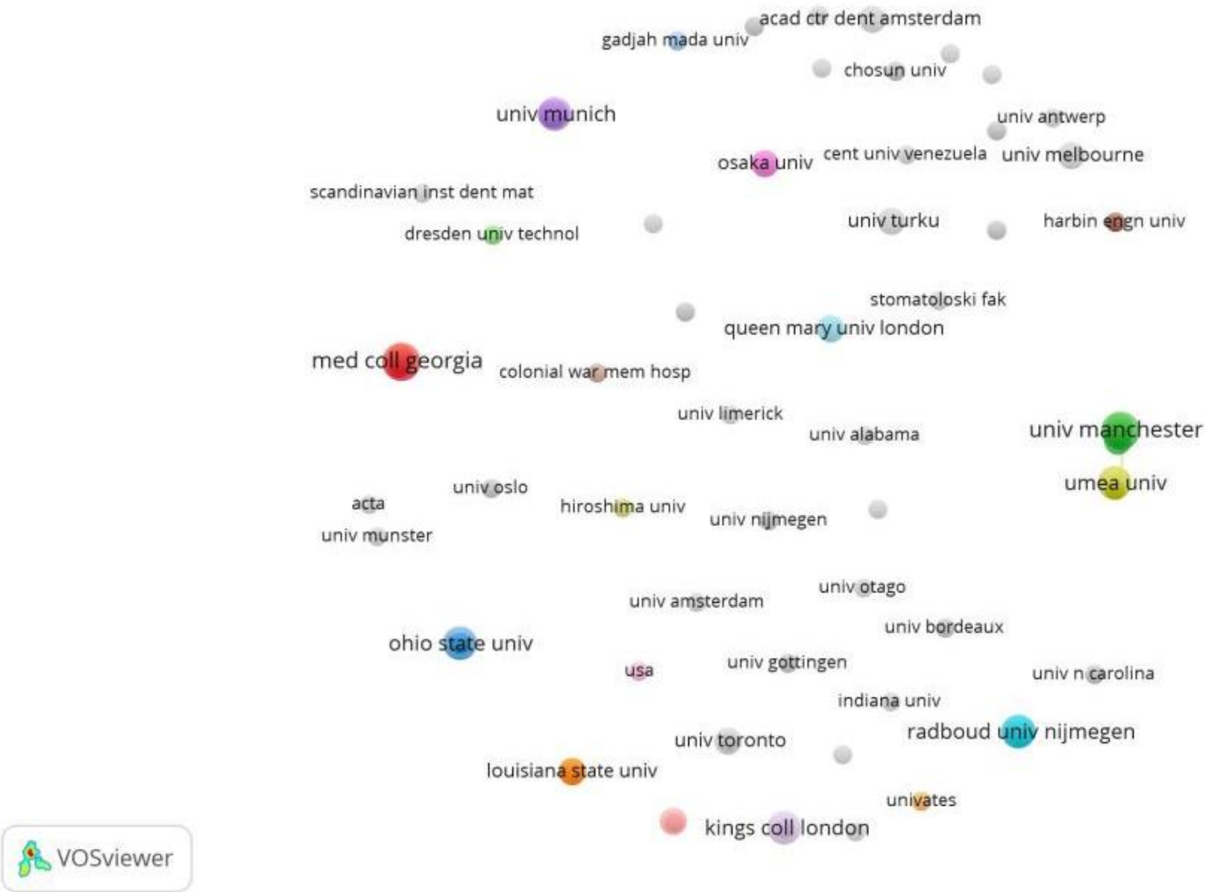

Figure 4. Correlation between institutions and number of publications in the studies. Circle sizes are related to the number of articles per institution.

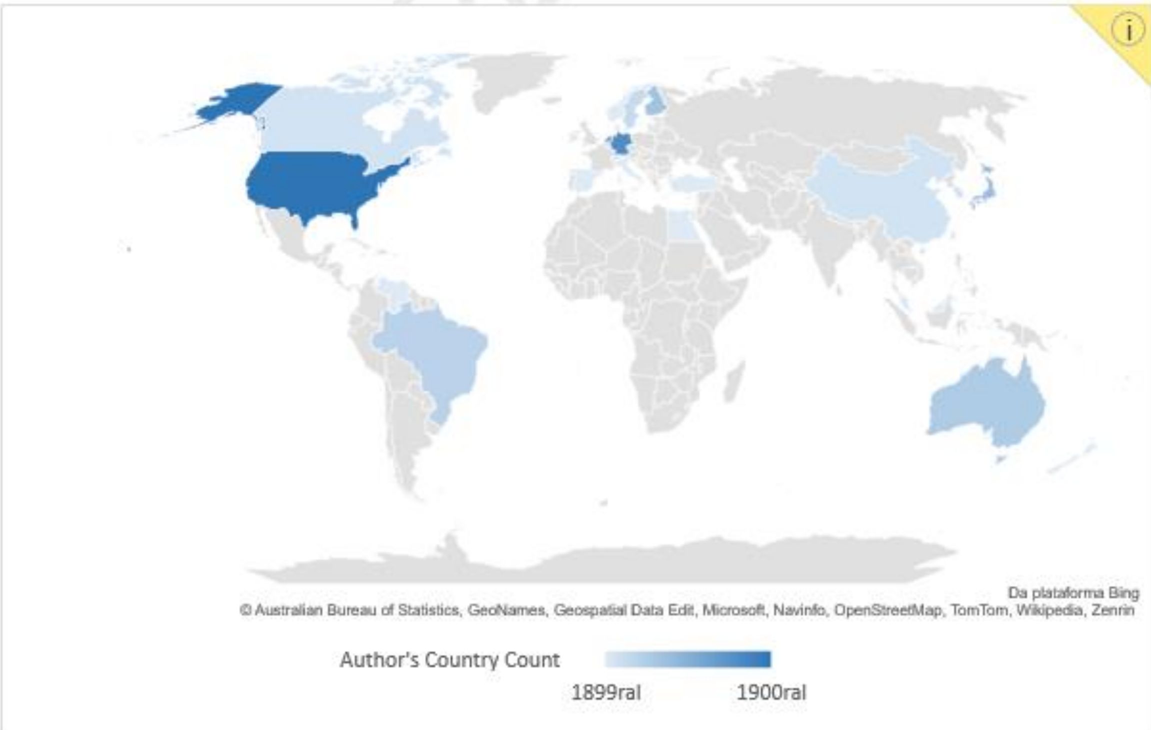

Figure 5. Countries of origin of the top 100 most cited articles.

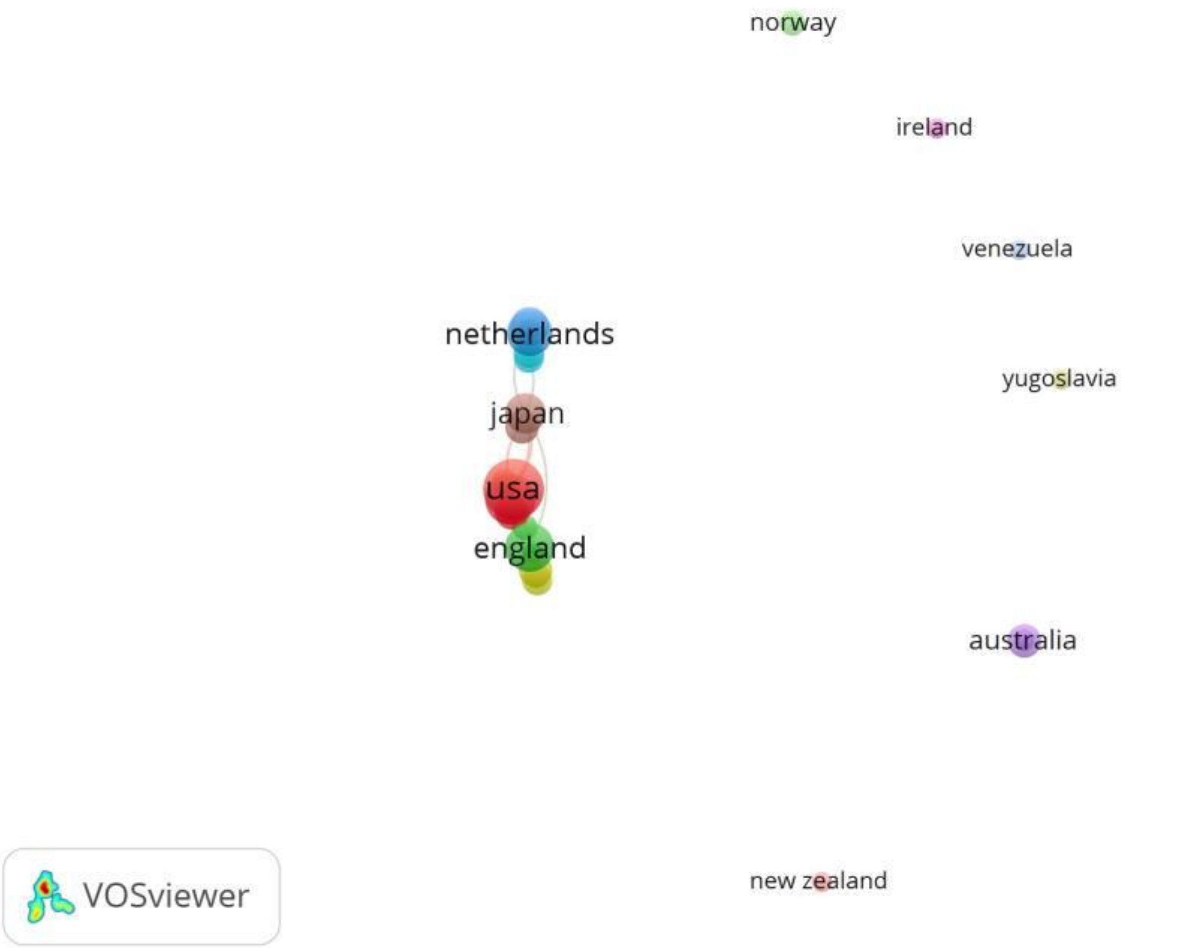

Figure 6. Analysis of the network of countries from the bibliometric research on "Glass Ionomer Cement". Circle sizes are related to the countries and their number of publications.

3.3 Journals

The top 100 most cited articles involving Glass Ionomer Cement were published in 27 different journals. Among the main journals, Dental Materials (DM) leads the ranking with 17 articles published, followed by the Journal of Dental Research (JDR) with 13 articles, and the Journal of Prosthetic Dentistry (JPD) with 10 articles, as shown in Figure 7. Table 1 contains the abbreviations for journals.

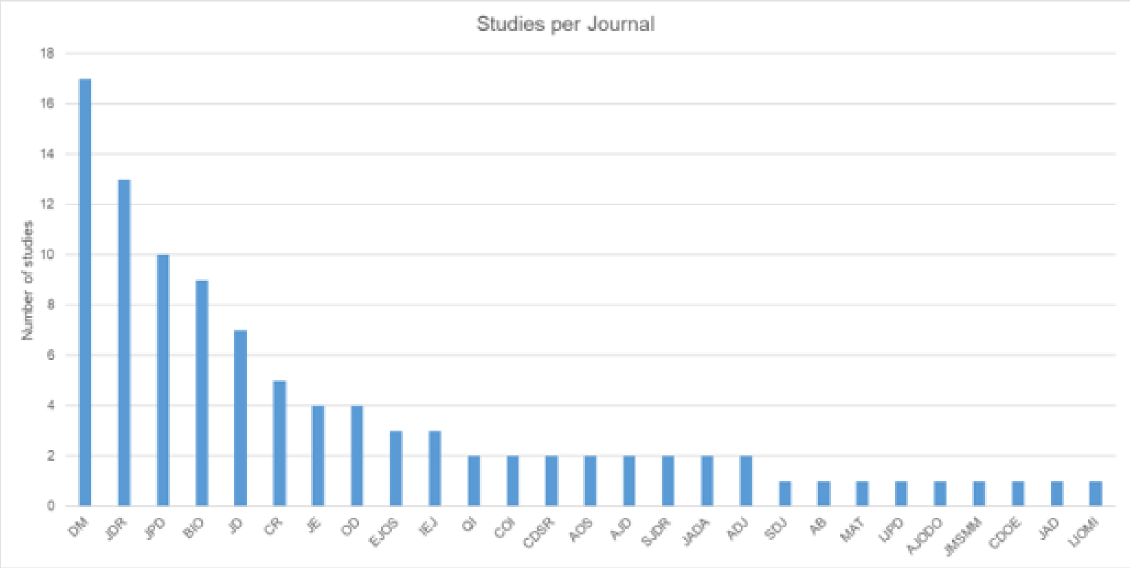

Figure 7. Number of studies published by Journals.

Table 2 – Abbreviation for the top 100 most cited journals on glass ionomer cement

JOURNAL	**ABBREVIATION FOR JOURNALS**
Dental Materias	DM
Journal of Prosthetic Dentistry	JPD
Journal of Dental Research	JDR
Biomaterials	BIO
Journal of The American Dental Association	JADA
Journal of Dentistry	JDR
European Journal of Oral Sciences	EJOS
Journal of Materials Science-Materials In Medicine	JMSMM
American Journal of Dentistry	AJD
Acta Odontologica Scandinavica	AOS
Quintessence International	QI
Cochrane Database of Systematic Reviews	CDSR
Acta Biomaterialia	AB
Scandinavian Journal of Dental Research	SJDR
Materials	MAT
Swedish Dental Journal	SDJ
Journal of Endodontics	JE
Operative Dentistry	OD
American Journal of Orthodontics and Dentofacial Orthopedics	AJODO
Australian Dental Journal	ADJ
Caries Research	CR
International Endodontic Journal	IEJ
International Journal of Paediatric Dentistry	IJPD
Clinical Oral Investigations	COI

Journal of Adhesive Dentistry	JADA
Community Dentistry and Oral Epidemiology	CDOE
International Journal of Oral & Maxillofacial Implants	IJOMI

The most represented publishers among the top 100 articles were Elsevier SCI LTD with 28 articles and Amer. Assoc. Dental Research with 8 articles published, as shown in Figure 8.

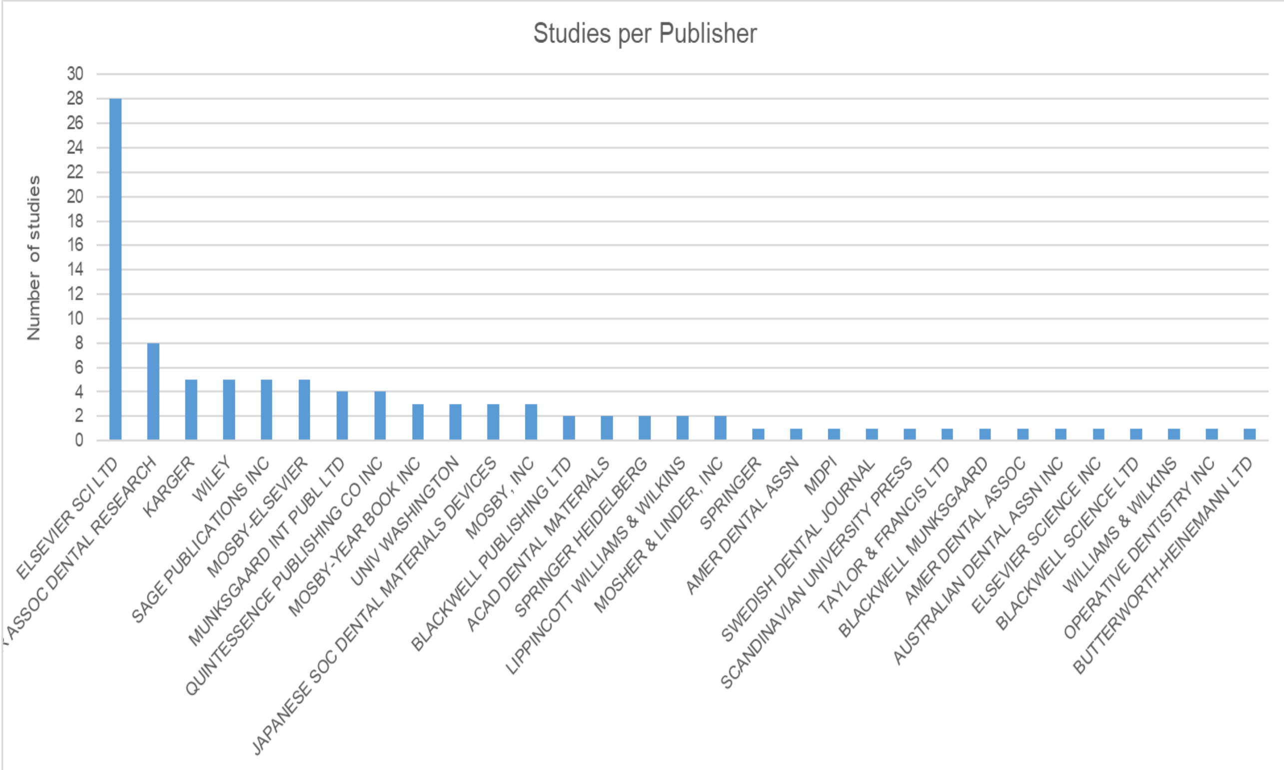

FIGURE 8. Number of studies published by Publishers of the top 100 most cited articles.

3.4 Keywords

"In total, 561 keywords were used. The most used keywords in this list of the top 100 articles were: Fluoride release (22 times), glass-ionomer cements (20 times), glass-ionomer cement (16 times), in-vitro (12 times), restorative materials (12 times), cements (12 times), glass-ionomer (11 times), resin (11 times), dentin (11 times) e adhesion (10 times). The most used keyword was repeated in 22 studies, and the frequency of keyword usage varied from 1 to 22 repetitions. Figure 9 shows a graphical representation in the form of a keyword map". [113]

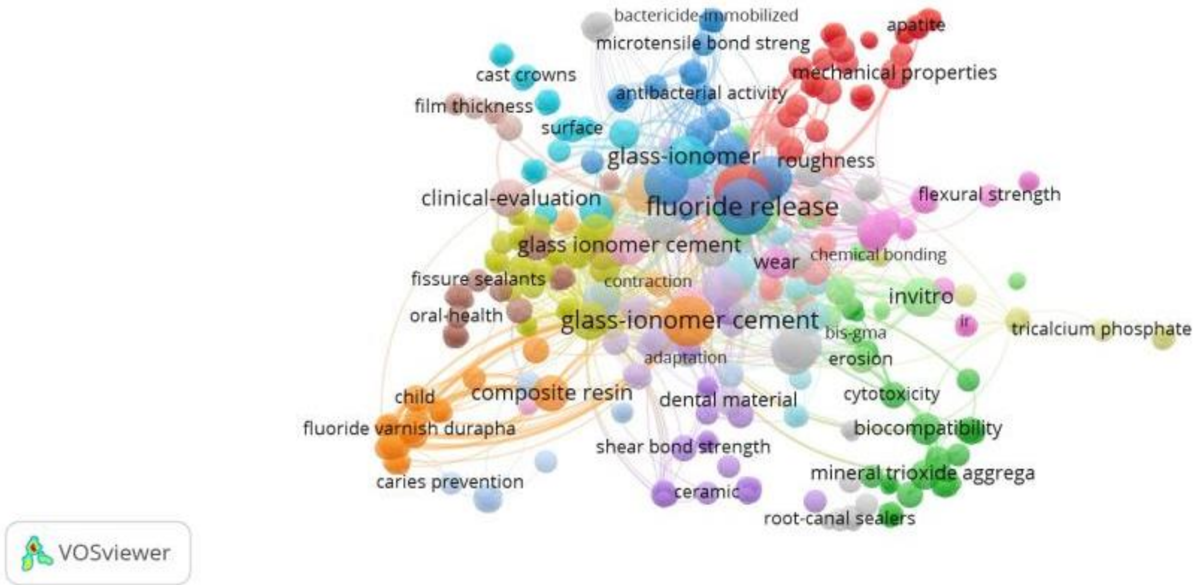

FIGURE 9. Keyword network analysis of the bibliometric research on "Glass Ionomer Cement". Circle sizes are proportional to the number of citations for each keyword used.

3.5 Temporal pattern of publications

Based on the distribution of 100 articles over the years, the period from 1998 to 2003 saw the highest concentration of publications, with 11 and 8 publications respectively, as shown in Figure 10.

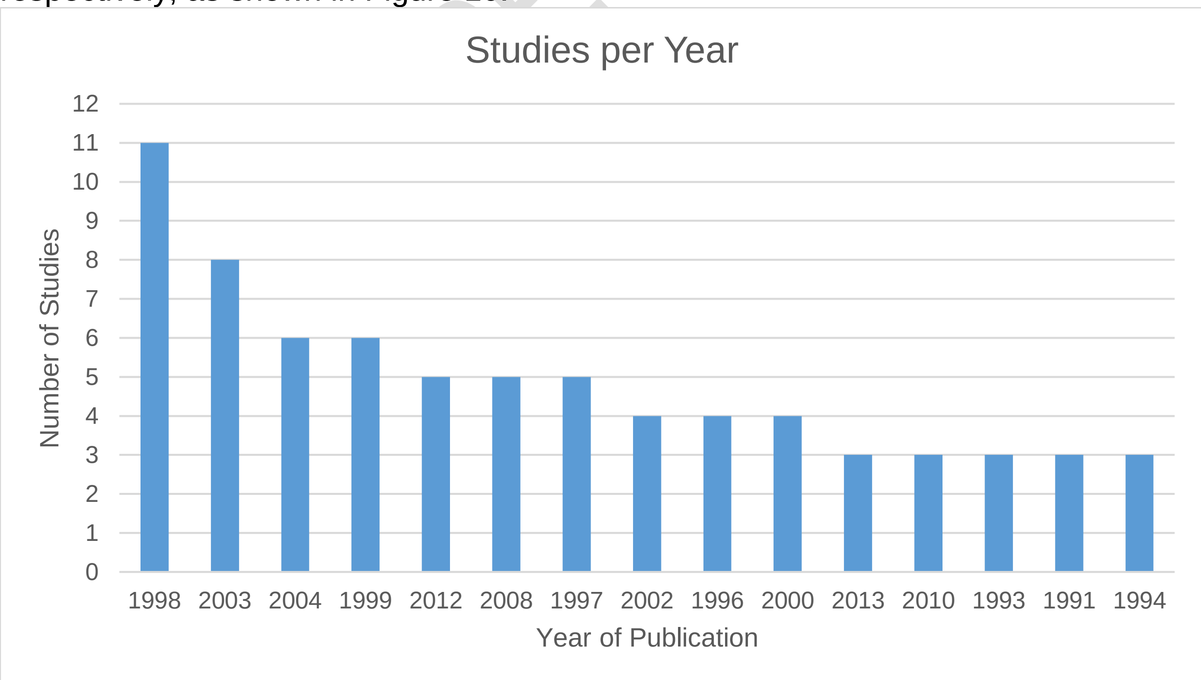

FIGURE 10. Temporal distribution of the top 100 most cited studies on "Glass Ionomer Cement" over the years.

4. DISCUSSION

Glass ionomer cement, due to its excellent properties, is considered one of the most versatile materials in dentistry, with applications in several areas, mainly in Pediatric Dentistry, which presents frequent needs for shorter treatments and with less sensitive application protocols [111]. In this way, glass ionomer cement (GIC) has been a subject of study in dentistry for over five decades and research is increasing aimed at improvements that guarantee greater resistance in the oral environment and longevity [9] in addition to improvements in the sense of being designed for be easy and quick to use without necessarily depending on an excellent finish or polishing, [111].

A bibliometric analysis of the top 100 articles on this constantly evolving material can provide valuable insights into the current state of research and emerging trends. The initial search revealed 5,186 articles in the Web of Science Clarivate Analytics database, contributing to comprehensive investigations into the properties and clinical performance of the material. This analysis highlights the relevance of GICs in dentistry, with various studies emphasizing their wide application and ongoing evolution, resulting in versatility that attracts the interest of dental researchers globally.

Research carried out over the years has maintained a consistent focus on improving the mechanical properties, clinical performance and biocompatibility of these materials, which entails extensive studies on GICs covering topics such as fluoride release, antibacterial activity, physical and mechanical resistance, longevity, adhesion, clinical efficacy, composition, contractions and biocompatibility.

The 100 most cited articles on GICs in dentistry, published between 1977 and 2018, represent a broad spectrum of studies that follow the substantial growth of research over time. Analysis of the distribution of these articles over these years highlights a particular increase in the years 1998 and 2003, shortly after the introduction of resin-modified glass ionomer cements into the dental market in the early 1990s. advantages of glass ionomer cements and composite resins, seeking a restorative material with good aesthetics, fluoride release, adhesion to the tooth, resistance and biocompatibility [23].

The evolution of GICs has gained notoriety due to its advantages, such as greater resistance and less sensitivity to humidity, as well as superior aesthetics [69]. This contributed to the proliferation of studies on GICs in dentistry, justifying the increase in scientific production during this period. Among the 100 most cited articles, the oldest was published in 1977 by Forsten L. in the Scandinavian Journal of Dental Research (SJDR) and has been cited 154 times. His study demonstrated that glass ionomer cement released more fluoride compared to silicate cement [41]. This finding was significant as fluoride release is crucial in caries prevention. The most recent article was published in 2018 in the International Journal of Paediatric Dentistry (IJPD) by Chisini and collaborators [79] and has been cited 112 times. More current articles were not found in this review, probably because these articles still have insufficient citations to enter this ranking of the top 100 most cited.

Among the 100 articles, the one that led the number of citations, with 547 citations, was the work of Wiegand, Buchalla and Attin [11], published in Dental Materials (DM), this is a review article, carried out on the basis of PubMed data with articles published from 1980 to 2004 that reviewed the fluoride releasing and recharging capabilities and the antibacterial properties of fluoride-releasing restoratives, discussing their effectiveness in preventing caries. They came to the conclusion that these materials, in laboratory studies, demonstrated cariostatic properties, however, it was not proven by clinical studies whether the incidence of secondary cavities could be reduced by the release of fluoride. Other articles received fewer citations, such as those by Hauman & Love [107], Brook & Hatton [108], Guggenberger and collaborators [109], and Watts & Cash [110], each with 97 citations. Regarding author relevance metrics in publications on the subject, two points can be considered: publishing a high number of articles or having highly cited publications [112]. Following this logic, Wiegand and colleagues [11] received the highest number of citations (547), standing out in the field of GIC research.

The investigation of the author co-citation network revealed little collaboration between authors, institutions and countries. A stronger network is essential for the advancement of research in the area, facilitating the exchange of experiences and perspectives. However, this collaboration was not widely used in research in the field of glass ionomer cement.

Among the institutions that produced the most, the University of Manchester and the Medical College of Georgia led with 4 manuscripts each, followed by Ohio State University, Umea University, University of São Paulo, Radboud University Nijmegen, King's College London, and University of Munich, each with 3 manuscripts. These data indicate where there was greater demand and research on the topic. However, these data do not reflect all the variants of information already described about GICs, due to different methods being employed in each publication, which can lead to different findings and learnings, but which are integrated.

The limitations of this publication include the choice of Web of Science Clarivate Analytics as the database, which may have omitted some relevant articles. Additionally, the difficulty of access to certain works for the academic community also limits the collection used. Self-citation may influence the total number of citations. The limitations of this publication are related to the choice of data structure for the study.

Therefore, the continuous growth of research on glass ionomer cements is evident, reflecting the quest for improvement and knowledge of these constantly evolving materials. However, it is important to consider that the ranking of the top 100 cited articles represents the current scenario, and due to constant scientific changes, future studies are needed to update reviews periodically.

5. CONCLUSION

The bibliometric analysis of the top 100 cited articles on glass ionomer cements (GICs) in dentistry demonstrates significant advancements in understanding and application of these materials over five decades. It underscores the relevance of GICs, highlighting their fluoride release properties, mechanical strength, antibacterial activity, and biocompatibility, which make them essential in dental practice. This analysis underscores the importance of periodic reviews and updates in the literature, promoting the dissemination of knowledge and continuous advancement in dental materials science.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Authors hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

6. REFERENCES

[1] Nicholson JW, Sidhu SK, Czarnecka B. Fluoride exchange by glass-ionomer dental cements and its clinical effects: a review. Biomaterial Investigations in Dentistry, 10(1); 2244982, 2023.

[2] Anusavice KJ et al. Phillips' science of dental materials. St. Louis, Mo.: Elsevier/Saunders, 2013.

[3] Lopes LELS, Tedesco TK, Calvo AFB, Imparato, JCP, Raggio DP, Mendes FM, Gimenes T. Is prior conditioning of dentin necessary in restoration with glass-ionomer cement? A systematic review and network meta-analysis. International Journal of Adhesion and Adhesives, 104;102748, 2021.

[4] Ge KX, Quock R, Chu CH, Yu OU. The preventive effect of glass ionomer cement restorations on secondary caries formation: A systematic review and meta-analysis. Dental Materials, 39(12); e1-e17, 2023.

[5] Souza MRP, Souza CLS, Lima TM. The use of different types of restorative glass ionomer cements used in clinical practice in class v cavities: literature review. Brazilian Journal of Development, 6(12): 97628–41, 2020.

[6] Oliveira GL et al. The Influence of Mixing Methods on the Compressive Strength and Fluoride Release of Conventional and Resin-Modified Glass Ionomer Cements. International Journal of Dentistry, 2019:1–7, 2019.

[7] Machado KDDS, Reges RV, Botelho TDL, Dos Santos FG. Effect of Handling and Powder and Liquid Proportion of Zinc Reinforced Glass Ionomer Cement on Surface Roughness Part 1. Revista Ciências e Odontologia, 3(1):20-24, 2019.

[8] Nicholson JW, Sidhu SK, Czarnecka B. Enhancing the mechanical properties of glass-ionomer dental cements: a review. Materials, 13(11):2510, 2020.

[9] Dornellas AP, Cavalcante KDT, Tedesco TK, Floriano I, Imparato JCP. Infraoccluded primary molar: Report of a case restored with encapsulated glass ionomer cement, one year of follow-up. Acta Biomedica Brasiliensia, 9(2):124-9, 2018.

[10] Soares PB, Carneiro TCJ, Calmon JL Castro LOCO. Bibliometric analysis of Brazilian scientific production on Construction Technology and Buildings in the Web of Science Database. Built Environment, Porto Alegre, 16(1):175- 85, 2016.

[11] Wiegand A, Buchalla W, Attin T. Review on fluoride-releasing restorative materials--fluoride release and uptake characteristics, antibacterial activity and influence on caries formation. Dent Mater, 23(3):343-62, 2007.

[12] Rosentiel, SF, Land MF, Crispin BJ. Dental luting agents: A review of the current literature. The Journal of Prosthetic Dentistry, 80(3):280-301, 1998.

[13] Yoshida Y et al. Evidence of Chemical Bonding at Biomaterial-Hard Tissue Interfaces. Journal of Dental Research, 79(2):709-714, 2000.

[14] Busscher HJ et al. Biofilm Formation on Dental Restorative and Implant Materials. Journal of Dental Research, 89(7):657-665, 2010.

[15] Nicholson JW. Chemistry of glass-ionomer cements: a review. Biomaterials, 19(6):485-494, 1998.

[16] Xie D et al. Mechanical properties and microstructures of glass-ionomer cements. Dental Materials, 16(2):129138, 2000.

[17] Beauchamp J et al. Evidence-Based Clinical Recommendations for the Use of Pit-and-Fissure Sealants. The Journal of the American Dental Association, 139(3):257-268, 2008.

[18] Bagheri R, Burrow MF, Tyas M. Influence of food-simulating solutions and surface finish on susceptibility to staining of aesthetic restorative materials. Journal of Dentistry, 33(5):389-398, 2005.

[19] Geurtsen W. Substances released from dental resin composites and glass ionomer cements. European Journal of Oral Sciences, 106(2): 687-695, 1998.

[20] Powis DR et al. Materials Science. Journal of Dental Research, 61(12):1416-1422, 1982.

[21] Swartz ML, Phillips RW, Clark HE. Long-term F Release from Glass Ionomer Cements. Journal of Dental Research, 63(2):158-160, 1984.

[22] Kenny SM, BUGGY M. Journal of Materials Science: Materials in Medicine, 14(11):923-938, 2003

[23] Sidhu SK, Watson TF. Resin-modified glass ionomer materials. A status report for the American Journal of Dentistry. American Journal of Dentistry, 8(1):59–67, 1995.

[24] Mjör IA. The reasons for replacement and the age of failed restorations in general dental practice. Acta Odontologica Scandinavica, 55(1):58-63, 1997.

[25] Gladys S et al. Comparative Physico-mechanical Characterization of New Hybrid Restorative Materials with Conventional Glass-ionomer and Resin Composite Restorative Materials. Journal of Dental Research, 76(4):883-94, 1997.

[26] Feilzer AJ, De gee AJ, Davidson CL. Curing contraction of composites and glass-ionomer cements. The Journal of Prosthetic Dentistry, 59(3):297-300, 1988.

[27] Imazato S. Bio-active restorative materials with antibacterial effects: new dimension of innovation in restorative dentistry. Dental Materials Journal, 28(1):11-9, 2009.

[28] Blatz MB et al. Influence of surface treatment and simulated aging on bond strengths of luting agents to zirconia. Quintessence International (Berlin, Germany: 1985), 38(9):745-753, 2007.

[29] forsten L. fluoride release and uptake by glass-ionomers and related materials and its clinical effect. biomaterials, 19(6):503-8, 1998.

[30] Ahn SJ et al. Experimental antimicrobial orthodontic adhesives using nanofillers and silver nanoparticles. Dental Materials, 25(2):206-13, 2009.

[31] Atmeh AR et al. Dentin-cement interfacial interaction: calcium silicates and polyalkenoates. Journal of Dental Research, 91(5):454-9, 2012.

[32] Ahovuo-saloranta A et al. Sealants for preventing dental decay in the permanent teeth. Cochrane Database of Systematic Reviews, 2013.

[33] Ernst CP et al. In vitro retentive strength of zirconium oxide ceramic crowns using different luting agents. The Journal of Prosthetic Dentistry, 93(6):551-8, 2005.

[34] Xu X, Burgess JO. Compressive strength, fluoride release and recharge of fluoride-releasing materials. Biomaterials, 24(14):2451–61, 2003.

[35] Agar JR et al. Cement removal from restorations luted to titanium abutments with simulated subgingival margins. The Journal of Prosthetic Dentistry, 78(1):43–7, 1997.

[36] Kopperud SE et al. Longevity of posterior dental restorations and reasons for failure. European Journal of Oral Sciences, 120(6):539–48, 2012.

[37] Moshaverinia A et al. Effects of incorporation of hydroxyapatite and fluoroapatite nanobioceramics into conventional glass ionomer cements (GIC). Acta Biomaterialia, 4(2):432–40, 2008.

[38] Piwowarczyk A, Lauer HC, Sorensen JA. In vitro shear bond strength of cementing agents to fixed prosthodontic restorative materials. The Journal of Prosthetic Dentistry, 92(3):265–73, 2004.

[39] Diaz-Arnold AM, Vargas MA, Haselton DR. Current status of luting agents for fixed prosthodontics. The Journal of Prosthetic Dentistry, 81(2):135–41, 1999.

[40] Geurtsen W, Spahl W, Leyhausen G. Residual Monomer/Additive Release and Variability in Cytotoxicity of Light-curing Glass-ionomer Cements and Compomers. Journal of Dental Research, 77(12):2012–19, 1998.

[41] Forsten L. Fluoride release from a glass ionomer cement. European Journal of Oral Sciences, 85(6):503–4, 1977.

[42] Attar N, Tam LE, Mccomb D. Mechanical and physical properties of contemporary dental luting agents. The Journal of Prosthetic Dentistry, 89(2):127–34, 2003.

[43] Lohbauer U. Dental Glass Ionomer Cements as Permanent Filling Materials? – Properties, Limitations and Future Trends. Materials, 3(1):76–96, 2009.

[44] Hatibović-kofman S, Koch G. Fluoride release from glass ionomer cement in vivo and in vitro. Swedish Dental Journal, 15(6):253–58, 1991.

[45] Lia ZC, White SN. Mechanical properties of dental luting cements. The Journal of Prosthetic Dentistry, 81(5):597–609, 1999.

[46] Forsten L. Fluoride release and uptake by glass ionomers. European Journal of Oral Sciences, 99(3):241–5, 1991.

[47] Lee K et al. Adhesion of Endodontic Sealers to Dentin and Gutta-Percha. Journal of Endodontics, 28(10):684–8, 2002.

[48] Ahovuo-Saloranta A et al. Pit and fissure sealants for preventing dental decay in permanent teeth. Cochrane Database of Systematic Reviews, 7(7), 2017.

[49] Hickel R, Brüshaver K, Ilie N. Repair of restorations – Criteria for decision making and clinical recommendations. Dental Materials, 29(1):28–50, 2013.

[50] Xie D et al. Preparation and evaluation of a novel glass-ionomer cement with antibacterial functions. Dental Materials, 27(5):487–96, 2011.

[51] Fujimoto Y et al. Detection of ions released from S-PRG fillers and their modulation effect. Dental materials journal, 29(4):392, 2010.

[52] Inokoshi S et al. Opacity and color changes of tooth-colored restorative materials. Operative Dentistry, 21(2):73–80, 1996.

[53] Meyer JM, Cattani-Lotente MA, Dupuis V. Compomers: between glass-ionomer cements and composites. Biomaterials, 19(6):529–39, 1998.

[54] Forss H. Release of Fluoride and Other Elements from Light-cured Glass Ionomers in Neutral and Acidic Conditions. Journal of Dental Research, 72(8):1257–62, 1993.

[55] Abdullah D et al. An evaluation of accelerated Portland cement as a restorative material. Biomaterials, 23(19):4001–10, 2002.

[56] Van Dijken JWV. Clinical evaluation of three adhesive systems in class V non-carious lesions. Dental Materials, 16(4):285–91, 2000.

[57] Smith DC. Development of glass-ionomer cement systems. Biomaterials, 19(6):467–78, 1998.

[58] Elsaka SE, Hamouda IM, Swain MV. Titanium dioxide nanoparticles addition to a conventional glass-ionomer restorative: Influence on physical and antibacterial properties. Journal of Dentistry, 39(9):589–98, 2011.

[59] Takahashi Y et al. Antibacterial effects and physical properties of glass-ionomer cements containing chlorhexidine for the ART approach. Dental Materials, 22(7):647–52, 2006.

[60] Quintas AF, Oliveira F, Bottino MA. Vertical marginal discrepancy of ceramic copings with different ceramic materials, finish lines, and luting agents: an in vitro evaluation. The Journal of Prosthetic Dentistry, 92(3):250–57, 2004.

[61] Ngo HC et al. Chemical exchange between glass-ionomer restorations and residual carious dentine in permanent molars: An in vivo study. Journal of Dentistry, 34(8):608–13, 2006.

[62] Walls AWG. Glass polyalkenoate (glass-ionomer) cements: a review. Journal of Dentistry, 14(6):231–46, 1986.

[63] Gorton J, Featherstone JDB. In vivo inhibition of demineralization around orthodontic brackets. American Journal of Orthodontics and Dentofacial Orthopedics, 123(1):10–4, 2003.

[64] Shigeki M, Maeda T, Ohta M. IR and NMR Analyses of Hardening and Maturation of Glass-ionomer Cement. Journal of Dental Research, 75(12):1920–7, 1996.

[65] Zhi QH, Lo ECM, Lin HC. Randomized clinical trial on effectiveness of silver diamine fluoride and glass ionomer in arresting dentine caries in preschool children. Journal of Dentistry, 40(11):962–7, 2012.

[66] Burke FJ et al. Restoration longevity and analysis of reasons for the placement and replacement of restorations provided by vocational dental practitioners and their trainers in the United Kingdom. Quintessence International (Berlin, Germany: 1985), 30(4):234–42, 1999.

[67] Wasson EA, Nicholson JW. New Aspects of the Setting of Glass-ionomer Cements. Journal of Dental Research, 72(2):481–3, 1993.

[68] Auschill TM et al. The effect of dental restorative materials on dental biofilm. European Journal of Oral Sciences, 110(1):48–53, 2002.

[69] Mount GJ. Buonocore Memorial Lecture. Glass-ionomer cements: past, present and future. Operative Dentistry, 19(3):82–90, 1994.

[70] Tyas MJ, Burrow MF. Adhesive restorative materials: a review. Aust Dent J.49(3):112-21; 2004.

[71] Maldonado A, Swartz ML, Phillips RW. An in vitro study of certain properties of a glass ionomer cement. 96(5):785–91, 1978.

[72] Ikemura K et al. A Review of Chemical-approach and Ultramorphological Studies on the Development of Fluoride-releasing Dental Adhesives Comprising New Pre-Reacted Glass Ionomer (PRG) Fillers. Dental Materials Journal, 27(3):315–39, 2008.

[73] Tam LE, Chan GP, Yim D. In vitro caries inhibition effects by conventional and resin-modified glass-ionomer restorations. Operative Dentistry, 22(1):4–14, 1997.

[74] Dauvillier BS et al. Visco-elastic Parameters of Dental Restorative Materials during Setting. Journal of Dental Research, 79(3):818–23, 2000.

[75] Benelli EM et al. In situ Anticariogenic Potential of Glass lonomer Cement. Caries Research, 27(4):280–4, 1993.

[76] Hickel R et al. Longevity of occlusally-stressed restorations in posterior primary teeth. American Journal of Dentistry, 18(3):198–211, 2005.

[77] Schäfer E, Zandbiglari T. Solubility of root-canal sealers in water and artificial saliva. International Endodontic Journal, 36(10):660–9, 2003.

[78] Attin T et al. Curing shrinkage and volumetric changes of resin-modified glass ionomer restorative materials. Dental Materials, 11(5-6):359–62, 1995.

[79] Chisini LA et al. Restorations in primary teeth: a systematic review on survival and reasons for failures. International Journal of Paediatric Dentistry, 28(2):123–39, 2018.

[80] De Amorim RG, Leal SC, Frencken J. E. Survival of atraumatic restorative treatment (ART) sealants and restorations: a meta-analysis. Clinical Oral Investigations, 16(2):429–41, 2011.

[81] Creanor SL et al. Fluoride Uptake and Release Characteristics of Glass lonomer Cements. Caries Research, 28(5):322–8, 1994.

[82] Montanaro L et al. Evaluation of bacterial adhesion of Streptococcus mutans on dental restorative materials. Biomaterials, 25(18):4457–63, 2004.

[83] Kleverlaan CJ, Van Duinen RNB, Feilzer AJ. Mechanical properties of glass ionomer cements affected by curing methods. Dental Materials, 20(1):45–50, 2004.

[84] Mejàre I et al. Caries-preventive effect of fissure sealants: a systematic review. Acta Odontologica Scandinavica, 61(6):321–30, 2003.

[85] Friedman S et al. Evaluation of success and failure after endodontic therapy using a glass ionomer cement sealer. Journal of Endodontics, 21(7):384–90, 1995.

[86] Van Meerbeek B et al. Adhesives and cements to promote preservation dentistry. Oper Dent. 2001;(Suppl 6):119–44.

[87] Randall RC, Wilson NHF. Restauradores de ionômero de vidro: Uma revisão sistemática do efeito do tratamento de cáries secundárias. Journal of Dental Research, 78(2):628–37, 1999.

[88] Alireza Moshaverinia et al. Modification of conventional glass-ionomer cements with N-vinylpyrrolidone containing polyacids, nano-hydroxy and fluoroapatite to improve mechanical properties. Dental Materials, 24(10):1381–90, 2008.

[89] Tyas MJ. Cariostatic effect of glass ionomer cement: a five-year clinical study. Australian Dental Journal, 36(3):236–9, 1991.

[90] Opdam NJM et al. Longevity and reasons for failure of sandwich and total-etch posterior composite resin restorations. The Journal of Adhesive Dentistry, 9(5):469–75, 2007.

[91] Retief DH et al. Enamel and Cementum Fluoride Uptake from a Glass Ionomer Cement. Caries Research, 18(3):250–7, 1984.

[92] Itota T et al. Fluoride release and recharge in giomer, compomer and resin composite. Dental Materials, 20(9):789–95, 2004.

[93] Kontakiotis EG, Wu MK, Wesselink PR. Effect of sealer thickness on long-term sealing ability: a 2-year follow-up study. International Endodontic Journal, 30(5):307–12, 2003.

[94] Cattani-Lorente MA et al. Effect of water on the physical properties of resin-modified glass ionomer cements. Dent Mater, 15(1):71–78, 1999.

[95] De Gee AJ et al. Early and long-term wear of conventional and resin-modified glass ionomers. Journal of Dental Research, 75(8):1613–619, 1996.

[96] De Moor RJG, Verbeeck RMH, De Maeyer EAP. Fluoride release profiles of restorative glass ionomer formulations. Dental Materials, 12(2):88–95, 1996.

[97] Breeding LC et al. Use of luting agents with an implant system: Part I. The Journal of Prosthetic Dentistry, 68(5):737–41, 1992.

[98] Toledano M et al. Sorption and solubility of resin-based restorative dental materials. Journal of Dentistry, 31(1):43–50, 2003.

[99] Frencken JE, Makoni F, Sithole WD. ART restorations and glass ionomer sealants in Zimbabwe: survival after 3 years. Community Dentistry and Oral Epidemiology, 26(6):372–81, 1998.

[100] Van Dijken JWV, Pallesen U. Long-term dentin retention of etch-and-rinse and self-etch adhesives and a resin-modified glass ionomer cement in non-carious cervical lesions. Dental Materials, 24(7):915–22, 2008.

[101] Frencken JE, Leal SC, Navarro MF. Twenty-five-year atraumatic restorative treatment (ART) approach: a comprehensive overview. Clinical Oral Investigations, 16(5):1337–46, 2012.

[102] Massara MLA, Alves JB, Brandão PRG. Atraumatic Restorative Treatment: Clinical, Ultrastructural and Chemical Analysis. Caries Research, 36(6):430–36, 2002.

[103] Keith SE et al. Marginal discrepancy of screw-retained and cemented metal-ceramic crowns on implants abutments. The International Journal of Oral & Maxillofacial Implants, 14(3):369–78, 1999.

[104] Zhou H et al. In vitro cytotoxicity evaluation of a novel root repair material. Journal of Endodontics, 39(4):478–83, 2013.

[105] Bachicha WS et al. Microleakage of endodontically treated teeth restored with posts. Journal of Endodontics, 24(11):703–08, 1998.

[106] Mcknight-Hanes C, Whitford GM. Fluoride Release from Three Glass Ionomer Materials and the Effects of Varnishing with or without Finishing. Caries Research, 26(5):345–50, 1992.

[107] Hauman CHJ, Love RM. Biocompatibility of dental materials used in contemporary endodontic therapy: a review. Part 2. Root-canal-filling materials. International Endodontic Journal, 36(3):147–60, 2003.

[108] Brook IM, Hatton PV. Glass-ionomers: bioactive implant materials. Biomaterials, 19(6):565–71, 1998.

[109] Guggenberger R, May R, Stefan KP. New trends in glass-ionomer chemistry. Biomaterials, 19(6): 479–83, 1998.

[110] Watts DC, Cash AJ. Analysis of optical transmission by 400-500 nm visible light into aesthetic dental biomaterials. Journal of Dentistry, 22(2):112–7, 1994.

[111] Machado CFA, Fernandes GVO, Fernandes JCH, Seabra M, Figueiredo A. Surface roughness of three different glass ionomers with or without finishing/polishing: an in vitro study. Int J Sci Dent., 2024;63(1):146-67.

[112] Chen Y, Yeung AWK, Pow EHN, Tsoi JKH. Current status and research trends of lithium disilicate in dentistry: A bibliometric analysis. J Prosthet Dent., 126(4):512-522, 2021.

[113] da Silva Torres A, Miranda AD, de Fátima Silva V, Martins OB, de Matos Torres M, Isolan CP, de Araújo CT. Bibliometric analysis of the 100 most cited articles on adhesive systems in dentistry. CONTRIBUCIONES A LAS CIENCIAS SOCIALES. 2024 May 8;17(5):e6724-.