

## TOP 50 MOST CITED ARTICLES ON ADHESIVE CEMENTATION IN DENTISTRY: A BIBLIOMETRIC ANALYSIS



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### ABSTRACT

In recent decades, adhesive cementing has undergone numerous transformations aimed at improving products. Adhesive cementation plays a key role in dentistry, offering high retention, fracture resistance, and longevity of restorations. With a wide diversity of applications in dental practice, its use is constantly growing. Due to the great technological and research advances, it is understood that these materials evolve even more, resulting in

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a more effective clinical practice. In view of this, it is essential to condense and evaluate this data in a skillful way. In these circumstances, literature review is an essential method for mapping the scientific landscape in a specific field of study, such as adhesive cementation. Thus, the present study conducted a bibliometric review of the 50 most cited articles on the subject. A pre-defined search with MESH terms was performed in the *Clarivate Analytics Web of Science database* in January 2024, using the terms (*Dental Cements OR Dental Cement OR Cements, Dental OR Cement, Dental OR Luting Agents OR Luting Agent OR Cementation OR Dental Bonding OR Bonding, Dental*) AND (*Dentistry*) AND (*Resin Cements OR Resin Cement OR Cements, Resin OR Cement, Resin*) in the title and/or abstract. Publications that evaluated adhesive cementation in the title and/or abstract were included, and publications that did not refer to the theme studied or that used the theme as a secondary subject were excluded. There were no restrictions regarding study design, year of publication, language, or journal impact factor. The most cited articles were manually analyzed, including information such as authors, number of citations, and institutions of the first author. The results obtained showed a great diversity of studies, with 74% of laboratory studies. The United States stands out with the largest number of publications evidencing the international relevance of the research area. These results suggest a crucial role of adhesive cementation in dental restorations. Most of the literature was conducted at the laboratory level. Given the importance and growing evolution of adhesive systems, bibliometric analysis can become a crucial mechanism in the selection and evaluation of the scientific literature produced in the search for better evidence.

**Keywords:** Adhesive cementation. Resin cements. Bibliometric analysis.

## INTRODUCTION

In the last 20 years, adhesive cementing has undergone numerous changes improving the quality of the products used. New cements have been introduced to the market due to improvements such as ease of use, reduction of steps, and time in clinical practice (Perdigão et al., 2021).

The most recent cementing materials developed for dental practice are resinous cements. These can be divided into adhesive or self-adhesive cements. When applying adhesive cements, the tooth must be previously conditioned and then the adhesive system must be applied, while in the use of self-adhesive cements, acid attack and application of adhesives are dispensable (Heboyan et al., 2023). Self-adhesive cements, in addition to excellent aesthetic aspect, have high mechanical properties, dimensional stability and micromechanical adhesion. In addition, they are considered moisture tolerant and release fluoride comparable to glass ionomer cements (Radovic et al., 2008).

Cementation materials are indicated for cementing crowns, inlays, onlays, veneers, fixed prostheses, endodontic pins and orthodontic appliances (Sakaguchi; Powers, 2011). Dental cements play a fundamental role in the cementation of indirect restorations because they aim to seal the space between the tooth and the restoration, in addition to increasing adhesion to the prepared tooth, preventing micro-infiltrations and cavities from occurring (Ribeiro et al., 2007).

Bibliometric analysis consists of a method of quantitative analysis of scientific research, including research in articles and journals, with the objective of analyzing and evaluating the index of academic production on the subject (Katz; Hicks, 1997). Thus, this work aims to collect and gather information from the top 50 most cited articles on adhesive cementation and to synthesize information from several primary studies, in order to provide the reader with a better understanding of adhesive cementation.

## METHODOLOGY

A bibliometric review on the topic of resin cements and adhesive cementation was carried out in the *Web of Science database of Clarivate Analytics*. As this is a review, this study does not require approval by the research ethics committee.

A search was performed on January 11, 2024, in the *Clarivate Analytics Web of Science* database, using the terms (*Dental Cements OR Dental Cement OR Cements, Dental OR Cement, Dental OR Luting Agents OR Luting Agent OR Cementation OR Dental*

*Bonding OR Bonding, Dental) AND (Dentistry) AND (Resin Cements OR Resin Cement OR Cements, Resin OR Cement, Resin)* in the title and/or abstract. The results were extracted from a table in Microsoft Excel software and organized in descending order of citation count. The paired selection of manuscripts was carried out by two researchers, AST and CPI, independently and previously calibrated.

The study sample included publications that mentioned resin cements evaluating adhesive cement in the title and/or abstract, and publications that did not refer to the theme studied or that were using the theme as a secondary subject were excluded. There was no restriction regarding the study design, year of publication, language, or journal impact factor of the manuscripts.

The most cited articles were manually stratified according to information retrieved from the *Clarivate Analytics Web of Science database*, such as: year of publication, authors, number of citations, journals, keywords, contributing institution, country, among others. The address provided to the first author was used to define the country of origin and the contributing institution of the article.

The relationship between the authors is determined based on the number of times they cite each other, using a network visualization made with the *VOSviewer* software (Leiden University, Netherlands).

## RESULTS

The initial search identified 8,895 articles in the *Web of Science* database. After comparing titles and abstracts, the 50 most cited manuscripts involving resinous cements and adhesive cementation are listed in order of rank 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 shown in Figure 1.

FIGURE 1. Flowchart of the study selection process and search strategy for the top 50 in resin cements and adhesive cementation.

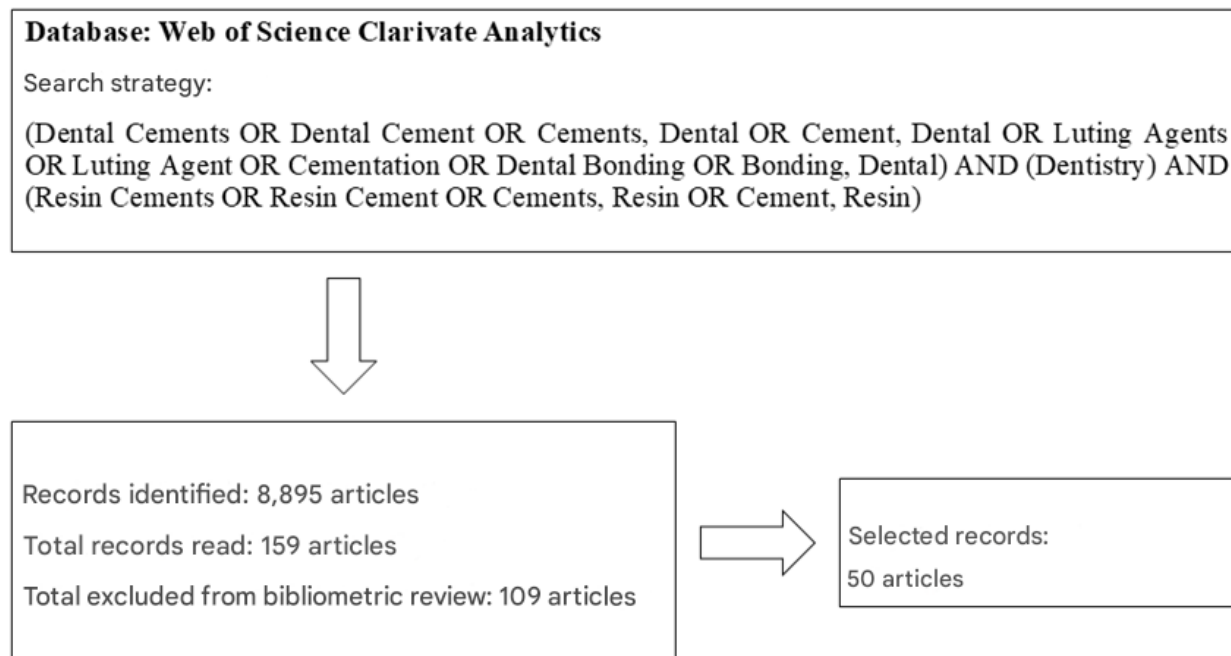


TABLE 1. Ranking of the most cited articles on resin cements and adhesive cementation in dentistry

Ranking	Autores	Títulos	Ano de publicação	Jornais	Instituições	Citações	Média de citações /Ano	Tipo de estudo
1	Özcan, M; Vallittu, PK	Effect of surface conditioning methods on the bond strength of luting cement to ceramics	2003	DM	University of Groningen	482	22,95	Laboratory test
2	Raigrodski, AJ et al.	The efficacy of posterior three-unit zirconium-oxide-based ceramic fixed partial dental prostheses: A prospective clinical pilot study	2006	JPD	University of Washington	389	21,61	Clinical trial
3	Goracci, C et al.	The adhesion between fiber posts and root canal walls. comparison between microtensile and push-out bond strength measurements	2004	EJOS	University of Siena	373	18,65	Laboratory test
4	Bouillaguet, S et al.	Microtensile bond strength between adhesive cements and root canal dentin	2003	DM	University of Geneva	363	17,29	Laboratory test
5	Rosenstiel, SF; Land, MF; Crispin, BJ	Dental luting agents: A review of the current literature	1998	JPD	Ohio State University College of Dentistry	332	12,77	Literature review
6	Wolfart, M et al.	Durability of the resin bond strength to zirconia ceramic after using different surface conditioning methods	2007	DM	University at Kiel	323	19,00	Laboratory test
7	Radovic, I et al.	Self-adhesive resin cements: A literature review	2008	JAD	University of Belgrade	313	19,56	Literature review
8	Özcan, M; Bernasconi, M	Adhesion to Zirconia Used for Dental Restorations: A Systematic Review and Meta-Analysis	2015	JAD	University of Groningen	312	34,67	Systematic review and meta-analysis
9	Ferracane, JL; Stansbury, JW; Burke, FJT	Self-adhesive resin cements - chemistry, properties and clinical considerations	2011	JOR	Oregon Health & Science University	284	21,85	Literature review
10	Atsu, SS et al.	Effect of zirconium-oxide ceramic surface treatments on the bond strength to adhesive resin	2006	JPD	Kirikkale University	277	15,39	Laboratory test
11	Lüthy, H; Loeffel, O; Hammerle, CHF	Effect of thermocycling on bond strength of luting cements to zirconia ceramic	2006	DM	University of Zurich	253	14,06	Laboratory test
12	Aboushellib, MN; Kleverlaan, CJ; Feilzer, AJ	Selective infiltration-etching technique for a strong and durable bond of resin cements to zirconia-based materials	2007	JPD	Academic Center for Dentistry Amsterdam	240	14,12	Laboratory test

13	Hikita, K et al.	Bonding effectiveness of adhesive luting agents to enamel and dentin	2007	DM	Catholic University of Leuven	239	14,06	Laboratory test
14	Kern, M; Barloj, A; Yang, B	Surface Conditioning Influences Zirconia Ceramic Bonding	2009	JDR	Christian-Albrechts University at Kiel	225	15,00	Laboratory test
15	Inokoshi, M et al.	Meta-analysis of Bonding Effectiveness to Zirconia Ceramics	2014	JDR	University of Leuven	223	22,30	Systematic review and meta-analysis
16	Dérand, P; Dérand, T	Bond strength of luting cements to zirconium oxide ceramics	2000	IJP	Public Dental Service	218	9,08	Laboratory test
17	Braga, RR et al.	Adhesion to tooth structure: A critical review of macro test methods	2010	DM	University of São Paulo School of Dentistry	217	15,50	Literature review
18	Pest, LB et al.	Adhesive post-endodontic restorations with fiber posts: push-out tests and SEM observations	2002	DM	University of Milan, Milan	217	9,86	Laboratory test
19	Goracci, C; Ferrari, M	Current perspectives on post systems: a literature review	2011	ADJ	University of Florence and Siena	215	16,54	Literature review
20	Blatz, MB et al.	Influence of surface treatment and simulated aging on bond strengths of luting agents to zirconia	2007	QI	University of Pennsylvania a School of Dental Medicine	204	12,00	Laboratory test
21	Tian, T et al.	Aspects of bonding between resin luting cements and glass ceramic materials	2014	DM	University of Hong Kong	200	20,00	Literature review
22	Derand, T; Molin, M; Kvam, K	Bond strength of composite luting cement to zirconia ceramic surfaces	2005	DM	Malmö University	194	10,21	Laboratory test
23	Monticelli, F et al.	Limited decalcification/diffusion of self-adhesive cements into dentin	2008	JDR	University of Granada	186	11,63	Laboratory test
24	Amaral, R et al.	Microtensile bond strength of a resin cement to glass infiltrated zirconia-reinforced ceramic: The effect of surface conditioning	2006	DM	São Paulo State University	184	10,22	Laboratory test
25	Yang, B; Barloj, A; Kern, M	Influence of air-abrasion on zirconia ceramic bonding using an adhesive composite resin	2010	DM	Christian-Albrechts University at Kiel	180	12,86	Laboratory test
26	Kopperud, SE et al.	Longevity of posterior dental restorations and reasons for failure	2012	EJOS	University of Oslo	170	14,17	Clinical trial
27	Özcan, M; Nijhuis, H; Valandro, LF	Effect of various surface conditioning methods on the adhesion of dual-cure resin cement with MDP functional monomer to zirconia after thermal aging	2008	DMJ	University Medical Center Groningen	168	10,50	Laboratory test
28	de Oyagüe, RC et al.	Influence of surface treatments and resin cement selection on bonding to densely-sintered zirconium-oxide ceramic	2009	DM	University Complutense of Madrid	166	11,07	Laboratory test
29	Piwowarczyk, A; Lauer, HC; Sorensen, JA	In vitro shear bond strength of cementing agents to fixed prosthodontic restorative materials	2004	JPD	Johann Wolfgang Goethe University	166	8,30	Laboratory test
30	Krämer, N; Lohbauer, U; Frankenberger, R	Adhesive luting of indirect restorations	2000	AJD	University of Erlangen-Nuremberg	163	6,79	Literature review
31	Matinlinna, JP et al.	Evaluation of resin adhesion to zirconia ceramic using some organosilanes	2006	DM	NiOM-Nordic Institute of Dental Materials	162	9,00	Laboratory test
32	Schmidlin, PR et al.	Effect of different surface pre-treatments and luting materials on shear bond strength to PEEK	2010	DM	University of Zurich	161	11,50	Laboratory test
33	Bitter, K et al.	Effects of luting agent and thermocycling on bond strengths to root canal dentine	2006	IEJ	University School of Dental Medicine	160	8,89	Laboratory test
34	Xu, HHK; Quinn, JB	Calcium phosphate cement containing resorbable fibers for short-term reinforcement and macroporosity	2002	B	Paffenbarger Research Center	158	7,18	Laboratory test

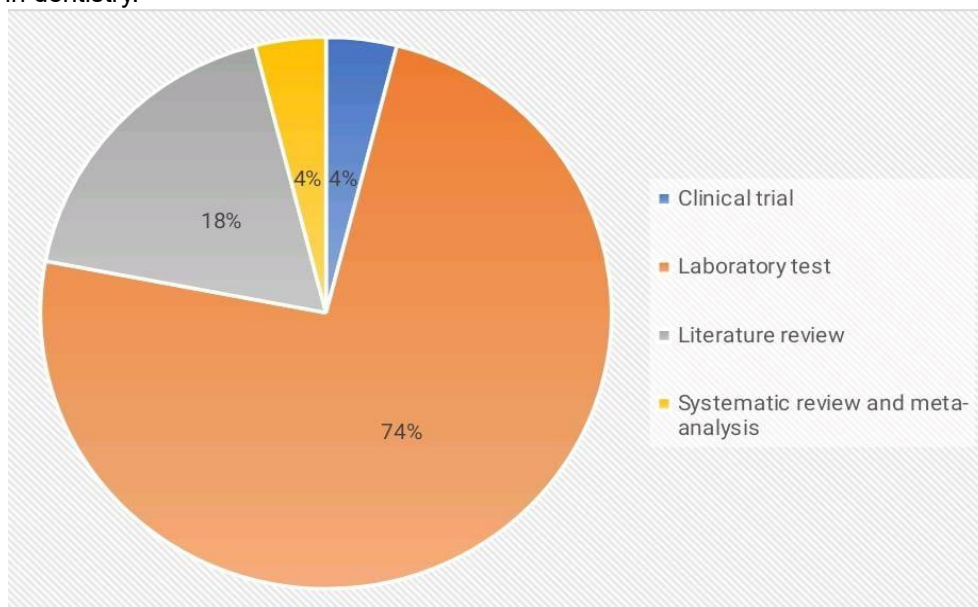


35	LUTZ, F; KREJCI, I; BARBAKOW, F	Quality and durability of marginal adaptation in bonded composite restorations	1991	DM	Zurich University	158	4,79	Laboratory test
36	Goracci, C et al.	Microtensile bond strength and interfacial properties of self-etching and self-adhesive resin cements used to lute composite onlays under different seating forces	2006	JAD	University of Florence and Siena	152	8,44	Laboratory test
37	Ferrari, M; Vichi, A; Grandini, S	Efficacy of different adhesive techniques on bonding to root canal walls: an SEM investigation	2001	DM	University of Siena	152	6,61	Laboratory test
38	Magne, P; Paranhos, MPG; Burnett, LH	New zirconia primer improves bond strength of resin-based cements	2010	DM	University of Southern California	149	10,64	Laboratory test
39	Qeblawi, DM et al.	The effect of zirconia surface treatment on flexural strength and shear bond strength to a resin cement	2010	JPD	State University of New York at Buffalo	148	10,57	Laboratory test
40	Abo-Hamar, SE et al.	Bond strength of a new universal self-adhesive resin luting cement to dentin and enamel	2005	COI	University of Regensburg	148	7,79	Laboratory test
41	Goracci, C et al.	Evaluation of the adhesion of fiber posts to intraradicular dentin	2005	OD	University of Florence and Siena	148	7,79	Laboratory test
42	Shimada, Y; Yamaguchi, S; Tagami, J	Micro-shear bond strength of dual-cured resin cement to glass ceramics	2002	DM	Tokyo Medical and Dental University	147	6,68	Laboratory test
43	Blatz, MB; Vonderheide, M; Conejo, J	The Effect of Resin Bonding on Long-Term Success of High-Strength Ceramics	2018	JDR	University of Pennsylvania School of Dental Medicine	144	24,00	Literature review
44	Attia, A et al.	Fracture load of composite resin and feldspathic all-ceramic CAD/CAM crowns	2006	JPD	Mansoura University	142	7,89	Laboratory test
45	Bitter, K; Kielbassa, AM	Post-endodontic restorations with adhesively luted fiber-reinforced composite post systems: A review	2007	AJD	University School of Dental Medicine	141	8,29	Literature review
46	Goracci, C et al.	The adhesion between prefabricated FRC posts and composite resin cores: microtensile bond strength with and without post-silanization	2005	DM	University of Florence and Siena	138	7,26	Laboratory test
47	Cavalcanti, AN et al.	Bond Strength of Resin Cements to a Zirconia Ceramic with Different Surface Treatments	2009	OD	UNICAMP	137	9,13	Laboratory test
48	Aboushelib, MN et al.	Innovations in bonding to zirconia-based materials: Part I	2008	DM	Department of Dental Materials Science	137	8,56	Laboratory test
49	Brentel, AS et al.	Microtensile bond strength of a resin cement to feldspathic ceramic after different etching and silanization regimens in dry and aged conditions	2007	DM	São Paulo State University	135	7,94	Laboratory test
50	Aksornmuang, J et al.	Microtensile bond strength of a dual-cure resin core material to glass and quartz fibre posts	2004	JD	Tokyo Medical and Dental University	134	6,70	Laboratory test

## TYPES OF STUDY, PUBLICATIONS, AND AUTHOR CITATIONS

It was found in the types of studies of the most cited articles in the area of resin cements and adhesive cementation in dentistry that 74% of these manuscripts are laboratory studies, 18% are literature reviews, and only 4% are clinical studies and systematic reviews and meta-analyses, as shown in Figure 2.

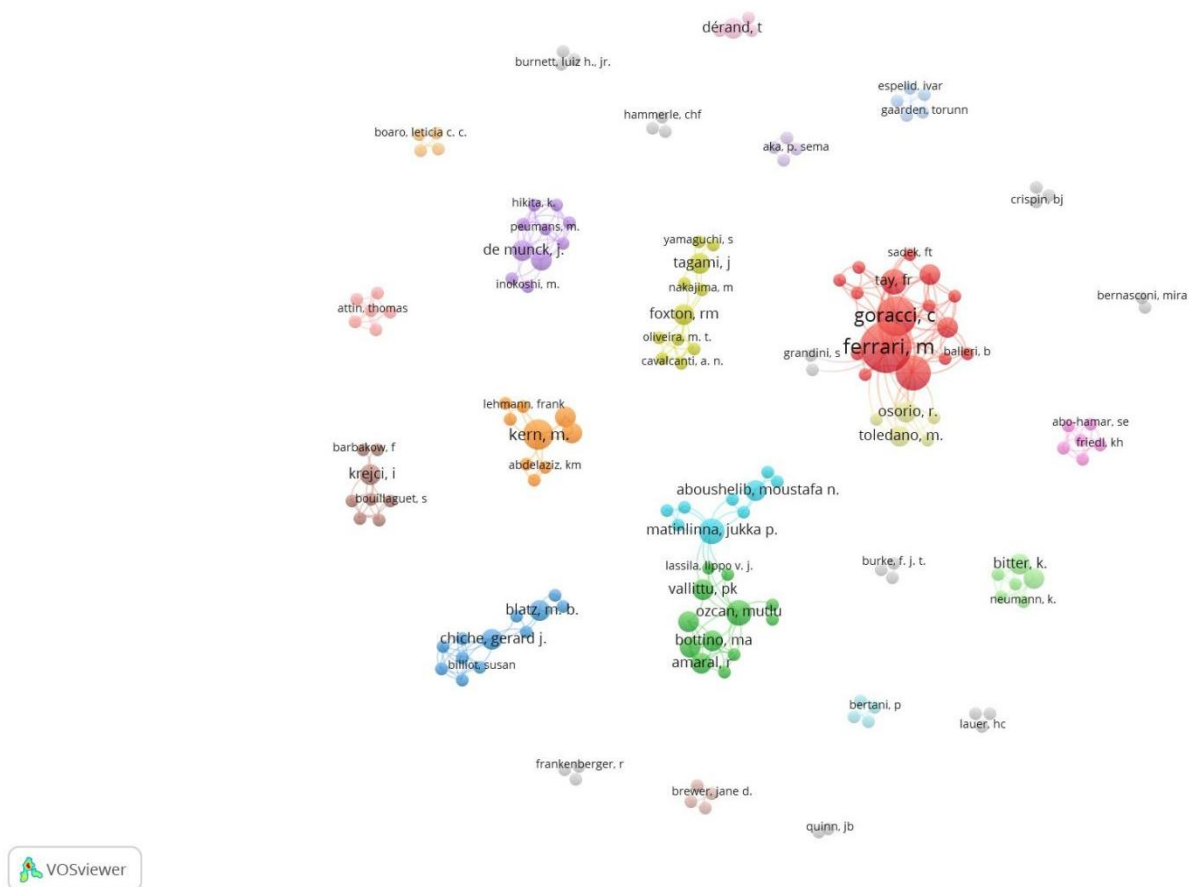
FIGURE 2. Types of studies of the 50 most cited articles in the area of resin cements and adhesive cementation in dentistry.



The number of authors and co-authors in the articles ranged from 2 to 8 (mean  $4.14 \pm 1.56$ ), taking into account that they may be repeated in one or more manuscripts. In total, 159 authors and co-authors were found in the 50 most cited articles on Resin cement and adhesive cementation in Dentistry. The authors and co-authors with the highest number of publications, followed by their respective scores, Ferrari M appeared in (9 articles), Goracci C (6 articles), Monticelli F (5 articles), Kern M (4 articles) and Tay FR (3 articles). About 130 authors and co-authors appeared in just one article. Figure 3 shows a graphic representation of the network between the authors and co-authors in the articles, showing few lines connecting them, showing little relationship between them.



FIGURE 3. Network of authors and co-authors. The size of the circles is related to the frequency at which they appear.



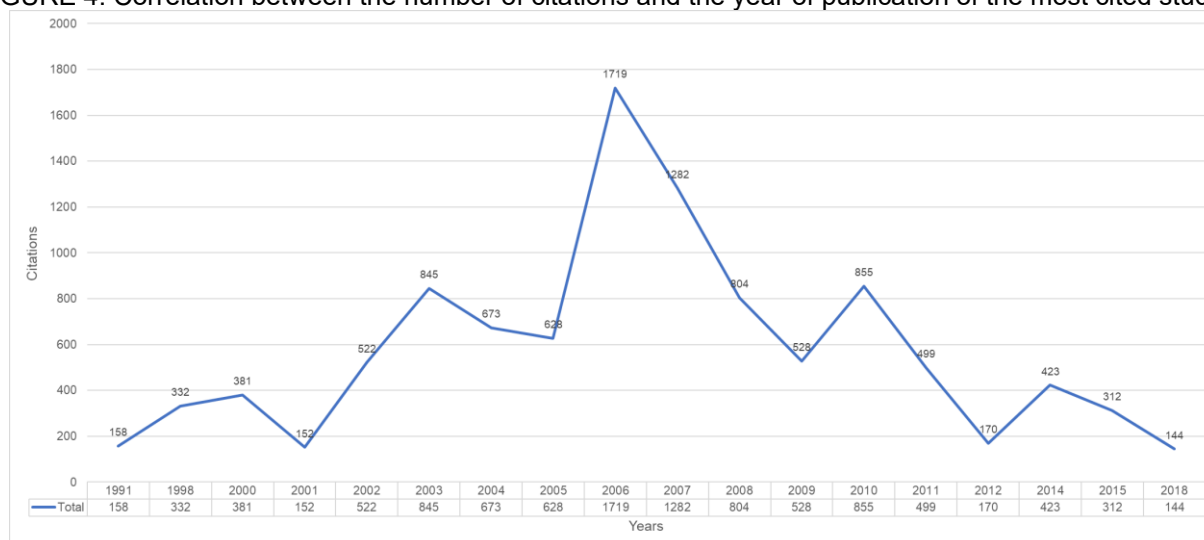
The most cited articles in the top 50 were in first position Özcan M and Vallittu, PK in 2003 with a total of 482 citations, followed by Raigrodski AJ and collaborators in 2006 with 389 citations, Goracci C and collaborators in 2004 with 373 citations, and Bouillaguet S et al. in 2003 with 363 citations. The number of citations ranged from 134 to 482 (mean  $208.54 \pm 79.56$ ). Around 8 articles reached 300 or more citations, in addition, all articles had more than 100 citations (Table 1).

One manuscript was the oldest in this bibliometric analysis, published in 1991 by Lutz F, Krejci I, Barbakow F in Dental Materials (DM) and was cited 158 times. While the most recent was published by Blatz MB, Vonderheide M, Conejo J in the Journal of Dental Research (JDR) in 2018 and has been cited 144 times.

Figure 4 shows the correlation between the number of citations and the year of publication of the studies of the 50 most cited articles on the topic of resin cements and adhesive cementation.

The citation distribution line shows high peaks in the years 2003, 2006, 2010 with 845, 1719 and 855 citations, respectively.

FIGURE 4. Correlation between the number of citations and the year of publication of the most cited studies.



## INSTITUTIONS AND COUNTRIES

A total of 60 different institutions are related to this work. The *University of Siena* leads the list with 8 published manuscripts, among the 50 most cited; followed by *University Groningen* with 5 articles, *University of São Paulo* and *University Kiel* with 4 articles each, as shown in Figure 5.

When looking only at the institutions of the first author, this number drops to 39 institutions, as can be seen in Table 2. *University of Florence and Siena* (653 citations) leads the list with 4 published manuscripts among the 50 most cited.

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

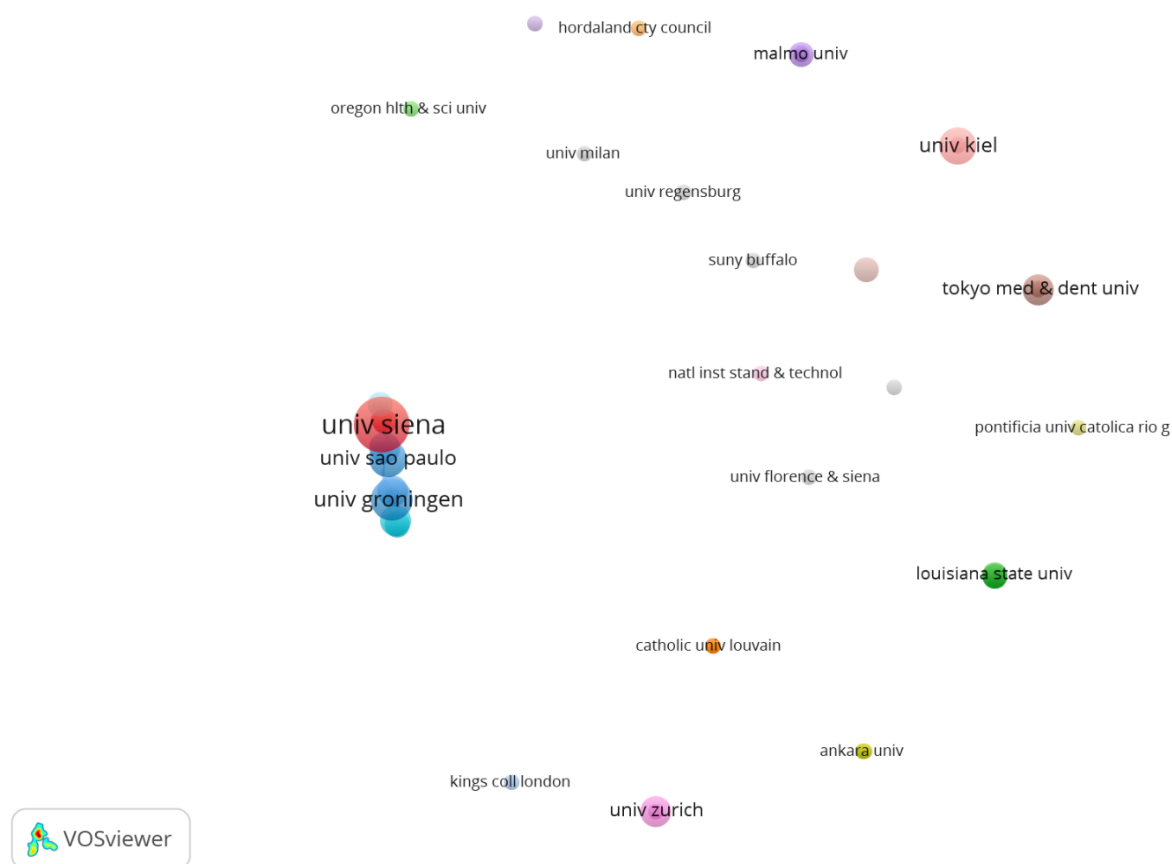


TABLE 2. Correlation between the institutions of the first author, number of publications and citations, in the top 50 most cited articles on composite resin.

First Author's Institutions	Number of articles	Total Citations
University of Florence and Siena	4	653
University of Pennsylvania School of Dental Medicine	2	348
University School of Dental Medicine	2	301
Christian-Albrechts University at Kiel	2	405
University of Groningen	2	794
São Paulo State University	2	319
University of Siena	2	525
Tokyo Medical and Dental University	2	281
University of Zurich	2	414
University of Granada	1	186
University of São Paulo School of Dentistry	1	217
University of Milan, Milan	1	217
Oregon Health & Science University	1	284
Kirikkale University	1	277
Paffenbarger Research Center	1	158
University of Hong Kong	1	200
Public Dental Service	1	218
Mansoura University	1	142
Catholic University of Leuven	1	239
University of Southern California	1	149
State University of New York at Buffalo	1	148

University of Geneva	1	363
Department of Dental Materials Science	1	137
Malmö University	1	194
UNICAMP	1	137
University of Leuven	1	223
University of Washington	1	389
University of Oslo	1	170
Johann Wolfgang Goethe University	1	166
University of Regensburg	1	148
Academic Center for Dentistry Amsterdam	1	240
NIOM-Nordic Institute of Dental Materials	1	162
University of Belgrade	1	313
Ohio State University College of Dentistry	1	332
University of Erlangen-Nuremberg	1	163
University Kiel	1	323
Zurich University	1	158
University Complutense of Madrid	1	166
University Medical Center Groningen	1	168
Total	50	10427

The studies originated in 15 different countries when looking only at the location of the first author, the total number of citations from all countries was 10,427 citations. The United States alone had 2,120 citations, as shown in Table 3. The main countries were the United States with 9 articles, Germany with 8 articles, Italy with 7 articles, and Brazil, Switzerland and the Netherlands with 4 articles each published among the 50 articles on resin cements and adhesive cementation. Figure 6 shows the map of the world with the countries of the first authors highlighted in blue.

When looking at the country of all authors and co-authors, the number of countries of origin increases to 17, so the United States remains in first place, with 12 manuscripts, Italy and Germany in second place with 10 manuscripts each, and Brazil with 8 manuscripts. Of these, only 15 are linked to at least one other country, as shown in figure 7.

TABLE 3. Number of articles published and number of citations from each country of origin of the 50 most cited articles on resin cements and adhesive cementation

Country Of the First Author	Number of Articles	Number of Citations
USES	9	2120
Germany	8	1506
Italy	7	1395
Switzerland	4	935
Brazil	4	673
Netherlands	4	1027
Japan	2	281
Norway	2	332
Sweden	2	412
Belgium	2	462

Spain	2	352
Egypt	1	142
Turkey	1	277
Serbia	1	313
Hong Kong	1	200
Total	50	10427

FIGURE 6. Map of the World, showing the countries of origin of the 50 most cited articles on resin cements and adhesive cementation. The greater the number of publications in that country, the bluer it becomes.

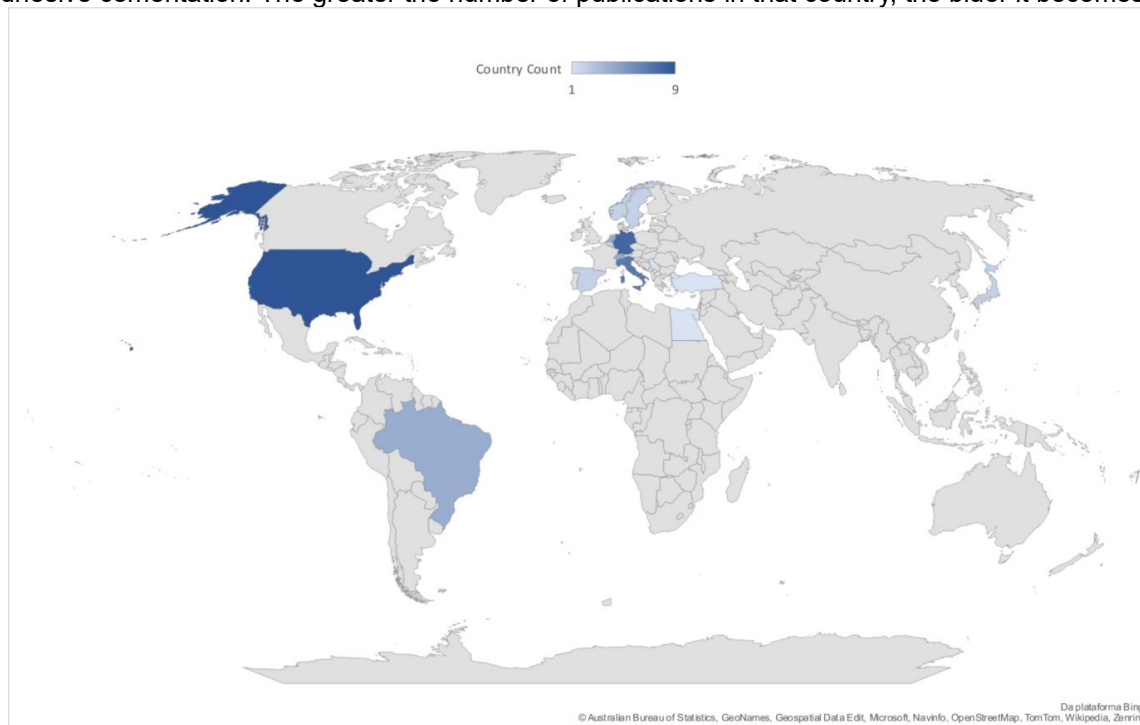
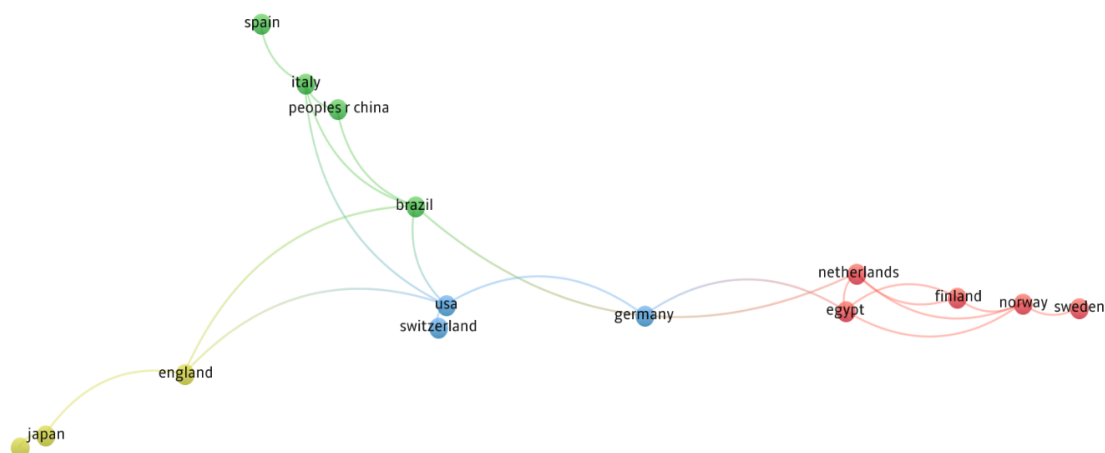


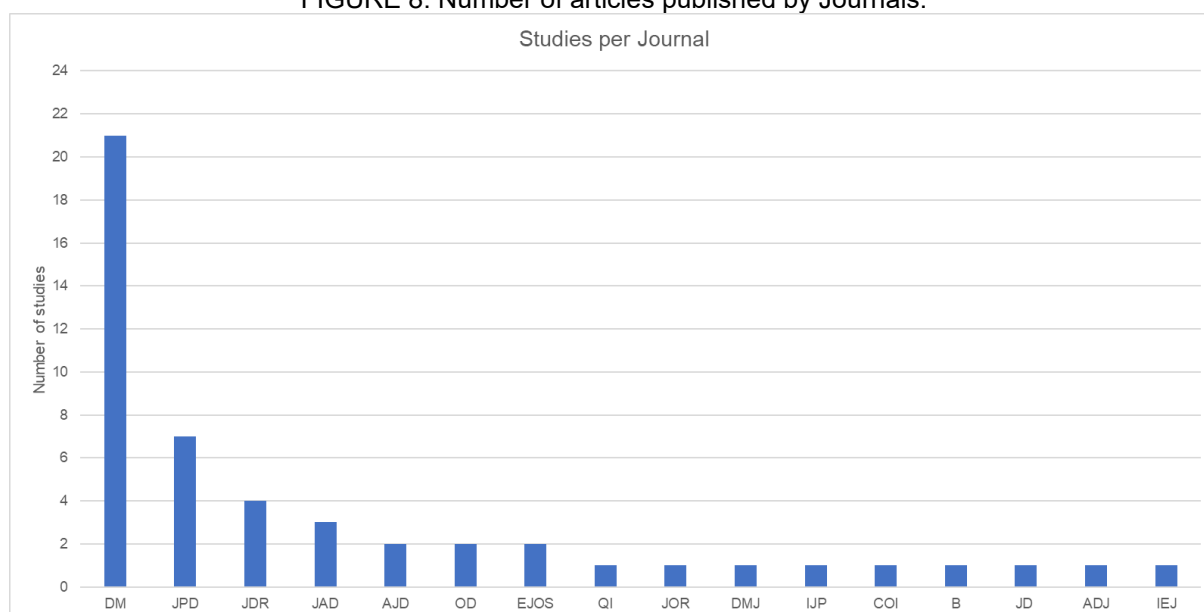
FIGURE 7. Analysis of the network of countries based on the bibliometric research carried out.



## DIARY

The 50 most cited articles involving resin cements and adhesive cementation were published in 16 different journals. Among the main ones are *Dental Materials* (DM) leading the ranking, with 21 articles, followed by the *Journal of Prosthetic Dentistry* (JPD) with 7 articles and *Journal of Dental Research* (JDR) with 4 articles published as shown in Figure 8.

FIGURE 8. Number of articles published by Journals.

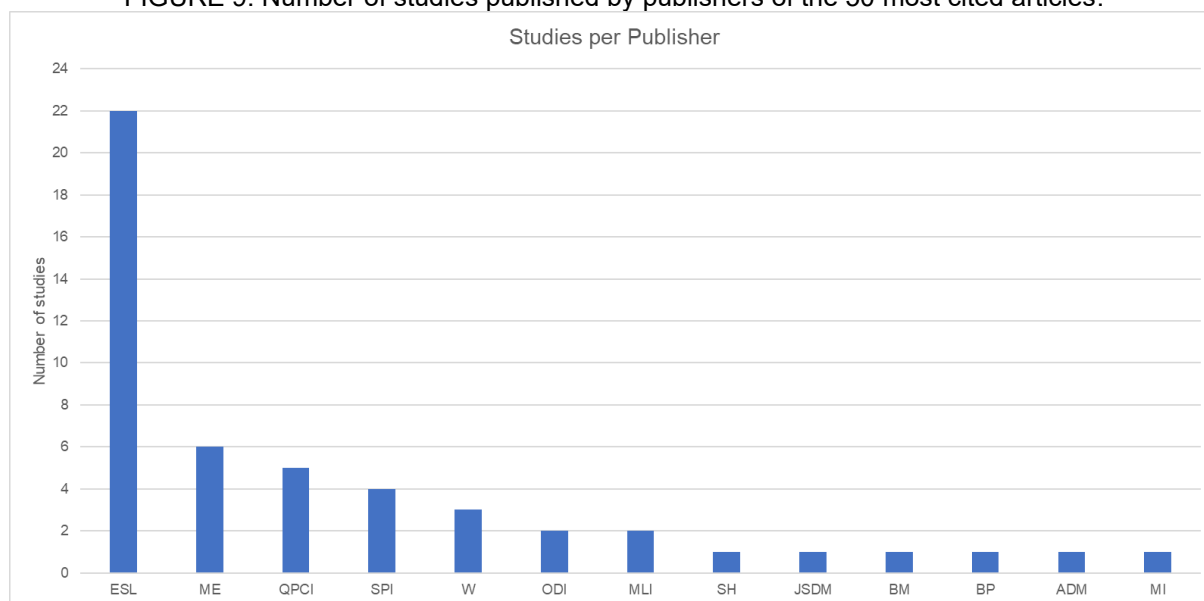


CAPTION: DM-Dental Materials (Impact Factor 4.6), JPD-Journal of Prosthetic Dentistry (Impact Factor 4.3), JDR- Journal of Dental Research (Impact Factor 5.7), AJD- American Journal of Dentistry (Impact Factor 0.9), OD- Operative Dentistry (Impact Factor 1.4), EJOS- European Journal of Oral Sciences (Impact Factor 1.8), QI- Quintessence International (Impact Factor 1.3), JOR- Journal of Oral Rehabilitation (Impact Factor 3.1),DMJ- Dental Materials Journal(Impact Factor 4.6),IJP- International Journal of Prosthodontics (Impact Factor 2.1),COI- Clinical Oral Investigations (Impact Factor 3.1),B- Biomaterials (Impact Factor 5.5),JD- Journal of Dentistry (Impact Factor 4.9),ADJ- Australian Dental Journal (Impact Factor 4.9), IEJ- International Endodontic Journal (Impact factor 1.9).

The most present publishers of the 50 articles were *Elsevier SCI LTD* (ESL) with 22 articles, *Mosby-Elsevier* (ME) with 6 articles, *Quintessence Publishing Co Inc* (QPCI) with 5 articles and *Sage Publications Inc* (SPI) with 4 articles published as shown in Figure 9.



FIGURE 9. Number of studies published by publishers of the 50 most cited articles.



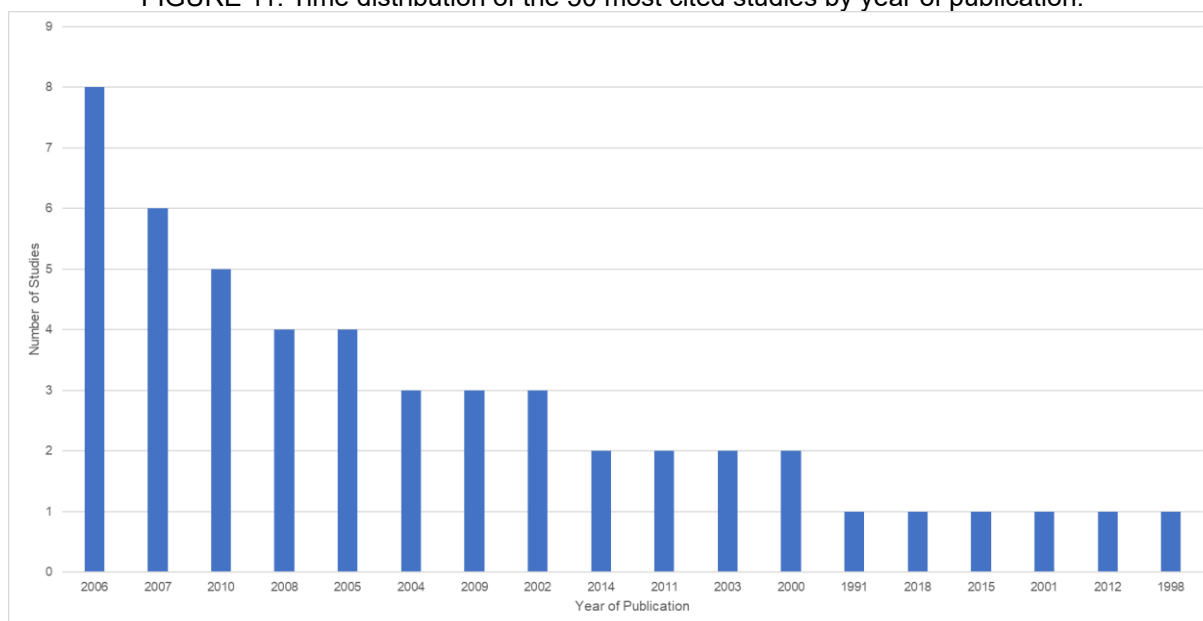
CAPTION: ESL-Elsevier SCI LTD , ME- Mosby-Elsevier , QPCI- Quintessence International,SPI- Springer Heidelberg,W- Wiley,ODI- Operative Dentistry Inc,MLI- Mosher & Linder, Inc,SH- Springer Heidelberg ,JSDMD- Japanese Soc Dental Materials Devices ,BM- Blackwell Munksgaard ,BP- Blackwell Publishing ,ADM- Acad Dental Materials,MI- Mosby, Inc.

## KEYWORDS

In total, 322 keywords were used in the 50 most cited articles. The most used keywords in this list of articles were: *Adhesion* (15 times), *bond strength* (12 times), *composite resin* (11 times), *durability* (9 times), *luting cements* (9 times), *dentin* (8 times), *in-vitro* (7 times), *strength* (7 times), *alumina* (7 times). The most commonly used keyword was repeated in 15 studies, and the frequency of keyword use ranged from 1 to 15 repetitions. Figure 10 shows a graphical representation in the form of a map of the keywords.

Based on the distribution of the 50 most cited articles and the year of their publications, the period of 2006, 2007 and 2010 were the years with the highest concentration of publications and the most productive, with 8, 6 and 5 studies respectively as shown in Figure 11.

FIGURE 11. Time distribution of the 50 most cited studies by year of publication.



## DISCUSSION

In the present study, the 50 most cited articles in the scientific literature on adhesive cementation were addressed, with Özcan, M.; Vallittu, PK (2003) stood out with the highest number of citations (482) with the work *Effect of surface conditioning methods on the bond strength of luting*. Secondly, Raigrodski AJ and co-authors with the work *The efficacy of posterior three-unit zirconium-oxide-based ceramic fixed partial dental prostheses: A prospective clinical pilot study* in 2006 with 389 citations. The work of Özcan, M.; Vallittu, PK (2003) is a laboratory study where the authors present how different surface treatment methods influence the adhesion strength of resin cement to ceramics. In this study it is evident that surface conditioning by corrosion with hydrofluoric acid significantly increases the bond strength in most feldspar ceramics, being a preferable technique for the bonding of cement to ceramics with a glass matrix. However, this method did not show improvement in bond strength to alumina or zirconium oxide ceramics.

The evaluation of the network of co-citations among the authors revealed limited cooperation between different researchers, institutions, and nations. A stronger collaborative network, which incorporates potential collaborators and groups of authors, is crucial to boost the advancement of the study, encouraging the sharing of knowledge and different points of view. However, this cooperation still seems to be underexplored in the studies examined.

Most of the most cited studies (74%) are laboratory studies, followed by literature reviews (18%) and clinical studies (4%). This predominance of laboratory studies highlights the importance of experimental research to understand the properties and characteristics of adhesive cementation materials before their clinical application (Özcan; Vallittu, 2003; Raigrodski et al., 2006; Goracci et al., 2004). These investigations are essential to support the choice of materials and techniques to be used in clinical practice, ensuring that dental professionals can offer more effective and safe treatments. Therefore, the emphasis on laboratory studies not only indicates the continuous need to synthesize and critically evaluate existing knowledge to guide clinical practices and future research, directly influencing the results of dental treatments (Radovic et al., 2008; Ferracane et al., 2011).

Another point to pay attention to is the correlation between the number of citations and how relevant the article is. The most cited articles are generally those whose discoveries or innovations have a broader impact on the understanding of the topic in question and, therefore, are increasingly referenced over time by other researchers. Considering that the number of citations varied between 482 and 134 citations, it can be inferred through this bibliometric review that the 50 most cited articles on adhesive cementation are classic studies of high relevance, which corroborates Garfield, 1972, who classifies articles that have more than 100 citations as classic studies. It turns out that the citation number cannot be the only parameter to understand the quality of the work. The context in which the citation is made, the journal where it was published, and what methodology was used should also be considered.

Journals with a high impact factor and a rigorous peer review tend to concentrate the most influential studies, reflecting a selection process based on scientific quality and innovation. The 50 most cited articles involving resin cements and adhesive cementation were published in 16 different journals. Among the main ones are *Dental Materials* (DM) leading the ranking, with 21 articles, followed by the *Journal of Prosthetic Dentistry* (JPD) with 7 articles and *Journal of Dental Research* (JDR) with 4 articles published. In this way, the analysis of the journals contributes to the understanding of which academic spaces are more relevant in terms of knowledge dissemination. The journal *Dental Material* (DM), highlighted in a dominant position, was established in 1985, with an impact factor of 4.6.

In addition, the most present publishers of the 50 articles were *Elsevier SCI LTD* (ESL) with 22 articles, *Mosby-Elsevier* (ME) with 6 articles, *Quintessence Publishing Co Inc* (QPCI) with 5 articles and *Sage Publications Inc* (SPI) with 4 articles published. The

importance of article editors in the 50 most cited articles on adhesive cementation is significant, as these editors are responsible for the dissemination and expansion of knowledge in the scientific area. Publishers play a central role in ensuring the quality of research and its wide distribution to the scientific community.

In addition, the diversity of countries represented in publications on resin cements and adhesive cementation highlights the relevance of this theme in dental research and practice. The publications originate from 15 different countries, and the United States leads in number of publications and citations, with 9 articles, reflecting its dominant position in dental research (Table 3). Germany with 8 articles, Italy with 7 articles, demonstrate not only the scientific advancement in these nations, but also the relevance of the subject in their research agendas. Followed by Brazil, Switzerland and the Netherlands with 4 articles each published among the 50 most cited articles on resin cements.

Institutions such as the *University of Siena*, *University of Groningen*, and *University of São Paulo* are highlighted for the frequency and impact of their contributions (Figure 5). These data underscore international collaboration and the concentration of *expertise* in particular regions and institutions. This fact indicates that research in this area is not restricted only to traditional research centers, but is also expanding to developing countries. This geographical variety allows for the exchange of knowledge and experiences, enriching discussions on best practices and innovations in adhesive cementing.

The most used keywords in this list of articles were: *Adhesion*, *bond strength*, *composite resin*, *durability*, *luting cements*, *dentin*, *in-vitro*, *strength*, *alumina*. The most used keyword was repeated in 15 studies, and the frequency of use of the keywords ranged from 1 to 15 repetitions (Figure 10). This suggests that while all of these terms are relevant to the field of dentistry, adherence stands out as a central topic in proven research.

The period of 2006, 2007 and 2010 were the years with the highest concentration of publications and the most productive, with a large number of influential publications (Figure 11) with 8, 6 and 5 studies respectively, mainly addressing the different methods and the need for adequate surface and cementation treatments to optimize the results and expectations that zirconia prostheses present good clinical performance (Raigrodski, 2006). Methods that combine mechanical preparation (jetting) with chemical interactions (primers containing MDP) generally have better performance (Wolfart et al., 2007), (Lüthy; Loeffel; Hammerle, 2006). Proper treatment of surfaces is critical to create a strong and

long-lasting bond, which is essential for the biomechanical aspect of the dental restoration system (Hikita et al., 2007).

In 2010, the scientific literature on adhesive cementation recorded the last sharp growth in publications, with 855 citations. One of the main subjects of discussion consists of the use of surface treatment aimed at improving the bond strength between zirconia and cements (Magne; Paranhos; Burnett, 2010). The study by Qeblawi et al. in 2010 evaluated different surface treatments on flexural strength and bond strength between zirconia and resin cement, in which the success of zirconia cementation depends on a suitable surface for adhesion.

It is worth mentioning that one manuscript was the oldest in this bibliographic analysis. Published in *Dental Materials* (DM) by Lutz, Krejci, Barbakow in 1991 and cited 158 times. The most recent manuscript was published in the *Journal of Dental Research* (JDR) in 2018 by Blatz, Vonderheide and Conejo was cited 144 times. Furthermore, the analysis of marginal adaptation and adhesive cementation in composite restorations stands out in the oldest manuscript, in which the longevity of the restorations is directly related to the quality of the marginal adaptation, (Lutz; Krejci; Barbakow, 1991). Accordingly, the most recent study by Blatz, Vonderheide and Conejo (2018), evaluated the durability of restorations resulting from an excellent marginal adaptation. Therefore, the concern with the longevity of restorations is an old theme of several studies and is closely related to obtaining a good adaptation.

However, in the last 6 years, no more recent studies have been found among the 50 most cited articles. The absence of more recent studies may suggest a reduction in research in the area, in view of one of the limitations of the study, in which the searches were carried out in a single database. However, this analysis offers an important insight for researchers interested in directing their studies or determining gaps in knowledge about adhesive cementation. Through the evaluation of the most cited articles, it becomes possible to identify the advances and consequences of research in the area, contributing to the determination of emerging themes and highlighting the values of research already carried out and established.

The choice of analyzing the 50 most cited articles in bibliometric studies is an effective strategy. This allows researchers to identify the most relevant and influential contributions in a given field, while also avoiding the dispersion that could occur if a larger number of publications were considered. This approach helps to highlight significant trends



and advancements, providing a clear picture of the current state of research and future directions. In addition, by focusing on articles with greater impact, studies can offer valuable insights into the areas that are shaping knowledge and practice in the discipline in question (Bornmann; Daniel, 2008).

The evaluation of the most cited articles, manually stratified based on information obtained from the *Clarivate Analytics Web of Science database*, offers a complete perspective on the effect and importance of research in a specific field of knowledge. Using criteria such as year of publication, authors, number of citations, journals, keywords, funding institution, and country of origin, it was possible not only to identify the most relevant articles for the advancement of research, but also to trace the trends and directions of academic production.

## CONCLUSION

The bibliometric analysis of the 50 most cited articles in adhesive cementation made it possible to verify how the theme has grown in importance in the field of dentistry. Thus, significant advances have been made, culminating in an improvement in the understanding and application of resin cements. Thus, adhesive cementation remains a dynamic and critical field for dentistry today and can change the way restorative methods are applied and the results of procedures. Nevertheless, the results of these studies may indicate the need for further research, especially randomized clinical trials to broaden understanding and improve the techniques and materials currently used.

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