

REVIEW ARTICLE

A Bibliometric Analysis of Resin-Bonded Bridge: Performance Analysis and Science Mapping

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ABSTRACT

The objective of this study was to identify and characterise various resin-bonded bridge (RBB) articles published in dental journals using bibliometric analysis. The search was performed using the Scopus database to generate publications related to RBB. Data analysis and visualisation were done using Microsoft Excel, Biblioshiny software or VOSviewer. The trend of publication shows an annual growth rate of 7.19 percent within the years 1973–2022. Sixteen articles were cited more than 100 times, with seven highly cited articles focusing on the survival and/or complications of RBB. Matthias, Kern is the most prolific author in RBB research with *Journal of Prosthetic Dentistry* being the most influential journal. “survival”, “dental bonding” and “zirconia” were identified as core research areas for RBB for the past 10 years. Future research on the incorporation of new technology in prosthesis fabrication to assess the survival and longevity of RBB is expected to increase, with an emphasis on bonding to new materials. This paper presents an overview of scientific production, prominent researchers and countries, emerging keywords and core research areas in RBB research.

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INTRODUCTION

A bibliometric study helps provide a comprehensive review of a topic of interest based on the enormous amounts of scientific output in the academic literature. The evolution of scientific output, influential authors, significant journals, productive countries, and institutes within a topic of interest can be mapped quantitatively using the information obtained from the publication history (1,2). Based on the publishing pattern, evaluation of research outputs using performance analysis acts as a critical indicator to assess the impact of a study, acknowledge prominent and prolific researchers in the area, and determine the impact factor of a journal's publication (3,4). Using the science mapping technique, the researcher is able to identify current research trends as well as present gaps in study areas, which helps policymakers and funding agencies in allocating research funding (5,6).

A resin-bonded bridge (RBB) was first introduced in 1973 as a conservative and provisional treatment to replace a missing anterior tooth prior to the introduction of dental

implants (7). Since then, major advancements in the RBB design, materials used, and clinical technique of tooth preparation to improve the survival and longevity of the prosthesis have been evaluated, which has led to a continuous increase in the amount of literature on this topic (8-11). Historically, one of the main drawbacks of the RBB was the dissolution of the exposed luting cement on the perforated retainer, which caused leakage underneath the retainers and eventually debonding of the restoration. The emergence of new technology in prosthesis fabrication, new broad material selection, and improvement of the dental adhesive system and luting cement help prolong the overall longevity of RBB and provide new options for RBB fabrication (12-14). In addition, the use of three-dimensional finite element analysis helps researchers gain a better understanding of the biomechanical behaviour of the restorations with respect to the different designs and materials used for RBB prior to the clinical study (15,16).

In this article, bibliometric analysis has been applied to evaluate research on RBB with the aim of providing an overview of the research field, highlighting four research questions: 1) What are the main characteristics of RBB research? 2) Who are the prolific and prominent authors in RBB research? 3) What is the characteristic of productive countries and influential journals that have published the most articles on RBB? 4) What are

the future research interests evaluated from emerging keywords and research core area that have been explored in RBB-related research?

METHODOLOGY

Bibliographic search strategy

A search was conducted among the core collection of the Scopus database. It was chosen due to its extensive thematic and broad coverage database of the health sciences. The search took place on January 17, 2023 with search strategy used keywords of the Boolean operator of “resin bonded bridge*” OR “adhesive bridge*” OR “acid-etched bridge*” OR “maryland bridge” OR “rochette bridge*”. The search was conducted within the topic field (title, keywords, and abstract). A predefined search filter was limited to only conference proceedings and articles in English, both articles in the press and at the final publication stage, and the dental field only. All data regarding bibliographic and citation information such as titles, authors, year of publication, number of citations, sources, abstracts, different keywords and other reference information were obtained and transferred in a comma separated values (CSV) UTF-8 (comma delimited) file format. The data was then saved in Microsoft Excel 1997-2003 Workbook files (Microsoft Corporation, USA) for data cleaning. Following the removal of duplicates, all articles were manually screened based on titles and abstracts and full texts, when needed. All data regarding bibliographic and citation information such as title, authors, year of publication, number of citations, sources, abstract different keywords and other references information were transferred back in a CSV UTF-8 (comma delimited) (Microsoft Corporation, United States) file format for data analysis. The flowchart of bibliometric analysis is shown in Figure 1.

Data analysis

A descriptive analysis of the variables was performed using Microsoft Excel software (Microsoft Corporation, United States) while analysis and visualisation of large networks were performed using statistical analysis software either using Biblioshiny software (RStudio Desktop, Boston, MA) or VOSviewer (Version 1.6.18).

RESULTS

The search yielded 1170 articles following the refinement criteria. Data cleaning was done to remove duplication and exclude irrelevant topics, leaving 697 documents from 96 journals to be analysed. The number of publications on RBB research fluctuated throughout the years with an annual growth rate of 7.91 percent. The highest number of publications recorded in the year 1995 (n = 42), while the highest citation was recorded for publication in the year 2000 with 914 citations (Fig.2a). Table 1a shows the top ten contributing journals in RBB-related research. The Journal of Prosthetic Dentistry published the most articles in RPD-related research,

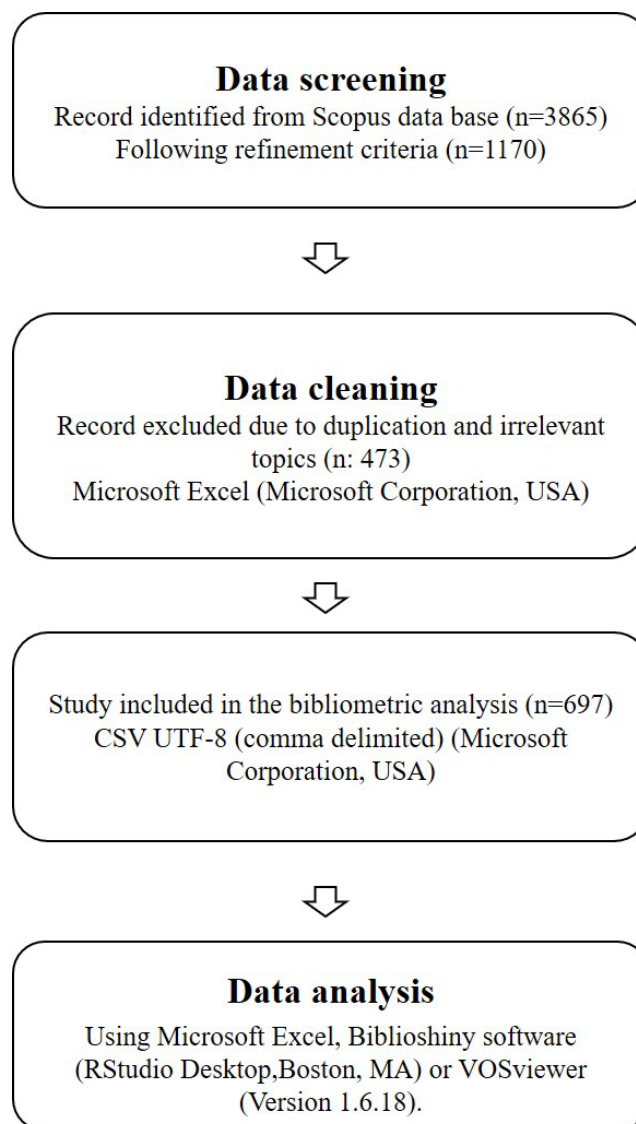


Figure 1: Flowchart of a bibliometric study

with 132 documents receiving the most citations (3542). It was followed by Quintessence International, which published 58 articles (779 citations). A total of 1577 authors contributed to the included articles, including 121 authors of single-authored documents. Table 1b shows the author profiles of the most productive authors and the most cited authors. Kern, Matthias received the most citations (1,376 citations) and was the most prolific author with 29 articles, followed by Creugers, Nico H.J. with 42 documents and 687 citations. Six authors (Kern, M, Creugers NHJ, Botelho MG, Vallittu PK, Van’t Hof MAT, Thompson VP) appeared on both lists, indicating that they were the most significant researchers in RBB research. International cooperation networks were constructed using a criterion of five or more collaborations. Figure 2b displays the network visualisation of collaboration between countries with a minimum number of five documents. The countries that are not connected to other countries are not included. Three significant clusters were identified: the United States (purple), Germany (brown), and the United

Kingdom (red). Information on the most cited articles (more than 100 citations) in RBB research is displayed in Table 1c (8, 17-30). Seven highly cited articles focus on survival or complications of RBB with articles on “Clinical complications in fixed prosthodontics” received the highest number of citations with 358 citations. Keyword analysis used keywords from titles and abstracts in RBB publications which help to provide insight in main topics and research trends in the domain of RBB. VOSviewer software (version 1.6.18) was used for visual content analysis of the relationship between the most frequent keywords. Keywords such with a different spelling, such as “resin-bonded bridge”, “resin-bonded bridges” and “resin bonded” were merged. For analysis of the high frequency keywords, term “resin bonded bridge”, “fixed

partial denture” and “dental restoration” were excluded. The top ten recurring terms were identified as high-impact terms based on the average citation (AC) scores and average normal citation (ANC) score was reported in Figure 3a. The term “failure” was used 76 times in an AC per year, while “success” was used 65 times in an AC per year. The top five keywords displayed ANC more than 3, indicating it is a significant term used in RBB research. Figure 3b depicts the density distribution of the keyword co-occurrence network for the last ten years (2012-2022). There were three major areas of core research (marked in red), namely research in association with the survival of RBB as the primary research core, followed by dental bonding, and research in association with new materials such as zirconia and fibre-reinforced

Table 1a: Number of documents and number of citations of major contributing journal in RBB publication

Journal	Impact factor	SJR* 2021	H index	Country	Documents	Citations	Average normal citation (ANC)
Journal of Prosthetic Dentistry	Q1	1.11	136	United States	132	3542	1.3335
Quintessence International	Q2	0.58	74	United States	58	799	0.7066
Journal of Dentistry	Q1	1.11	124	Netherlands	44	1291	1.9246
Dental Update	Q4	0.15	34	United Kingdom	36	226	0.3541
International Journal of Prosthodontics	Q2	0.59	99	United States	33	828	1.3620
Dentistry Today	Q4	0.1	26	United States	32	34	0.0566
Journal of Esthetic and Restorative Dentistry	Q1	0.8	64	United States	30	309	0.6846
British Dental Journal	Q2	0.58	87	United Kingdom	24	533	1.0857
Journal Of Oral Rehabilitation	Q1	0.94	98	United Kingdom	23	748	1.7619
General Dentistry	Q3	0.2	36	United States	22	79	0.2453

* SJR- Scimago Journal and Country Rank

Table 1b: Author profile articles of most productive (with at least 8 articles) and most cited authors in RBB-related research.

The most productive authors				The most cited author				
Author	Author Profile			Author	Author Profile			
	H index	Affiliation/Country	Number of articles		H index	Affiliation/Country	Number of citations	Average normal citation
Kern, Matthias	65	Christian-Albrechts-Universität zu Kiel, Germany	29	Kern, Matthias	65	Christian-Albrechts-Universität zu Kiel	1376	2.7932
Creugers, Nico H.J.	42	Radboud University Medical Center, Netherlands	20	Creugers Nico H.J.	42	Radboud University Medical Center, Netherlands	687	2.0481
Botelho, Michael George	25	The University of Hong Kong	14	Vallittu, Pekka Kalevi	71	Welfare Division, Turku, Finland	609	2.5152
Vallittu, Pekka Kalevi	71	Welfare Division, Turku, Finland	11	Livaditis, Gus J	23	Private Practice, Baltimore, United States	450	1.9564
Rammelsberg, Peter	39	Universitätsklinikum Heidelberg, Germany	10	Edelhoff Daniel	40	Ludwig-Maximilians-Universität München, Munich, Germany	446	3.0518
Van't Hof, Martin A.T.	60	Radboud Universiteit, Nijmegen, Netherlands	9	Van't Hof Martin A.T.	60	Radboud Universiteit, Nijmegen, Netherlands	429	2.6788
Matsumura, Hideo	38	Nihon University, Japan	8	Sasse, Martin	10	Christian-Albrechts-Universität zu Kiel, Germany	393	3.5064
Llzcán, Mutlu	59	Center for Dental Medicine, Zurich, Switzerland	8	Thompson, Van Purdy	52	King's College London	385	1.5474
Thompson, Van Purdy	52	King's College London	8	Strub, Joerg Rudolf	53	Universität Freiburg, Germany	377	2.247
				Botelho, Michael George	25	The University of Hong Kong	310	1.266

Table 1c: Articles information on the most cited articles (more than 100 citations) in RBB research

Article information	Publication Year	Authors	Total citations (Scopus)	Average citation per year	Main topic
Clinical complications in fixed prosthodontics.	2003	Goodacre CJ, Bernal G., Rungcharassaeng K, Kan JYK	358	9.11	Complications
Tooth structure removal associated with various preparation designs for anterior teeth	2002	Edelhoff D, Sorensen JA	287	8.18	Clinical technique
Attachment of a splint to enamel of lower anterior teeth	1973	Rochette A.L.	269	1.00	Clinical technique
Etched castings: An improved retentive mechanism for resin-bonded retainers	1982	Livaditis GJ, Thompson VP	245	4.08	Bonding
Resin-bonded, glass fiber-reinforced composite fixed partial dentures: A clinical study	2000	Vallittu PK, Sevelius C	212	4.63	Clinical performance/ Survival
The congenitally missing upper lateral incisor. a retrospective study of orthodontic space closure versus restorative treatment	2000	Robertsson S, Mohlin B	189	4.13	Clinical study /Patient satisfaction
Bonding to oxide ceramics - Laboratory testing versus clinical outcome	2015	Kern M	183	8.06	Bonding
Prosthetic treatment planning on the basis of scientific evidence	2008	Pjetursson BE, Lang NP	181	7.84	Complication/ Survival
A systematic review of the survival and complication rates of resin-bonded bridges after an observation period of at least 5 years	2008	Pjetursson BE, Tan WC, Tan K, Brägger U, Zwahlen M, Lang NP	147	6.37	Complications /Survival
Anterior fixed partial dentures utilizing the acid-etch technique and a cast metal framework	1977	Howe DF, Denehy GE	139	1.00	Clinical technique
Clinical long-term survival of two-retainer and single-retainer all-ceramic resin-bonded fixed partial dentures	2005	Kern M	138	5.78	Survival
Survival rates of resin-bonded, glass fiber-reinforced composite fixed partial dentures with a mean follow-up of 42 months: A pilot study	2004	Vallittu PK	120	6.97	Survival
The Effect of Resin Bonding on Long-Term Success of High-Strength Ceramics	2018	Blatz MB, Vonderheide M, Conejo J	116	6.91	Bonding
Stress distribution of inlay-anchored adhesive fixed partial dentures: A finite element analysis of the influence of restorative materials and abutment preparation design	2002	Pascal M, Nikolaos P, Urs CB, Ivo K	110	3.14	Finite element analysis (Material/Design)
Long-term survival characteristics of 832 resin-retained bridges and splints provided in a post-graduate teaching hospital between 1978 and 1993	1999	S. Djemal, D. Setchell, P. King, J. Wickens	108	5.09	Survival
To what extent does the longevity of fixed dental prostheses depend on the function of the cement? Working Group 4 materials: cementation	2007	Daniel Edelhoff, Mutlu Özcan	101	4.16	Bonding

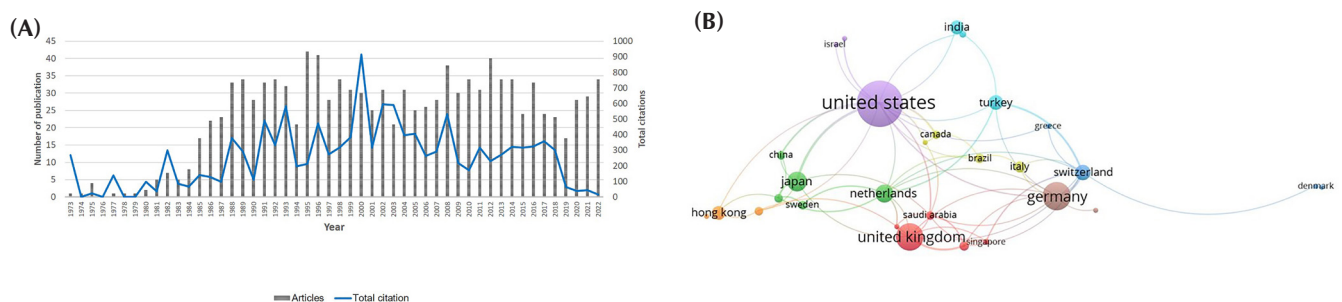


Figure 2: (A) The total number of citations versus the number of publications on RBB-related research from 1973 to 2022. (B) Network visualisation of collaboration between countries with a minimum number of five documents. The bubble size indicates the number of documents published, where the bigger bubbles indicated more documents published from the country and link length indicates the closeness of collaboration.

composite.

DISCUSSION

To the author’s knowledge, there are no bibliometric studies available on RBB research that have been published. Thus, the aim of this study is to provide

detailed evaluation of the published article in RBB research using bibliometric indicators. The publication output of RBB research revealed an annual percentage growth rate of 7.91%. The Journal of Prosthetic Dentistry (SJR 2021 = 1.11, H-index = 136) remains the most influential journal, contributing the most to RBB research as the world’s first prosthodontic journal and the official

(A)

Keyword	Average citation (AC)	Average normalised citation (ANC)
failure	76.16	3.8647
success	65.00	3.5389
review	61.25	3.1528
clinical trial	63.40	3.1522
randomised clinical trial	41.00	3.1366
debonding	53.83	2.2534
complication	41.33	1.9190
fibre-reinforced composite	24.13	1.3687
longevity	11.58	1.3611
patient satisfaction	13.66	1.2025

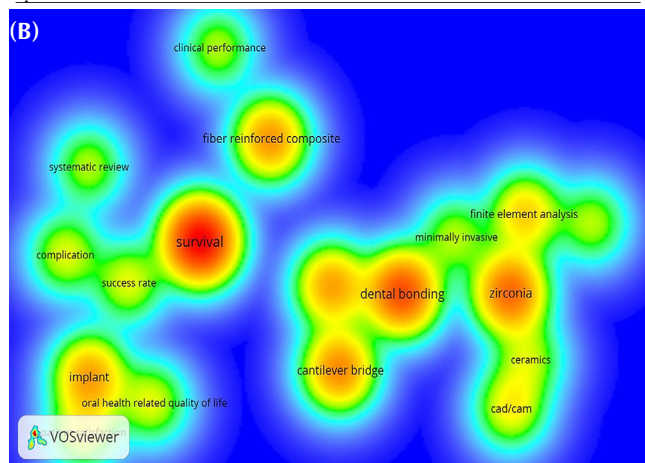


Figure 3: (A) List of keywords in RBB research that consists the highest average citation (AC) and average normalised citation (ANC) scores from year 1973-2022. (B) The keyword co-occurrence network density distribution map showing the core research arewherethe high-density nodes (red) reflected the “hot” core research topic in RBB-related research

publication of the United States and international prosthodontic organisations (31). This is in line with our finding that the United States contributes to the most articles in RBB research and has become the centre of international collaboration, apart from Germany and the United Kingdom. The result of the international collaboration link from this study would be valuable for researchers looking for potential collaborators, either locally or internationally.

Kern, Matthias is the most influential author in RBB research, with the highest number of academic publications and the highest number of citations; two of his articles were included in the top ten most frequently cited publications (22,25). In addition, five more authors appeared on both the highly cited and most published lists (Creugers NHJ, Botelho MG, Vallittu PK, Van't Hof MAT, Thompson VP), indicating that they were the most relevant researchers in RBB research. Two articles from Pterjussion et al. in 2008 on RBB complications and survival were also cited more than 100 times, with an AC of more than five citations per year (8,23). Rochette's article received 296 citations, provides a historical reference on the significance development of the RBB (7). Although the number of times an article has been cited is directly proportional to the time since its publication, current publications with significant impact

in the field may be cited more (4). For example, articles title “Bonding to oxide ceramics - Laboratory testing versus clinical outcome” that were published in 2015 were cited 183 times compared to the earliest published article (22). It is also noted that the main focus of seven highly cited articles in RBB research is either a review, systematic review, or clinical study assessing clinical performance, complications, and survival in RBB. Systematic reviews and well-conducted clinical studies are well-known for providing reliable evidence-based data, which may explain the high citation counts of the article mentioned.

Three other highly cited articles focus on “bonding” which reflects the evolution and innovation of new bonding agents, surface treatment, and luting cement in improving the bond strength and long-term durability of RBB and tooth structure in the current year (9,22,30). This is consistent with the trend research topic, which revealed that bonding has been among the emerging topics of interest for the past ten years. The topic of bonding is closely related to another RBB primary core topic, which is zirconia. It is well known that the structure of zirconia's polycrystalline composition makes it challenging to bind to tooth structure, making bonding to zirconia difficult (32). Besides zirconia, fiber reinforced composites are among the emerging materials of interest for fabricating RBB due to their superiority in aesthetics as compared to the conventional metal wing in the metal-ceramic RBB design. However, although it has an excellent aesthetic outcome, better adhesion to the luting agent, and demonstrates good clinical outcome, they are considered short-term permanent prostheses (20,33,34).

The “survival” of RBB remains in the hot research domain based on the distribution of the research topic over the last ten years. Pjetursson et al., who conducted a series of six systematic reviews on biological and technical complications, reported that, despite the high survival rate of RBB after at least five years, prospective studies with a follow-up time of 10 years or more are needed to evaluate the long-term outcomes of RBB (8). Additionally, according to the research mapping, it is anticipated that more RBB studies will be conducted in conjunction with FEA studies. FEA can model and assess the stress distribution of prostheses as well as act as a supplement prior to clinical studies. It can be incorporated with different loads in different designs of prostheses to evaluate the effect on the abutment teeth as well as surrounding tissue (16,35). Kihara et al., who used FEA to design an anterior cantilever RBB, concluded that FEA was useful for determining the optimal design of RBB for each patient (15). It is also anticipated that more research on the incorporation of new technology in designing the prosthesis using computer-aided design (CAD) and manufacturing the prosthesis using computer-aided manufacturing (CAM) techniques will generate new interest in RBB research in evaluating longevity and

increasing the survival of RBB (13,36).

Finally, a number of the study's limitations should be addressed. The search was restricted to dental English articles available in the Scopus database. Although Scopus is one of the largest databases for health science and the most commonly accepted and widely used database for scientific analysis, it does not cover all RBB research articles. Thus, other databases may have been used, such as Web of Science or PubMed. Nevertheless, based on previous advice and recommendations, the author should settle on one appropriate database to reduce the need for that consolidation, as it can help prevent potential human errors (1). Secondly, bibliometric analysis uses quantitative methodologies, so the content or quality of publications cannot be analysed. Thus, it is important that only reliable and reputable database sources (such as Scopus, Web of Science, or PubMed) be used during data extraction. In addition, our study only implies the citation count from the Scopus database, which might differ from the citation from the Web of Science.

CONCLUSION

With the rise of RBB research around the world, important citations and partnerships between authors, institutions, and countries were identified. It also gives important information about well-known researchers and countries, new keywords, and the main research fields in RBB research, which can help researchers find possible future research partners and research subjects. This in turn helps policymakers and funding organisations allocate research funds more effectively.

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