

All-Ceramic Resin-Bonded Fixed Denture Prostheses Survival and Complication Rates: A Review

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Abstract This review identified research related to the survival and complication rates of all-ceramic resin-bonded fixed dental prostheses (RBFDPs) and ranked them according to their quality of research. An electronic search in PubMed, MEDLINE, Science Direct, complemented by a manual search was done. Only clinical (in vivo) studies on all-ceramic RBFDPs with a mean follow-up period of at least two years or more were included. The critical appraisal skills program (CASP) was used to evaluate the papers and to put emphasis on their results. Among 140 screened articles, 1 randomized controlled trial (RCT), 4 prospective and 3 retrospective cohort studies were included in this review. The CASP evaluation showed high-quality for four studies with calculated quality scores, ranging from 90-102.5. The other four studies showed a low-level of calculated scores, ranging from 57.5-70. The overall survival rate for all-ceramic RBFDPs was calculated as 94.2%. The calculated annual failure rate was estimated at 1.12%. De-bonding and framework fracture were the most common complications. Additionally, all included studies reported all-ceramic RBFDPs in the anterior area and were more frequently designed with a cantilever design bonded to one abutment tooth and the polycrystalline ceramic (zirconia) framework material shows good clinical outcomes. To conclude, all-ceramic RBFDPs seem to work best and last longest in the anterior area, the framework material of choice is zirconia which works better with a cantilever design.

Keywords: all-ceramic, complication rate, resin-bonded fixed dental prostheses, survival rate

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1. Introduction

Missing anterior teeth are a critical issue from both aesthetic and functional aspects. Missing teeth could occur as a consequence of some syndromes or as a result of traumatic injuries. Teeth could be extracted as a result of deep caries and periodontal diseases. [1,2] The replacement of a single missing tooth has a significant impact on patients to restore both their aesthetic and function. Several treatment options are available to replace missing teeth such as orthodontic intervention; resin-bonded fixed denture prostheses (RBFDPs), conventional fixed dental prostheses (FDPs) and implants. However, all the treatment options have advantages and limitations. [1,2] The RBFDPs is characterized by several advantages over other treatment options for the replacement of missing teeth. The main advantage is the low invasiveness compared with FDPs and implants, as no or minimal tooth preparation is needed for RBFDPs. [3] In a laboratory study, it was stated that 25% to 50% less tooth substance is removed for an RBFDP preparation compared with a conventional full-coverage metal-ceramic fixed prosthesis. [4] Specifically, RBFDPs preserve tooth structure; and hence, preserve the pulp vitality. [5,6] Finally, the treatment cost-effectiveness

related to RBFDPs is considerably lower than for conventional FDPs or single-tooth implants. [7]

Resin-bonded fixed denture prostheses (RBFDPs) are fixed partial dentures that are luted to tooth substance, primarily enamel, which has been etched to provide micromechanical retention for the resin luting cement. [8] The fitting surface is altered to facilitate a chemo-mechanical bond which is the primary mode of retention for this type of bridge-work. This surface area of the retainer should be maximized without compromising the aesthetic appearance of the bridge. In order to achieve this, the retainer tends to be placed on the lingual or palatal aspect of the abutment tooth.

Survival is defined as the RBFDP remaining insitu without de-bonding more than once, for the entire observation period. [9,10] Failure is defined as the RBFDPs that were lost or required re-fabrication. [9,10] The survival of RBFDPs is determined by the mechanical properties of the prosthetic materials, the tooth preparation design and the quality of the adhesive bond. [11] The survival rates of RBFDPs vary widely from 59% to 100%. [11,12] The metal RBFDPs have shown acceptable survival rates of 87.7%, which was reported in a systematic review over a five-year period. [9] The most common cause of failure for RBFDPs was de-bonding. The de-bonding mostly occurred at metal-ceramic RBFDPs fabricated with perforated cast

metal framework. The use of a non-perforated cast metal framework improved the poor performance of the RBFDP. Nevertheless, the adhesive cementation of the metal-ceramic RBFDPs remains a challenge. Overall, the resin bonded treatment option has considerably increased in recent years. However, long-term survival and complications are still under investigations. Currently, there is no clear and well-established clinical evidence regarding the survival and complication rates of all-ceramic RBFDPs in relation to the materials used, the location of the bridge and the design of the prosthesis. The aim of this review was to identify the papers related to the survival and complication rates of all-ceramic RBFDPs and rank them according to the quality of the research and to draw a clear conclusion for the survival and complication rates of all-ceramic RBFDPs after a mean observation study period of at least 2 years or more.

2. Materials and Methods

2.1. Study Selection

An initial electronic search on Pub-Med, MEDLINE and Science Direct. The review of research was conducted from January 2000 to June 2020 for English language articles published in the dental literature, using the keywords "resin-bonded bridge", or "Maryland bridge", or "adhesive", or "metal-free bridge", or "all-ceramic resin-bonded bridge", or "zirconia resin-bonded bridge" and "survival" and "survival rate" and "complication rate". Thereafter, the articles were obtained and screened for possible inclusion and exclusion criteria.

Longitudinal prospective and retrospective clinical studies (in vivo) (randomized controlled trials, controlled clinical trials and cohort studies) reporting data with regards to the outcome of treatment with different all-ceramic RBFDPs were accepted for inclusion. In contrast, case studies and clinical reports were excluded. Studies with a mean follow up of two years or more were included while studies with a mean follow up of less than 2 years were excluded. In addition, studies which included at least 10 patients at review were included. Furthermore, this review was augmented by a hand search of the bibliographies of the selected papers for additional papers on the subject. Only articles published within the last 20 years (1997-2017) were included in order to obtain a review of the current materials of all-ceramic RBFDPs. The studies which were chosen for the review had to include data on survival and complication rates [Table 1](#).

Table 1. Table to show the inclusion and exclusion criteria of the literature research

Inclusion criteria	Exclusion criteria
Human trials.	Case report.
Mean follow-up of 2 years or more.	Study period less than 2 years.
Prospective and retrospective cohort studies.	Expert opinion.
Published in dental journals.	Study before 2000.
Patient needed to be examined clinically at the follow-up visit.	Studies conducted on less than 10 patients.
Included at least 10 patients at review.	Publications were based on patient records (i.e., questionnaires, interviews).
Language: English or translated to English.	Studies were not in English language.

An initial literature search was conducted and subsequently refined to yield critical articles for further evaluation. The articles were then rated in terms of study type and risk of bias to determine what emphasis might be placed on particular elements of the available literature, thus identifying the strongest evidence for any outcomes reported.

2.2. Focused Questions

1. How can the identified papers be ranked according to the quality of the research undertaken and therefore, the emphasis placed on the results?
2. What are the survival and complication rates of all-ceramic RBFDPs after a mean observation study period of at least 2 years or more? More precisely, what are the influences of differing all-ceramic materials, location of the bridge-work (maxilla, mandible, anterior, posterior) and, the number and arrangement of retainers (one, two or multiple / cantilever or fixed) on the survival and complication rates of all-ceramic RBFDPs after a mean observation study period of at least 2 years or more?

2.3. Search Strategy

The MeSH terms were used as follows:

1. Search (((zirconia) OR "All ceramic")) AND (("resin bonded bridge") OR "RBFDP")) AND (((("Success rate") OR "Failure rate") OR "Complication rate").
2. Search (((("resin bonded bridges") OR "acid etched bridge") OR "Maryland bridge")) AND (((("ceramics") OR Zirconium) OR Zirconia)) AND (("failure rate") OR "survival Rate").

2.4. Critical Evaluation

Even though a study has been published in a well-known journal or was written by a well-reputed person, this is not in itself an indication of its reliability and relevance. The Critical Appraisal Skills Program (CASP) was used to evaluate the papers and to put emphasis on their results. [13] CASP approaches to research in three steps. First, the study's validity is assessed to decide whether the study was unbiased by evaluating its methodological quality. Second, in looking at the results, we consider whether the study's results are clinically relevant. In the final step, we think about how to apply these results to a patient or population.

The eight studies were evaluated by 11 questions. Some questions were modified to be appropriate to the study, and some questions needed further sub-questions to make them more precise for the evaluator. For example, the first question of CASP was, "Did the study address a clearly focused issue?" In order to be more appropriate, the question was modified to, "Were the outcomes of the study clear? what did the study evaluate?" This question then needed some sub-questions in relation to the study issue to help in evaluation, such as success rate, survival rate and failure rate. A scoring system was created to find the highest level of evidence to rely on in this study, and it was ranged between 0-110. Every question was worth 10

grades for "Yes", 5 grades for "Not clear" and a zero grade for "No". Then, the traffic light coloured system was used to make it simple and clear for the reader, green for "Yes", yellow for "Not clear" and red for "No".

3. Results

140 publications were identified through database research as potentially relevant to the review (Figure 1). After reviewing the titles and the abstracts, 90 articles were discarded as not related to the present review and 50 full-text articles were obtained. After the inclusion and exclusion criteria were applied, 43 articles were eliminated, leaving 7 articles for final assessment. One article was eliminated as there was no full-text available in the English language. Finally, hand research in

bibliographies was applied, and two further articles were obtained.

3.1. Included Studies

Eight studies were selected, the oldest study was published in 2011, the most recent study was published in 2017, and the median year of publication was 2014. One study was a randomized control trial, while four of the studies were prospective, and three were retrospective-cohort studies Table 2. [14,15,16,17,18,19,20,21] The bias and quality of the RCT and cohort studies were evaluated by the Critical Appraisal Skills Programme. The CASP evaluation showed high-quality for four studies with a calculated quality score ranging from 90-102.5. The other four studies showed a low-level of calculated score ranging from 57.5-70.

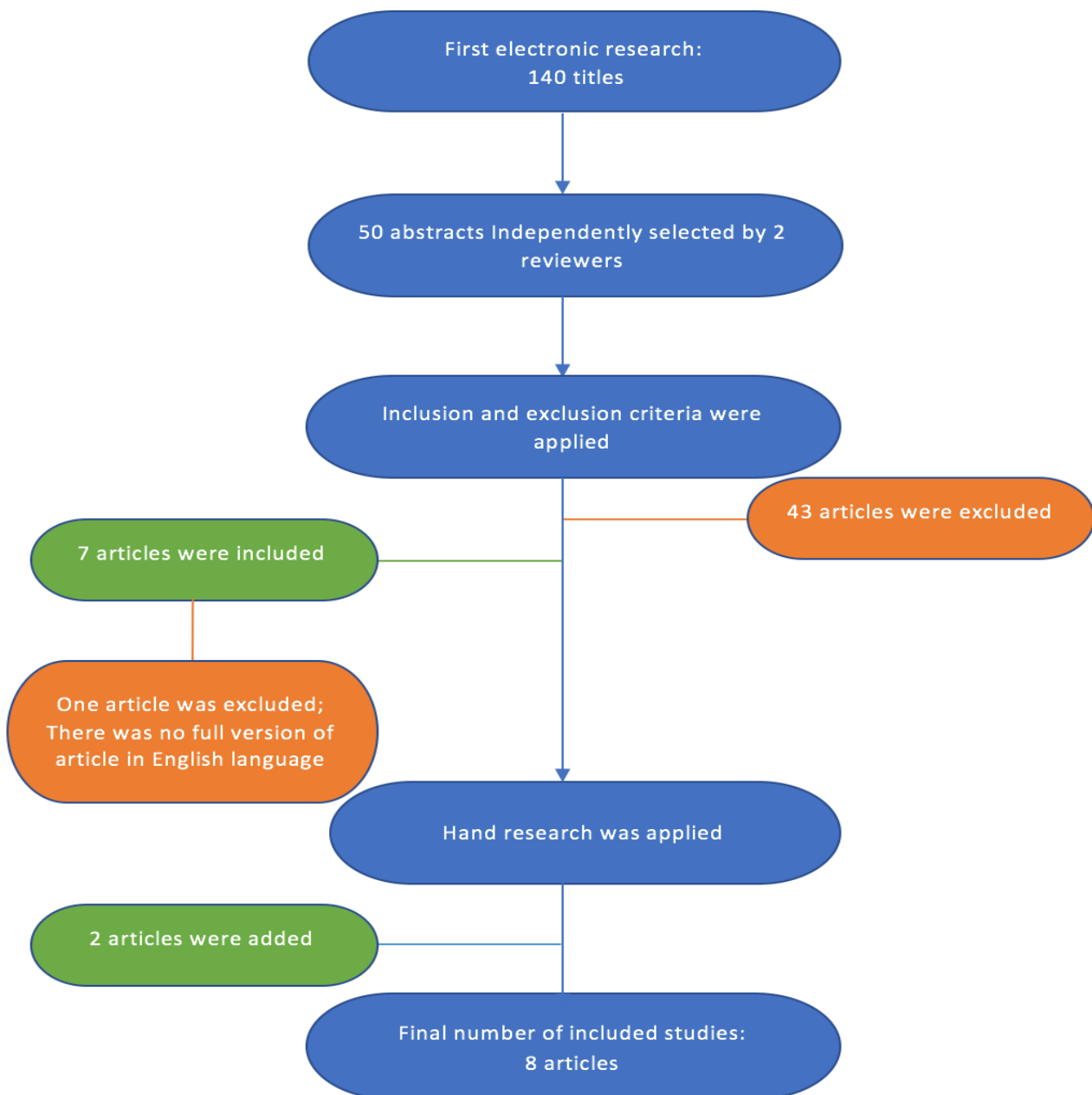


Figure 1. Flowchart to demonstrate the progress of the study and the numbers of papers identified

Table 2. Table to show the included studies with year of publication and the type of study

Study	Year	Type of study
Kern et al.	2017	Retrospective
Kern	2017	Prospective
Sasse & Kern	2014	Prospective
Galiatsatos & Bergou	2014	Prospective
Sailer & Hammerle	2014	Retrospective
Sasse et. al.	2012	Randomized Control Trial
Sailer et. al.	2013	Retrospective
Kern & Sasse	2011	Prospective

The included studies had a total of more than 283 patients, with 344 all-ceramic RBFDPs. The proportion of patients with all-ceramic RBFDPs who were lost to follow-up during the study period was available for only two of the eight studies. The shortest study mean observation period was 4.44 years, while the most extended mean observation period study was 15.7 years. Seven studies were reported on anterior all-ceramic RBFDPs while just one study reported on posterior all-ceramic RBFDPs. In addition, the design of the all-ceramic RBFDPs was mostly a cantilever design (reported in six studies), while a fixed-fixed design was used in one study and one study used both designs

Table 3. The number of patients, the mean follow-up, the material used in the study, the design of the retainer, the location of the missing teeth and the survival rate of the all-ceramic RBFDPs

Study	No. patients at review	The Mean follow up	Material	Design	Location	Survival rate %
Kern et al.	87	7.68	Polycrystalline (zirconia) Ceramic CAD/CAM	Cantilever	Anterior	98.2%
Kern	16	15.7 years	Glass ceramic In-Ceram	Cantilever	Anterior	95.4%
Sasse & Kern	37	5.15 years	Polycrystalline (zirconia) ceramic CAD/CAM	Cantilever	Anterior	100%
Galiatsatos & Bergou	49	8 years	Glass ceramic (In Ceram)	Fixed-Fixed	Anterior	92.6%
Sailer & Hammerle	15	4.44 years	Polycrystalline (zirconia) ceramic	Cantilever	Anterior	100%
Sasse et. al.	25	5.35 years	Polycrystalline (zirconia) ceramic CAD/CAM	Cantilever	Anterior	100%
Sailer et. al.	28	6 years	Glass ceramic (Empress and e. max)	Cantilever	Anterior & Posterior	100%
Kern & Sasse	14	10 years	Glass ceramic (In-Ceram)	Cantilever & Fixed-Fixed	Anterior	Cantilever= 94.4% Fixed-Fixed= 67.3%

Table 4. The total number of RBFDPs (A), number of failure (B), the mean follow-up (C), the exposure time (D), the estimated annual failure rate (F) and the mode of failure. The failure rate was calculated by dividing the number of failures in the numerator by the total exposure time (RBFDP time or abutment time) in the denominator

Study	Total number of RBFDPs A	Number of failures B	The Mean follow up/years C	Exposure time / year D=A*C	Estimated annual failure rate % F=(B/D) *100	The mode of failure
Kern et al.	108	7	7.68	829.44	0.8	De-bonding + chipping
Kern M	22	2	15.7	345.4	0.6	Framework fracture
Sasse & Kern	42	0	5.15	216.3	0	Caries + De-bonding
Galiatsatos & Bergou	54	4	8.00	432	0.9	Framework fracture+ De-bonding
Sailer & Hammerle	15	0	4.44	66.6	0	De-bonding
Sasse et. al.	30	0	3.5	160.5	0	De-bonding + abutment rotation
Sailer et. al.	35	0	6.00	210	0	Chipping
Kern & Sasse	38	8	10.00	364	2.20	Framework fracture

(cantilever & fixed-fixed). Furthermore, four studies used glass-ceramic material, and four other studies used polycrystalline (zirconia) ceramic CAD/CAM material. Most of the studies made conservative preparations on abutments, although, one study applied the all-ceramic RBFDPs directly without any preparation for anterior abutments and minimal inlay tooth preparation for posterior abutment teeth. The most prevalent bonding system used in the eight studies was Panagia 21 TC.

3.2. Survival Rate

All eight studies reported the survival and complication rates of the all-ceramic RBFDPs. The results showed five studies reported between 98% and 100% survival rates while three studies reported between 92.6% and 95.4%. The one study which reported a fixed-fixed design demonstrated a 67% survival rate. An overall survival rate for all-ceramic RBFDPs was calculated as 94.2% (95% CI: 67.3-100%) (Table 3).

3.3. Failure

In total, 21 out of 344 all-ceramic RBFDPs were known to be lost or had de-bonded more than once. The calculated annual failure rate was estimated at 1.12% (95% CI: 0.6-2.20%) (Table 4).

3.4. Biological Complications

3.4.1. Dental Caries & Periodontitis

Only one study with a total of 42 abutment teeth, reported the incidence of caries. [14] This occurred in only one abutment, which was restored with a composite restorative material. Periodontitis was reported as a possible complication in two studies, but no actual cases were reported Table 4.

3.4.2. Loss of Vitality of Abutment Teeth

In all the eight studies, there was no reported loss of vitality of abutment teeth; hence statistical analysis was not possible Table 4.

3.4.3. Abutment tooth Fracture

Abutment fracture was not reported in any study. One study reported rotation in one abutment, which was de-rotated using a thermoformed splint Table 4. [19]

3.5. Technical Complications

3.5.1. De-bonding (Loss of Retention)

De-bonding was the most frequent technical complication of all-ceramic RBFDPs. It was addressed in five of the eight studies. It was not reported in three studies. De-bonding was mostly reported in studies which used polycrystalline (zirconia) material. Only one study that used glass-ceramic material reported two de-bonded RBFDPs out of 54 all-ceramic RBFDPs Table 4.

3.6. Material Complications

3.6.1. Framework Fracture and Veneer Chipping

Framework fracture was the second most frequent complication of all-ceramic RBFDPs. It was reported in three studies and was related to the all-ceramic framework material. There were no fractures reported when polycrystalline (zirconia) framework material was used. Veneer chipping was also another complication which was reported in two studies. Veneer chipping was found in both glass-ceramic (e. max) and polycrystalline (zirconia) material Table 4.

3.6.2. Patient Satisfaction

Patient satisfaction with aesthetics and function was reported only in one study. [18] There was just one patient out of 49 who was unsatisfied. This was due to a large edentulous space in the upper anterior area, which could not be replaced by only one pontic to produce a symmetrical appearance.

4. Discussion

The subject of all-ceramic RBFDPs has been selected as a sub-set of RBFDPs in general. This is a relatively new area of RBFDP treatment, and the volume of literature is therefore smaller. A brief literature search for all-ceramic RBFDPs identified 140 articles published in

this area over the past 20 years. However, following the application of inclusion and exclusion criteria, only eight articles were identified for this review. The evaluation of quality was developed and applied in an attempt to rank the papers in terms of their bias and the emphasis that might be placed on their results. There are three systematic reviews [6,9,10] for RBFDPs, but only one for all-ceramic RBFDPs. [22]

The results of this review demonstrated a lack of clinically-useful evidence studies to indicate the superiority of one material of all-ceramic over another, and a lack of evidence to demonstrate the effect of the position within the mouth on the success of such bridge-work of all-ceramic RBFDPs. In addition, there is a lack of evidence to suggest which design of all-ceramic bridge-work was the most successful, although lower success rates for fixed-fixed were reported compared with a cantilever design. Finally, there is a lack of evidence to suggest that the cementation agent makes a significant difference in all-ceramic RBFDPs survival. There appeared to be no evidence in relation to occlusal factors on the survival rate of all-ceramic RBFDPs. Overall, from the limited numbers of studies available, all-ceramic RBFDPs would appear to show a reasonable survival rate in the medium term (two years or more). Therefore, clinicians might be advised to ensure their placement using cantilever design, in a low occlusal stress situation and with composite luting cement. These results are consistent with the systematic review published. [22]

The CASP evaluation showed a high-quality for four studies with calculated quality scores ranging from 90-102.5. The other four studies showed a low-level of calculated scores ranging from 57.5-70. Even though there were high-quality studies, there were no significant differences in all-ceramic RBFDPs survival rate between the two groups.

The overall survival rate of all-ceramic RBFDPs in the papers reviewed in this review was 94.2% (95% CI: 67.3-100%) based on the eight included studies reporting on 344 all-ceramic RBFDPs. This is higher than compared with a 5- year survival rate in a previous systematic review [23] of 91.4 (95% CI: 86.7- 94.4%) based on 18 studies with 1755 RBFDPs. However, the systematic review by Thoma et al. included other framework materials such as all-ceramic and fibre reinforced composite. [10]

This review showed different material combinations experience different complications. The main problem with glassy ceramic RBFDPs is framework fracture. But relatively few glass-ceramic RBFDPs are lost due to de-bonding. Two studies reported this, one study using a glass-ceramic material framework reported no de-bonding but a high incidence of RBFDPs failure due to material framework fracture. [14] Another study using the glass-ceramic material framework also reported no de-bonding but a relatively high rate of covering aesthetic feldspathic porcelain veneer fractures. [16] On the other hand, polycrystalline ceramic (zirconia) material shows less frequency of framework fracture but a moderately higher incidence of de-bonding. Hence, even though polycrystalline ceramic RBFDPs showed a significantly higher survival rate than the glass-ceramic, there is still the issue of de-bonding.

The result with all-ceramic RBFDPs was also investigated regarding the position in the oral cavity. From the limited studies available, seven studies reported on all-ceramic RBFDPs in the anterior area of the mouth, whereas only one study reported on all-ceramic RBFDPs to replace both the anterior and the posterior teeth. The survival rate was similar in both areas, but a minor complication was reported for the posterior area, which was chipping the framework of the veneering porcelain. In a previous systematic review, the incidence of de-bonding rate was reported to be higher in the posterior area compared with the anterior area, although, it was at the margin of statistical significance ($p = 0.056$). [23]

Recently, all-ceramic RBFDPs are more frequently designed with cantilever design bonded to one abutment tooth, instead of using fixed-fixed design. In the eight papers identified for this review, the cantilever design was used in six studies, whereas the fixed-fixed design was only used in one study, and one study used both designs. The idea behind the cantilever design is to minimize the number of prostheses de-bonding, which is induced by the differential movement of the abutment teeth in different directions under functional loading. The cantilever design showed a better clinical outcome compared with fixed-fixed design; the survival rate was approximately 95-100% using the cantilever design compared with the fixed-fixed design which showed a survival rate of between 67.3% and 92.6%. Two published systematic reviews have also reported that the cantilever design showed significantly higher survival rates and significantly lower de-bonding rates than the fixed-fixed design. [9,23]

Overall, despite limitations of information and knowledge in the present review, all-ceramic RBFDPs seem to work best and last longest in the anterior area, and the framework material of choice appears to be zirconia which works better with a cantilever design.

5. Conclusion

The all-ceramic RBFDPs appeared to provide an effective-short to medium term (two years or more). The factors influencing the outcomes of the all-ceramic RBFDPs were the location in the mouth, the design of the all-ceramic RBFDPs, and the selection of framework material. The present review has illustrated that the all-ceramic RBFDP exhibited the best outcomes in the anterior regions, with a cantilever design and when made of zirconia-ceramic. However, the level of evidence was low, and there is a strong need for additional studies in the area of all-ceramic RBFDPs with well-established randomized control trials and cohort studies.

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Conflicts of Interest

There are no conflicts of interest.

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