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A systematic review of the survival and complication rates of resin-bonded bridges after an observation period of at least 5 years

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Abstract

Objectives: The objectives of this systematic review were to assess the 5-year survival of resin-bonded bridges (RBBs) and to describe the incidence of technical and biological complications.

Methods: An electronic Medline search complemented by manual searching was conducted to identify prospective and retrospective cohort studies on RBBs with a mean follow-up time of at least 5 years. Patients had to have been examined clinically at the follow-up visit. Assessment of the identified studies and data extraction were performed independently by two reviewers. Failure and complication rates were analyzed using random-effects Poissons regression models to obtain summary estimates of 5-year proportions.

Results: The search provided 6110 titles and 214 abstracts. Full-text analysis was performed for 93 articles, resulting in 17 studies that met the inclusion criteria. Meta-analysis of these studies indicated an estimated survival of RBBs of 87.7% (95% confidence interval (CI): 81.6–91.9%) after 5 years. The most frequent complication was debonding (loss of retention), which occurred in 19.2% (95% CI: 13.8–26.3%) of RBBs over an observation period of 5 years. The annual debonding rate for RBBs placed on posterior teeth (5.03%) tended to be higher than that for anterior-placed RBBs (3.05%). This difference, however, did not reach statistical significance ($P = 0.157$). Biological complications, like caries on abutments and RBBs lost due to periodontitis, occurred in 1.5% of abutments and 2.1% of RBBs, respectively.

Conclusion: Despite the high survival rate of RBBs, technical complications like debonding are frequent. This in turn means that a substantial amount of extra chair time may be needed following the incorporation of RBBs. There is thus an urgent need for studies with a follow-up time of 10 years or more, to evaluate the long-term outcomes.

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Resin-bonded bridges (RBBs) were first developed as a conservative fixed reconstruction for missing anterior teeth, before dental implants became available. Early RBBs with perforated cast retainers, as described briefly by Rochette (1973) and in greater detail by Howe & Denehy (1977), were considered temporary restorations, with approximately 2 years of service. These early prostheses were placed with minimal or no tooth preparation. The technique had also been further extended to the posterior region (Livaditis 1980). Since the development of the first RBBs in the 1970s, there have been significant changes in the design, the materials used, and the tooth preparation, to improve the longevity of the prostheses.

Contrary to initial beliefs, the use of RBBs is not an easy clinical procedure; careful treatment planning and clinical skills are required. The tooth preparation has to be designed to minimize tensile forces. Case selection also plays a great role in the longevity of the prostheses. Short clinical crown height with limited interocclusal distance may be considered as relative contraindications. The various retainer and tooth surface treatments together with the cement (bonding) used also have some bearings on the success. Owing to these variables, the survival rates of RBBs vary widely between studies. Various factors included the observation periods, retainer designs, abutment preparations, surface treatment and bonding techniques applied, the type of luting agent used, the mobility of the abutments, the interocclusal relationship and the location of the prostheses.

In a meta-analysis on RBBs, the authors reported a 74% survival rate at 4 years (Creugers & Van't Hof 1991). However, the majority of the included studies had maximum follow-ups of 5 years or less. The type of retention and location of the RBBs did not seem to affect the survival rate. Survival rates of 5 years and more were not analyzed due to the limited number of RBBs that were followed for these periods of time. Thus, in view of more recent follow-up of the studies, with better clinical techniques and materials, a systematic review with more recent and updated data would be beneficial. In addition, a mean follow-up period of at least 5 years would provide a more meaningful interpretation of the survival rate (Pjetursson et al. 2004a). In order to compare the results of survival and complication rates for tooth-supported fixed dental prostheses (FDPs) and implant-supported single crowns (SCs) with optional treatments like RBBs, it would be of importance to perform systematic reviews based on the same level of evidence and accomplished with exactly the same methodology.

This systematic review is part of a series of six systematic reviews based on the same methodology that have evaluated the survival of tooth- and implant-supported fixed reconstructions of different designs and described the incidence of biological and technical complications after an observation period of at least 5 years (Lang et al. 2004; Pjetursson et al. 2004a, 2004b; Tan et al. 2004; Jung et al. 2008).

It has been demonstrated that after 5 years of service, the survival of FDPs with different designs was 91.4% for tooth-supported cantilever FDPs (Pjetursson et al. 2007), 93.8% for conventional tooth-supported FPDs (Pjetursson et al. 2007) and 94.5% for implant-supported SCs (Jung et al. 2008).

The main objectives of this systematic review were to obtain the long-term survival rate of RBBs and to evaluate the incidence of specific technical and biological complications over an observation period of at least 5 years.

Material and methods

Search strategy and study selection

A Medline (PubMed) search from 1965 up to and including January 2007 was conducted for articles published in the dental literature, and limited to human trials, using the search terms 'resin-bonded bridges,' 'fixed partial dentures OR bridges,' 'adhesive bridges,' 'acid-etched bridges,' 'maryland bridges,' 'resin-bonded bridges survival rate,' 'denture, partial, fixed, resin-bonded,' and 'resin-bonded fixed partial dentures.'

Manual searches of the bibliographies of all full-text articles and related reviews, selected from the electronic search, were also performed.

From this extensive search, there were no randomized-controlled clinical trials (RCTs) available comparing RBBs with the conventional FDPs.

Inclusion criteria

In the absence of RCTs, this systematic review was based on prospective and retrospective cohort studies. The additional inclusion criteria for study selection were that:

- the studies had a mean follow-up time of 5 years or more,
- the publications were reported in the dental literature, with no language restriction,
- the patients included had been examined clinically at the follow-up visit, i.e., publications based on patient records only, on questionnaires or interviews were excluded and
- the studies reported details on the characteristics of the suprastructures.

Selection of studies

Titles and abstracts of the searches were initially screened by independent reviewers (B.E.P., W.C.T., K.T. and U.B.) for possible inclusion in the review. The full text of all studies of possible relevance was then obtained for independent assessment by two reviewers. Any disagreement was resolved via discussion.

Figure 1 describes the process of identifying the 17 studies selected from an initial yield of 6110 titles. Data were extracted independently by two reviewers using a data extraction form. Disagreement regarding data extraction was resolved by consensus.

Excluded studies

Of the 93 full-text articles examined, 76 were excluded from the final analysis (see reference list).

The main reasons for exclusion were a mean observation period of <5 years, multiple publications on the same patient cohorts with the same observation period and publications based on questionnaires, interviews or patient records, without clinical examination (Fig. 1).

Data extraction

Of the 17 studies included, information on the survival of the reconstructions and on biological and technical complications was retrieved. Survival was defined as the RBBs remaining *in situ* at the examination without multiple debonding, but irrespective of its condition. Failure was defined as the RBBs that were lost and required refabrication, or multiple recementations.

Biological complications included caries on abutment teeth, and periodontal disease progression.

Technical complications analyzed included loss of retention, with or without loss of the reconstruction, and fractures of veneers, with or without loss of the reconstruction. From the studies included, the number of events for all these categories were extracted and the corresponding total exposure time of the reconstruction was calculated.

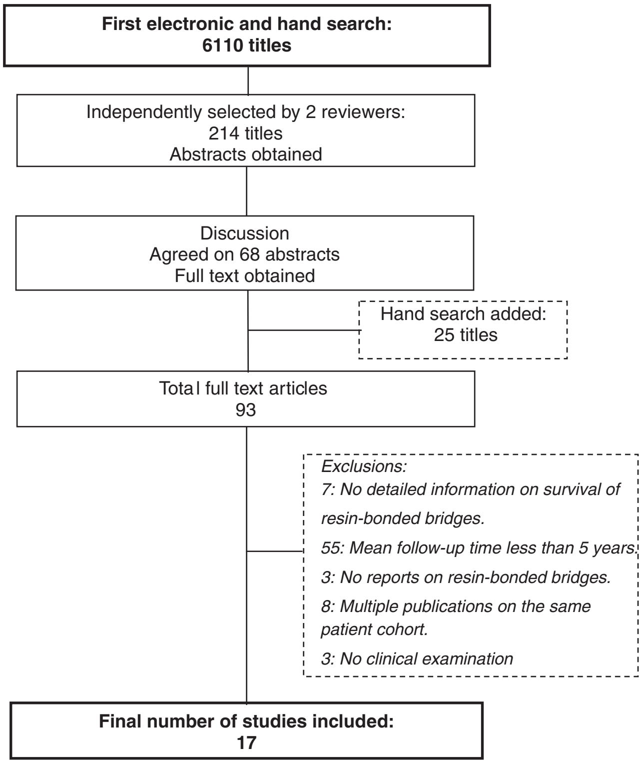

Fig. 1. Search strategy

Statistical analysis

Failure and complication rates were calculated by dividing the number of events (failures or complications) in the numerator by the total exposure time (RBB-time or abutment-time) in the denominator.

The numerator could usually be extracted directly from the publication. The total exposure time was calculated by taking the sum of:

(1) Exposure time of RBBs/abutments, that could be followed for the whole observation time.
(2) Exposure time up to a failure of the RBBs/abutments that were lost due to failure during the observation time.
(3) Exposure time up to the end of observation time for RBBs/abutments that did not complete the observation period due to reasons such as death, change of address, refusal to participate, non-response, chronic illnesses, missed appointments and work commitments.

For each study, event rates for RBBs and/or abutments were calculated by dividing the total number of events by the total RBBs or abutments' exposure time in years. For further analysis, the total number of events was considered to be Poisson distributed for a given sum of RBBs exposure years, and Poisson regression with a logarithmic link-function and total exposure time per study as an offset variable were used (Kirkwood & Sterne 2003a).

Robust standard errors were calculated to obtain 95% confidence intervals (CIs) of the summary estimates of the event rates. In order to assess the heterogeneity of the study-specific event rates, the Spearman goodness-of-fit statistics and associated *P*-value were calculated. If the goodness-of-fit *P*-value was below 0.05, indicating heterogeneity, random-effects Poisson's regression (with γ-distributed random effects) was used to obtain a summary estimate of the event rates. Five- and 10-year survival proportions were calculated via the relationship between event rate and survival function S, $S(T) = \exp(-T \times \text{event rate})$, by assuming constant event rates (Kirkwood & Sterne 2003b). The 95% CIs for the survival proportions were calculated using the 95% confidence limits of the event rates.

Multivariable Poisson regression was used to investigate formally whether event rates varied by position of the reconstruction, namely, maxilla vs. mandible or anterior vs. posterior.

All analyses were performed using Stata®, version 8.2 (Stata Corp., College Station, TX, USA).

Results

Included studies

A total of 17 studies on RBBs were included in the analysis. The characteristics of the selected studies are shown in Table 1.

These studies reported on 16 different patient cohorts. The oldest study was published in 1990, and the median year of publication was 1996. Nine of the studies were prospective and the remaining eight were retrospective studies (Table 1).

The studies included around 1500 patients between the age of 13 and 78 years. The proportion of patients with RBBs who could not be followed for the complete study period was available for 11 of the 17 studies and ranged from 0% to 48% (Table 1).

Although one of the most important advantages of RBBs is the requirement of minimal tooth preparation, the studies included used various techniques. These ranged from conservative minimal preparations to extensive preparations with grooves, guide planes and wrap-around design to improve the retention of the prostheses. In the same way, in order to enhance the resin-to-metal bond, a variety of metal treatments were used. These included micromechanical retention with sandblasting, chemical etching or electroetching, or macromechanical retention with perforations, or surface treatment with silica coating. A number of different luting cements were used in the studies included, of which dual-cured resin cements were most frequently used (Table 1).

The studies were mainly conducted in an institutional environment such as in universities or specialists' clinics (Table 1).

In one of the studies, the survival of conventional two-retainer design RBBs was compared with single-retainer cantilever RBBs (Kern 2005). Another research group randomly assigned the reconstructions into groups examining the effect of retainer designs, like perforated vs. etched

Table 1. **Study and patient characteristics of the studies reviewed for resin-bonded bridges**

Study	Year of publication	Study design	Manufacturing procedure			No. of patients	Age range	Mean age	Setting	Drop-out (%)
			Preparation	Metal treatment	Cement					
Garnett et al.	2006	Retrospective	Various techniques	Sandblasted	Panavia Ex Panavia 21	45	13–44	17.6	University	47%
Kern	2005	Prospective	Conservative, grooves and proximal boxes	All ceramic Silica-coated and silanated Sandblasted	Panavia TC Panavia 21 TC	30	NR	NR	University	0%
Zalkind et al.	2003	Retrospective	Wrap-around design with grooves, rests and guide planes	Sandblasted	Panavia	51	15–55	NR	Specialist	0%
Hikage et al.	2003	Prospective	Deep occlusal rests and inlays	Oxidation Sandblasted	SuperBond C & B	24	NR	NR	University	NR
Corrente et al.	2000	Retrospective	Extended guide planes	Electroetching	Panavia Ex	67	32–58	42.1	NR	NR
de Kanter et al.	1998	Prospective	Approximal grooves, guide planes and occlusal stops	Electroetching Sandblasted Silica-coated	ClearFil F2 Panavia Ex Microfill Pontic C	175	16–72	39	University	NR
Pröbster & Henrich	1997	Prospective	Various techniques	Silica-coated Sandblasted Etched	Concise, Microfill Pontic, Comspan	264	NR	29	University	17%
Hansson & Bergström	1996	Retrospective	Wrap-around design with vertical grooves	Sandblasted	Comspan Opaque	32	18–70	34.4	University	9%
Bergbreiter et al.	1996	Prospective	Grooves and rests	Silica-coated and silanated	Microfill pontic	32	NR	NR	University	48%
Samama	1996	Retrospective	NA	Electroetching	Superbond	121	NR	NR	Private practice	NR
de Rijk et al.	1996	Retrospective	Various techniques	NA	NA	146	NR	NR	University	5%
Priest	1995	Prospective	Wrap-around design, with guide planes and rests	Perforated Electroetching Chemically etched	various	83	NR	NR	Specialist	20%
Hosseini	1994	Retrospective	Extended guide planes	Perforated	NA	90	20–59	37.3	Specialist	NR
Barrack & Bretz	1993	Prospective	Wrap-around design with grooves and rests	Electroetching Sandblasted	Conclude Comspan Panavia Ex Panavia Opaque	109	14–69	45	Specialist	22%
Thayer et al.	1993	Retrospective	NA	Perforated Etched	Various	NR	NR	NR	University	NR
Creugers & Käyser	1992	Prospective	Various techniques	Perforated Electroetching	Clearfil F, Silar Conclude Panavia Ex	183	13–78	30	University	8%
Creugers et al.	1990	Prospective	Various techniques	Perforated Electroetching	Clearfil F, Silar Conclude Panavia Ex	183	13–78	30	University	0%

NA, not available; NR, not reported.

***Table 2*. Annual failure rates and survival of resin-bonded bridges (RBBs)**

Study	Year of publication	Total no. of RBBs	Mean follow-up time	No. of failure	Total RBB exposure time	Estimated failure rate (per 100 RBB years)	Estimated survival after 5 years (%)
Kern	2005	37	5.2	5	192	2.60	87.8
Zalkind et al.	2003	51	9.1	20	464	4.31	80.6
Corrente et al.	2000	61	6.7	1	422	0.24	98.8
de Kanter et al.	1998	201	5.0	42	1005	4.18	81.1
Pröbster & Henrich	1997	325	5.0	29	1625	1.78	91.5
Hansson & Bergström	1996	34	6.1	6	207	2.90	86.5
Bergbreiter et al.	1996	74	6.5	8	481	1.66	92.0
Samama	1996	145	5.8	4	835	0.48	97.6
Priest	1995	31	5.3	15	164	9.15	63.3
Barrack & Bretz	1993	127	5.8	9	737	1.22	94.1
Thayer et al.	1993	85	7.3	13	621	2.09	90.1
Creugers & Käyser	1992	203	7.5	35	1488	2.35	88.9
Total		1374	6.0	187	8241		
Summary estimate (95% CI)*						2.61 (1.68–4.06)	87.7% (81.6–91.9%)

*Based on random-effects Poisson regression, test for heterogeneity $P<0.0001$.
CI, confidence interval.

metal and groups comparing different cements (Creugers et al. 1990; Creugers & Käyser 1992). The remaining studies reported on survival and complication rates without comparing different treatment modalities.

Two of the studies (Creugers et al. 1990; Creugers & Käyser 1992) reported on the same patient cohort. The older study (Creugers et al. 1990) was included because it gave additional information on technical complications, but was not used for survival analysis.

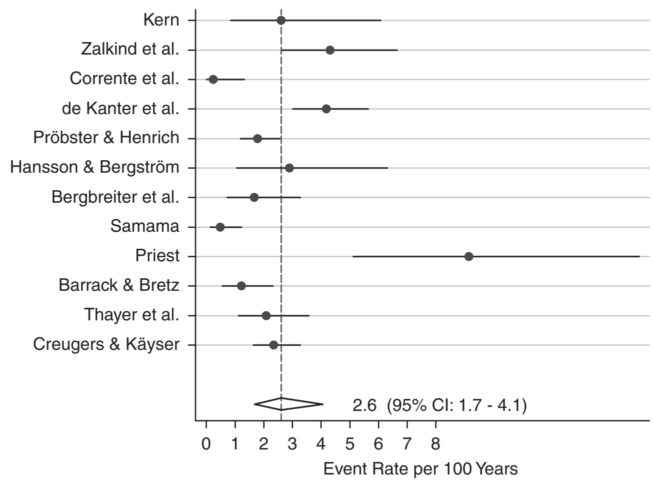

Fig. 2. Annual failure rates (per 100 years) of RBBs.

Survival

RBB survival was defined as the RBB remaining *in situ* with or without modification for the observation period. Twelve of the 17 studies reported on the survival of the reconstructions (Table 2). Of the originally 1374 RBBs placed, 187 RBBs were known to be totally lost or to have debonded more than once. The estimated study-specific 5-year survival proportion varied between 63.3% and 98.8% (Table 2).

The estimated failure rate per 100 RBB years ranged from 0.24% to 9.15% (Fig. 2), and the summary estimate, derived from random-effects Poisson regression, was 2.61 failures per 100 RBB years (95% CI: 1.68–4.06%) (Table 2).

The summary estimate for the survival after 5 years for RBBs was 87.7% (95% CI: 81.6–91.9%) (Table 2).

None of the included studies had a follow-up time of more than 10 years. The longest mean observation period (9.1 years) was reported by Zalkind et al. (2003). For this study, the estimated annual failure was 4.31 per 100 RBB years, translating into a 10-year survival of 65%.

Upon further investigation utilizing multivariable Poisson regression, the annual failure rate of RBBs placed in the maxilla was lower compared with that for RBBs placed in the mandible (1.07% vs. 2.36%). This difference, however, did not reach statistical significance ($P=0.370$) (Table 3).

The survival of RBBs could not be analyzed separately with regard to the position in the dental arch (anterior vs. posterior), but two of the studies included reconstructions placed in the same region of the jaw. Kern (2005), solely evaluating RBBs placed in the anterior, reported a 5-year survival rate of 87.8%, and de Kanter et al. (1998) reported survival rates after 5 years of 81.1%.

Success

Success was defined as an RBB being free of all complications over the entire observation period. This information could not be extracted from any of the 17 studies included in this systematic review.

Biological complications

Information on two kinds of biological complications, caries and RBBs lost due to periodontitis, could be extracted from the included studies.

Dental caries

Four studies with a total of 1254 abutments gave information on caries occurring

Table 3. **Annual failure and debonding rates analyzed according to the position of the resin-bonded bridges (RBBs) in the mouth**

	Total number of RBBs	Estimated annual rate	5-year summary estimate (95% CI)	Total number of RBBs	Estimated annual rate	5-year summary estimate (95% CI)	*P*-value*
		Maxilla			Mandible		
Survival	247	1.07† (0.45–2.54)	94.8%† (88.1–97.8%)	160	2.36† (0.38–14.45)	88.9%† (48.6–98.1%)	$P = 0.370$
Debonding	519	4.08† (2.70–6.15)	18.4%† (12.6–26.5%)	611	3.93† (1.99–7.76)	17.8%† (9.5–32.2%)	$P = 0.973$
		Anterior			Posterior		
Survival	37	NA	NA	201	NA	NA	NA
Debonding	674	3.05† (1.80–5.16)	14.1%† (8.6–22.7%)	461	5.17† (3.11–8.62)	22.8%† (14.4–35%)	$P = 0.157$

*Based on multivariable random-effect Poisson regression.
†Based on random-effects Poisson regression.
CI, confidence interval; NA, not available.

at the abutments. In random-effects Poisson model analysis, the estimated cumulative rate of caries occurring at abutments over an observation period of 5 years was 1.5% (95% CI: 0.3–7.1%) (Table 4).

Recurrent periodontitis

Four studies provided information on periodontal disease progression resulting in loss of the entire reconstruction, and seven out of 253 RBBs were lost due to recurrent periodontitis in these studies.

In standard Poisson model analysis, the estimated cumulative rate of RBBs lost due to recurrent periodontitis over a 5-year observation period was 2.1% (95% CI: 0.9–4.8%) (Table 4).

Technical complications

Debonding (loss of retention)

Debonding was the most frequent technical complication of RBBs.

Debonding of the reconstruction was addressed in all included studies, and affected 436 out of the 1693 RBBs. The annual RBB complication rate ranged between 1.22 and 12.8.

In random-effects Poisson model analysis, the estimated annual rate was 4.26%, translating into a cumulative rate of debonding over a 5-year observation period of 19.2% (95% CI: 13.8–26.3%) (Table 4).

The incidence of debonding was also analyzed according to the jaw position: a group of eight studies with a total of 519 RBBs placed in the maxilla and a group of seven studies with a total of 611 RBBs placed in the mandible. For the group of RBBs placed in the maxilla, the annual complication rate was estimated at 4.08%, translating into a 5-year rate of debonding of 18.4% (95% CI: 12.6–26.5%). Similar results were obtained for the group of RBBs placed in the mandible. The annual complication rate was estimated at 3.93%, giving a 5-year rate of debonding of 17.8% (95% CI: 9.5–32.2%) (Table 3).

The studies were also divided according to the position in the mouth: a group of eight studies with a total of 674 RBBs placed on anterior teeth and a group of seven studies with a total of 461 RBBs placed on posterior teeth. The group with posterior RBBs demonstrated a higher, 22.8% (95% CI: 14.4–35%) 5-year rate of debonding, compared with the debonding rate of 14.1% (95% CI: 8.6–22.7%) for the anterior RBBs. This difference, however, did not reach statistical significance ($P = 0.157$) (Table 3).

Seven studies reported on the rate of RBBs lost after multiple debonding, resulting in an annual failure rate of 1.61%, translating into a 5-year failure rate of 7.7% (Table 4).

Material complications: framework and veneer fractures

Six studies reported on the loss of reconstructions due to material fractures. These included fractures of the framework or the veneer material. Thirteen out of 451 RBBs were lost due to material fractures.

The annual RBB failure rate ranged between 0% and 2.08% (Table 4). The highest annual rate of material failures was reported for all-ceramic resin-bonded reconstructions (Kern 2005).

In a random-effect Poisson model analysis, the estimated cumulative rate of RBBs lost due to material fractures over a 5-year observation period was 2.5% (95% CI: 1.3–4.7%) (Table 4).

Five studies reported on the rate of minor veneer fractures (ceramic chipping) that could be repaired without losing the reconstruction.

For ceramic chipping, the annual complication rate was estimated at 1.17%, translating into a 5-year rate of 5.7% (Table 4).

Discussion

This systematic review is part of a series of six systematic reviews addressing the survival and complication rates of FDPs of different designs.

In the absence of RCTs, a lower level of evidence with prospective and retrospective cohort studies was used in this as well as in the previous systematic reviews to summarize the available information about the survival and complication rates of RBBs after a period of at least 5 years.

The results of longitudinal cohort studies with a mean follow-up time of at least 5 years regarding the survival and success of RBBs and their biological and technical complications were reviewed systematically. Survival was defined as RBB remaining *in situ* without multiple debonding.

Multiple debonding (two or more) was considered a failure because the failure rate has been shown to increase with each rebonding. Creugers & Käyser (1992) reported a significantly lower survival rate for RBBs that were rebonded when compared with the original RBBs. Similar observations on RBBs with multiple debonding were also reported by other authors (Marinello et al. 1990).

In several of the studies included, only debonding was reported. There was a mixture of definitions for survival, ranging from 'complete' survival with no debonding to 'functional' survival, with previous loss of retention, but functional after recementation. Biological complications and technical complications were not routinely reported.

Table 4. **Biological and technical complications**

Study	Year of publication	Total no. of abutments	Estimated rate of caries on abutments (per 100 abutment years)	Total no. of RBBs	Estimated rate of RBBs lost due to periodontitis (per 100 RBB years)	Estimated rate of RBBs lost due to veneer or framework fractures (per 100 RBB years)	Estimated rate of RBBs lost due to multiple debonding (per 100 RBB years)	Estimated rate of debonding (per 100 RBB years)	Estimated rate of minor veneer fractures (repairs) (per 100 RBB years)
Garnett et al.	2006	45	NA	39	NA	NA	NA	6.15	NA
Kern	2005	53	NA	37	NA	2.08	0	0	1.04
Zalkind et al.	2003	NA	NA	51	NA	NA	4.31	7.71	NA
Hikage et al.	2003	NA	NA	26	NA	NA	NA	3.59	NA
Corrente et al.	2000	327	0	61	0	0.24	NA	2.84	NA
de Kanter et al.	1998	402	NA	201	NA	NA	NA	9.35	NA
Pröbster & Henrich	1997	650	0.80	325	NA	NA	NA	4.80	NA
Hansson & Bergström	1996	68	0	34	0.48	0	1.93	2.42	0.48
Bergbreiter et al.	1996	NA	NA	74	NA	NA	1.66	2.29	0.62
Samama	1996	NA	NA	145	NA	NA	0.48	1.32	NA
de Rijk et al.	1996	NA	NA	164	NA	NA	NA	3.16	NA
Priest	1995	NA	NA	31	0.31	0.31	NA	12.80	NA
Hosseini	1994	NA	NA	90	NA	NA	NA	1.71	NA
Barrack & Bretz	1993	NA	NA	127	0.68	NA	0.54	1.22	0.41
Thayer et al.	1993	209	0.33	85	NA	0.64	NA	5.31	NA
Creugers & Käyser	1992	NA	NA	203	NA	NA	2.15	4.17	NA
Creugers et al.	1990	NA	NA	203	NA	0.32	NA	NA	2.89
Summary estimate event rates (95% CI)			0.30* (0.06–1.47)		0.41† (0.18–0.97)	0.50* (0.26–0.97)	1.61* (0.85–3.03)	4.26* (2.97–6.12)	1.17* (0.57–2.41)
Cumulative 5-year complication rates (95% CI)			1.5%* (0.3–7.1%)		2.1%† (0.9–4.8%)	2.5%* (1.3–4.7%)	7.7%* (4.2–14.1%)	19.2%* (13.8–26.3%)	5.7%* (2.8%–11.4%)

*Based on random-effects Poisson regression.

†Based on standard Poisson regression.

CI, confidence interval; NA, not available; RBB, resin-bonded bridge.

It must be acknowledged that information on long-term survival is still scarce, and the results of the present review should not be extrapolated to follow-up times measured in decades. The present review, moreover, demonstrated that longitudinal studies with observation periods of 10 years or more are lacking.

Although there was *no* language restriction in the present systematic review, the inclusion of papers of languages other than English did not yield additional studies for final inclusion. This concurred with an empirical study, which found little effect on the combined effect estimates in meta-analyses of RCTs, with the inclusion or exclusion of studies published in languages other than English (Egger et al. 2003).

Instead of performing a formal quality assessment of the included studies and sensitivity analysis, this review used stringent inclusion criteria. For example, only studies with clinical follow-up examinations were included to avoid the potential inaccuracies in event description in studies that based their analysis on patient self-reports.

The present systematic review reported a cumulative failure rate for RBBs of 12.3% after 5 years. Clearly, a limitation of the present review is the assumption of a constant annual event rate. Nevertheless, the results of the present analysis should be robust as only information of studies with a mean follow-up of 5 years or more was included. The survival rate of this study was higher when compared with another meta-analysis on RBBs with a shorter follow-up period (Creugers & Van't Hof 1991). In that study, the survival rate at 4 years was 74%. The higher survival rate reported in the present systematic review is possibly due to improvements in the technique utilized in newer studies.

The original idea behind RBBs was to enable fixed reconstruction with minimal tooth preparation, hence, the conservation of tooth structure. For anterior RBBs, the use of minimal preparation is considered sufficient by most authors. The extension of the tooth preparations with a wrap-around design, grooves and rests, which has been recommended (de Kanter et al. 1998) in recent years to increase retention for RBBs placed on posterior teeth, cannot qualify as a conservative method.

Creugers et al. (1989a) reported better retention with micromechanical retention when compared with macromechanical retention, and cements like Clearfil F® and Panavia Ex® (Carex/Kurary, Haarlem, the Netherlands) were better than Conclude® (3M Dental Products, St Paul, MN, USA) when used with micromechanical retainers.

The present systematic review reported lower failure rates for RBBs placed in the maxilla compared with RBBs placed in the mandible. Moreover, the rate of debonding was lower for RBBs placed on anterior teeth compared with those placed on posterior teeth. This is in agreement with the results from Creugers et al. (1989b), who reported the highest survival rate for anterior RBBs and that the mandibular posterior RBBs had the highest debonding rates.

The studies included were mainly conducted in an institutional environment, such as universities or specialists' clinics. Therefore, the long-term outcomes observed here could not be generalized to dental services provided in private practice. In a study based on annual reports of government agencies administering dentistry in the regions of England, Wales and Scotland, a high failure rate of RBBs was reported in the General Dental Services of the National Health Service (Hussey & Wilson 1999). Although RBBs were more inexpensive when compared with conventional FDPs, the cost of managing complications, like rebonding the RBBs, was very high over the 10-year observation period.

When considering the fact that RBBs were initially developed as an interim restoration, they have a good survival rate of 87.7% after 5 years. However, when comparisons were made with conventional FDPs (Pjetursson et al. 2007), and implants (Jung et al. 2008), RBBs had lower survival rates.

It is of interest to compare the evidence available for RBBs and implant-supported SCs, where several parallels and differences can be drawn. In a recent systematic review on implant-supported SCs, 26 studies were included (Jung et al. 2008). However, only 13% or 50% of those studies gave information on the survival of the reconstructions. The remaining 13 studies only reported on the survival of the implants, but gave no detailed information on the suprastructure. In the present systematic review, 17 studies were included, but as for the implant-supported SCs, only 12% or 70% of those studies reported on the survival of the reconstructions. The remaining studies gave detailed information on debonding of the reconstructions without mentioning their survival.

It seems that studies in the dental literature often concentrated on one aspect of the reconstruction without reporting on the functional survival of the reconstruction. Functional survival of the reconstruction is of great importance from the clinical point of view, as it presents the reconstructions that are functional in the patients' oral cavity, which is perceived by the patients as a surrogate for 'success.'

The implant-supported SCs showed a lower annual failure rate, 1.14% (95% CI: 0.83–1.56%) (Jung et al. 2008), compared with an annual failure rate of 2.61% (95% CI: 1.68–4.06%) for RBBs. This translates into 5-year survival rates of 94.5% and 87.7%, respectively. Thus, it should be cautioned that on the basis of the annual failure rate, there may be more failures per year for RBBs when compared with implant-supported SCs.

From the literature, few 10-year follow-up studies were available. For implant-supported SCs, the longest mean observation period was 10 years (Brägger et al. 2005), while that for RBBs was 9.1 years, as reported by Zalkind et al. (2003). From these studies, the annual failure rate was 1.2% and 4.3% for implant-supported SCs and RBBs, respectively. This translates into a 10-year survival rate of 89.4% for implant-supported SCs compared with a 10-year survival rate of 65% for RBBs.

Therefore, more long-term studies with a follow-up period of 10 years or more, would provide a better insight into the longevity of RBBs.

Literature-based systematic reviews of prognosis and survival outcomes are hampered by a variety of problems (Altman 2001). The present systematic review revealed several shortcomings in the previous clinical studies. Hence, it appears appropriate to make the following recommendations: long-term cohort studies on RBBs should be prospective and should have complete follow-up information, preferably with a similar length of follow-up for all patients. This means that data on well-defined time periods should be reported for the entire cohort, especially for the different years after insertion.

Conclusion

Despite the high survival rate of RBBs after 5 years, technical complications such as debonding are frequent. This, in turn, means that substantial amounts of extra chair time may by needed following the incorporation of RBBs. Thus, there is an urgent need for prospective studies with a follow-up time of 10 years or more, to evaluate the long-term outcomes of RBBs.

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