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EPA Consensus Project Paper: Anterior Full or Partial Coverage Single Tooth Restorations - A Systematic Review of Survival and Complication Rates

ABSTRACT

Introduction: The aim of this systematic review was to assess the literature reporting on the failure rates, survival rates and complication rates and patient reported outcome measures (PROMs) of anterior full (FC) or partial (PC) coverage single tooth restorations after a mean observation period of at least 3 years. Methods: Systematic search was conducted using the electronic databases: MEDLINE, EMBASE and Cochrane library. Data regarding survival (restoration failure) and complication rates and PROMs were extracted and presented descriptively. Results: Altogether 42 studies were included in the analysis (28 with FC, 12 with PC and 2 with both types of restorations). For FC restorations the estimated annual failure rate was 0.72 (95%CI: 0.33-1.57), resulting in a 5-year survival rate of 96.4% (95%CI: 92.4-98.3). For PC restorations, the estimated annual failure rate was 0.62 (95%CI: 0.27-1.46), resulting in a 5-year survival rate of 96.9% (95%CI: 93.0-98.7). There was no significant difference between the groups regarding survival or technical complications, while significantly fewer biological complications were observed with PC compared to FC restorations (test for subgroup differences, p=0.01). Conclusions: FC and PC restorations showed high 5-year survival rates but the teeth restored with FC restorations may be more prone to biological complications.

INTRODUCTION

The desire for esthetic appearance has been guiding the dental treatments and the development of prosthetic materials over the past decades. Harmonious smile can be achieved by re-creating the ideal tooth morphology and soft tissue contour according to an esthetic checklist.[1] Metal-ceramic restorations were introduced in 1960's followed by reinforced glass ceramics and polycrystalline ceramic materials several decades later.[2] Additionally, the development of computer aided design / computer aided manufacturing (CAD/CAM) methods has been increasing the options for esthetic materials available and enabling the efficient workflow including chair-side options.[3,4]

Anterior teeth are restored either due to esthetic or functional reasons where the size of the restoration depends on the existing tooth structure. In addition, the chosen material affects the preparation type and the invasiveness of the treatment. Conventional anterior crown preparations yield up to 72% of the tooth structure is loss, leading to possible loss of vitality.[5,6] The required tooth structure removal for conventional metal-ceramic crowns can be 4.3 times more than for a veneer preparation,[6] which is supporting the indication of more minimally invasive methods and materials.

The mechanical and adhesive properties of a prosthetic materials can have an impact on the clinical outcomes of the restorations. Metal-ceramic crowns were for a long time a gold standard for restoring teeth due to their excellent mechanical properties.[2,7] During the last three decades polycrystalline ceramic materials, especially zirconia (3Y-TZP, 4Y-TZP, 5Y-TZP), is preferred as material of choice providing similar mechanical properties, esthetic outcomes with lower costs.[8-11] On the other hand, glass-ceramic-based materials i.e., feldspathic porcelain and leucite- or lithium disilicate reinforced glass-ceramics, have better optical properties imitating the optical properties of natural tooth structures the best.[2,12,13] Additionally, glass-ceramic materials can be etched, silanized and adhesively luted with composite resin cements resulting in higher fracture load values compared to cementation with conventional cements such as glass ionomer cement.[14] As a result of the favorable adhesive properties, the glass-ceramic materials can be used as minimally invasive and partial restorations, whereas the use of metal-ceramic and zirconia require more invasive preparation types and require sufficient ferrule for durable crowns. Additionally, there is increased interest for CAD/CAM composite materials as partial coverage restorations in anterior and posterior area.[15,16]

Patient-related outcome measures (PROMs) can be used to evaluate and enhance the quality of patient care.[17] In dentistry, PROMs have been used for assessing patients' satisfaction and expectations to different treatment methods and appearance and function of the dental restorations.[18-22] When modern prosthetic materials and methods provide sufficient clinical results, patient's opinion may play a bigger role in choice of the treatment and material type.

Retrospective studies show high survival rates ranging between 78 – 85% for full crowns in 20 – 25 years of follow-up periods.[23-25] Limited information is available on the reports covering the invasiveness of the preparations and their effect to the treatment outcomes compared to less invasive treatment options. Therefore, the aim of this systematic review was to assess the literature reporting on the failure rates, survival rates and complication rates as well as patient reported outcome measures (PROMs) of anterior full or partial coverage single tooth restorations after a mean observation period of at least 3 years. The study hypothesis was that there would be no significant differences in survival rates between the different restoration types.

MATERIAL AND METHODS

PROTOCOL DEVELOPMENT AND ELIGIBILITY CRITERIA

The study protocol was registered in PROSPERO (CRD42022307877). The Preferred Reporting Items for Systematic Review and Meta-analyses (PRISMA) statement was used for reporting the review.[26,27]

FOCUSED QUESTION

Two focused questions were asked: 1) What are the survival and complication rates of anterior full or partial coverage single tooth restorations (full coverage crowns, partial crowns, veneers) after a mean observation period of at least 3 years? 2) Are the survival and complication rates of anterior full or partial coverage single tooth restorations similar?

PICO

PICO terms were used as follows:

P Population: Subjects receiving indirect anterior (from canine to canine) single tooth restorations in the maxilla and mandible

I Intervention: Anterior partial coverage restorations (partial crowns, veneers)

C Comparison: Anterior full coverage crowns

O Outcome: Primary outcome was survival rate (restoration failure rate) and secondary outcomes were technical and/or biological complication rates, esthetic outcomes, patient-reported outcome measures (PROMS). Survival was defined as the restoration remaining in situ with or without modification for the observation period.

SEARCH STRATEGY

Medline (PubMed), Embase, Cochrane Central Register of Controlled Trials (CENTRAL) electronic databases were screened for suitable studies. Clinical studies, randomized controlled trials (RCTs), prospective cohort studies, retrospective cohort studies and case series published from 1st of January 1990 to 31st of December 2021 in English language in the dental literature were included to the search. Additionally, the reference lists of all included full-text articles were screened for further possible studies.

SEARCH PROTOCOL

Search terms for identifying the "population" were:

- Indirect single-unit restorations on anterior teeth

  [MeSH terms]: Dental prostheses

  OR

[Text Words]: "dental restoration permanent" OR "indirect restoration" OR "single unit tooth restoration" OR "single tooth restoration" OR "anterior tooth" OR "front tooth"

OR

[Emtree terms]: dental restoration

Search terms for identifying the for identifying the "intervention" were:

- Partial restorations

[MeSH terms]: dental veneers

OR

[Text Words]: "dental veneer" OR "veneer" OR "veneer*, dental" OR "dental laminate*" OR "laminate*, dental" OR "partial coverage restoration" OR "short-wrap veneer" OR "medium-wrap veneer" OR "long-wrap veneer" OR "palatal veneer" OR "full-wrap veneer" OR "porcelain veneer" OR "indirect veneer"

OR

[Emtree terms]: dental veneer

Search terms for identifying the for identifying the "comparison" were as follows:

- Complete crowns

[MeSH terms]: crowns

OR

[Text Words]: "crown" OR "dental crown*" OR "crown*, dental" OR "full crown*" OR "full coverage restoration*" OR "complete coverage restoration*"

OR

[Emtree terms]: tooth crown

Search terms for identifying the for identifying the "outcome" were:

- Survival (rates) and/or clinical success, technical and/or biological complication (rates), esthetic outcome, patient related outcome measures

[MeSH terms]: survival OR survival analysis OR survival rate OR dental restoration failure OR complications OR fractures OR tooth fractures OR dental caries OR esthetics OR visual analogue scale questionnaire OR patient reported outcome measures

OR

[Text Words]: "Rate*, Survival" OR "Survival rate*" OR "Mean survival time*" OR "Survival time*, mean" OR "Time*, mean survival" OR "cumulative survival rate*" OR "Rate*, cumulative survival" OR "Survival rate*, cumulative" OR "Survival analyses" OR "Analysis, Survival" OR "Analyses, survival" OR "success" OR "failure" OR "dental prosthesis failure" OR "clinical behaviour" OR "adverse event" OR "technical complication*" OR "technical failure*" OR "biological complication*" OR "biological failure*" OR "single damaged tooth" OR "single restored tooth" OR "solitary restored tooth" OR "trauma tooth" OR "crack" OR "cracked tooth syndrome" OR "cracked tooth" OR "fractured tooth" OR "broken tooth" OR "tooth substance loss" OR "decayed tooth" OR "secondary caries" OR "chipping" OR "debonding" OR "loss of vitality" OR "esthetic*" OR "evaluation" OR "analog scale*, visual" OR "scale*, visual analog" OR "visual analog scales" OR "VAS" OR "questionnaire" OR "patient related" OR "patient reported outcome*" OR "patient-reported outcome*" OR "patient reported outcome measures" OR "Outcome*, Patient reported" OR "Outcome*, patient-reported" OR "patient opinion" OR "patient perception" OR "patient report"

OR

[Emtree terms]: survival time OR survival rate OR complication OR fracture OR tooth fracture OR dental caries OR esthetics OR visual analog scale OR patient-reported outcome

INCLUSION CRITERIA

Clinical studies were included such as randomized controlled clinical trials, prospective cohort studies, retrospective cohort studies and case series with a mean follow-up period of at least 3 years and a minimum of 10 patients at follow-up. An additional requirement was that the included patients were examined clinically at the follow-up visits.

EXCLUSION CRITERIA

Studies that did not distinct the results between anterior and posterior restorations or between tooth- and implant-retained restorations and the studies reporting insufficient data were excluded. Additionally, several publications on the same patient population (the longest follow-up available is considered) were excluded from the search.

SELECTION OF PUBLICATIONS

The screening of the titles and abstracts was performed independently by two reviewers (JH and FMR). Full-text articles of selected abstracts were obtained for the final selection based on inclusion/exclusion criteria. Material and methods, results and discussion of the full-text articles were assessed for the final inclusion by two reviewers (JH, FMR). In case of disagreement during any step of the screening, consensus was attained by discussions between all authors. Cohen's Kappa-coefficient was calculated for title, abstract and full-text screening as a measurement of agreement.

DATA EXTRACTION

The extracted parameters from the selected full-texts on a study level were: author(s), year of publication, study design, planned / actual number of patients, drop-out rate, mean age

of the patient, age range and operators. In case of a study comparing different materials or restoration types, the results were extracted on study subgroup level. On study group / subgroup level, the following parameters were extracted: restoration type, restoration material, restoration location (tooth, jaw), brand of the restoration material, composition of the veneering material, brand of veneering material, manufacturing process, cement used, number of restorations, number of vital / non vital abutment teeth, mean follow-up time, follow-up range, the number of lost restorations, the number of biological complications (caries, endodontic failure, periodontal, root fracture), the number of technical complications (restoration fracture, loss of retention, minor chipping, major chipping, marginal gap, marginal discoloration), number of esthetic complications (discrepancy in color), the number of patients without complications, patient-reported outcome measures (which method was used for evaluating PROMs, patient satisfaction to treatment and esthetic results). Table 1 describes the included studies.

The failure rate, survival rate and the complication rate of the restorations was calculated based on included studies and subgroups by the type of the restoration (full coverage or partial coverage restorations) and by the restoration material.

STATISTICAL ANALYSIS

All statistical analyses were performed using the R system for statistical computing and graphics (R Foundation, Vienna, Austria) (R Core Team, 2022). Characteristics of all included studies and study subgroups were summarized descriptively as frequencies and percentages for categorical variables and as median and inter-quartile range for continuous or count variables. It should be noted that although in the PROSPERO registration the main outcome was described as survival rate of the restorations, restoration failure rates were analyzed, and the survival rates were derived from the failure rates. Restoration failure and complication rates were calculated by dividing the number of restoration failures / complications in the numerator by the total restoration exposure time (in years) in the denominator. While the number of failures (and complications) could be extracted directly from the studies (or study subgroups), the total restoration exposure time had to be calculated. It was not possible to extract individual restoration exposure times (see PROSPERO registration), as these were either not reported at all or were incomplete. Instead, the total restoration exposure time was calculated as number of restorations * mean follow-up time (years).

The resulting annual failure rates were multiplied by a factor of 100 in order to express the restoration failure rate per 100 crown or restoration years as previously reported.[28] Restoration failure rates were analyzed using generalized linear models (GLM) with negative binomial error and log link function, using the function glmmTMB from the R package glmmTMB.[29] The total exposure time was used as an offset in the models (log-transformed, due to the log link function). In order

Table 1. Summary of the characteristics of the 42 included studies.

		Overall	Missing (%)
n		**42**	**0**
Study design n (%)			0
	Retrospective CS	14 (33.3)	
	Prospective CS	25 (59.5)	
	RCT	3 (7.1)	
Country n (%)			2.4
	Italy	11 (26.8)	
	Germany	10 (24.4)	
	Switzerland	3 (7.3)	
	USA	4 (9.8)	
	Netherlands	3 (7.3)	
	Belgium	2 (4.9)	
	Japan	2 (4.9)	
	Norway	1 (2.4)	
	Spain	1 (2.4)	
	Sweden	1 (2.4)	
	Turkey	1 (2.4)	
	Australia	1 (2.4)	
	China	1 (2.4)	
Center n (%)			2.4
	University	22 (53.7)	
	Private practice	16 (39.0)	
	Both	1 (2.4)	
	Not defined	2 (4.9)	
Restoration type n (%)			0
	FC	28 (66.7)	
	PC	12 (28.6)	
	FC, PC	2 (4.8)	

Table 1 continued overleaf

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Table 1 continued:

Restoration material n (%)			0
	Re-inforced glass ceramic	16 (38.1)	
	Alumina	9 (21.4)	
	Feldspathic porcelain	5 (11.9)	
	Zirconia	5 (11.9)	
	Indirect composite	2 (4.8)	
	Metalceramic	1 (2.4)	
	Feldspathic porcelain, Alumina	1 (2.4)	
	Feldspathic porcelain, Indirect composite	1 (2.4)	
	Metalceramic, Feldspathic porcelain	1 (2.4)	
	Indirect composite, Re-inforced glass ceramic	1 (2.4)	
Planned number of patients (median, IQR)		50.0 [24.8, 106.2]	4.8
Actual number of patients (median, IQR)		40.0 [20.5, 84.0]	4.8
Percentage drop-out (median, IQR)		2.9 [0.0, 12.0]	11.9
Mean patient age (median, IQR)		40.9 [38.4, 48.5]	38.1
Minimum patient age (median, IQR)		18.0 [18.0, 20.0]	54.8
Maximum patient age (median, IQR)		70.0 [66.5, 79.5]	54.8
Percentage female patients (median, IQR)		60.0 [50.6, 68.0]	23.8
Number of restorations (median, IQR)		82.0 [46.5, 120.2]	0

to estimate the summary measure for the restoration failure rate (per 100 restoration years), with a 95% confidence interval, one GLM with an intercept only was fitted to restoration failure rates of studies (or study subgroups) with full coverage restorations and another to studies (or study subgroups) with partial coverage restorations. In order to estimate a rate ratio for the comparison of the rates of the two groups, a GLM was fitted on all studies (or study subgroups) with type of restoration (partial vs. full coverage) as an explanatory variable. As a sensitivity analysis, restoration failure rates of the studies (and study subgroups) were summarized by random-effects meta-analysis of the incidence rates, using the function rma.uni from the R package metaphor.[30] Type of restoration (partial vs. full coverage) was used as a moderator in this analysis, and the restricted maximum likelihood estimator to estimate the amount of heterogeneity. Restoration failure rates of individual studies and study subgroups as well as the summary measures estimated by the GLMs and meta-analysis were used to calculate 5-year survival rates via the relationship between event rate and survival function S, $S(T) = \exp(-T * \text{event rate})$, assuming constant restoration failure rates.[31] Likewise, 95% confidence intervals for the survival rates were calculated based on the 95% confidence limits of the restoration failure rates. Furthermore, two multivariable GLMs were fitted to formally compare reconstruction subtypes and to assess other study characteristics: one GLM included type of restoration and restoration material as explanatory variables, one included type of restoration and study design (RCT and prospective cohort vs. retrospective cohort) as explanatory variables. A model containing all three variables was not fitted due to overfitting.

Technical and biological complication rates were calculated in the same way as the restoration failure rates and they were also summarized by GLMs and meta-analysis. Numbers of individual components of technical and biological complications were reported descriptively. Esthetic complication rates were neither calculated nor analyzed. PROMs were descriptively analyzed only since these outcomes were rarely reported.

EVALUATION OF RISK OF BIAS

The methodological quality of all included comparative studies was assessed by two independent reviewers (JH, FMR). RoB 2.0 tool (Risk of Bias tool as stated in the Cochrane Handbook of Systematic Reviews) was used for assessing the quality of randomized controlled trials (RCTs), while the Newcastle-Ottawa Scale (NOS) was used to assess the quality of cohort studies.

RESULTS

SEARCH

The results of the search are visualized in the flow chart *(Figure 1)*. In the systematic search, 2548 titles were found. After screening the titles and abstracts, 111 articles were included for full-text analysis. A total of 59 articles were considered for data extraction while 42 of them were included to the analysis complying with the inclusion criteria. Cohen's Kappa value of agreement was 0.814 (95% CI [0.775-0.853]) for title and abstract screening and 0.944 (95% CI [0.758-1.130]) for full texts.

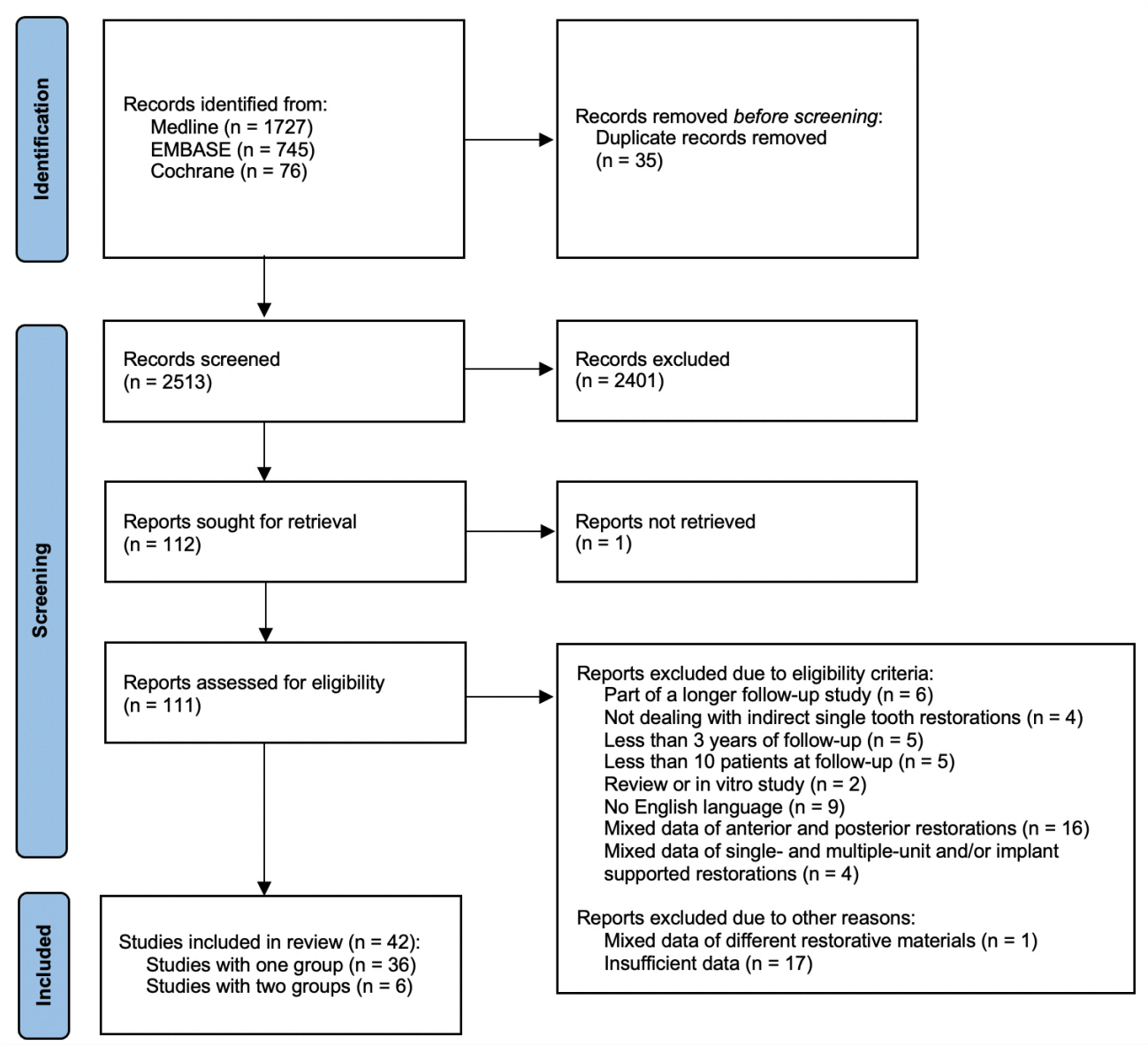

Figure 1: PRISMA 2020 flow diagram for study selection.[81] For more information, visit: http://www.prisma-statement.org.

DESCRIPTION OF THE STUDIES

Of the included 42 studies, 28 were on full coverage restorations,[32-59] 12 on partial coverage restorations[16,60-70] and 2 on both types of restorations.[71,72] In two studies partial coverage restorations were palatal veneers[16,70] but in the rest of the studies the partial coverage restorations were buccal veneers. For full coverage restorations the materials (n) used were alumina (10), feldspathic porcelain (3), indirect composite (1), metal ceramic (2), reinforced glass-ceramic (9) and zirconia (5). For partial coverage restorations the materials (n) used were feldspathic porcelain (5), indirect composite (3) and reinforced glass-ceramic (6). In studies comparing both types of restorations, reinforced glass-ceramic (2) was used. Six of the studies had two subgroups including different materials or restoration designs.[16,35,40, 66,71,72] The mean follow-up times of the studies varied between 24 to 223 months.

Table 1 summarizes the characteristics of all the studies and Table 2 presents the characteristics of each individual study.

RISK OF BIAS ASSESSMENT

The quality assessment of the included studies was completed according to New Castle Ottawa scale for prospective and retrospective studies *(Table 3)* and according to the Cochrane Collaboration recommendations (RoB 2.0 tool) for included randomized controlled trials *(Table 4)*. Out of the 39 prospective and retrospective studies the majority (n=32) were rated as good level of quality and 7 were rated as fair. For the three randomized controlled trials a high risk of performance bias and detection bias was estimated, meaning that in the study set-up, the blinding of the participants, personnel or the person assessing outcomes was not possible. However, regarding the primary and secondary outcomes of the included studies, attrition bias was rated low.

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Table 2. Description of the included studies.

Author and year	Type of Study	Country	Center	Restoration type	Planned number of patients	Actual number of patients	Drop out %	Mean Age (years)	Female %	Number of restorations	Restoration material	Restoration material brand	Cement used	Study outcomes measured/ calculated with
Pröbster 1996	prospective CS	Germany	University	FC	18	18	0	36.3	77.8	28	Alumina	In-Ceram	Zinc-phosphate cement, and glass ionomer cement	Cumulative survival rate, cracks, fractures, gaps, marginal wear, caries, tooth sensitivity
Fradeani & Aquilano 1997	prospective CS	Italy	Private practice	FC	55	55	0	38.5	65.5	101	Re-inforced glass ceramic	IPS Empress	Dual, Variolink, Opal Luting Composite, zinc-phosphate cement	Cumulative survival rate, Modified USPHS criteria
Oden et al 1998	prospective CS	Sweden	Private practice	FC	58	58	0	NR	65.5	17	Alumina	Procera AllCeram	Zinc-phosphate cement, glass ionomer cement, and dual-cure resin cement	CDA criteria
Erpenstein et al 2000	retrospective CS	Germany	Private practice	FC	410	410	0	40.8	NR	270	Metalceramic, Feldspathic porcelain	AGC Galvano-Ceramic Wieland, Dicor	Zinc-phosphate cement	Cumulative survival rate, Fractures of the restorations
McLaren & White 2000	prospective CS	USA	Private practice	FC	107	96	10.3	NR	NR	97	Alumina	In-Ceram	Panavia, Ketac-Cem, Flecks	Cumulative survival rate, fractures
Segal 2001	retrospective CS	USA	Private practice	FC	263	253	0.0	NR	NR	177	Alumina	In-Ceram	Vitremer	Failure rate, Structural integrity (chips, cracks, and fractures), marginal integrity
Fradeani et al 2002	prospective CS	Italy	Private practice	FC	13	13	0.0	48.3	76.9	40	Feldspathic porcelain	In-Ceram Spinell	Panavia 21 TC	Cumulative survival rate, modified CDA/Ryge criteria
Fradeani & Redemagni 2002	retrospective CS	Italy	Private practice	FC	59	54	8.5	40	50.8	93	Re-inforced glass ceramic	IPS Empress	Dual Cement, Variolink	Cumulative survival rate, modified CDA/Ryge criteria
Bindl & Mormann 2004	prospective CS	Switzerland	University	FC	29	24	17.2	53	55.2	36	Feldspathic porcelain, Alumina	Vita Mark II, Spinell Vita	Tetric composite resin	Cumulative survival rate, modified USPHS criteria, PI, PBI
Fradeani et al 2005	prospective CS	Italy	Private practice	FC	106	106	NR	40.5	55.7	50	Alumina	Procera AllCeram, In-Ceram Alumina	Panavia 21 TC, Fuji Plus, RelyX Luting	Cumulative survival rate, proximal contacts, occlusal relationships, shade match, contour, marginal adaptation
De Backer et al 2006	retrospective CS	Belgium	University	FC	456	NR	NR	41	60.5	190	Metalceramic	NR	NR	Cumulative survival rate, biological (caries, periodontal problems, endodontic problems), technical or patient-related (fractures) failures

Table 2 continued overleaf

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Table 2. Description of the included studies.

Walter et al 2006	prospective CS	Germany	University	FC	70	66	5.7	38.8	58.6	61	Alumina	Procera AllCeram	Ketac-Cem	Cumulative survival rate, complications
Zitzmann et al 2007	prospective CS	Switzerland	University	FC	50	39	22.0	NR	NR	32	Alumina	Procera AllCeram	Panavia F and Ketac-Cem Aplicap	Cumulative survival rate, modified USPHS criteria
Lehmann et al 2009	RCT	Germany	NR	FC	71	71	0.0	50.5	66.2	46	Indirect composite	Artglass	Solid Bond C	Cumulative survival rate, failures, complications, occlusal contacts, PI, patients' rating of esthetics and functionality
Valenti & Valenti 2009	retrospective CS	Italy	Private practice	FC	146	144	1.4	NR	67.1	101	Re-inforced glass ceramic	IPS Empress 2	Variolink 2	Cumulative survival rate, modified CDA/Ryge criteria
Schmitt et al 2010	prospective CS	Germany	University	FC	10	9	10.0	42.1	60.0	17	Zirconia	Lava	Ketac-Cem	CDA criteria, periodontal parameters, PI
Kokubo et al 2011	prospective CS	Japan	University	FC	39	31	20.5	50.9	76.9	64	Alumina	In-Ceram Alumina	Panavia F 2.0, GC Fuji Luting S	Cumulative survival rate, CDA criteria, PI, GI
Rinke et al 2011	retrospective CS	Germany	University	FC	113	80	29.2	NR	34.5	163	Alumina	In-Ceram Alumina	NR	Cumulative survival rate, technical (fractures, chippings, loss of retention) and biologic (caries, endodontic and periodontal problems) complications
Gehrt et al 2013	prospective CS	Germany	University	FC	41	37	9.8	34	63.4	74	Re-inforced glass ceramic	IPS e.max	Variolink 2, Vivaglass	Cumulative survival rate, PI, GI, BOP, PD, occlusal contacts, wear,technical complications (chippings, fractures, loss of retention), biological complications (endodontic problems, caries)
Monaco et al 2013	retrospective CS	Italy	Private practice	FC	398	261	34.4	48.6	43.0	343	Zirconia	16 zirconia brands	Resin cements, glass-ionomer cements, zinc phosphate cement, and temporary cement	Cumulative survival rate, modified USPHS criteria
Simeone & Gracis 2015	retrospective CS	Italy	Private practice	FC	106	106	0.0	52	68.9	106	Re-inforced glass ceramic	IPS Empress II and IPS e.max Press	Multilink Automix, RelyX/S ADH, Speedcem, Variolink and Variolink Veneer	Cumulative survival rate, Cvar-Ryge criteria (marginal discoloration and marginal adaptation)
Toman & Toksavul 2015	prospective CS	Turkey	University	FC	35	34	2.9	NR	60.0	98	Re-inforced glass ceramic	IPS Empress 2	Variolink 2	Cumulative survival rate, modified CDA/Ryge criteria
Valenti & Valenti 2015	retrospective CS	Italy	Private practice	FC	59	59	0.0	NR	NR	39	Re-inforced glass ceramic	NR	Multilink Automix	Cumulative survival rate, modified CDA/Ryge criteria

Table 2 continued overleaf

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Table 2. Description of the included studies.

Dogan et al 2017	prospective CS	USA	University	FC	18	18	0.0	44.5	50.0	19	Zirconia	Lava	RelyX Unicem	Survival rate, modified CDA/Ryge criteria, patient satisfaction
Teichmann et al 2017	prospective CS	Germany	University	FC	45	37	17.8	32.9	40.0	38	Re-inforced glass ceramic	IPS Empress 2 / IPS e.max Press	Ketac Cem Maxi Cap and adhesive cement	Cumulative survival rate, technical complications (chippings, fractures, marginal discrepancy, loss of retention), biological complications (caries, periodontal and endodontic problems),PI, GI, BOP, PD, CDA criteria
Miura et al 2018	retrospective CS	Japan	University	FC	62	56	9.7	51.4	74.2	63	Zirconia	Cercon Smart	Fuji I, Panavia F, ResiCem	Cumulative survival rate, complications (chipping, fractures, loss of retention)
Malament et al 2019	prospective CS	USA	Private practice	FC	NR	556	NR	NR	NR	656	Re-inforced glass ceramic	IPS e.max Press	Variolink 2	Cumulative survival rate, failures (chipping, marginal breakdown)
Serra-Pastor et al 2021	prospective CS	Spain	University	FC	NR	34	NR	NR	NR	59	Zirconia	Lava Frame	Ketac-Cem	Cumulative survival rate, technical complications (fractures, loss of retention), PI, GI, gingival thickness, marginal stability, biological (caries, endodontic problems) complications, patient satisfaction
Nordbo et al 1994	prospective CS	Norway	University	PC	41	41	0.0	24	NR	135	Feldspathic porcelain	Ceramco	Porcelite Veneer Cement	Loss of retention, chipping, wear, marginal integrity, caries, marginal discoloration, overcontouring
Fradeani 1998	prospective CS	Italy	Private practice	PC	21	21	0.0	NR	42.9	83	Re-inforced glass ceramic	IPS Empress	Dual, Variolink, Opal Luting Composite, Variolink II	Modified USPHS criteria
Magne et al 2000	prospective CS	Switzerland	NR	PC	16	16	0.0	33	68.8	48	Feldspathic porcelain	LFC-Duceram	Herculite Incisal LT	Color match, cracks, chippings, fractures, marginal performance (adaptation, seal, caries recurrence), tooth vitality, occlusal pattern and comfort, patient satisfaction
Peumans et al 2004	prospective CS	Belgium	University	PC	25	22	12.0	NR	NR	81	Feldspathic porcelain	GC Cosmotech Porcelain	G-Cera Porcelain Veneer Bonding System	Fracture rate, esthetics (color match, surface roughness), marginal integrity (marginal adaptation, retention, caries), tooth vitality, patient satisfaction

Table 2 continued overleaf

Table 2. Description of the included studies.

Smales & Etemadi 2004	retrospective CS	Australia	Private practice	PC	50	50	0.0	NR	158.0	110	Feldspathic porcelain	Mirage	Mirage and Ultra-Bond	Cumulative survival rate, failures (fracture, debonding, color mismatch)
Vailati et al 2013	prospective CS		University	PC	12	12	0.0	39.4	41.7	115	Feldspathic porcelain, Indirect composite	Creation CC, NA	Miris	USPHS criteria, patient satisfaction
Guess et al 2014	prospective CS	Germany	University	PC	25	14	44.0	NR	48.0	44	Re-inforced glass ceramic	IPS Empress	Variolink 2	Cumulative survival rate, modified USPHS criteria
Gresnigt et al 2019a	RCT	Netherlands	University	PC	10	10	0.0	54.5	70.0	48	Indirect composite, Re-inforced glass ceramic	Estenia, IPS Empress Esthetic	Variolink Veneer	Cumulative survival rate, modified USPHS criteria
Gresnigt et al 2019b	prospective CS	Netherlands	University	PC	118	104	11.9	42.1	67.8	384	Re-inforced glass ceramic	Creation Ci ZT	Urethane dimethacrylate	Cumulative survival rate, modified USPHS criteria, oral health impact profile
Malchiodi et al 2019	prospective CS	Italy	NR	PC	13	13	0.0	NR	53.8	79	Re-inforced glass ceramic	IPS e.max Press	Variolink Esthetic DC Refill	Cumulative survival rate, chipping, fractures, proportions of teeth (width/length)
Rinke et al 2020	retrospective CS	Germany	Private practice	PC	37	31	16.2	46.1	54.1	101	Re-inforced glass ceramic	Cergo	Variolink, Calibra	Cumulative survival rate, modified USPHS criteria, pulp vitality
Crins et al 2021	RCT	Netherlands	University	PC	24	19	20.8	36.7	25.0	122	Indirect composite	Clearfil Estenia C&B	Panavia F	Cumulative survival rate, functional (fractures, loss of retention, marginal adaptation, anatomy), biological (caries, endodontic treatment), and esthetic conditions
Yang et al 2016	retrospective CS	China	University	FC (36.5%), PC (63.5%)	4634	4371	5.7	38.4	NR	5587	Re-inforced glass ceramic	IPS e.max Press	RelyX Unicem (FC) Panavia F (PC)	Cumulative survival rate, modified USPHS criteria
Fabbri et al 2014	retrospective CS	Italy	Both	FC (54.1%), PC (45.9%)	312	NR	NR	NR	54.2	503	Re-inforced glass ceramic	NR	Variolink 2, Multilink Automix (FC, PC)	Cumulative survival rate, modified CDA criteria, patient satisfaction

Abbreviations: BOP, bleeding on probing; CS, clinical study; CDA, California Dental Association; FC, full coverage; GI, gingival index; NR, not reported; PBI, papilla bleeding index; PC, partial coverage PD, probing depth; PI, plaque index; RCT; randomized controlled clinical trial; USPHS, United States Public Health Services

Table 3. Quality assessment of included cohort studies according to NOS.

Author (year)	Selection	Comparability	Outcome	Quality
Bindl & Mormann (2004)	3	2	3	Good
De Backer et al (2006)	2	2	3	Fair
Dogan et al (2017)	3	2	3	Good
Erpenstein et al (2000)	2	1	2	Fair
Fabbri et al (2014)	3	2	2	Good
Fradeani (1998)	3	2	2	Good
Fradeani & Aquilano (1997)	3	2	2	Good
Fradeani et al (2002)	3	2	2	Good
Fradeani et al (2005)	2	2	2	Fair
Fradeani & Redemagni (2002)	3	2	3	Good
Gehrt et al (2013)	3	2	3	Good
Gresnigt et al (2019) b	3	2	3	Good
Guess et al (2014)	3	2	3	Good
Kokubo et al (2011)	3	2	3	Good
Magne et al (2000)	2	2	2	Fair
Malament et al (2019)	3	1	2	Good
Malchiodi et al (2019)	2	1	2	Fair
McLaren & White (2000)	3	1	2	Good
Miura et al (2018)	3	2	3	Good
Monaco et al (2013)	3	2	3	Good
Nordbo et al (1994)	3	2	2	Good
Oden et al (1998)	3	2	3	Good
Peumans et al (2004)	3	2	3	Good
Probster (1996)	3	1	3	Good
Rinke et al (2020)	3	2	3	Good
Rinke et al (2011)	3	2	3	Good
Schmitt et al (2010)	2	2	3	Fair
Segal (2001)	3	1	3	Good
Serra-Pastor et al (2021)	3	2	2	Good
Simeone & Gracis (2015)	3	2	3	Good
Smales & Etemadi (2004)	3	2	2	Good
Teichmann et al (2017)	3	1	3	Good
Toman & Toksavul (2015)	3	1	3	Good
Vailati et al (2013)	2	2	3	Fair
Valenti & Valenti (2009)	3	1	3	Good
Valenti & Valenti (2015)	3	1	3	Good
Walter et al (2006)	3	1	3	Good
Yang et al (2016)	3	2	3	Good
Zitzmann et al (2007)	3	1	3	Good

Table 4. Quality assessment for included randomized controlled trials, according to the Cochrane Collaboration recommendations (RoB 2.0 tool).

Author (year)	Selection bias Sequence generation	Selection bias Allocation concealment	Performance bias (blinding of participants and personnel)	Detection bias (blinding of outcome assessment)	Attrition bias (loss of patients to follow-up)	Selective reporting bias (selective revealing ir suppression of information)
Crins et al (2021)	Low	Low	High	High	Low	Low
Gresnigt et al (2019) a	Low	Low	High	High	Low	Low
Lehmann et al (2009)	Low	Low	High	Unclear	Low	Low

PRIMARY OUTCOME

Table 5 presents descriptive statistics of the 48 studies and study subgroups (42 studies of which 6 included 2 different study subgroups) together with the estimated restoration failure rate (per 100 restoration years) and 5-year restoration survival rate and summary measures for studies and study subgroups with full coverage and partial coverage restorations estimated by GLM and meta-analysis. For full coverage restorations we estimated an annual failure rate of 0.72 (95% CI 0.33 to 1.57) and a 5-year survival rate of 96.4 % (95% CI 92.4 to 98.3). For partial coverage restorations we estimated an annual failure rate of 0.62 (95% CI 0.27 to 1.46) and a 5-year survival rate of 96.9 % (95% CI 93.0 to 98.7). The meta-analysis estimated very similar rates but with narrower 95% confidence intervals.

Figure 2 presents the forest plot of the restoration failure rates for studies/study subgroups with full coverage restorations (top part), partial coverage restorations (bottom part) and over all studies (last row). The meta-analysis showed very high heterogeneity between the studies (Cochrane's Q test with p<0.01 and Higgin's I^2 of 100% within both restoration types and overall). Neither the GLM, nor the meta-analytic test for subgroup differences showed evidence for a difference in restoration failure rates between full coverage and partial coverage restorations (rate ratio, RR, estimate from GLM 0.86, 95% CI 0.26 to 2.88, p=0.81; test for subgroup differences from meta-analysis, p=0.75, Figure 2). It should be noted that restoration failure rate, and consequently the 5-year survival rate could not be calculated for all studies and study subgroups (*see Table 2 and Figure 2 for details*). Neither the restoration material, nor the type of study was significantly associated with restoration failure rate in multivariable GLMs.

SECONDARY OUTCOMES

Technical complication rates (per 100 restoration years) could be calculated from 36 studies / study subgroups (21 with full coverage restorations and 15 with partial coverage restorations). Biological complication rates (per 100 restoration years) could be calculated from 27 studies / study subgroups (15 with full coverage restorations 12 with partial coverage restorations). Esthetic complications were however very rarely reported (only in 2 studies) and could not be analyzed in the current review.

Restoration fracture, chipping of the ceramic, loss of retention, marginal gap and marginal discoloration were the most frequently reported technical complications. The technical complication rate was estimated as 0.76 (95% CI from 0.34 to 1.73) for full coverage restorations and as 1.5 (95% CI 0.69 to 3.25) for partial coverage restorations by the GLM *(Table 6, Figure 3*). Neither the GLM, nor the meta-analysis for subgroup differences showed evidence for a difference in technical complication rates between full coverage and partial coverage restorations (RR from GLM 1.97, 95% CI 0.62 to 6.23, p=0.25; test for subgroup differences from meta-analysis, p=0.75, Figure 3).

Caries, endodontic problems, periodontal problems, and root fracture were the most frequently reported biological complications. The biological complication rate was estimated as 0.77 (95% CI 0.31 to 1.88) for full coverage restorations and as 0.18 (95% CI -0.02, 1.56) for partial coverage restorations by the GLM *(Table 7, Figure 4*). The meta-analytic test for subgroup differences suggested that the biological complication rate was significantly reduced by 50% for partial coverage restorations compared to full coverage restorations (Rate ratio 0.50, 95% CI from 0.26 to 0.75, p=0.01, Figure 4). The corresponding GLM estimated an even stronger but statistically non-significant reduction in biological complications (Rate ratio 0.23, 95% CI from 0.04 to 1.51, p=0.13).

It should be noted that the technical and biological complication rates could not be calculated for all studies and study subgroups (*see Tables 3 and 4 and Figures 3 and 4*). Thus, as for the primary outcome, the meta-analyses estimated similar complication rates but with narrower 95% confidence intervals compared to those estimated from GLMs. For the studies where the data was present, the restoration material did not affect to complication rates.

Patient satisfaction was reported in 12 studies and study subgroups (5 with full coverage restorations and 7 with partial coverage restorations). In six of the studies and study subgroups

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Table 5. Restoration failure rates and 5-year survival rates of 42 studies with 6 sub-studies (two groups in one study).

Study	Study design	Material	Number of restorations	Mean follow-up time	Follow-up range	Number of restoration failures	Total exposure time (years)	Estimated failure rate (per 100 restoration years)	Estimated 5-year survival rate (%)
FULL COVERAGE RESTORATIONS									
Probster 1996	prospective CS	Alumina	28	30	1.3 to 56.63	0	70	0	100.0
Fradeani & Aquilano 1997	prospective CS	Re-inforced glass ceramic	101	37	6 to 68	2	311	0.64	96.8
Oden et al 1998	prospective CS	Alumina	17	60	60 to NA	0	85	0	100.0
Erpenstein et al 2000	retrospective CS	Metalceramic	175	96		5	1400	0.36	98.2
Erpenstein et al 2000	retrospective CS	Feldspathic porcelain	95	132		19	1045	1.82	91.3
McLaren & White 2000	prospective CS	Alumina	97	223	1 to 86	2	1803	0.11	99.4
Segal 2001	retrospective CS	Alumina	177	72		2	1062	0.19	99.1
Fradeani et al 2002	prospective CS	Feldspathic porcelain	40	50	22 to 60	1	167	0.6	97.0
Fradeani & Redemagni 2002	retrospective CS	Re-inforced glass ceramic	93		48 to 132	1			
Bindl & Mormann 2004	prospective CS	Feldspathic porcelain	18	45	12 to 61	1	67	1.49	92.8
Bindl & Mormann 2004	prospective CS	Alumina	18	45	12 to 61	1	67	1.49	92.8
Fradeani et al 2005	prospective CS	Alumina	50	24	6 to 60	0	98	0	100.0
De Backer et al 2006	retrospective CS	Metalceramic	190	120	3.6 to 300		1900		
Walter et al 2006	prospective CS	Alumina	61	72		2	366	0.55	97.3
Zitzmann et al 2007	prospective CS	Alumina	32	55	1 to 92	0	147	0	100.0
Lehmann et al 2009	RCT	Indirect composite	46	60		7	230	3.04	85.9
Valenti & Valenti 2009	retrospective CS	Re-inforced glass ceramic	101		12 to 120	3			
Schmitt et al 2010	prospective CS	Zirconia	17	39		0	56	0	100.0
Kokubo et al 2011	prospective CS	Alumina	64	60		2	320	0.62	96.9
Rinke et al 2011	retrospective CS	Alumina	163	162	NA to 223.2	18	2200	0.82	96.0
Gehrt et al 2013	prospective CS	Re-inforced glass ceramic	74	80	34 to 109.7	3	490	0.61	97.0
Monaco et al 2013	retrospective CS	Zirconia	343	60		2	1715	0.12	99.4
Fabbri et al 2014	retrospective CS	Re-inforced glass ceramic	231	37	24 to 72	2	718	0.28	98.6
Simeone & Gracis 2015	retrospective CS	Re-inforced glass ceramic	106	56	12 to 132	0	495	0	100.0
Toman & Toksavul 2015	prospective CS	Re-inforced glass ceramic	98	105	12 to 156	8	854	0.94	95.4
Valenti & Valenti 2015	retrospective CS	Re-inforced glass ceramic	39		39 to 108	0			

Table 5 continued overleaf

Table 5 continued

Yang et al 2016	retrospective CS	Re-inforced glass ceramic	3550	60		117	17750	0.66	96.8
Dogan et al 2017	prospective CS	Zirconia	19	59		0	93	0	100.0
Teichmann et al 2017	prospective CS	Re-inforced glass ceramic	38	137		22	433	5.08	77.6
Miura et al 2018	retrospective CS	Zirconia	63	84	1 to 144	0	441	0	100.0
Malament et al 2019	prospective CS	Re-inforced glass ceramic	656	125		0	6822	0	100.0
Serra-Pastor et al 2021	prospective CS	Zirconia	59	72		3	354	0.85	95.9
TOTAL			6859	78		223	41559		
Summary estimate (GLM)								0.72 (0.33 to 1.57)	96.4 (92.4 to 98.3)
Summary estimate (MA)								0.72 (0.31 to 1.13)	96.5 (94.5 to 98.4)
PARTIAL COVERAGE RESTORATIONS									
Nordbo et al 1994	prospective CS	Feldspathic porcelain	135	36		2	405	0.49	97.6
Fradeani 1998	prospective CS	Re-inforced glass ceramic	83	72		1	498	0.2	99.0
Magne et al 2000	prospective CS	Feldspathic porcelain	48	54		0	216	0	100.0
Peumans et al 2004	prospective CS	Feldspathic porcelain	81	120		2	810	0.25	98.8
Smales & Etemadi 2004	retrospective CS	Feldspathic porcelain	110	72		6	660	0.91	95.6
Vailati et al 2013	prospective CS	Feldspathic porcelain	64	50	22.8 to 75.6	0	265	0	100.0
Vailati et al 2013	prospective CS	Indirect composite	51	50	18 to 72	0	214	0	100.0
Fabbri et al 2014	retrospective CS	Re-inforced glass ceramic	272	37	24 to 72	3	845	0.35	98.2
Guess et al 2014	prospective CS	Re-inforced glass ceramic	44	84		1	308	0.32	98.4
Yang et al 2016	retrospective CS	Re-inforced glass ceramic	2037	60		51	10185	0.5	97.5
Gresnigt et al 2019a	RCT	Indirect composite	24	97	89 to 120	6	194	3.09	85.7
Gresnigt et al 2019a	RCT	Re-inforced glass ceramic	24	97	89 to 120	0	194	0	100.0
Gresnigt et al 2019b	prospective CS	Re-inforced glass ceramic	384	56	8 to 133	19	1786	1.06	94.8
Malchiodi et al 2019	prospective CS	Re-inforced glass ceramic	79	36	14 to 66	1	237	0.42	97.9
Rinke et al 2020	retrospective CS	Re-inforced glass ceramic	101	130		10	1092	0.92	95.5
Crins et al 2021	RCT	Indirect composite	122	40	36.4 to 42	6	412	1.46	93.0
TOTAL			3659	68		108	18320		
Summary estimate (GLM)								0.62 (0.27 to 1.46)	96.9 (93.0 to 98.7)
Summary estimate (MA)								0.62 (0.24 to 1.00)	96.9 (95.1 to 98.8)

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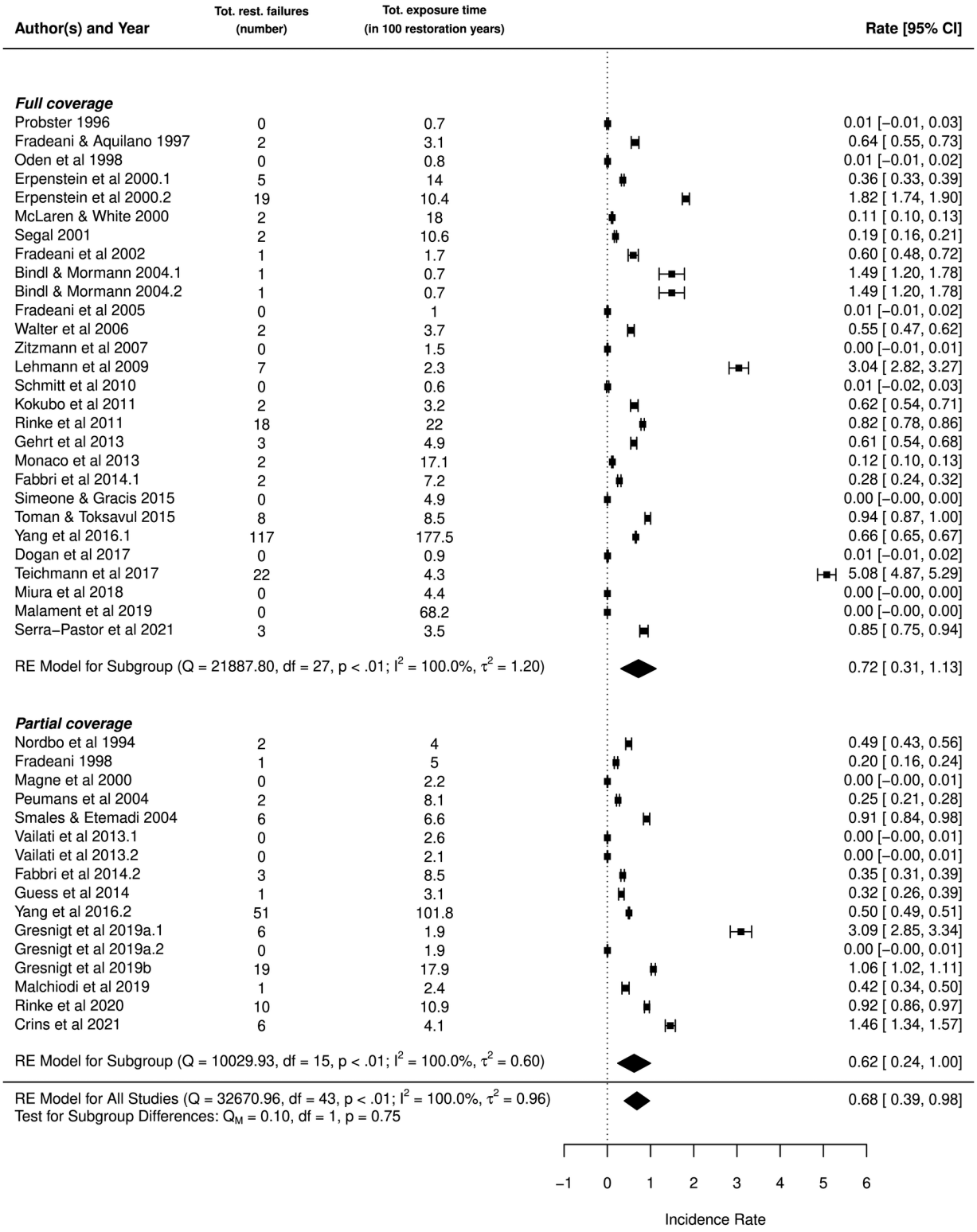

Figure 2: Forest plot of the restoration failure rates (per 100 restoration years) of all 44 studies/study subgroups for which the restoration failure rate could be calculated (16 with partial coverage restorations, 28 with full coverage restorations). The broken vertical line shows the estimated overall incidence rate of failures.

PROMs were evaluated by interviewing the patients.[51,60,62,63,72] One study reported PROMs based on Oral Health Impact profile questionnaire (OHIP).[67] Additionally, five studies and study subgroups used visual analog scale (VAS).[16,45,55,59] For all the studies, mainly the satisfaction to the treatment outcome was asked. Due to the small number of studies and heterogeneity in reporting the PROMs, the results were reported descriptively. For the studies interviewing the patients, the PROMs results were mainly rated as excellent to good (91 – 100%) for partial coverage restorations,[62,63] while in some studies the

Table 6. Restoration technical complication rates divided by restoration types. Some of the studies had two study groups.

Study	Number of restorations	Number of technical complications	Restoration Fractures	Loss of retention	Chipping	Marginal gap	Marginal discoloration	Total exposure time (years)	Estimated technical complication rate (per 100 restoration years)
FULL COVERAGE RESTORATIONS									
Fradeani & Aquilano 1997	101	2	2	0				311	0.64
Oden et al 1998	17	0	0					85	0
Segal 2001	177	2	2					1062	0.19
Fradeani et al 2002	40	3	3	0	1	0	0	167	1.8
Bindl & Mormann 2004	18	1	1	0	0	0		67	1.49
Bindl & Mormann 2004	18	1	1	0	0	0		67	1.49
Fradeani et al 2005	50	2	0	0	0			98	2.04
Walter et al 2006	61	2	2					366	0.55
Zitzmann et al 2007	32	0	0	0				147	0
Schmitt et al 2010	17	0	0		0	0		56	0
Kokubo et al 2011	64	2	2					320	0.62
Rinke et al 2011	163	10	9	1				2200	0.45
Gehrt et al 2013	74	1	1	0	0			490	0.2
Monaco et al 2013	343	13	1	0	11	1		1715	0.76
Simeone & Gracis 2015	106	9	0	9				495	1.82
Toman & Toksavul 2015	98	3	3		0			854	0.35
Dogan et al 2017	19	0	0	0	0	0	0	93	0
Teichmann et al 2017	38	12	7	2	3	0		433	2.77
Miura et al 2018	63	0	0	0				441	0
Malament et al 2019	656	0	0					6822	0
Serra-Pastor et al 2021	59	3	1	2				354	0.85
TOTAL	2214	66	35	14	15	1	0	16643	
Summary estimate (GLM)									0.76 (0.34 to 1.73)
Summary estimate (MA)									0.76 (0.41 to 1.11)

Table 6 continued overleaf

Table 6 continued

PARTIAL COVERAGE RESTORATIONS									
Nordbo et al 1994	135	2	2	0	0	0	0	405	0.49
Fradeani 1998	83	1	1		0	0	0	498	0.2
Magne et al 2000	48	1	0	0	1		0	216	0.46
Peumans et al 2004	81	40	2	0	7	16	15	810	4.94
Smales & Etemadi 2004	110	8	6	2				660	1.21
Vailati et al 2013	64	0	0	0	0	0	0	265	0
Vailati et al 2013	51	0	0	0	0	0	0	214	0
Fabbri et al 2014	272	6	5	1				845	0.71
Guess et al 2014	44	1	1	1	0	0	0	308	0.32
Gresnigt et al 2019a	24	17	3	3	3	4	4	194	8.76
Gresnigt et al 2019a	24	1	0	0	0	0	1	194	0.52
Gresnigt et al 2019b	384	26	15	3	1	1	6	1786	1.46
Malchiodi et al 2019	79	1	0	1				237	0.42
Rinke et al 2020	101	17	8	9			0	1092	1.56
Crins et al 2021	122	6	0	0	5			412	1.46
TOTAL	1622	127	43	20	17	21	26	8135	
Summary estimate (GLM)									1.50 (0.69 to 3.25)
Summary estimate (MA)									1.50 (0.32 to 2.68)

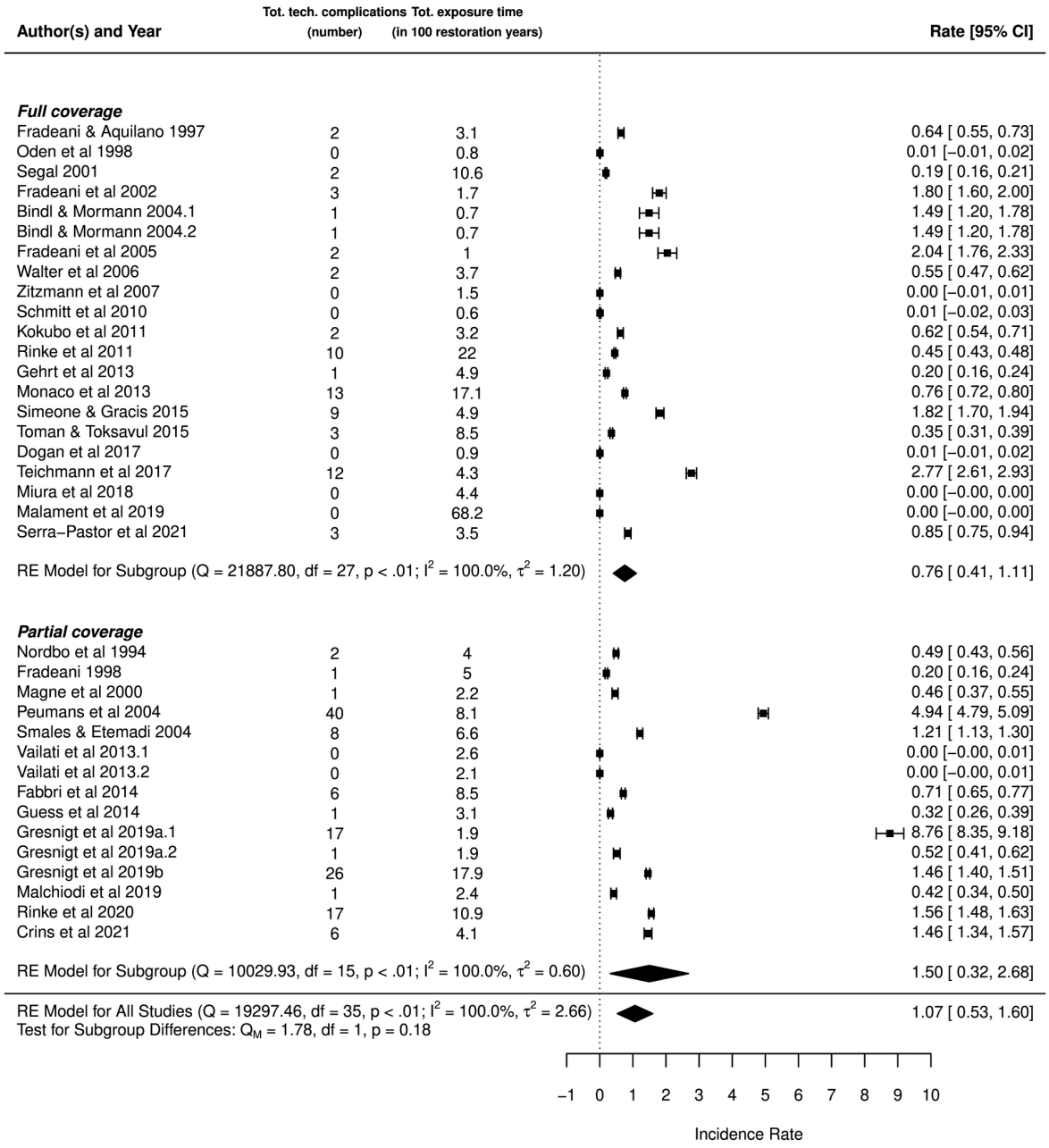

Figure 3: Forest plot of the technical complication rates (per 100 restoration years) of all the of all 36 studies/study subgroups for which the technical complication rate could be calculated (15 with partial coverage restorations and 21 with full coverage restorations). The broken vertical line shows the estimated overall incidence rate of technical complications.

results for anterior restorations could not be extracted. For the OHIP questionnaire, the patients were satisfied with the treatment and reported no problems related to Oral Health Related Quality of Life.[67] Two studies evaluated the PROMs of anterior zirconia full coverage crowns measured with VAS.[55, 59] The patient satisfaction was reported to be high (in VAS 0–10 scale varying from 9.04 – 9.8).

DISCUSSION

This systematic review was conducted in order to assess the dental literature reporting on the failure, survival, and complication rates as well as patient reported outcome measures (PROMs) of anterior full and partial coverage single tooth restorations (full coverage crowns, partial crowns, veneers) after a mean observation period of at least 3 years. Results of the meta-analysis showed no significant difference for 5-year failure, survival, or technical complication rates between the full and partial coverage restorations. Biological complications occurred more frequently with full coverage than partial coverage but the difference was statistically significant only in the random effects meta-analysis and not in the GLM analysis. The study hypothesis was therefore partially rejected.

Table 7. Restoration biological complication rates divided by restoration types. Some of the studies had two study groups.

Study	Number of restorations	Number of biological complications	Secondary caries	Endodontal problems	Periodontal problems	Root fracture	Total exposure time (years)	Estimated biological complication rate (per 100 restoration years)
Probster 1996	28	1	1	0			70	1.44
Fradeani & Aquilano 1997	101	0	0	0	0	0	311	0
Oden et al 1998	17	1	0	1			85	1.18
Fradeani et al 2002	40	0	0	0	0	0	167	0
Fradeani et al 2005	50	0	0	0			98	0
Zitzmann et al 2007	32	1	0	0		1	147	0.68
Rinke et al 2011	163	13	5	7			2200	0.59
Gehrt et al 2013	74	3	1	2	0		490	0.61
Monaco et al 2013	343	35	0	0	0	0	1715	2.04
Simeone & Gracis 2015	106	0	0	0			495	0
Toman & Toksavul 2015	98	5	0		0	5	854	0.59
Dogan et al 2017	19	1	0	0	0	1	93	1.08
Teichmann et al 2017	38	10	2	2	3	3	433	2.31
Miura et al 2018	63	2	0	0		2	441	0.45
Serra-Pastor et al 2021	59	2	0	1		1	354	0.56
TOTAL	1231	74	9	13	3	13	7953	
Summary estimate (GLM)								0.77 (0.31 to 1.88)
Summary estimate (MA)								0.77 (0.40 to 1.13)

Table 7 continued overleaf

Table 7. Restoration biological complication rates divided by restoration types. Some of the studies had two study groups.

PARTIAL COVERAGE RESTORATIONS								
Nordbo et al 1994	135	0	0		0		405	0
Fradeani 1998	83	0	0				498	0
Magne et al 2000	48	0	0	0		0	216	0
Peumans et al 2004	81	11	8	3			810	1.36
Smales & Etemadi 2004	110	1		1			660	0.15
Vailati et al 2013	64	0	0	0	0	0	265	0
Vailati et al 2013	51	0	0	0	0	0	214	0
Guess et al 2014	44	0	0	0		0	308	0
Gresnigt et al 2019a	24	0	0	0			194	0
Gresnigt et al 2019a	24	0	0	0			194	0
Gresnigt et al 2019b	384	5	1	1		3	1786	0.28
Rinke et al 2020	101	4	2	2			1092	0.37
TOTAL	1149	21	11	7	0	3	6641	
Summary estimate (GLM)								0.18 (0.02 to 1.56)
Summary estimate (MA)								0.18 (-0.04 to 0.40)

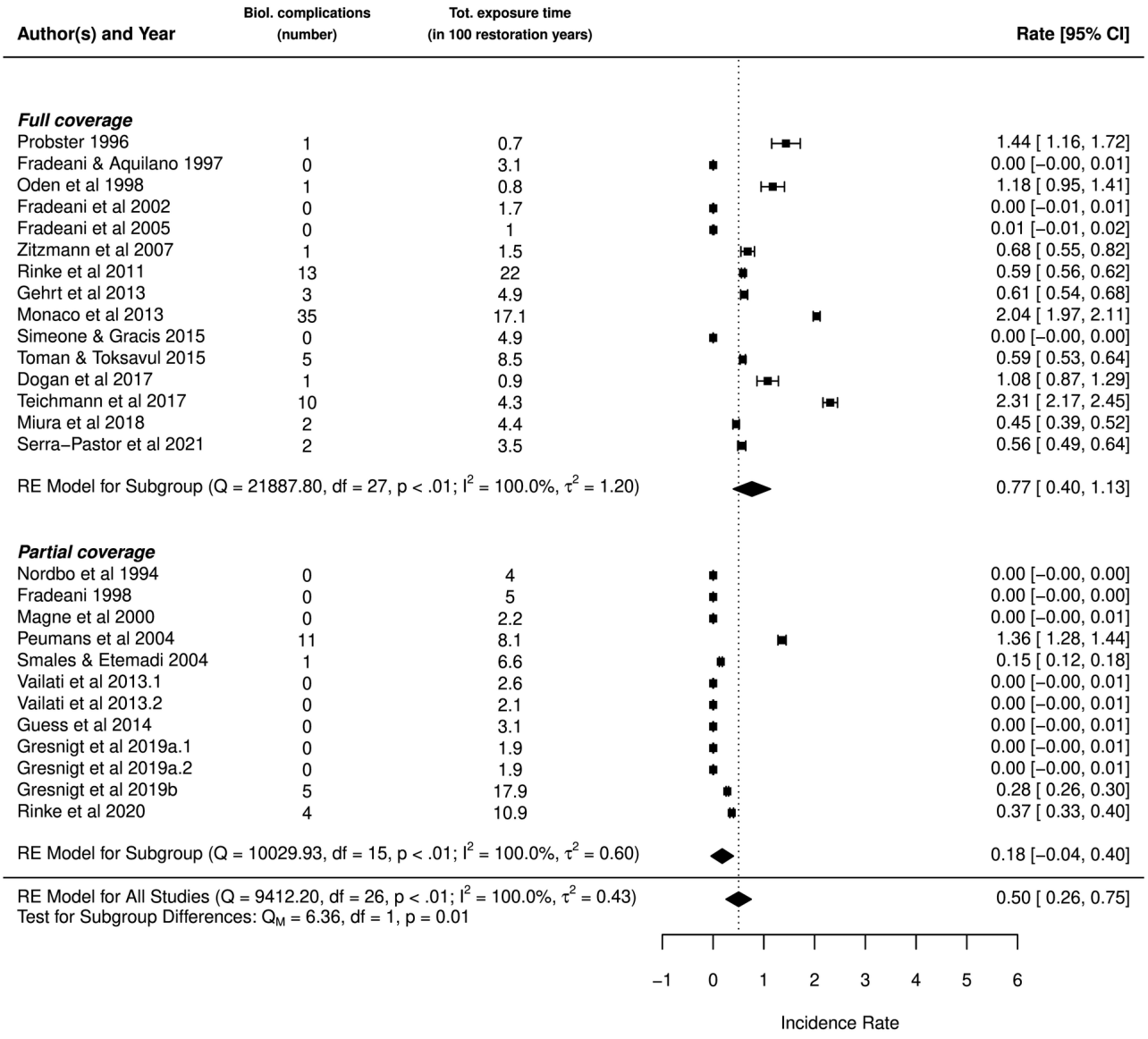

Figure 4: Forest plot of the biological complication rates (per 100 restoration years) of all the 27 studies/study subgroups for which the biological complication rate could be calculated (12 with partial coverage restorations and 15 with full coverage restorations). The broken vertical line shows the estimated overall incidence rate of biological complications.

In the present review, full coverage restoration was defined as full crown, restoration covering all the tooth surfaces. Partial coverage restoration could be either buccal or palatal veneer or partial restoration / crown, leaving some tooth surfaces free. The search for partial coverage restorations resulted only in buccal and palatal veneers, but in most of the studies the extension of the veneer to palatal site was not clearly defined. Also, preparation type was not always defined and was therefore not analyzed in this review.

The cumulative 5-year survival rate was high for both full (96.4%) and partial (96.9%) coverage restorations. Another systematic review comparing the tooth-supported anterior and posterior single crowns reported significant differences in survival and technical complication rates between different materials used where feldspathic/silica-based ceramics and zirconia exhibited lower survival rates (90.7% and 91.2% respectively) and higher complication rates compared to metal-ceramic crowns.[28] In that review, feldspathic/silica-based ceramics showed significantly lower survival rate for posterior crowns compared to anterior ones, which could have explained the generally lower survival rates compared to present review evaluating only anterior restorations. However, with other materials, no differences were found when restored tooth was evaluated per location. In the present systematic review, studies with a very heterogenous group of restoration materials were evaluated and we found no significant association between restoration material and restoration failure or complication rates. The heterogeneity limited further analysis in the present study. Many excluded studies did not report the results according to tooth location.

In their review Sailer *et al* reported complications of zirconia crowns due to veneering porcelain chippings and secondary caries due to poor marginal fit.[28] The data of the review was collected between the years 2006 and 2013 and therefore studies with mainly the first-generation zirconia restorations were included, which explains the high numbers of technical and biological complications. This was due to different handling process of early zirconia restorations compared to metal ceramic ones. A learning curve with porcelain firing process and the anatomical shape of the zirconia framework was needed in order to reduce the technical complications.[73,74] In the present review zirconia restorations did not differ from other materials in terms of survival rate and complications proving the effect of material development, at least for anterior restorations, although, the relatively small number of studies (n=5) reporting zirconia restorations might not represent the actual clinical situation.

The present study indicated that the biological complications were significantly more common in full coverage restorations compared to partial coverage restorations. The most frequently reported complications were secondary caries, endodontic problems, and root fracture. Especially more frequent root fractures were observed in the full coverage restoration group. However, the possible reasons for the differences between the groups such as aggressive preparation design or possible root canal posts included, could not be analyzed due to missing information in original studies.

Rinke *et al*. attributed the technical and biological complications to larger amounts of exposed dentin (>50%) meaning extensive preparations.[69] Less invasive concepts were also supported by clinical results of a study where the maxillary anterior teeth affected by severe erosion were restored with minimal or non-prep restorations.[16] Whenever possible, the minimally invasive preparation types and partial coverage restoration types should be chosen.[5,6] However, the choice of the restoration type is often limited due to available tooth substance and as a consequence full coverage restorations might be preferred.There is an increasing interest in assessing the patient-reported outcome measures (PROMs) in clinical studies. In the present review, 12 studies and study subgroups reported some level of PROMs. However, the measurement and reporting the findings was very heterogeneous. Hence, the results could not be analyzed and no conclusions could be drawn to compare the restoration types from this perspective. The selection of the methods included patient interviews (n=6), OHIP questionnaire (n=1) and VAS questions (n=5). All these methods have their shortcomings. With a simple questionnaire, information on the patient preferences can be collected. However, this kind of questions are not standardized and the comparison between studies is therefore difficult. A more standardized way would be to use OHIP questionnaires focusing on collecting information on general health status, oral disorders, oral symptoms and health behavior.[75] However, due the nature of the questions, such questionnaires are considered too general for specific dental treatments.[76] VAS questionnaire on the other hand is easy and fast to address patient satisfaction. Also, the results in general could be comparable in numbers (visual analog scale from 0 to 10). Yet, the VAS questions are not similar or standardized across the studies. The limitation of using VAS might be the fact that the number of the questions are limited (preferably a maximum of six) and the questions can have influence on each other, when positive and negative toning questions are presented consecutively.[77]

The reporting style and interpreting the results of PROMs are not standardized and the comparison between studies can be challenging as seen in the current review. Additionally, the connection between the clinical outcomes and PROMs is not yet fully defined.[78] When novel fixed prosthodontic materials and methods seem to work well, in the long run the patient's opinion might and should play larger role in selecting the right treatment of choice for each patient.

The systematic search for the present review resulted in large number of studies but majority of them were excluded. Several of the excluded full texts reported either mixed results of anterior and posterior restorations or did not otherwise specify the results per tooth location. Additionally, the retrospective nature of the one third of all included studies was limiting the data analysis due to missing information. This also affected to the Newcastle-Ottawa Scale (NOS) rating of risk of bias in these studies. Typically, the lower rating was given for categories representing the exposed cohort, selection of the non-exposed cohort and adequacy of follow-up of cohorts especially when the dropouts were not reported. There is evidence that the authors of the individual studies tend to rate their studies lower in NOS than the authors of the systematic reviews.[79] It was suggested to contact the authors for unpublished data in case of low NOS rating or insufficient information. When preparing the present review, 23 corresponding authors were contacted for additional information, but only two of them provided the requested information for three studies.[44,46,54] Of the included full texts, 17 studies were performed in private practice and 22 at university settings and three studies did not report where the study was conducted. In that respect, the results could also be generalized for everyday work in private practices. However, it should be noted that possibly not all the confounding factors could be evaluated in the present review. For example, the effect of cementation process and cement types on survival rates, failure rates or complication rates could not be evaluated due to very heterogenous group of cements used. In several studies, several cement types were used, and the results of the individual studies or sub-studies were not reported according to the cement type used.

This review provides a comprehensive overview on, restoration failure rates, restoration survival and complication rates of anterior full and partial coverage restorations. However, the heterogeneity and type of the studies was limiting

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the comparison of the outcomes. Most of the studies were observational and used only one restoration type, whereas randomized controlled clinical trials comparing these two restoration types did not exist. Therefore, the data synthesis was not based on a comparative effect size but on the restoration failure rate. The estimated cumulative 5-year survival rates were calculated from annual failure rate assuming that the restoration failure rates are constant, although the failure behavior might change during the follow-up time, being for example higher in the first couple of years or after the restorations are in service for several more years.[43,71,80] The failure rate seemed to be similar for both restoration types since no differences were observed in survival rates.

CONCLUSIONS

Full and partial coverage restorations presented high 5-year survival rates ranging from 96.4 to 96.9% and low annual failure rates ranging from 0.62 to 0.72 No difference in technical complications were observed, but teeth with full coverage restorations seem to be more prone to biological complications. Patient-reported outcome measures (PROMs) could not be compared due to broad heterogeneity between the evaluation methods. There is a need for standardized tool to measure PROMs with different dental treatments. The results of this review encourage to practice less invasive preparation designs in order to save tooth substance where possible.

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Appendix 1. Excluded studies during data extraction.

Author (year)	Title	Journal	Reason for exclusion
Aristidis GA and Dimitra B (2002)	Five-year clinical performance of porcelain laminate veneers	Quintessence International	Mixed data of anterior and posterior restorations
Aslan YU, Uludamar A and Özkan Y (2019)	Clinical performance of pressable glass-ceramic veneers after 5, 10, 15, and 20 years: A retrospective case series study	Journal of Esthetic & Restorative Dentistry	Mixed data of anterior and posterior restorations
Barnes D, Gingell JC, George D, Adachi E, Jefferies S and Sundar VV (2010)	Clinical evaluation of an all-ceramic restorative system: a 36-month clinical evaluation	American Journal of Dentistry	Insufficient data
Behr M, Zeman F, Baitinger T, Galler J, Koller M, Handel G and Rosentritt M (2014)	The clinical performance of porcelain-fused-to-metal precious alloy single crowns: chipping, recurrent caries, periodontitis, and loss of retention	International Journal of Prosthodontics	Mixed data of single- and multiple-unit and/or implant supported restorations
Beier US, Dhima M, Koka S, Salinas TJ and Dumfahrt H (2012)	Comparison of two different veneer preparation designs in vital teeth	Quintessence International	Part of a longer follow-up study
Beier US, Kapferer I, Burtscher D and Dumfahrt H (2012)	Clinical performance of porcelain laminate veneers for up to 20 years	International Journal of Prosthodontics	Mixed data of anterior and posterior restorations
Brambilla GP and Cavallè E - Part 1 (2007)	Fractured incisors: a judicious restorative approach--part 1	International Dental Journal	Less than 10 patients at follow-up
Brambilla GP and Cavallè E - Part 2 (2007)	Fractured incisors: a judicious restorative approach--Part 2	International Dental Journal	Less than 10 patients at follow-up
Brambilla GP and Cavallè E - Part 3 (2007)	Fractured incisors: a judicious restorative approach--part 3	International Dental Journal	Less than 10 patients at follow-up
Caserío Valea M and Alonso de la Peña V (2017)	Titanium posts and bonded amalgam core longevity: A 22-year clinical survival retrospective study	Journal of the American Dental Association	Insufficient data
Cehreli MC, Kokat AM, Ozpay C, Karasoy D and Akca K (2011)	A randomized controlled clinical trial of feldspathic versus glass-infiltrated alumina all-ceramic crowns: a 3-year follow-up	The International journal of prosthodontics	Mixed data of anterior and posterior restorations
Cerny D, Eckert S and Mounajjed R (2019)	Retrospective 9-Year Clinical Outcome Report on Adhesive Post-endodontic Treatment of Anterior Teeth Using Prefabricated Fiber Posts	The International journal of prosthodontics	Insufficient data
Chana H, Kelleher M, Briggs P and Hooper R (2000)	Clinical evaluation of resin-bonded gold alloy veneers	Journal of Prosthetic Dentistry	Insufficient data
Cortellini D and Canale A (2012)	Bonding lithium disilicate ceramic to feather-edge tooth preparations: a minimally invasive treatment concept	Journal of Adhesive Dentistry	Insufficient data
Crins L, Bronkhorst EM, Opdam NJM, Huysmans M and Loomans B (2020)	A randomized controlled trial on restorative treatment of tooth wear	Journal of dental research	Part of a longer follow-up study
D'Souza D and Kumar M (2010)	Esthetics and Biocompatibility of Composite Dental Laminates	Medical Journal Armed Forces India	Less than 3 years of follow-up

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De Angelis F, D'Arcangelo C, Angelozzi R and Vadini M (2021)	Retrospective clinical evaluation of a no-prep porcelain veneer protocol	Journal of Prosthetic Dentistry	Mixed data of anterior and posterior restorations
Dostálová T, Racek J, Lozeková E and Rerichová M (2003)	Composite veneers, crowns, and inlay bridges after orthodontic therapy--a three-year prospective study	General Dentistry	Mixed data of single- and multiple-unit and/ or implant supported restorations
Du RT, Li Y and Fan DN (2009)	A retrospective study on the long-term clinical outcomes of 310 porcelain laminate veneers	Chung-Hua Kou Chiang i Hsueh Tsa Chih Chinese Journal of Stomatology	No English language
Dumfahrt H (1999)	Porcelain laminate veneers. A retrospective evaluation after 1 to 10 years of service: Part I--Clinical procedure	International Journal of Prosthodontics	Insufficient data
Fradeani M, Redemagni M, Corrado M (2005)	Porcelain laminate veneers: 6- to 12-year clinical evaluation--a retrospective study	International Journal of Periodontics & Restorative Dentistry	Mixed data of different restorative materials
Galindo ML, Sendi P, Marinello CP (2011)	Estimating long-term survival of densely sintered alumina crowns: a cohort study over 10 years	Journal of Prosthetic Dentistry	Insufficient data
Glazer B (2000)	Restoration of endodontically treated teeth with carbon fibre posts--a prospective study	Journal Canadian Dental Association	Less than 3 years of follow-up
Gresnigt MM, Kalk W, Ozcan M (2013)	Randomized clinical trial of indirect resin composite and ceramic veneers: up to 3-year follow-up	Journal of Adhesive Dentistry	Less than 3 years of follow-up
Guess PC, Stappert CF (2008)	Midterm results of a 5-year prospective clinical investigation of extended ceramic veneers	Dental Materials	Part of a longer follow-up study
Güncü MB, Cakan U, Muhtarogullari M, Canay S (2015)	Zirconia-based crowns up to 5 years in function: a retrospective clinical study and evaluation of prosthetic restorations and failures	International Journal of Prosthodontics	Mixed data of single- and multiple-unit and/ or implant supported restorations
Haselton DR, Diaz-Arnold AM, Hillis SL (2000)	Clinical assessment of high-strength all-ceramic crowns	Journal of Prosthetic Dentistry	Insufficient data
Huettig F, Gehrke UP (2016)	Early complications and performance of 327 heat-pressed lithium disilicate crowns up to five years	The Journal of Advanced Prosthodontics	Less than 3 years of follow-up
Imburgia M, Cortellini D, Valenti M (2019)	Minimally invasive vertical preparation design for ceramic veneers: a multicenter retrospective follow-up clinical study of 265 lithium disilicate veneers	The International Journal of Esthetic Dentistry	Mixed data of anterior and posterior restorations
Jiang YL, Sun J, Weng WM, Zhang FQ (2006)	Long-term observation of 920 porcelain fused to metal prostheses	Shanghai Kou Qiang Yi Xue / Shanghai Journal of Stomatology	No English language
Jun SK, Oh JS (2005)	Achieving anterior aesthetics in the geriatric patient using full-coverage metal-ceramic crowns	Practical procedures & aesthetic dentistry	Less than 10 patients at follow-up
Kamruddin K, Tat TE, Muttlib NAA, Alawi R, Rahman NA, Jamayet NB (2015)	A 7-year study on survival rate of fixed partial denture and post & core done by 5th year dental students of School of Dental Sciences, Universiti Sains Malaysia	International Journal of Pharma and Bio Sciences	Not dealing with indirect single tooth restorations
Keough BE, Kay HB, Sager RD, Keen E (2011)	Clinical performance of scientifically designed, hot isostatic-pressed (HIP'd) zirconia cores in a bilayered all-ceramic system	Compendium of Continuing Education in Dentistry	Mixed data of anterior and posterior restorations
King PA, Setchell DJ, Rees JS (2003)	Clinical evaluation of a carbon fibre reinforced carbon endodontic post	Journal of Oral Rehabilitation	Not dealing with indirect single tooth restorations
Klink A, Groten M, Huettig F (2018)	Complete rehabilitation of compromised full dentitions with adhesively bonded all-ceramic single-tooth restorations: Long-term outcome in patients with and without amelogenesis imperfecta	Journal of Dentistry	Mixed data of anterior and posterior restorations

Kokubo Y, Sakurai S, Tsumita M, Ogawa T, Fukushima S (2009)	Clinical evaluation of Procera AllCeram crowns in Japanese patients: results after 5 years	Journal of Oral Rehabilitation	Mixed data of anterior and posterior restorations
Liu F, Yang YD, Ding Z, Zhang F (2007)	Relationship between clinical assessment and patient satisfaction in anterior esthetic restorations	Zhonghua kou qiang yi xue za zhi = Zhonghua kouqiang yixue zazhi = Chinese journal of stomatology	No English language
Malament KA, Margvelashvili-Malament M, Natto ZS, Thompson V, Rekow D, Att W (2021)	10.9-year survival of pressed acid etched monolithic e.max lithium disilicate glass-ceramic partial coverage restorations: Performance and outcomes as a function of tooth position, age, sex, and the type of partial coverage restoration (inlay or onlay)	Journal of Prosthetic Dentistry	Less than 10 patients at follow-up
Malament KA, Socransky SS (1999)	Survival of Dicor glass-ceramic dental restorations over 14 years: Part I. Survival of Dicor complete coverage restorations and effect of internal surface acid etching, tooth position, gender, and age	Journal of Prosthetic Dentistry	Mixed data of single- and multiple-unit and/ or implant supported restorations
Marklund S, Bergman B, Hedlund SO, Nilson H (2003)	An intraindividual clinical comparison of two metal-ceramic systems: a 5-year prospective study	International Journal of Prosthodontics	Mixed data of anterior and posterior restorations
Mohey el-Din el-Khodery A, el-Badhdady YM, Ibrahim RM (1990)	A comparative study of restorative techniques used to reinforce intact endodontically treated anterior teeth	Egyptian dental journal	Review or in vitro study
Murphy E, Ziada HM, Allen PF (2005)	Retrospective study on the performance of porcelain laminate veneers delivered by undergraduate dental students	European Journal of Prosthodontics & Restorative Dentistry	Insufficient data
Naumann M, Blankenstein F, Kiessling S, Dietrich T (2005)	Risk factors for failure of glass fiber-reinforced composite post restorations: A prospective observational clinical study	European Journal of Oral Sciences	Not dealing with indirect single tooth restorations
Naumann M, Koelpin M, Beuer F, Meyer-Lueckel H (2012)	10-year survival evaluation for glass-fiber-supported postendodontic restoration: A prospective observational clinical study	Journal of Endodontics	Not dealing with indirect single tooth restorations
Nohl FS, King PA, Harley KE, Ibbetson RJ (1997)	Retrospective survey of resin-retained cast-metal palatal veneers for the treatment of anterior palatal tooth wear	Quintessence International	Insufficient data
Olley RC, Andiappan M, Frost PM (2018)	An up to 50-year follow-up of crown and veneer survival in a dental practice	Journal of Prosthetic Dentistry	Insufficient data
Paniz G, Zarow M, Nart J, Peña M, Coltro G, Tomasi C, et al (2020)	Dual-center cross-sectional analysis of periodontal stability around anterior all-ceramic crowns with a feather-edge or chamfer subgingival preparation	International Journal of Periodontics and Restorative Dentistry	Insufficient data
Peumans M, Van Meerbeek B, Lambrechts P, Vuylsteke-Wauters M, Vanherle G (1998)	Five-year clinical performance of porcelain veneers	Quintessence International	Part of a longer follow-up study
Piovesan EM, Demarco FF, Cenci MS, Pereira-Cenci T (2007)	Survival rates of endodontically treated teeth restored with fiber-reinforced custom posts and cores: A 97-month study	International Journal of Prosthodontics	Insufficient data
Poroch L, Forna NC (2010)	Clinical evaluation of the possibilities of restoring the dental and periodontal esthetics using veneers vs. metal ceramic crowns	Revista Medico-Chirurgicala a Societatii de Medici Si Naturalisti Din Iasi	No English language
Rinke S, Lange K, Roediger M, Gersdorff N (2015)	Risk factors for technical and biological complications with zirconia single crowns	Clinical Oral Investigations	Insufficient data
Rinke S, Lange K, Ziebolz D (2013)	Retrospective study of extensive heat-pressed ceramic veneers after 36 months	Journal of Esthetic & Restorative Dentistry	Part of a longer follow-up study

Rinke S, Pabel AK, Schulz X, Rödiger M, Schmalz G, Ziebolz D (2018)	Retrospective evaluation of extended heat-pressed ceramic veneers after a mean observational period of 7 years	Journal of Esthetic & Restorative Dentistry	Part of a longer follow-up study
Sarkis-Onofre R, Jacinto RC, Boscato N, Cenci MS, Pereira-Cenci T (2014)	Cast metal vs. glass fibre posts: a randomized controlled trial with up to 3 years of follow up	Journal of dentistry	Less than 3 years of follow-up
Scotti R, Catapano S, D'Elia A (1995)	A clinical evaluation of In-Ceram crowns	International Journal of Prosthodontics	Mixed data of anterior and posterior restorations
Segal BS (2000)	A pragmatic perspective on reconstructive dentistry and the utilization of posterior all-ceramic crowns	The Journal of the Tennessee Dental Association	Review or in vitro study
Shang X, Mu Y (2002)	Clinical application and effective assessment of cerinate porcelain laminate veneers	Chinese Medical Journal	Insufficient data
Signore A, Benedicenti S, Kaitsas V, Barone M, Angiero F, Ravera G (2009)	Long-term survival of endodontically treated, maxillary anterior teeth restored with either tapered or parallel-sided glass-fiber posts and full-ceramic crown coverage	Journal of Dentistry	Insufficient data
Sorrentino R, Galasso L, Tetè S, De Simone G, Zarone F (2012)	Clinical Evaluation of 209 All-Ceramic Single Crowns Cemented on Natural and Implant-Supported Abutments with Different Luting Agents: A 6-Year Retrospective Study	Clinical Implant Dentistry and Related Research	Mixed data of anterior and posterior restorations
Tanner J, Niemi H, Ojala E, Tolvanen M, Närhi T, Hjerppe J (2018)	Zirconia single crowns and multiple-unit FDPs-An up to 8 -year retrospective clinical study	Journal of Dentistry	Mixed data of anterior and posterior restorations
Vavřičková L, Dostálová T, Charvát J, Bartoňová M (2013)	Evaluation of the three-year experience with all-ceramic crowns with polycrystalline ceramic cores	Prague Medical Report	Insufficient data
Walls (1995)	The use of adhesively retained all-porcelain veneers during the management of fractured and worn anterior teeth: Part 2. Clinical results after 5 years of follow-up	British Dental Journal	Insufficient data
Walton TR (1999)	A 10-year longitudinal study of fixed prosthodontics: clinical characteristics and outcome of single-unit metal-ceramic crowns	The International journal of prosthodontics	Mixed data of anterior and posterior restorations
Walton TR (2009)	Changes in the outcome of metal-ceramic tooth-supported single crowns and FDPs following the introduction of osseointegrated implant dentistry into a prosthodontic practice	The International journal of prosthodontics	Mixed data of anterior and posterior restorations
Wu XY, Ye Y, Zhong Q (2020)	A comparative study on the effect of glass fiber post and metal post in restoration of anterior tooth defect	Shanghai kou qiang yi xue / Shanghai journal of stomatology	No English language
Xu SP, Luo XP, Shi YJ (2012)	Esthetic restoration for anterior teeth with the hot pressed porcelain laminate veneers	Shanghai Kou Qiang Yi Xue / Shanghai Journal of Stomatology	No English language
Xu WX, Xu K, Ruan DP (2007)	DT Light-Post system for prosthodontic treatment of residual root and crown teeth	Shanghai Kou Qiang Yi Xue / Shanghai Journal of Stomatology	No English language
Xu X, Cao XM, Ji HH, Yang Y, Gao YG (2008)	Effects of DT Light-Post system versus casting post pore on anterior teeth restoration	Journal of Clinical Rehabilitative Tissue Engineering Research	No English language
Zhou TF, Wang XZ, Liu JY, Sun Q, Wang XK (2016)	Preliminary clinical evaluation of the esthetic effect of deep discolored anterior teeth restored with zirconia veneers	Beijing da Xue Xue Bao. Yi Xue Ban / Journal of Peking University. Health Sciences	No English language
Zürcher AN, Hjerppe J, Studer S, Lehner C, Sailer I, Jung RE (2021)	Clinical outcomes of tooth-supported leucite-reinforced glass-ceramic crowns after a follow-up time of 13-15 years	Journal of Dentistry	Mixed data of anterior and posterior restorations

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