A Systematic Review and Meta-analysis Evaluating the Survival, Failure, and Complication Rates of Metal-Ceramic, Veneered, and Monolithic All-Ceramic Tooth-Supported Multiple-Unit Fixed Dental Prostheses (FDPs)—Part 2

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Purpose: To evaluate the 5-year survival of metal-ceramic and all-ceramic tooth-supported fixed dental prostheses (FDPs) and assess biologic and technical complication rates. ***Materials and Methods:*** Randomized clinical trials and prospective studies on tooth-supported FDPs with a mean follow-up of ≥ 3 years were included. A systematic search of MEDLINE (PubMed), Embase, and Cochrane CENTRAL (January 2014 to December 2024) identified relevant studies. An additional 17 studies from prior systematic reviews were included to cover earlier periods. Survival and complication rates were estimated using robust Poisson regression models to generate pooled 5-year survival estimates. ***Results:*** In total, 41 studies, including 600 metal-ceramic and 1,532 all-ceramic FDPs, met the inclusion criteria. The 5-year survival rates were 92.9% for veneered densely sintered zirconia, 91.3% for metal-ceramic, 88.4% for glass-infiltrated alumina, 87.9% for monolithic densely sintered zirconia, and 82.5% for lithium disilicate–reinforced glass-ceramic FDPs. Lithium disilicate FDPs showed significantly lower survival than metal-ceramic restorations, while differences among other materials were not statistically significant. Overall, 71.0% of restorations remained complication-free after 5 years. All-ceramic FDPs had higher rates of marginal caries and loss of retention than metal-ceramic FDPs. Framework fractures were more prevalent in all-ceramic restorations, particularly in lithium disilicate–reinforced glass-ceramic and glass-infiltrated alumina FDPs (> 10% over 5 years). Ceramic chipping was common but least frequent in monolithic zirconia FDPs. ***Conclusions:*** Veneered and monolithic densely sintered zirconia and metal-ceramic FDPs demonstrate comparable 5-year survival rates. High fracture rates make weaker ceramics unsuitable for multiunit restorations. Monolithic zirconia offers improved resistance to chipping and framework fractures. *Int J Prosthodont 2026;39:444–462. doi: 10.11607/ijp.9666*

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In recent decades, improved socioeconomic conditions, advancements in preventive care, and increased patient adherence to professional maintenance programs have contributed to greater tooth retention in aging populations.[1] Consequently, most patients requiring tooth replacement are only partially edentulous and, therefore, mostly seeking for fixed restorations. The established use of dental implants as a successful treatment modality,[2] together with a growing preference for less invasive prosthetic treatments,[3] has further narrowed the indications for tooth-supported fixed

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dental prostheses (FDPs). However, tooth-supported FDPs remain a scientifically valid treatment option, with high estimated 5-year (93.8%) and 10-year (89.4%) survival rates that are similar to those reported for implant-supported single crowns.[4] Clinical scenarios in which dental implants may not be the first option, due to medical conditions or anatomical limitations, or cases with the presence of previously restored adjacent teeth, remain suitable indications for tooth-supported FDPs.

Traditionally, metal-ceramic FDPs have been considered the gold standard due to their reliable mechanical properties and long-term clinical success.[5,6] However, the high costs associated with gold alloys, and the increased demand for improved esthetics and biocompatibility have pushed the development and clinical adoption of high-strength ceramic materials. Among these, zirconia has emerged as well documented option, offering high flexural strength and fracture toughness, along with the increasing use of CAD/CAM workflows. Nevertheless, the first generations of zirconia, mostly composed of 3 mol% yttria-stabilized tetragonal zirconia polycrystal (3Y-TZP), presented esthetic challenges due to their high opacity. To improve the esthetics of these restorations, the 3Y-TZP frameworks required veneering with feldspathic or glass-ceramic materials.[7] However, the veneered 3Y-TZP restorations exhibited high rates of chipping of the veneering ceramic.[6] To overcome this issue, new types of zirconia ceramics were introduced. These more recent zirconia variations are more translucent due to increased contents of yttria (typically ranging from 4 to 6 mol%) and hence more esthetic. They enabled the use of partial veneering, microveneering, or monolithic designs, aiming to reduce complications while maintaining mechanical integrity.[8] These new zirconia generations have increased yttria content (typically ranging from 4 to 6 mol%), which stabilizes some cubic crystal phases at room temperature. Partially stabilized zirconia (PSZ), often available in the form of 4Y and 5Y-PSZ, offers improved translucency and esthetic properties. However, these materials tend to have reduced mechanical strength compared to 3Y-TZP.[7] Most recently, graded variations of zirconia ingots containing both a 3Y-TZP core (with high flexural strength and fracture toughness) and a more translucent 5Y-TZP surface (with lower stability values) were introduced to fulfil both esthetic and mechanical needs.[9,10] Similarly, other reinforced ceramics with improved optical properties, such as lithium disilicate reinforced glass-ceramics, have been used and proposed for monolithic restorations in single and short-span FDPs.[11–13]

Because the previous systematic review was published in 2015, the number of clinical studies reporting on survival and complication rates of metal-ceramic and all-ceramic FDPs has grown substantially and studies reporting on monolithic or microveneered all-ceramic FDPs have appeared.[14–16]

The objectives of this systematic review were the following:

- To update the previous systematic reviews on tooth-supported metal-ceramic and all-ceramic FDPs with an additional literature search of controlled and prospective studies.[5,6]
- To obtain overall robust estimates of the long-term survival and complication rates of metal-ceramic and all-ceramic FDPs over an observation period of 5 years.
- To compare the survival and complication rates of all-ceramic FDPs with those of metal-ceramic FDPs to assess if metal-ceramics can still be considered the gold standard.

MATERIALS AND METHODS

This systematic review is reported in accordance with the Preferred Reporting Items for Systematic review and Meta-Analysis (PRISMA) 2020 guidelines.[17] A comprehensive protocol was developed and registered in PROSPERO (CRD42021277877).

Focused Questions

According to the previous publications,[5,6] this systematic review aimed to answer the following focused question: "Are the survival and complications rates of metal-ceramic and all-ceramic tooth-supported FDPs similar after an observation period of 5 years?"

Inclusion and Exclusion Criteria

The inclusion criteria for this systematic review were defined according to the PICOS acronym:

- (P) Population: Subjects with anterior and/or posterior edentulous areas.
- (I) Intervention: All-ceramic tooth-supported FDPs.
- (C) Comparison: Metal-ceramic tooth-supported FDPs.
- (O) Outcomes: Survival rates and technical and/or biologic complication rates.
- (S) Study Design: Randomized controlled clinical trials (RCTs) and prospective cohort studies.

Additional inclusion criteria for study selection were the following:

- Studies with a minimum mean follow-up period of 3 years.
- Patients had to be clinically examined at follow-up visits (ie, studies based solely on patient records, questionnaires, or interviews were excluded).
- Studies had to report details on the characteristics of the restorations, materials, methods, and results.

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- Studies had to include at least 10 patients.
- Only studies published in English language were considered.

Search Strategy

Two of the review authors (P.R. and A.B.) independently screened titles and abstracts in duplicate across three different databases (PubMed, Embase, Cochrane Central Register of Controlled Trials [CENTRAL]) for studies published between January 1, 2014 and December 4, 2024. The detailed search strategy for the electronic screening is reported in the Appendix Box 1 (all Appendix items available in the online version of this article). Any disagreements were resolved through discussion or, if resolution was not achieved, a third review author was consulted (J.P.) to make the final decision. The same review authors also conducted in duplicate the full-text analysis of all the included studies selected during the screening process and determined their inclusion in the systematic review. Reasons for exclusion were recorded. When multiple studies reported results from the same cohort, only the study with the longest follow-up period was included. Additionally, 17 prospective studies from previous systematic reviews on tooth-supported FDPs by Sailer et al[5] and Pjetursson et al[6] were considered for incorporation in this updated review. The previous review covered a literature search until end of 2013.

Data Extraction

After calibration, data from the included studies were extracted in duplicate by three review authors (A.B., B.E.P., and R.I.) using predefined data extraction forms. Any disagreements were resolved through discussion.

For each study, the following data were extracted : author(s), year of publication, study design, study setting, initial number of patients, age (mean), actual number of patients at end of study, dropout rate, follow-up time (mean), reported survival rate, initial number of FDPs, number of abutment teeth, number of pontics, location (anterior/posterior), framework material, brand name of framework material, manufacturing procedures, veneering material, type of cement, number of FDPs failed (anterior vs posterior), reported biologic complications (total number of biologic complications, caries on abutment teeth, FDPs lost due to caries, FDPs lost due to abutment tooth fracture), reported technical complications (total number of technical complications, failure due to framework fracture, minor ceramic chippings what could be polished, major ceramic chippings that needed repair, failure due to catastrophic veneering ceramic fracture, loss of retention), FDPs remade due to esthetic issues and marginal discoloration.

After data extraction, all the restoration materials were categorized based on their framework material and design (monolithic vs veneered restorations). For meta-analytic purposes, monolithic and microveneered restorations were combined in the same group.

Quality Assessment of the Included Studies

Quality assessment and risk of bias evaluation were independently performed during the data extraction phase, employing the newly developed Quality-Assessment-Scale for Reconstructive Studies (QAS-RS), which has been specifically developed for prospective and retrospective clinical medical or dental reconstructive studies by the authors of this review. This scale encompasses seven methodologic domains: *(1)* appropriateness of sample size determination, *(2)* frequency of follow-up assessments *(3)* adequacy of inclusion and exclusion criteria, *(4)* methods of outcome assessment, *(5)* quality of reporting on failures and complications, *(6)* duration of follow-up, and *(7)* dropout rate throughout follow-up (Appendix Box 2). Similar to other quality assessment scales in the literature,[18–20] the QAS-RS employs a star system, with each domain rated on four different levels corresponding to values from 0 to 3 stars. The overall quality assessment of the included studies was categorized as low (0 to 7 stars), moderate (8 to 14 stars) or high (15 to 21 stars; see Appendix Box 2).

Data Analysis

In the present systematic review, failure and complication rates were calculated by dividing the number of events (failures or complications) in the numerator by the total restoration or abutment tooth exposure 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 the following:

- Exposure time of restorations that could be followed for the whole observation time.
- Exposure time up to a failure of the restorations that were lost during the observation time.
- Exposure time up to the end of observation time for restorations in patients that were lost to follow-up 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 the restorations were calculated by dividing the total number of events by the total restorations' exposure time in years. For further analysis, the total number of events was considered to be Poisson distributed for a given sum of restoration exposure and Poisson regression were used with a logarithmic link-function and total exposure time per

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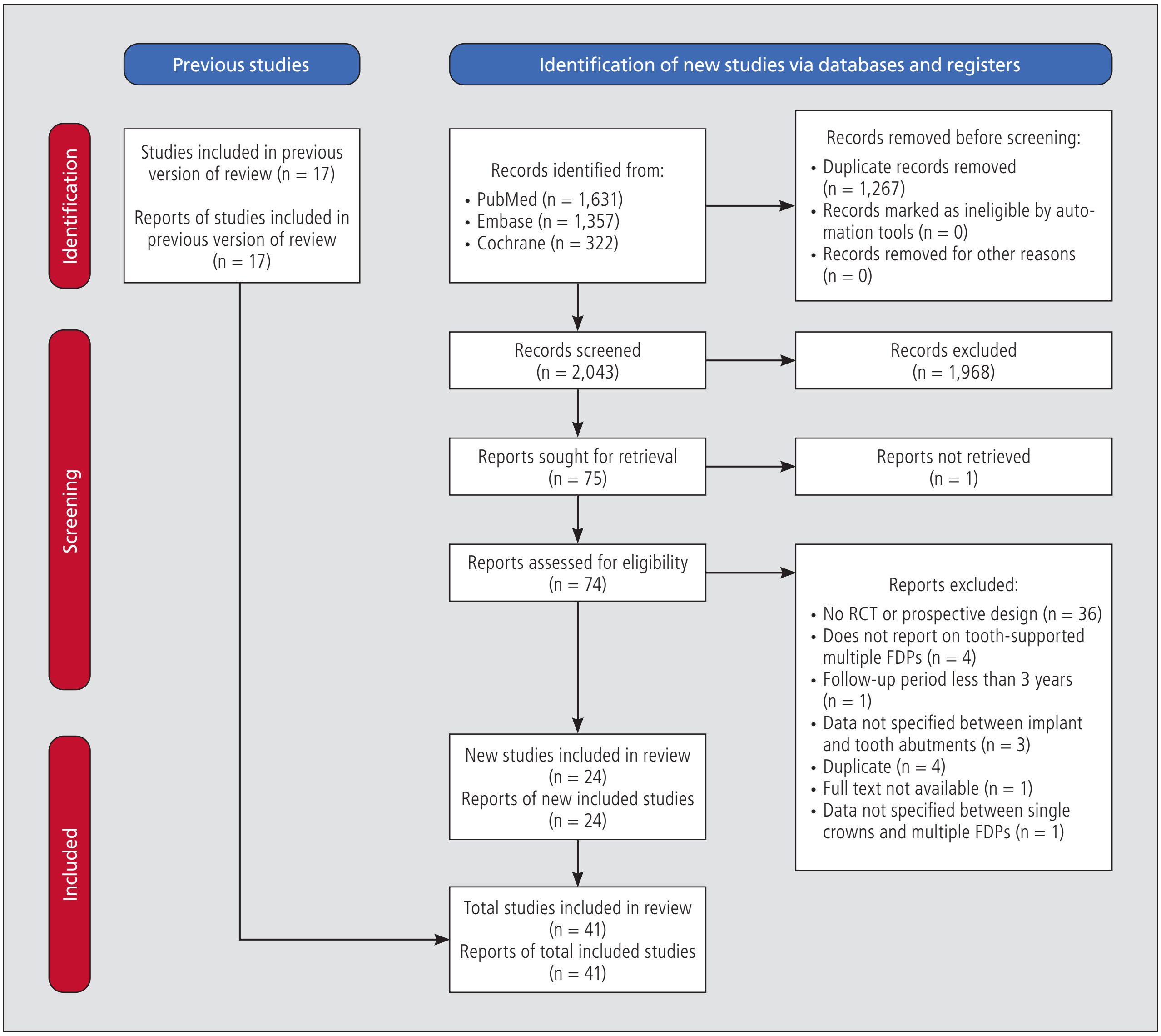

Fig 1 PRISMA 2020 flow diagram for updated systematic reviews, which included searches of databases and registers only.

study as an offset variable.[21,22] To assess heterogeneity of the study specific event rates, Spearman goodness-of-fit statistics and associated *P* values were calculated. To reduce the effect of heterogeneity robust standard errors were calculated to obtain 95% CIs of the summary estimates of the event rates.

The 5-year failure/complication proportions were calculated via the relationship between event rate and failure/complication function *F*: $F(T) = \exp(-T \times \text{event rate})$ by assuming constant event rates.[21,22] 95% CIs for the failure/complication 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 the material used. All analyses were performed using Stata version 15.1 (Stata).

RESULTS

Study Selection Process

A total of 3,310 articles were retrieved through electronic database searches, comprising 1,631 from PubMed, 1,357 from Embase, and 322 from the Cochrane Central Register of Controlled Trials (CENTRAL). Following the removal of duplicates, 2,043 articles were retained for title and abstract screening. Of these, 74 studies were assessed in full text, resulting in the inclusion of 24 studies. Detailed reasons for exclusion are presented in

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Appendix Table 1. In addition, 17 relevant studies were included from prior systematic reviews, yielding a total of 41 studies reporting on tooth-supported multiple-unit FDPs (Fig 1).

Characteristics of the Included Studies

A total of 41 studies were included in the multiple-unit FDP group, reporting 51 patient cohorts and 2,132 restorations. Of these, 8 were RCTs, and 33 were prospective cohort studies. Retrospective studies were excluded from the present systematic review.

Five distinct restorative material/design categories were identified: metal-ceramic (9 cohorts[23–31]); monolithic, microveneered, or veneered lithium disilicate–reinforced glass-ceramics (7 cohorts[11,29,32–36]); glass-infiltrated alumina/zirconia (5 cohorts[30,37–40]); veneered densely sintered zirconia (27 cohorts[23–26,28,30,41–60]); and monolithic or microveneered densely sintered zirconia (3 cohorts[14,15,23]). Research interest in glass-infiltrated alumina/zirconia FDPs appears to have diminished, represented by a median publication year of 2004 and an absence of published studies since 2015.

Out of the eight included RCTs, seven made direct comparisons between different restorative materials/designs for FDPs. Four RCTs compared metal-ceramic with veneered densely sintered zirconia FDPs,[24–26,28] and one compared metal-ceramic with lithium disilicate–reinforced glass-ceramic FDPs.[29] Two RCTs compared three groups: one evaluated metal-ceramic, veneered, and monolithic densely sintered zirconia FDPs;[23] the other assessed metal-ceramic, glass-infiltrated alumina, and veneered densely sintered zirconia FDPs.[30] The remaining RCT investigated veneering techniques for CAD/CAM-fabricated densely sintered zirconia frameworks, comparing hand layered and pressed methods.[49]

Regarding the scope of material evaluation, two studies investigated three distinct material/design groups, 6 studies assessed two material/design cohorts, while the remaining 33 studies focused on a single material cohort. A detailed overview of the included studies is presented in Table 1.

Survival and Failure Rates

A total of nine studies provided data on the survival and failure rates of metal-ceramic FDPs, encompassing 600 restorations with a mean follow-up period of 6.1 years. The estimated annual failure rate was 1.83%, corresponding to a 5-year survival rate of 91.3% (Table 2).

The meta-analysis included four categories of all-ceramic FDPs. For veneered or monolithic lithium disilicate–reinforced glass-ceramic FDPs, seven studies including 207 FDPs with a mean observation period of 6.5 years were included. The estimated annual failure rate for this group was 3.85%, translating to a 5-year survival rate of 82.5%. Reinforced glass-ceramic FDPs were also divided according to design. Four studies reported on 137 monolithic FDPs, and two studies reported on 52 veneered reinforced glass-ceramic FDPs. There was no statistically significant difference ($P = .914$) between the groups representing in annual failure rates of 3.67% and 3.54%, respectively. Glass-infiltrated alumina/zirconia FDPs were evaluated in five studies, incorporating 198 FDPs with a mean follow-up period of 5.1 years. The annual failure rate for this material was 2.46%, resulting in a 5-year survival rate of 88.4% (see Table 2).

Densely sintered zirconia FDPs were stratified into two groups: traditionally veneered FDPs and monolithic or microveneered FDPs. A total of 27 studies reported on 991 veneered densely sintered zirconia FDPs, with a mean follow-up time of 5.7 years. The estimated annual failure rate for this category was 1.46%, equating to a 5-year survival rate of 92.9%. For monolithic or microveneered densely sintered zirconia FDPs, three studies including 136 FDPs with a mean follow-up time of 3.4 years, yielding an estimated annual failure rate of 2.58% and a 5-year survival rate of 87.9% (see Table 2). Further investigation into the 12 failures observed in the monolithic or microveneered densely sintered zirconia FDPs revealed that 9 were biologic in nature, such as caries, periodontal breakdown, or abutment tooth fracture, while only 3 were due to technical issues.[14,15,23]

Comparative analysis of failure rates demonstrated that veneered densely sintered zirconia FDPs (1.46%) exhibited failure rates comparable to metal-ceramic FDPs (1.83%). In contrast, monolithic or microveneered densely sintered zirconia FDPs (2.58%) and glass-infiltrated alumina FDPs (2.46%) showed slightly elevated failure rates, while lithium disilicate–reinforced glass-ceramic FDPs exhibited the highest annual failure rate (3.85%) (Tables 2 and 3).

Statistical comparisons between all-ceramic FDPs and metal-ceramic FDPs as a reference revealed a significantly lower survival rate for lithium disilicate–reinforced glass-ceramic FDPs ($P = .005$). No statistically significant differences were observed among other all-ceramic FDP types when compared to metal-ceramic FDPs (see Table 3).

Technical and Biologic Complications

Table 4 and Appendix Table 2 provide a summary of the estimated annual complication and failure rates associated with technical and biologic complications or failures in metal-ceramic and all-ceramic FDPs.

Over a mean follow-up time of 5 years, 529 FDPs were assessed for overall failure or complication rates. The estimated complication/failure rate was 29.0%, indicating that 71% of FDPs remained intact or free from all complications after a 5-year follow-up period.

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Technical complications

Technical complications encompassed framework fractures, ceramic fractures or chipping, loss of retention, marginal discoloration, and esthetic failures.

Framework fractures were rare in metal-ceramic FDPs, with an estimated 5-year fracture rate of 0.1%. However, higher rates were observed in all-ceramic FDPs: 12.2% for lithium disilicate–reinforced glass-ceramic FDPs, 10.2% for glass-infiltrated alumina/zirconia FDPs, 3.2% for monolithic densely sintered zirconia FDPs, and 1.3% for veneered densely sintered zirconia FDPs (see Table 4). Statistical comparisons indicated significantly higher framework fracture rates for all-ceramic FDPs, except for veneered densely sintered zirconia FDPs, where the difference approached statistical significance (P = .064; see Appendix Table 2).

In the present systematic review, the data on ceramic fractures or surface chippings was divided into three categories: catastrophic fracture of the veneering ceramic so extensive that the restoration must be remade, surface chipping that can be repaired with a composite filling or a ceramic veneer adhesively bonded to the existing surface, and small surface chipping that can simply be polished (see Table 4 and Appendix Table 2).

Catastrophic fractures of the veneering or surface ceramic leading to complete restoration failure were reported in 1.8% of FDPs, with the highest incidence in lithium disilicate–reinforced glass-ceramic FDPs (3.8%), followed by veneered densely sintered zirconia (1.8%) and metal-ceramic FDPs (1.8%). This complication was not seen for the included glass-infiltrated alumina and monolithic densely sintered zirconia FDPs (see Table 4).

The overall incidence of ceramic fractures requiring repair with composite or additional ceramic veneer was 6.8% over 5 years. Metal-ceramic FDPs (10.0%), glass-infiltrated alumina FDPs (9.5%), and veneered densely sintered zirconia FDPs (6.6%) exhibited the highest fracture rates (see Table 4). The incidence of minor ceramic chipping, which could be polished, was on average 15.9%, with the highest rates observed in metal-ceramic FDPs (19.0%), veneered densely sintered zirconia FDPs (17.3%), and glass-infiltrated alumina FDPs (15.7%; see Table 4).

Loss of retention was uncommon in metal-ceramic FDPs (0.6%) and lithium disilicate–reinforced glass-ceramic FDPs (1.2%). However, significantly higher rates were noted for monolithic densely sintered zirconia FDPs (3.0%), veneered densely sintered zirconia FDPs (3.6%), and glass-infiltrated alumina FDPs (4.6%; see Table 4 and Appendix Table 2).

Marginal discoloration incidence ranged from 4.5% to 22.0%, with the highest rates in veneered densely sintered zirconia FDPs (22.0%), followed by glass-infiltrated alumina FDPs (21.2%) and metal-ceramic FDPs (18.6%). Significantly lower rates were observed in lithium disilicate–reinforced glass-ceramic FDPs (4.5%) and monolithic densely sintered zirconia FDPs (7.1%; see Table 4 and Appendix Table 2).

Biologic complications

The most frequently reported biologic complications were secondary caries at the abutment level, as well as FDP failures due to secondary caries or abutment tooth fractures. The 5-year incidence of secondary caries on abutment level was 1.6% based on 2,230 abutment teeth, with rates ranging from 0.6% to 3.2%. Notably, all-ceramic restorations demonstrated significantly higher secondary caries rates compared to metal-ceramic FDPs (see Table 4 and Appendix Table 2).

The incidence of FDP loss due to secondary caries was 1.5% based on 1,701 restorations, with 5-year failure rates ranging from 0.4% to 2.1%. No statistically significant differences among FDP types were observed (see Table 4 and Appendix Table 2).

The overall 5-year incidence of FDP loss due to abutment tooth fractures was 1.1% based on 1,600 restorations. Except for monolithic densely sintered zirconia FDPs, which exhibited a failure rate of 5.5%, the incidence ranged from 0% to 1.1% (see Table 4).

Quality Assessment of the Included Studies

The quality assessment of the included studies is presented in Appendix Table 3. Based on the newly developed QAS-RS, 14 of the included studies were rated as high quality, 37 as moderate quality, and none as low quality. Most of the included studies were lacking description on the determination of the sample size. The reason for the moderate quality of the 37 studies was not identical across the studies. It was frequently related to poor description of inclusion or exclusion criteria, incomplete reporting of failures and complications, relatively short follow-up time, or lack of reporting on participants dropping out of the study.

DISCUSSION

Over the past decade, systematic reviews have been widely employed in dentistry to synthesize cumulative evidence regarding optimal treatment strategies for clinically relevant questions. They serve as an evidence-based tool to support clinicians in the decision-making process regarding different treatment options. Originally, systematic reviews were primarily used to collate and analyze findings from RCTs.[61] However, in the absence of adequately powered RCTs directly comparing metal-ceramic and all-ceramic FDPs, prospective cohort studies with strict inclusion criteria were considered eligible for inclusion in the present review. This approach enabled the evaluation of survival and complication rates of metal-ceramic and all-ceramic FDPs with a minimum observation period of 3 years.

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Table 1 Overview of the Included Studies

Study			Patient			Restoration				
Reference	Study design	Setting	Initial (n)	Mean age (years)	Calculated dropout (%)	Initial FDPs (n)	Abutment teeth (n)	Pontics (n)	FDPs anterior (n)	FDPs posterior (n)
Metal-ceramic										
Pontevedra et al (2023a)	RCT	University	30	57	0.0	34	60	30	0	30
Sailer et al (2018a)	RCT	University	58	60.9	22.4	31	NR	NR	0	36
Suarez et al (2018a)	RCT	University	20	NR	0.0	60	40	20	0	20
Nicolaisen et al (2016a)	RCT	University	34	51.5	0.0	152	34	17	0	17
Hey et al (2013)	Prospective	University	23	NR	0.0	45	66	42	0	31
Pelaez et al (2012a)	RCT	University	37	NR	0.0	40	40	20	0	20
Makarouna et al (2011a)	RCT	University	18	47	55.6	41	38	19	6	13
Christensen and Ploeger (2010a)	RCT	Private practice multicenter	259	50	3.9	100	NR	NR	NR	NR
Walton et al (2009)	Prospective	Specialists	233	49	21.0	190	787	NR	NR	NR
Reinforced glass-ceramic										
Garling et al (2019)	Prospective	University	28	47.5	21.4	36	72	1	6	30
Teichmann et al (2017)	Prospective	University	24	40.7	20.1	33	NR	NR	11	16
Reich et al (2014)	Prospective	University and private practice	33	54.9	3.03	38	76	38	18	14
Solá-Ruiz et al (2013)	Prospective	University	19	49	0.0	21	42	21	20	1
Makarouna et al (2011b)	RCT	University	19	47	26.3	18	36	18	8	10
Esquivel et al (2008)	Prospective	University	21	NR	0.0	30	60	30	0	30
Marquardt and Strub (2005)	Prospective	University	43	39.9	0.0	31	62	31	24	7
Glass-infiltrated alumina										
Chaar et al (2015)	Prospective	University	58	46.8	10.3	65	130	65	0	65
Christensen and Ploeger (2010b)	RCT	Private practice multicenter	259	50	3.09	34	NR	NR	NR	NR

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Restoration					
Framework material	Brand name framework material	Manufacturing procedure	Veneering material	Type of cement	Quality assessment
Cobalt-chromium alloy	Ceramill Sintron R 71 L, Amann Girrbach	CAD/CAM and veneering	Feldspar ceramic (VITA VM13, VITA Zahnfabrik)	Self-adhesive resin cement	High
Metal-gold alloy	Degudent U, Dentsply Sirona	Casting and veneering	Duceram-Plus, Dentsply Sirona	Resin cement	High
Cobalt-chromium alloy	Heraenium Pw, Kulzer	Casting and veneering	Feldspar ceramic (VITA VM13)	Resin cement	High
Metal–high gold alloy	BioPontoStar, BEGO	Casting and veneering	Feldspar ceramic (VITA VM13)	Resin-enhanced glass ionomer	Moderate
Metal-titanium grade 2	Everest T-Blank, KaVo	CAD/CAM and veneering	Low-fusing feldspathic ceramic (Vita Titanium Porcelain, VITA Zahnfabrik)	Zinc phosphate	Moderate
Cobalt-chromium alloy	Heraenium Pw, Heraeus Kulzer	Casting and veneering	Feldspar ceramic (VITA VM13)	Glass ionomer	Moderate
Metal	NR	NR	NR	Glass ionomer	Moderate
- High noble alloy—silver-free - High noble alloy—gold, platinum, palladium	- Argedent 65SF, Argen - Captek, Precious Chemicals - Ceramco Ultra Crown SF, Dentsply	- Casting and pressing - Hand adaptation and veneering - Casting and veneering	- Pulse interface, Jensen Dental - Creation, Jensen Dental - Ceramco Soft-Wear Enamels, Dentsply	Resin-modified glass ionomer	Moderate
High noble metal alloys	NR	NR	NR	Zinc phosphate	Moderate
Lithium disilicate	IPS e.max Press, Ivoclar Vivadent	Heat-pressing	NA	Resin and glass-ionomer cement	Moderate
Lithium disilicate	IPS e.max Press	Heat-pressing and microveneering	IPS Eris for E2, Ivoclar Vivadent	Resin and glass-ionomer cement	High
Lithium disilicate	IPS e.max CAD LT, Ivoclar Vivadent	- CAD/CAM - CAD/CAM and microveneering	Fluoroapatite glass-ceramic (IPS e.max Ceram, Ivoclar Vivadent)	Resin cement	Moderate
Lithium disilicate	IPS e.max Press	Heat-pressing and veneering	NR	Resin cement	Moderate
Lithium disilicate	NR	- Heat-pressing - Heat-pressing and veneering	NR	Glass ionomer	Moderate
Lithium disilicate	IPS e.max Press	Heat-pressing	NA	Glass-ionomer and dual-cure resin cement	Moderate
Lithium disilicate	IPS Empress 2, Ivoclar Vivadent	Heat-pressing and veneering	Apatite sintered glass-ceramic	Resin cement	Moderate
Glass-infiltrated zirconia-reinforced alumina	VITA In-Ceram ZIRCONIA for inLab, VITA Zahnfabrik	CAD/CAM framework and veneering	Feldspar ceramic (VITA VM7, VITA Zahnfabrik)	Glass ionomer	Moderate
Glass-infiltrated alumina	Wol-ceram, Wol-Dent	- Electrophoretic deposition and veneering - Electrophoretic deposition and pressing	Cerabien, Noritake Dental	Resin-modified glass ionomer	Moderate

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Table 1 Overview of the Included Studies *(cont)*

Study			Patient			Restoration				
Reference	Study design	Setting	Initial (n)	Mean age (years)	Calculated dropout (%)	Initial FDPs (n)	Abutment teeth (n)	Pontics (n)	FDPs anterior (n)	FDPs posterior (n)
Suàrez et al (2004)	Prospective	University	16	NR	0.0	18	36	22	0	18
von Steyern et al (2001)	Prospective	University and private practice	18	NR	0.0	20	40	20	0	20
Sorensen et al (1998)	Prospective	University	47	NR	2.1	61	122	61	21	40
Densely sintered zirconia (veneered)										
Pontevedra et al (2023b)	RCT	University	30	62	0.0	30	60	30	0	30
Blatz et al (2022)	Prospective	University	25	55.6	16.0	25	50	25	0	25
Matta et al (2022)	Prospective	University	30	50.1	43.3	30	NR	50	0	30
Sola-Ruiz et al (2022)	Prospective	University	27	NR	11.1	27	NR	NR	27	0
Zarone et al (2020)	Prospective	University	37	45.3	0.0	48	96	1	0	48
Serra-Pastor et al (2019)	Prospective	University	52	NR	1.9	27	73	NR	NR	NR
Rinke et al (2018)	Prospective	University	75	49.4	28.0	99	198	117	0	99
Sailer et al (2018b)	RCT	University	58	60.9	22.4	40	NR	NR	0	40
Suarez et al (2018b)	RCT	University	20	NR	0.0	20	40	20	0	20
Teichmann et al (2018)	Prospective	University	17	40.1	11.8	22	NR	NR	3	17
Nicolaisen et al (2016b)	RCT	University	34	51.5	0.0	17	34	17	0	17
Ioannidis and Bindl (2016)	Prospective	University	55	52.6	3.6	59	138	59	0	59
Naenni et al (2015a)	RCT	University	20	55.8	10.0	20	36	18	0	18
Naenni et al (2015b)	RCT	University	20	52.3	10.0	20	36	18	0	18
Tanaka et al (2015)	Prospective	University	10	53.3	10.0	10	20	11	2	8
Beuer et al (2015)	Prospective	University	44	NR	0.0	22	NR	NR	0	22
Konstantinidis et al (2014)	Prospective	University	27	54.9	29.6	20	42	NR	NR	NR
Burke et al (2013)	Prospective	Private practice	36	NR	22.2	41	82	44	14	27
Raigrodski et al (2012)	Prospective	University	16	48	6.2	20	40	20	0	20
Pelaez et al (2012b)	RCT	University	37	NR	0.0	20	40	20	0	20

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	Restoration					
	Framework material	Brand name framework material	Manufacturing procedure	Veneering material	Type of cement	Quality assessment
	Glass-infiltrated zirconia-reinforced alumina	VITA In-Ceram Zirconia	Split casting	NR	Zinc phosphate and glass ionomer	Moderate
	Glass-infiltrated alumina	VITA In-Ceram Alumina, VITA Zahnfabrik	Split casting	Feldspathic porcelain	Zinc phosphate	Moderate
	Glass-infiltrated alumina	VITA In-Ceram Alumina	Split casting	Vitadur-N, VITA Zahnfabrik	Glass ionomer	Moderate
	Zirconia	Wieland Zenotec, Wieland Dental	CAD/CAM and veneering	Fluoroapatite glass-ceramic (IPS e.max Ceram)	Self-adhesive resin cement	High
	Zirconia	IPS e.max ZirCAD, Ivoclar Vivadent	CAD/CAM and veneering	IPS e.max CAD	Resin cement	Moderate
	Zirconia	Lava Frame, Lava system, 3M ESPE	CAD/CAM and veneering	Lava Ceram, 3M ESPE	Glass ionomer	Moderate
	Zirconia	Lava Frame Zirconia, 3M ESPE	CAD/CAM and veneering	Lava Ceram	Resin cement	High
	Zirconia	Procera Zirconia, Nobel Biocare	CAD/CAM and veneering	Procera All Zircon, Nobel Biocare	Resin cement	High
	Zirconia	Lava Frame Zirconia	NR	Lava Ceram	Glass ionomer	Moderate
	Zirconia	Cercon base, Dentsply Sirona	CAD/CAM and veneering	Cercon Ceram-S, Dentsply Sirona	Zinc phosphate	Moderate
	Zirconia	Cercon, Dentsply Sirona	CAD/CAM and veneering	Ceron-Ceram-S	Resin cement	High
	Zirconia	IPS e.max ZirCAD	CAD/CAM and veneering	Fluoroapatite glass-ceramic (IPS e.max Ceram)	Resin cement	High
	Zirconia	DigiZon, AmannGirrbach Dental	CAD/CAM and veneering	Initial Zr-Keramik, GC Europe	Resin-reinforced glass ionomer	High
	Zirconia	BeCe CAD Zirkon+, BEGO	CAD/CAM and veneering	VITA VM 9	Resin-enhanced glass ionomer	Moderate
	Zirconia	Vita In-Ceram 2000YZ cubes, VITA Zahnfabrik	CAD/CAM and veneering	Vitadur Alpha, VITA Zahnfabrik	Resin cement	Moderate
	Zirconia	IPS e.max ZirCAD	CAD/CAM and pressing	IPS e.max ZirPress, Ivoclar Vivadent	Resin cement	Moderate
	Zirconia	IPS e.max ZirCAD	CAD/CAM and veneering	IPS e.max Ceram Margin, Ivoclar Vivadent	Resin cement	Moderate
	Ce-TZP-Ablanks	P-nano ZR, Panasonic Healthcare	CAD/CAM and veneering	CERABIEN ZR, Kuraray Noritake	Resin cement	Moderate
	Zirconia	Everest ZS, KaVo	CAD/CAM and veneering	Initial ZR, GC Europe	Glass ionomer	Moderate
	Zirconia	Zenotec Zr Bridge, Wieland Dental	CAD/CAM and veneering	Feldspathic	Glass ionomer	Moderate
	Zirconia	Lava Y-TZP, 3M ESPE	CAD/CAM and veneering	Lava Ceram	Resin cement	Moderate
	Zirconia	NR	CAD/CAM and veneering	Lava Ceram	Resin-modified glass ionomer	High
	Zirconia	Lava, 3M ESPE	CAD/CAM and veneering	Lava Ceram	Resin-modified glass ionomer	Moderate

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Table 1 Overview of the Included Studies *(cont)*

Study			Patient			Restoration				
Reference	Study design	Setting	Initial (n)	Mean age (years)	Calculated dropout (%)	Initial FDPs (n)	Abutment teeth (n)	Pontics (n)	FDPs anterior (n)	FDPs posterior (n)
Lops et al (2012)	Prospective	University	28	46.2	14.3	28	82	NR	18	10
Sax et al (2011)	Prospective	University	45	48.3	53.3	57	114	NR	NR	NR
Christensen and Ploeger (2010c)	RCT	Private practice multicenter	259	50	3.1	163	NR	NR	NR	NR
Beuer et al (2010)	Prospective	University	38	50.9	0.0	18	36	20	2	16
Wolfart et al (2009)	Prospective	University	48	55	4.2	24	48	24	0	24
Molin and Karlsson (2008)	Prospective	Specialists and GP	18	59	0.0	19	38	19	NR	NR
Tinschert et al (2008)	Prospective	University	46	NR	13.0	65	156	94	15	50
Densely sintered zirconia (monolithic and microveneered)										
Pontevedra et al (2023c)	RCT	University	30	54	10.5	30	60	30	0	30
Lestan et al (2022)	Prospective	Private practice	20	58.7	0.0	33	77	45	0	33
Habibi et al (2020)	Prospective	University	57	61.1	0.0	73	148	87	4	69

NA = not applicable; NR = not reported.

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	Restoration					
	Framework material	Brand name framework material	Manufacturing procedure	Veneering material	Type of cement	Quality assessment
	Zirconia	NR	NR	NR	NR	Moderate
	Zirconia	NR	Direct Ceramic Machining (DCM) system and veneering	Prototype ceramic	Resin cement	Moderate
	Zirconia	- Cercon Zirconia - Everest Metoxit AG - IPS e.max ZirCAD - Lava Zirconia	- Direct ceramic machining and veneering - CAD/CAM and veneering - CAD/CAM and pressing	- Feldspathic, Ceramco PFZ, Dentsply - Feldspathic, Initial ZR, GC Corporation - Glass-ceramic, CZR Press, Cerabien, Noritake Dental - Feldspathic, IPS e.max ZirPress - Feldspathic, Lava Ceram	Resin-modified glass ionomer	Moderate
	Zirconia	IPS e.max ZirCAD	CAD/CAM and veneering	Fluoroapatite glass-ceramic (IPS e.max Ceram)	Glass ionomer	Moderate
	Zirconia	Cercon Base	- CAD/CAM and veneering - CAD/CAM and pressing	-CerconCeramS, Dentsply Sirona - Cercon Ceram Express	Glass ionomer	High
	Zirconia	Cad.esthetic CAD/CAM	CAD/CAM and veneering	Feldspar (Vita D veneering ceramic, VITA Zahnfabrik) and fluroroapatite glass-ceramic (IPS e.max Ceramdent)	Zinc phosphate and resin cement	High
	Zirconia	Pressed DC-Zirkon	CAD/CAM (Precident DCS system) and veneering	Feldspar (Vita D veneering ceramic)	Zinc phosphate and resin cement	Moderate
	Zirconia	Wieland Zenotec	CAD/CAM	NA	Self-adhesive resin cement	High
	Zirconia	Zolid white, Amann Girrbach AG	CAD/CAM	NA	Resin-modified glass-ionomer cement	Moderate
	Zirconia	Cercon ht light/medium/ white, Dentsply Sirona	- CAD/CAM - CAD/CAM and microveneering	Cercon Ceram Kiss, Dentsply Sirona	Glass ionomer, resin, and provisional	Moderate

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Table 2 Annual Failure Rates and Survival of Metal-Ceramic and All-Ceramic FDPs

Study	Year of publication	Total number of FDPs	Calculated mean exposure time (years)	Number of failures	Total FDPs exposure time (years)	Estimated annual failure rate* (per 100 FDP years)	Estimated survival after 5 years* (%)
Metal-ceramic							
Pontevedra et al	2023a	30	5	0	150	0	100%
Sailer et al	2018a	36	8.2	1	294	0.34	98.3%
Suarez et al	2018a	20	5.3	0	105	0	100%
Nicolaisen et al	2016a	17	3	0	51	0	100%
Hey et al	2013	31	6	3	186	1.61	92.3%
Pelaez et al	2012a	20	4.2	0	83	0	100%
Makarouna et al	2011a	19	2.5	1	48	2.08	90.1%
Christensen and Ploeger	2010a	96	2.7	5	263	1.90	90.9%
Walton et al	2009	331	7.5	57	2,483	2.30	89.2%
Total		600	6.1	67	3,663		
Summary estimate (95% CI)*						1.83 (1.22–2.73)	91.3% (87.2%–94.1%)
Reinforced glass-ceramic							
Garling et al	2019	36	12.9	12	464	2.59	87.9%
Teichmann et al	2017	33	8.9	15	240	6.25	73.2%
Reich et al	2014	38	3.7	2	123	1.63	92.2%
Solá-Ruiz et al	2013	21	10	6	210	2.86	86.7%
Makarouna et al	2011b	18	4.7	6	84	7.17	70.0%
Esquivel et al	2008	30	3.3	5	100	5.00	77.9%
Marquart and Strub	2005	31	4.2	6	129	4.65	79.3%
Total		207	6.5	52	1,350		
Summary estimate (95% CI) *						3.85 (2.62–5.66)	82.5% (75.3%–87.7%)
Glass-infiltrated alumina							
Chaar et al	2015	65	9.7	4	631	0.63	96.9%
Christensen and Ploeger	2010b	34	2.2	11	74	14.86	47.6%
Suàrez et al	2004	18	3	1	53	1.89	91.0%
von Steyern et al	2001	20	5	2	95	2.11	90.0%
Sorensen et al	1998	61	3	7	165	4.24	80.9%
Total		198	5.1	25	1,018		
Summary estimate (95% CI)*						2.46 (0.66–9.16)	88.4% (63.3%–96.8%)
Densely sintered zirconia, veneered							
Pontevedra et al	2023b	30	4.9	1	148	0.68	96.7%
Blatz et al	2022	25	4.5	0	112	0	100%
Matta et al	2022	30	7.2	4	216	1.85	91.2%
Sola-Ruiz et al	2022	27	11.6	5	313	1.60	92.3%
Zarone et al	2020	48	13.9	1	669	0.15	99.3%
Serra-Pastor et al	2019	27	3.9	1	104	0.96	95.3%
Rinke et al	2018	99	9.9	24	982	2.44	88.5%
Sailer et al	2018b	40	8.9	5	357	1.40	93.2%
Suarez et al	2018b	20	5.3	0	105	0	100%
Teichmann et al	2018	22	20	1	200	0.50	97.5%
Nicolaisen et al	2016b	17	3	0	51	0	100%

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Table 2 Annual Failure Rates and Survival of Metal-Ceramic and All-Ceramic FDPs *(cont)*

Study	Year of publication	Total number of FDPs	Calculated mean exposure time (years)	Number of failures	Total FDPs exposure time (years)	Estimated annual failure rate* (per 100 FDP years)	Estimated survival after 5 years* (%)
Ioannidis and Bindl	2016	59	6.1	3	359	0.84	95.9%
Naenni et al	2015a	20	2.9	0	52	0	100%
Naenni et al	2015b	20	3.1	0	55	0	100%
Tanaka et al	2015	10	3	1	30	3.33	84.6%
Beuer et al	2015	22	3	1	64	1.56	92.5%
Konstantinidis et al	2014	20	2.7	0	55	0	100%
Burke et al	2013	41	4.2	1	172	0.58	97.1%
Raigrodski et al	2012	20	4.7	0	94	0	100%
Pelaez et al	2012b	20	4.2	1	83	1.20	94.2%
Lops et al	2012	28	6.5	2	182	1.10	94.7%
Sax et al	2011	57	7.6	15	433	3.46	84.1%
Christensen and Ploeger	2010c	163	2.4	15	386	3.89	82.3%
Beuer et al	2010	18	2.9	1	53	1.89	91.0%
Wolfart et al	2009	24	4.0	1	97	1.03	95.0%
Molin and Karlsson	2008	19	5.0	0	95	0	100%
Tinschert et al	2008	65	3.1	0	202	0	100%
Total		991	5.7	83	5,669		
Summary estimate (95% CI) *						1.46 (0.92–2.32)	92.9% (89.0%–95.5%)
Densely sintered zirconia, monolithic or microveneered							
Pontevedra et al	2023c	30	4.5	4	136	2.71	87.3%
Lestan et al	2022	33	3.3	2	109	1.83	91.2%
Habibi et al	2020	73	3.3	6	221	2.94	86.3%
Total		136	3.4	12	466		
Summary estimate (95% CI) *						2.58 (2.11–3.14)	87.9% (85.5%–90.0%)
Overall results		2132	5.7	239	12,166		
Summary estimate (95% CI)*						1.96 (1.56–2.48)	90.6% (88.3%–92.5%)

*Based on robust Poisson regression.

Table 3 Summary of Annual Failure Rates, Relative Failure Rates, and Survival Estimates for FDPs with Metal-Ceramic FDPs as Reference

Type of FDP	Total number of FDPs	Total FDPs exposure time (years)	Mean calculated FDPs exposure time (years)	Estimated annual failure rate* (95% CI)	5-year survival summary estimate* (95% CI)	Relative failure rate** (95% CI)	*P***
Metal-ceramic	600	3,633	6.1	1.83 (1.22–2.73)	91.3% (87.2%–94.1%)	1.00 (Ref.)	
Reinforced glass-ceramic	207	1,350	6.5	3.85 (2.62–5.66)	82.5% (75.3%–87.7%)	2.11 (1.24–3.56)	.005
Glass-infiltrated alumina	198	1,018	5.1	2.46 (0.66–9.16)	88.4% (63.3%–96.8%)	1.34 (0.38–4.68)	.644
Densely sintered zirconia, veneered	991	5,669	5.7	1.46 (0.92–2.32)	92.9% (89.0%–95.5%)	0.80 (0.44–1.45)	.464
Densely sintered zirconia, monolithic and microveneered	136	466	3.4	2.58 (2.11–3.14)	87.9% (85.5%–90.0%)	1.41 (0.93–2.14)	.108

*Based on robust Poisson regression.
**Based on multivariable robust Poisson regression including all types of FDPs.

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Table 4 Overview of Biologic and Technical Complications of Different Types of FDPs

	Overall results—all FDPs			Metal-ceramic			Reinforced glass-ceramic		
Failure or complication	No. of abutments or FDPs	Estimated annual complication rates (95% CI)	Cumulative 5-year complication rates (95% CI)	No. of abutments or FDPs	Estimated annual complication rates (95% CI)	Cumulative 5-year complication rates (95% CI)	No. of abutments or FDPs	Estimated annual complication rates (95% CI)	Cumulative 5-year complication rates (95% CI)
Total number of FDPs or abutments with biologic complications	848	1.74* (1.29–2.33)	8.3%* (6.3%–11.0%)	368	1.82* (1.59–2.08)	8.7%* (7.7%–9.9%)	54	1.56* (0.44–5.54)	7.5%* (2.2%–24.2%)
Caries on abutment level	2,230	0.32* (0.18–0.57)	1.6%* (0.9%–2.8%)	987	0.12* (0.08–0.18)	0.6%* (0.4%–0.9%)	122	0.43* (0.16–1.11)	2.1%* (0.8%–5.4%)
FDPs lost due to caries	1,701	0.30* (0.19–0.48)	1.5%* (0.9%–2.4%)	250	0.09* (0.01–0.53)	0.4%* (0.07%–2.6%)	153	0.25* (0.08–0.83)	1.2%* (0.4%–4.0%)
FDPs lost due to abutment tooth fracture	1,600	0.22* (0.14–0.36)	1.1%* (0.7%–1.8%)	250	0	0%	153	0.25* (0.08–0.77)	1.2%* (0.4%–3.8%)
Total number of FDPs experiencing technical complications	980	2.35* (1.08–5.15)	11.1%* (5.2%–22.7%)	399	0.67* (0.08–5.92)	3.3%* (0.4%–25.6%)	54	4.89* (2.73–8.75)	21.7%* (12.8%–35.4%)
FDPs lost due to framework fracture	2,102	0.62* (0.33–1.19)	3.1%* (1.6%–5.8%)	600	0.03* (0.002–0.31)	0.1%* (0.01%–1.5%)	207	2.59* (1.54–4.37)	12.2%* (7.4%–19.6%)
Minor ceramic chippings—polished	1,348	3.47* (2.01–5.98)	15.9%* (9.6%–25.8%)	219	4.22* (2.38–7.49)	19.0%* (11.2%–31.2%)	119	1.10* (0.66–1.81)	5.3%* (3.3%–8.7%)
Major ceramic chippings—repaired	1,311	1.41* (0.71–2.81)	6.8%* (3.5%–13.1%)	200	2.11* (0.56–8.01)	10.0%* (2.7%–33.0%)	101	0.43* (0.04–4.50)	2.1%* (0.2%–20.2%)
Failure due to catastrophic fracture of the veneering ceramic	1,676	0.35* (0.17–0.74)	1.8%* (0.8%–3.6%)	250	0.35* (0.06–2.12)	1.8%* (0.3%–10.1%)	159	0.77* (0.39–1.53)	3.8%* (1.9%–7.4%)
Loss of retention	1,229	0.49* (0.25–0.96)	2.4%* (1.2%–4.7%)	454	0.13* (0.05–0.30)	0.6%* (0.3%–1.5%)	70	0.24* (0.05–1.05)	1.2%* (0.3%–5.1%)
FDPs remade due to esthetic issues	619	0.03* (0.004–0.22)	0.1%* (0.02%–1.1%)	37	0	0%	102	0	0%
Marginal discoloration	406	3.67* (1.87–7.21)	16.8%* (8.9%–30.3%)	87	4.11* (2.92–5.80)	18.6%* (13.6%–25.2%)	82	0.91* (0.35–2.38)	4.5%* (1.7%–11.2%)

*Based on robust Poisson regression.

Although a 3-year follow-up may be insufficient for a comprehensive assessment of long-term survival, the relatively recent introduction of all-ceramic FDPs necessitated this compromise.

In this review, survival was defined as FDPs remaining in situ with or without modifications. Success rate was not defined, but the number of FDPs remaining in situ without any biologic or technical complications during the observation period was reported.

The meta-analysis revealed that lithium disilicate–reinforced glass-ceramic FDPs (both veneered and monolithic) demonstrated significantly higher failure rates compared to metal-ceramic FDPs, which remain the traditional gold standard. The predominant reason for failure in reinforced glass-ceramic FDPs was framework fracture, affecting 12.2% of restorations. In contrast, zirconia-based FDPs (both veneered and monolithic) and glass-infiltrated alumina FDPs exhibited survival rates comparable to metal-ceramic FDPs. However, the use of glass-infiltrated alumina has declined, with no clinical studies published on this material in the past decade. Failures in this group were primarily related to framework fractures (10.2% of 11.6% total failures).

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Glass-infiltrated alumina			Densely sintered zirconia—veneered			Densely sintered zirconia—monolithic and microveneered		
No. of abutments or FDPs	Estimated annual complication rates (95% CI)	Cumulative 5-year complication rates (95% CI)	No. of abutments or FDPs	Estimated annual complication rates (95% CI)	Cumulative 5-year complication rates (95% CI)	No. of abutments or FDPs	Estimated annual complication rates (95% CI)	Cumulative 5-year complication rates (95% CI)
65	1.90* (0.99–3.30)	9.1%* (4.8%–15.2%)	255	1.34* (0.55–3.24)	6.5%* (2.7%–15.0%)	106	3.33* (1.30–8.52)	15.4%* (6.3%–34.7%)
206	0.64* (0.36–1.13)	3.2%* (1.8%–5.5%)	778	0.41* (0.22–0.77)	2.0%* (1.1%–3.8%)	137	0.41* (0.07–2.33)	2.0%* (0.4%–11.0%)
198	0.20* (0.08–0.51)	1.0%* (0.4%–2.5%)	964	0.36* (0.20–0.63)	1.8%* (1.0%–3.1%)	136	0.43* (0.20–0.91)	2.1%* (1.0%–4.5%)
198	0.10* (0.008–1.22)	0.5%* (0.04%–5.9%)	896	0.23* (0.13–0.40)	1.1%* (0.7%–2.0%)	103	1.12* (0.70–1.79)	5.4%* (3.5%–8.5%)
65	3.64* (2.32–5.42)	16.7%* (11.0%–23.7%)	356	3.58* (2.19–5.85)	16.4%* (10.4%–25.4%)	106	2.42* (1.08–5.42)	11.4%* (5.3%–23.7%)
198	2.16* (0.47–10.01)	10.2%* (2.3%–39.4%)	961	0.26* (0.16–0.42)	1.3%* (0.8%–2.1%)	136	0.64* (0.42–0.99)	3.2%* (2.1%–4.8%)
99	3.40* (0.32–36.24)	15.7%* (1.6%–83.7%)	805	3.80* (1.83–7.86)	17.3%* (8.8%–32.5%)	106	0.91* (0.25–3.32)	4.4%* (1.2%–15.3%)
99	1.99* (0.56–7.06)	9.5%* (2.8%–29.7%)	805	1.36* (0.50–3.70)	6.6%* (2.5%–16.9%)	106	0.30* (0.08–1.11)	1.5%* (0.4%–5.4%)
198	0	0%	933	0.36* (0.12–1.06)	1.8%* (0.6%–5.2%)	136	0	0%
65	0.95* (0.35–2.06)	4.6%* (1.7%–9.8%)	534	0.73* (0.43–1.24)	3.6%* (2.1%–6.0%)	106	0.61* (0.17–2.21)	3.0%* (0.8%–10.5%)
83	0	0%	324	0.05* (0.007–0.41)	0.3%* (0.03%–2.0%)	30	0%	0
18	4.76* (1.56–10.76)	21.2%* (7.5%–41.6%)	189	4.97* (2.25–10.96)	22.0%* (10.7%–42.2%)	30	1.47* (0.18–5.21)	7.1%* (0.9%–22.9%)

Among the remaining materials, the lowest annual failure rates were reported for veneered zirconia based FDPs (1.46%), followed by metal-ceramic FDPs (1.83%) and monolithic zirconia FDPs (2.58%). Although monolithic zirconia has been increasingly promoted for both tooth- and implant-supported restorations, owing to reduced chipping risk and compatibility with digital workflows, its performance in the present review was inferior to veneered zirconia. Out of 136 monolithic zirconia FDPs with a mean follow-up of 3.4 years, 12 failures were observed.[14,15,23] Predominantly due to biologic complications such as caries (2 FDPs), periodontal diseases (1 FDPs), and abutment tooth fractures (4 FDPs)—complications that might have little to do with the restoration material. Three failures were attributed to framework fractures, while two failures were of unspecified cause.[14,15,23]

When biologic complications were analyzed, a significantly higher incidence of secondary caries at abutment teeth was observed for all-ceramic FDPs compared with metal-ceramic FDPs. The most frequent technical complication across all groups was minor ceramic chipping, with an overall incidence of 15.9% after 5 years. Monolithic zirconia FDPs showed the lowest incidence of

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chipping (4.4%), compared to 15.7% for glass-infiltrated alumina, 17.3% for veneered zirconia, and 19.0% for metal-ceramic FDPs. Chipping in metal-ceramic FDPs appeared most frequently during the first year in function, subsequently decreasing over time.[62] The high chipping incidence in early generations of zirconia FDPs may be attributed to inadequate framework support or mismatched thermal expansion coefficients between framework and veneering ceramics.

Marginal discoloration was, a frequently encountered complications with a 5-year complication rate of 4.5% for reinforced glass-ceramic FDPs, 7.1% for monolithic zirconia-ceramic FDPs, 18.6% for metal-ceramic FDP, 21.2% for glass-infiltrated alumina FDPs, and 22.0% for veneered zirconia-ceramic FDPs. The drawback of this analysis was that it is based few observations for all material groups except veneered zirconia-ceramic. In terms of retention, glass-infiltrated alumina and densely sintered zirconia FDPs both veneered and monolithic exhibited significantly higher rates of debonding compared with metal-ceramic and reinforced glass-ceramic FDPs. These discrepancies may relate to restoration misfit and larger cement gaps, particularly in densely sintered zirconia FDPs. Furthermore, both veneered and monolithic zirconia FDPs demonstrated higher debonding rates compared with metal-ceramic and reinforced glass-ceramic FDPs.

Overall, densely sintered zirconia has proven to be a durable framework material with a low incidence of framework fracture, especially when appropriate connector dimensions are maintained, and span lengths are limited. Nevertheless, complications such as discoloration, secondary caries, and debonding remain more frequent in zirconia based FDPs than in metal-ceramic FDPs.

Two previous systematic reviews conducted by our research group assessed survival and complications of metal-ceramic and all-ceramic FDPs.[5,6] The first included five retrospective studies on metal-ceramic FDPs and nine studies on all-ceramic FDPs, of which 89% were prospective and 11% retrospective.[5] The included studies were pooled regardless of material/design, and the review concluded that all-ceramic FDPs exhibited significantly higher failure rates compared with metal-ceramic FDPs. The second systematic review published in 2015 included 15 studies (66% prospective, 34% retrospective) on metal-ceramic FDPs and 29 studies (97% prospective, 3% retrospective) on all-ceramic FDPs, that were stratified by material type. Unlike the earlier reviews, the present analysis exclusively included prospective studies, thereby reducing bias from incomplete data and inconsistent reporting. Furthermore, outcomes were distinguished between veneered and monolithic designs for zirconia based FDPs. While lithium disilicate–reinforced glass-ceramic FDPs were evaluated, the limited number of studies precluded separate analysis of veneered vs monolithic designs.

Comparing across reviews, the survival rate of metal-ceramic FDPs decreased from 94.4% at 5 years based on mainly retrospective studies to 91.3% when only prospective studies were considered, suggesting earlier reports may have overestimated the survival rate.

The present systematic review incorporated seven RCTs evaluating the material and design characteristics of FDPs. Six RCTs[23–26,28,30] compared metal-ceramic FDPs with densely sintered zirconia FDPs; none of these studies reported a statistically significant difference in clinical outcomes between the two materials, which is consistent with the findings of the present systematic review. In contrast, one RCT[29] directly comparing metal-ceramic FDPs with lithium disilicate–reinforced glass-ceramic FDPs demonstrated a significantly higher survival rate for metal-ceramic FDPs. This outcome is likewise in agreement with the results of the present systematic review.

In this review, stringent study inclusion criteria were used. Only studies with a clinical follow-up examination of at least 3 years were included to avoid the potential inaccuracies in event description in studies that based their analysis on patient self-reports. Clearly, a limitation of the present review is the assumption of a constant annual event rate throughout the follow-up time. Interpreting the results it must be kept in mind that the mean observation period for monolithic densely sintered zirconia-ceramic FDPs was 3.4 years compared to an average follow-up time ranging from 5.1 to 6.5 years for the other material/design groups. Another limitation of this review is that it was mainly based on studies that were conducted in an institutional environment, such as university or specialized implant clinics. Therefore, the long-term outcomes observed, cannot be generalized to dental services provided in private practice.

Research Implications

It was evident from the search of the dental literature that there is a need for longitudinal studies reporting on tooth-supported FDPs with 10 or more years of follow-up. The present systematic review revealed several shortcomings in the conduct and reporting of clinical studies on tooth-supported FDPs leading to the following recommendations: long-term cohort studies on restorations should be prospective, have complete follow-up information preferentially with similar follow-up period for all patients. Owing to various definitions of success, authors should report data survival/failures in combination with incidence of complications. Survival and success (free of all complications) of the restorations should be reported. Validated criteria should be used

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for the assessment of biologic and technical complications. Furthermore, all potential complications should be addressed and reported giving the reader a complete overview of the outcome.

CONCLUSIONS

The 5-year survival rates of densely sintered zirconia-ceramic FDPs, both veneered and monolithic, and glass-infiltrated alumina were comparable to those of metal-ceramic FDPs. Significantly higher annual failure rates were observed for lithium disilicate–reinforced glass-ceramic FDPs, primarily due to framework fractures. Complication such as caries, retention loss and marginal discoloration that can be related to semi optimal fit were more frequent by all-ceramic FDPs. The use of monolithic ceramic FDPs, in contrast to veneered designs, was associated with reduced incidence of ceramic fractures and surface chippings.

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Highlighted Literature

Treatment of Central Giant Cell Granuloma of the Jaws with Intralesional Denosumab: Initial Report

Central giant cell granuloma (CGCG) is a rare, benign but aggressive osteolytic lesion affecting the jaws. Traditional surgical management, while effective, often results in functional and aesthetic deficits due to the resection of bone and soft tissue. Medical treatment with corticosteroids, subcutaneous calcitonin, or intravenous bisphosphonates has demonstrated variable success. Recent studies have shown that denosumab, a monoclonal antibody targeting RANKL (receptor activator of nuclear factor kappa-B ligand), can inhibit osteoclast activity, thus providing a novel treatment approach. This study reports the outcomes of eight patients with CGCG treated with intralesional denosumab injections (mean follow-up 36 months, range 12 to 61 months), highlighting its efficacy in reducing the size of the lesion, increasing bone density, and avoiding the need for surgery in most of the cases.

Jolly SS, Rattan V, Jha V, Bhadada SK. *Int J Oral Maxillofac Surg* 2026;55:417–424. **References:** 34. **Reprints:** Jolly SS: satnamsurgeon@gmail.com—*Tony Pogrel, USA*

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APPENDIX

Appendix Box 1 Electronic Search Strategies

PubMed search strategy
((crowns OR crown OR dental crowns OR crowns, dental OR Denture, Partial, Fixed) OR (crown* OR fixed partial denture* OR FPD OR FPDs OR fixed dental prosthesis OR fixed dental prostheses OR FDP OR FDPs OR bridge*)) AND (Ceramic OR ceramics OR metal ceramic restorations OR ceramic* OR all-ceramic OR Dental Porcelain OR metal-ceramic OR monolithic OR full contour OR veneered) AND (Survival OR survival rate OR survival analysis OR dental restoration failure OR prosthesis failure OR treatment failure)
Embase search strategy
('dental crown'/exp OR 'dental crown' OR (('dental'/exp OR dental) AND ('crown'/exp OR crown)) OR 'fixed partial denture'/exp OR 'fixed partial denture' OR (fixed AND partial AND ('denture'/exp OR denture)) OR 'fixed dental prosthesis'/exp OR 'fixed dental prosthesis' OR (fixed AND ('dental'/exp OR dental) AND ('prosthesis'/exp OR prosthesis)) OR 'bridge'/exp OR bridge OR 'fdp'/exp OR fdp OR fpd) AND ('ceramic'/exp OR ceramic OR (('metal'/exp OR metal) AND ('ceramic'/exp OR ceramic)) OR 'all ceramic' OR 'dental porcelain'/exp OR 'dental porcelain' OR (('dental'/exp OR dental) AND ('porcelain'/exp OR porcelain)) OR 'metal ceramic' OR monolithic OR (full AND ('contour'/exp OR contour)) OR 'full contour' OR veneered) AND ('survival'/exp OR survival OR 'survival rate'/exp OR 'survival rate' OR (('survival'/exp OR survival) AND rate) OR 'survival analysis'/exp OR 'survival analysis' OR (('survival'/exp OR survival) AND ('analysis'/exp OR analysis)) OR 'dental restoration failure'/exp OR 'dental restoration failure' OR (('dental'/exp OR dental) AND ('restoration'/exp OR restoration) AND ('failure'/exp OR failure)) OR 'prosthesis failure'/exp OR 'prosthesis failure' OR (('prosthesis'/exp OR prosthesis) AND ('failure'/exp OR failure)) OR 'treatment failure'/exp OR 'treatment failure' OR (('treatment'/exp OR treatment) AND ('failure'/exp OR failure))) AND [1-1-2014]/sd NOT [5-12-2024]/sd
Cochrane search strategy
((crowns OR crown OR dental crowns OR crowns, dental OR Denture, Partial, Fixed) OR (crown* OR fixed partial denture* OR FPD OR FPDs OR fixed dental prosthesis OR fixed dental prostheses OR FDP OR FDPs OR bridge*)) AND (Ceramic OR ceramics OR metal ceramic restorations OR ceramic* OR all-ceramic OR Dental Porcelain OR metal-ceramic OR monolithic OR full contour OR veneered) AND (Survival OR survival rate OR survival analysis OR dental restoration failure OR prosthesis failure OR treatment failure) in Title Abstract Keyword

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Appendix Box 2 Quality-Assessment-Scale for Reconstructive Studies (QAS-RS)

Sample
1. Sample size determination (1 possible answer):
a) sample size was calculated for the primary outcomes of interest.***
b) sample size was calculated but not based on the primary outcomes.**
c) sample size was discussed but not formally calculated.*
d) sample size determination was not reported.
2. Reporting of follow-up frequency (1 possible answer):
a) patients were followed up regularly at predefined intervals throughout the entire observation period.***
b) patients were followed up irregularly during the observation period.**
c) patients were only evaluated at the end of the observation period.*
d) follow-up frequency was not reported.
3. Inclusion and exclusion criteria (1 possible answer):
a) clearly reported, comprehensive, representative for the respective clinical indication.***
b) clearly reported, representative for the respective clinical indication but not comprehensive.**
c) not clearly described.*
d) not reported.
Outcomes
4. Outcomes assessment (1 possible answer):
a) outcomes were clinically evaluated by calibrated examiners using validated methods.***
b) outcomes were clinically evaluated using validated methods, without examiner calibration.**
c) outcomes were clinically evaluated using non-validated methods.*
d) no clinical evaluation was performed.
5. Reporting of failures and complications (1 possible answer):
a) failures and all potential biological and technical complications were reported in detail, including timepoints of occurrence.***
b) failures and all potential biological and technical complications were reported in detail, without specifying detailed timepoints.**
c) failures and some complications were reported, but not all potential biological and technical complications were addressed.*
d) only failures were reported; biological and technical complications were not addressed.
6. Follow-up duration (1 possible answer):
a) mean follow-up period ≥ 5 years, allowing realistic assessment of failures and biological and technical complications.***
b) mean follow-up period between 3 and 5 years.**
c) mean follow-up period ≤ 3 years.*
d) follow-up period not specified.
7. Dropout rate during follow-up (1 possible answer):
a) less than 3% of subjects lost to follow-up per observation year (eg, < 15% dropout over 5 years, < 30% dropout over 10 years).***
b) between 3–5% of subjects lost to follow-up per observation year (eg,15–25% dropout over 5 years, 30–50% dropout over 10 years).**
c) more than 5% of subjects lost to follow-up per observation year (eg, > 25% dropout over 5 years, > 50% dropout over 10 years).*
d) dropout rate not reported.
Grading of Study Quality
0–7 stars: Low quality
8–14 stars: Moderate quality
15–21 stars: High quality
(Maximum achievable score: 21 stars)

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Appendix Table 1 Studies Excluded After Full-Text Analysis and Reasons for Exclusion

Reference	Reason for exclusion	Reference	Reason for exclusion
Abdulrahman et al (2021)	1	Nilsson et al (2022)	1
Alenezi and Aloqayli (2023)	1	Norström Saarva et al (2017)	1
Alfadhli et al (2022)	1	Phang et al (2020)	1
Alsterstål-Englund et al (2019)	1	Pihlaja et al (2016)	1
Becker et al (2019)	2	Pihlaja et al (2014)	1
Bömicke et al (2019)	2	Pontevedra et al (2022)	6
Brandt et al (2019)	1	Pott et al (2024)	1
Broseghini et al (2014)	3	Pott et al (2018)	1
Cândea et al (2021)	2	Prabhu et al (2016)	1
Christensen et al (2016)	4	Rabel et al (2024)	1
Cristea et al (2023)	1	Raedel et al (2022)	1
Datta and Sandhu (2022)	1	Rathmann et al (2024)	1
Di Fiore et al (2023)	1	Reitemeier et al (2019)	7
Ermatinger et al (2024)	1	Sailer et al (2017)	6
Forrer et al (2020)	1	Schneider (2016)	1
Galli et al (2024)	1	Serra-Pastor et al (2019)	6
Håff et al (2014)	1	Solá-Ruíz et al (2015)	6
Koenig et al (2024)	5	Tanner et al (2018)	1
Koenig et al (2013)	1	Tartaglia et al (2015)	5
Masaka et al (2023)	1	Teichmann et al (2019)	1
Mikeli et al (2015)	1	Worni et al (2017)	1
Monaco et al (2016)	1	Yang et al (2016)	1
Moráguez et al (2015)	5	Zafar and Ghani (2014)	1
Moscovitch (2015)	1	Zenthöfer et al (2015)	2
Naishlos et al (2022)	1	Zvonimir et al (2019)	1

1 = no RCT or prospective design; 2 = does not report on tooth-supported FDPs; 3 = follow-up period less than 3 years; 4 = full text not available; 5 = data not specified between implant and tooth abutments; 6 = duplicate; 7 = data not specified between single crowns and multiple FDPs.

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Appendix Table 2 Relative Complication Rates for Different Types of FDPs

Failure/ complication	Metal-ceramic	Reinforced glass-ceramic		Glass-infiltrated alumina		Densely sintered zirconia—veneered		Densely sintered zirconia—monolithic and microveneered	
		Relative complication rate*	*P**	Relative complication rate*	*P**	Relative complication rate*	*P**	Relative complication rate*	*P**
Total number of FDPs or abutments with biologic complications	1.00 (Ref.)	0.86 (0.34-2.17)	.742	1.05 (0.94-1.17)	.434	0.74 (0.31-1.75)	.488	1.83 (0.92-3.66)	.087
Caries on abutment level	1.00 (Ref.)	3.49 (1.46-8.32)	.005	5.25 (2.90-9.49)	< .0001	3.35 (1.64-6.85)	.001	3.34 (0.90-12.3)	.070
FDPs lost due to caries	1.00 (Ref.)	2.82 (0.38-20.8)	.309	2.22 (0.34-14.7)	.406	4.07 (0.69-23.90)	.120	4.86 (0.81-29.1)	.084
FDPs lost due to abutment tooth fracture	1.00 (Ref.)	7761453 (20806210-29000000)	< .0001	3057296 (268339-34800000)	< .0001	7179352 (2692892-19100000)	< .0001	34900000 (13700000-88600000)	< .0001
Total number of FDPs experiencing technical complications	1.00 (Ref.)	7.27 (1.01-52.2)	.049	5.42 (0.79-37.2)	.085	5.32 (0.73-38.8)	.099	3.60 (0.48-26.94)	.212
FDPs lost due to framework fracture	1.00 (Ref.)	94.97 (8.85-1018.5)	< .0001	79.16 (5.30-1182.3)	.002	9.40 (0.88-101.0)	.064	23.58 (2.25-246.9)	.008
Minor ceramic chippings - polished	1.00 (Ref.)	0.26 (0.13-0.52)	< .0001	0.81 (0.14-4.77)	.812	0.90 (0.37-2.20)	.816	0.22 (0.07-0.63)	.005
Major ceramic chippings - repaired	1.00 (Ref.)	0.20 (0.02-2.02)	.174	0.94 (0.21-4.27)	.936	0.64 (0.13-3.08)	.582	0.14 (0.03-0.66)	.013
Failure due to catastrophic fracture of the veneering ceramic	1.00 (Ref.)	2.18 (0.37-13.1)	.392	0	< .0001	1.02 (0.14-7.46)	.985	0	< .0001
Loss of retention	1.00 (Ref.)	1.87 (0.43-8.23)	.407	7.53 (3.35-16.9)	< .0001	5.80 (2.21-15.23)	< .0001	4.80 (1.40-16.50)	.013
FDPs remade due to esthetic issues	1.00 (Ref.)	0.47 (0.07-3.21)	.440	0.40 (0.02-8.79)	.561	11900000 (1583253-89500000)	< .0001	0.33 (0.03-3.79)	.374
Marginal discoloration	1.00 (Ref.)	0.22 (0.09-0.53)	.001	0.92 (0.67-1.25)	.583	1.21 (0.53-2.73)	.649	0.36 (0.26-0.49)	< .0001

*Based on multivariable robust Poisson regression including all types of FDPs with metal-ceramic FDPs as reference.

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Appendix Table 3 Quality-Assessment-Scale for Reconstructive Studies (QAS-RS) of the Included Studies

Reference	Sample			Outcomes				Total (maximum 21)	Overall quality assessment
	Sample size determination	Reporting of follow-up frequency	Inclusion and exclusion criteria	Outcome assessment	Reporting of failures and complications	Follow-up duration	Dropout rate during follow-up		
Metal-ceramic									
Pontevedra et al (2023a)	1	3	3	3	1	3	3	17	High
Sailer et al (2018a)	0	3	2	3	3	3	3	17	High
Suarez et al (2018a)	0	3	2	3	3	3	3	17	High
Nicolaisen et al (2016a)	0	3	2	2	2	2	3	14	Moderate
Hey et al (2013)	0	3	2	1	2	3	3	14	Moderate
Pelaez et al (2012a)	0	3	2	2	1	2	3	13	Moderate
Makarouna et al (2011a)	0	3	1	1	1	2	1	9	Moderate
Christensen and Ploeger (2010a)	0	3	3	1	2	1	3	13	Moderate
Walton et al (2009)	0	2	0	1	1	3	3	10	Moderate
Reinforced glass-ceramic									
Garling et al (2019)	0	3	2	1	1	3	3	13	Moderate
Teichmann et al (2017)	0	3	2	3	3	3	3	17	High
Reich et al (2014)	0	3	2	1	1	2	3	12	Moderate
Solá-Ruiz et al (2013)	0	3	2	1	1	3	3	13	Moderate
Makarouna et al (2011b)	0	3	1	1	1	2	1	9	Moderate
Esquivel et al (2008)	0	3	2	3	1	2	3	14	Moderate
Marquardt and Strub (2005)	0	3	2	1	1	2	3	12	Moderate
Glass-infiltrated alumina									
Chaar et al (2015)	0	3	2	1	2	3	3	14	Moderate
Christensen and Ploeger (2010b)	0	3	3	1	2	1	3	13	Moderate
Suàrez et al (2004)	0	3	2	3	1	2	3	14	Moderate
von Steyern et al (2001)	0	3	2	1	1	3	3	13	Moderate
Sorensen et al (1998)	0	3	3	1	1	2	3	13	Moderate
Densely sintered zirconia (veneered)									
Pontevedra et al (2023b)	1	3	3	3	1	3	3	17	High
Blatz et al (2022)	0	2	2	3	2	2	2	13	Moderate
Matta et al (2022)	0	2	2	2	1	3	1	11	Moderate
Sola-Ruiz et al (2022)	3	3	2	1	2	3	3	17	High

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Appendix Table 3 Quality-Assessment-Scale for Reconstructive Studies (QAS-RS) of the Included Studies *(cont)*

	Sample			Outcomes					
Reference	Sample size determination	Reporting of follow-up frequency	Inclusion and exclusion criteria	Outcome assessment	Reporting of failures and complications	Follow-up duration	Dropout rate during follow-up	Total (maximum 21)	Overall quality assessment
Zarone et al (2020)	0	3	2	3	3	3	3	17	High
Serra-Pastor et al (2019)	0	3	2	1	1	2	3	12	Moderate
Rinke et al (2018)	0	3	2	1	2	3	3	14	Moderate
Sailer et al (2018b)	0	3	2	3	3	3	3	17	High
Suarez et al (2018b)	0	3	2	3	3	3	3	17	High
Teichmann et al (2018)	0	3	2	3	3	3	3	17	High
Nicolaisen et al (2016b)	0	3	2	2	2	2	3	14	Moderate
Ioannidis and Bindl (2016)	0	1	2	3	1	3	3	13	Moderate
Naenni et al (2015a)	1	3	2	3	1	2	2	14	Moderate
Naenni et al (2015b)	1	3	2	3	1	2	2	14	Moderate
Tanaka et al (2015)	0	3	2	2	2	2	2	13	Moderate
Beuer et al (2015)	0	3	2	1	2	2	3	13	Moderate
Konstantinidis et al (2014)	2	3	3	1	3	1	1	14	Moderate
Burke et al (2013)	0	3	2	3	3	2	1	14	Moderate
Raigrodski et al (2012)	0	3	2	3	2	2	3	15	High
Pelaez et al (2012b)	0	3	2	2	1	2	3	13	Moderate
Lops et al (2012)	0	3	0	1	1	3	3	11	Moderate
Sax et al (2011)	0	3	1	2	3	3	1	13	Moderate
Christensen and Ploeger (2010c)	0	3	3	1	2	1	3	13	Moderate
Beuer et al (2010)	0	3	2	1	2	1	3	12	Moderate
Wolfart et al (2009)	0	3	2	2	3	2	3	15	High
Molin and Karlsson (2008)	0	3	1	3	3	3	3	16	High
Tinschert et al (2008)	0	3	2	1	3	2	2	13	Moderate
Densely sintered zirconia (monolithic and microveneered)									
Pontevedra et al (2023c)	1	3	3	3	1	2	3	16	High
Lestan et al (2022)	0	3	1	3	1	2	3	13	Moderate
Habibi et al (2020)	0	3	1	1	3	2	3	13	Moderate

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