A Critical Appraisal of the Survival and Complication Rates of Tooth-Supported All-Ceramic and Metal-Ceramic Fixed Dental Prostheses: The Application of Evidence-Based Dentistry

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Purpose: This paper aimed to practice evidence-based dentistry by critically appraising relevant evidence to address a common question in prosthodontics. It sought to answer whether the survival and complication rates of all-ceramic fixed dental prostheses (FDPs) were comparable or superior to those of metal-ceramic FDPs, and to use this knowledge to guide clinical decisions. ***Materials and Methods:*** A 6S search was conducted. No decision support systems or summaries were available. The journal *Evidence-Based Dentistry* (zero synopses), Trip database (three synopses, discarded), Cochrane database (three systematic reviews, discarded), MEDLINE OVID (six systematic reviews, one accepted), and Embase (zero systematic reviews) were searched. The selected systematic review assessed the survival and complication rates of all-ceramic and metal-ceramic FDPs. One additional prospective cohort study was considered relevant. ***Results:*** The systematic review addressed a well-focused clinical question, but its internal validity was compromised. The search was not systematic; inclusion methodology and impact of study characteristics on results were unclear. The external applicability was limited by compromised internal validity, broad outcome definitions, inaccurate results, and incomplete examination of stated aims. With care, however, the results could be applied to clinical practice. Estimated event rates and 5-year outcomes with a 95% confidence interval were calculated, with the survival rate of metal-ceramic FDPs significantly higher than that of all-ceramic FDPs. All-ceramic FDPs experienced a high incidence of technical failure. The prospective cohort addressed a well-focused clinical question with good internal validity. It compared outcomes of metal-ceramic FDPs provided before and after the introduction of implant therapy. Patient cohorts were clearly defined, similar at baseline, and treated equally. Ten-year Kaplan-Meier cumulative survival with standard errors was reported. Metal-ceramic FDP survival rates were high and significantly improved since the introduction of implants and the decreased use of structurally compromised abutments. ***Conclusion:*** The results of the systematic review and prospective cohort were complementary: Metal-ceramic FDPs had high survival, with a significantly greater 5-year survival rate than all-ceramic FDPs. Differences in complications were unknown, but evidence indicated that the complication incidence of metal-ceramic FDPs was lower than that of all-ceramic FDPs. This evidence was directly applicable to the clinical scenario and will help guide clinical decision making. *Int J Prosthodont 2011;24:417–427.*

Evidence-based dentistry is the practice of applying the best available scientific results to guide clinical management.[1] However, analysis of the plethora of evidence to guide daily patient decisions is time-consuming. Competent appraisal can also prove challenging, especially when more advanced statistical techniques are applied. A 6S search strategy (systems, summaries, synopses of systematic reviews, syntheses [systematic reviews], synopses of studies, and studies) has been recommended to aid clinicians in finding relevant clinical evidence in a timely manner.[2]

Computerized systems, summaries, and synopses help clinicians by pre-appraising evidence and presenting pertinent details in a user-friendly and time-efficient manner. Unfortunately, the two top tiers of the search strategy (systems and summaries) are not

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Figs 1a and 1b *(left)* Anterior smile and *(right)* intraoral view of a failed 20-year-old maxillary tooth-supported metal-ceramic FDP. Complications included caries, vertical root fracture, loss of vitality, ceramic chipping, and compromised esthetics.


Figs 1c and 1d *(left)* Anterior view and *(right)* occlusal view during assessment of abutment tooth integrity. The failed metal-ceramic FDP and teeth with a hopeless prognosis were removed. Preparations were refined and biologic and structural integrity of the abutment teeth were confirmed.

currently available for dental management, and the third tier (synopses) is in limited supply. Synopses of published systematic reviews or studies are available through the journal *Evidence-Based Dentistry* and the electronic Trip database, syntheses (systematic reviews) are available through the Cochrane database as well as individual journals, and primary research (studies) is continually peer-reviewed and published.

Many practitioners primarily seek the conclusions from systematic reviews to answer clinical queries without realizing that the identified systematic review may itself prove flawed. A systematic review was defined by Cook et al[3] as assembling, critically appraising, and synthesizing without bias all relevant scientific studies that addressed a specific question. These reviews consist of retrospective, observational research and may vary in methodologic quality,[4] and thus vary in scientific validity.

Practitioners also tend to avoid using primary research, especially if such research is not a randomized controlled trial, erroneously believing that the systematic review of randomized controlled trials offers the "best evidence" when available. Different questions require different research strategies, with the exploration of many questions in prosthodontics not viable using an experimental randomized trial. Without analyzing the clinical query accurately, without identifying which research would best address the query, and without critically appraising such research, patient clinical management cannot be guided by evidence. Since dentistry currently lacks computerized decision-supporting systems, summaries, and a rich source of synopses, the onus is on the practitioner to be both time-rich and analytically savvy to access the evidence available in current publications. The author argues that accessibility bias is a major factor limiting the application of evidence-based dentistry.

This paper aimed to explore the practice of evidence-based dentistry through critically appraising relevant evidence to address a common clinical question in prosthodontics and, thus, begin to address accessibility bias. It is hoped that journals will periodically choose a common clinical question to appraise and that efforts are made to understand the evidence currently present rather than generating extra data in what can cynically be described as a race to see who can turn their research into a systematic review.

Materials and Methods

Scenario and Clinical Query

A 48-year-old woman wished to replace her failing 20-year-old maxillary tooth-supported fixed dental prosthesis (FDP, commonly known as a "bridge") (Fig 1). She had considered her treatment options (removable dental prosthesis, implant-supported FDP, and tooth-supported FDP) and wished to proceed with a tooth-supported FDP. Her main concerns were as follows: "Is there now some better way to make bridges? Would they last longer? I would like the new bridge to last as long as possible."

The patient's failing tooth-supported FDP had been a metal-ceramic construction. Metal-ceramic technology was first used in 1965[5]; newer technologies, such as all-ceramic constructions, are now available. It has been argued that all-ceramic constructions have manufacturing and clinical advantages over metal-ceramic constructions, but it also has been purported that they may suffer from a higher incidence of complications.[6–9]

To gather evidence to address the clinical query, the pertinent details were transformed into a four-tiered foreground question in a PICO format.[10]

- Patient: A patient with biologically sound abutment teeth that have been assessed to have sufficient structural integrity for a tooth-supported FDP
- Intervention: All-ceramic FDP
- Comparison: Metal-ceramic FDP
- Outcome: Survival and complication rate (comparable or superior)

The FDPs of interest were tooth-bounded. The outcome of cantilever FDPs will not be considered in this paper.

The aims were to critically appraise evidence to explore whether the survival and complication rates of all-ceramic FDPs were comparable or superior to that of metal-ceramic FDPs when abutment teeth were biologically and structurally sound and to use this knowledge to guide the clinical decision for this specific patient.

Search

The 6S model[2] guided the search. Computerized decision support systems or summaries of the management of edentulous spaces were unavailable. A systematic review (or associated synopsis) would provide the next best level of evidence, followed by primary research (randomized controlled trial or cohort study) assessing the outcomes of metal-ceramic and all-ceramic FDPs. The journal *Evidence-Based Dentistry*, Trip database, Cochrane database, MEDLINE (OVID, 1950 to 2009), and Embase (1980 to 2009) were searched. Table 1 summarizes the search strategy.

Synopses Search. A search of the *Evidence-Based Dentistry* journal (zero synopses) and the Trip database (three synopses[11–13]) was conducted. The synopses and full text of the three associated systematic reviews[11–13] were reviewed. Each of the reviews included prospective and retrospective FDP cohort studies. No randomized controlled trials were available. An analysis of 31 FDP studies by Torabinejad and coworkers[11] did not assess the outcome of different FDPs (resin-bonded, cantilever, partial coverage, all-ceramic, or metal-ceramic). Likewise, the review by Tan et al[12] of 19 studies was not collated to assess the outcome of the different FDPs (11.6% metal-ceramic, 88.4% gold acrylic). The review by Scurria and coworkers[13] of 9 studies also did not report outcomes of individual FDPs (50% cantilever, 25% partial coverage). Unfortunately, the data from these systematic reviews could not be specifically applied to the clinical question.

Database Search for Syntheses. A search of the Cochrane library revealed 11 reviews (2 Cochrane, 9 other reviews) and 1 protocol (submitted in 2002). Eight reviews were not relevant; 3[11–13] were the same reviews identified previously by the Trip database.

MEDLINE (OVID, 1950 to 2009) and Embase (1980 to 2009) databases were further searched for evidence. Search terms to identify the prostheses type, outcome, and construction material were used.

- **Stage 1: Identification of prosthesis type.** The Glossary of Prosthodontic Terms changed the classification of "bridges" from fixed partial dentures (FPDs) to fixed dental prostheses (FDPs) in 2005.[22] Both formal terms and the colloquial term were included in a combination of medical subject headings and truncated keywords.
- **Stage 2: Identification of the outcome of interest.** Outcomes of interest were survival, success, and complications. Truncated keywords were used.
- **Stage 3: Identification of specific metal-ceramic FDPs.** Metal-ceramic constructions are classified by the glossary[22] as both metal-ceramic and ceramometal. They were previously known as porcelain-fused-to-metal (PFM) and vita metal keramik (German, VMK). Truncated keywords were used.
- **Stage 4: Identification of specific all-ceramic FDPs.** Terms used to describe all-ceramic reconstructions included "all ceramic," "dental porcelain,"

Table 1 Summary of Search Methods

Search terms			Results
Synopses search			
Evidence-Based Dentistry			
1.	(evidence based dentistry) in the journal field		67 articles
2.	(fixed and dent* and prosth*) OR (fixed and partial and dent*) OR (bridge) as keywords; (fixed dental prostheses) OR (fixed partial denture) as medical subject headings		112,473 (Medline)
3.	(1) AND (2)		Electronic search (no results) Hand title search (no results)
Trip	(fixed and dent* and prosth*) OR (fixed and partial and dent*) OR (bridge)		49 results 3 SR[11–13] (full text examined, 0 included)
Database search			
Cochrane	(fixed and dent* and prosth*) OR (fixed and partial and dent*) OR (bridge)	1 protocol (2002) 2 Cochrane reviews 9 other reviews	3 SR[11–13] (full text examined, 0 included)
MEDLINE (OVID) AND Embase			
1.	(fixed and dent* and prosth*) OR (fixed and part* and dent*) OR (bridg*) as keywords; OR (fixed dental prostheses) OR (fixed partial denture) as medical subject headings	112,473 (MEDLINE) 50,437 (Embase)	
2.	(surviv* or success* or complicat*)	1,821,842 (MEDLINE) 1,294,157 (Embase)	
3.	(porcelain and fused and metal) OR (PFM) OR (ceram* and metal) OR (vita and metal and keramik) OR (VMK)	3,824 (MEDLINE) 1,521 (Embase)	
4.	(ACC) OR (all and ceram*) OR (dent* and porcelain) OR (In and ceram) OR (lithium and disilicate) OR (procera) OR (empress) OR (emax) OR (lanthanum) OR (dicor) OR (Vita) OR (Lava) OR (Y-TZP) OR (zircon* and oxide) as keywords; (ceramics) as medical subject heading	31,443 (MEDLINE) 20,776 (Embase)	
5.	(1) AND (2)	12,461 (MEDLINE) 6,497 (Embase)	
6.	a. (3) AND (5) b. (4) AND (5) c. (3) AND (4) AND (5)	317 (MEDLINE) 12 (Embase) 858 (MEDLINE) 44 (Embase) 266 (MEDLINE) 10 (Embase)	Title search of 56 articles identified by Embase (no relevant studies identified)
7.	MEDLINE (6c, 266 articles) limit to review (optimal) using clinical queries	33	6 SR[11–16] (full text examined) 1 SR[16] was most relevant and included in the appraisal
8.	MEDLINE 6(a), 6(b) individual title search from Sept 2006 to Oct 2009		5 studies[17–21] (full text examined) 1 study[21] included in the appraisal

SR = systematic review.
*Truncation of keywords.

and "ceramics," as well as specific manufacturing ingredients and brand names. A combination of medical subject headings and truncated keywords was used.

- **Stage 5: Refining the search.** The search was further refined in steps 5 through 7, outlined in Table 1. No relevant articles were identified in Embase; six systematic reviews were identified in MEDLINE.[23]

Three[11–13] of these reviews had been previously identified and discarded; two[14,15] contained duplicate data, reporting narrow outcomes (single all-ceramic FDP system, In Ceram), and were discarded. The final review by Sailer and coworkers[16] was considered relevant to the clinical question. This review also used data collated from two other systematic reviews: Pjetursson et al[24] and Tan et al.[12]

Database Search for Additional Studies. Studies from groups 6a and 6b (see Table 1) and the Cochrane database (original search) were reviewed by title to identify whether other evidence relevant to the clinical question had been published since the systematic review. Five further articles were identified using MEDLINE. Three[17–19] articles contained duplicate data from an earlier study[25] and had been included in the systematic review.[16] One article[20] was eliminated since its results were considered restrictive (pilot study, 16 subjects, mean follow-up: 31.2 months). One article[21] was relevant to the clinical question and was included for appraisal.

Results, Sailer et al[16]

Study Validity

The internal validity of a systematic review is associated with a clearly focused question, choice of inclusion criteria, search strategy, data extraction, and assessment of data quality.

This systematic review[16] addressed a focused clinical question. It aimed to assess the 5-year survival and incidence of complication for all-ceramic FDPs and to compare these with those of metal-ceramic FDPs. To explore evidence regarding all-ceramic FDPs, articles were identified and assessed by the authors. To gather evidence regarding metal-ceramic FDPs, the authors used data that had been identified previously by another systematic review.[24] This second systematic review was an update of an earlier review.[12] A similar team of authors were involved in all three reviews.

Inclusion Criteria. The inclusion criteria for each systematic review was outlined but appeared to have been abbreviated. The systematic reviews included prospective and retrospective cohort studies where the prostheses had been assessed clinically during a mean follow-up of at least 3[16] or 5[24] years. The authors stated that randomized controlled trials were unavailable. Inclusion criteria regarding survival and complication reporting within the individual studies were not outlined. Despite this, studies were excluded for inadequate survival/complication reporting. This abbreviation of inclusion criteria precluded readers from assessing their merits and limited the repeatability of the review.

The review by Sailer et al[16] included eight prospective studies and one retrospective study. The single retrospective study was unlikely to provide additional relevant information and could introduce unnecessary bias. Considering the accepted limitations of retrospective studies, it would have been prudent for the authors to discuss this inclusion decision.

The review by Pjetursson et al[24] identified five retrospective studies. This was disconcerting since at least one of these studies was prospective, not retrospective.[26,27] This crucial classification error cast doubt on the interpretation of the rest of the data.

Search for Articles. The electronic search included MEDLINE (OVID, 1966 to November 2006) and the Dental Global Publication Research System (1990 to December 2005) for the Sailer et al[16] review and only MEDLINE (PubMED, 1996 to September 2006) for the Pjetursson et al review.[24] Other common databases such as Cochrane and Embase were not included in either search strategy. This electronic search was restrictive. The literature has found that inclusion of only a single extra database (Embase) may yield 25% to 83% additional unique articles.[28]

Articles were limited to English, German, and French[16] or only English.[12,24]

The electronic search was complemented by hand searches of the references of the full-text articles reviewed (39[16] and 83[24] articles), as well as other reviews that had been electronically identified as reporting on the topic.

The authors did not search for unpublished studies. Study registries, conference proceedings, and leading academics were not consulted. This omission limits the validity of the results. In previous situations, consultation with leading experts identified approximately 40% of included articles.[29]

The search strategy for the Sailer et al review[16] was outlined in a flow diagram. Search terms included "dental porcelain" AND "fixed partial dentures" OR "ceramics" AND "fixed partial dentures." The search strategy for the Pjetursson et al review[24] was divided across two systematic reviews,[12,24] making it difficult to follow. A flow chart was provided in the earlier Tan et al review.[12] Search terms included fixed partial dentures OR bridges AND partial edentulism.

For each review, it was unclear whether the search terms were keywords or medical subject headings. Truncation (dent*, ceramic*, bridg*, edent*) and brand/manufacturing names (Procera, zirconium oxide, Empress, PFM, VMK, MCC) were not used. Both reviews used the historic search term "fixed partial dentures" and omitted its 2005[14] replacement "fixed dental prostheses." For the purposes of this critical appraisal, a basic search was re-run to assess the impact of this omission. It identified two additional articles that may have met the inclusion criteria. These articles were published in Russian and Czech, again highlighting the language restriction. The search strategies were not comprehensive.

In the Sailer et al review,[16] the method of refining the search for articles regarding all-ceramic

FDPs from an initial yield of 3,473 articles was not clearly described. Three independent reviewers were involved. Titles were assessed to refine the search to 100 abstracts (independent process, uncertain how disagreement was resolved); abstracts were reviewed to yield 39 articles for full-text assessment (review process not stated). The articles were reviewed to yield 9 included studies (independent process, disagreement resolved by discussion). There was no formal assessment of the agreement between the reviewers at any stage of this process (eg, kappa analysis). This review[16] included a list of all full-text articles that were reviewed and excluded, with a brief but sufficient explanation for exclusion.

In the Pjetursson et al[24] andTan et al[12] reviews, the method for refining the search for articles regarding metal-ceramic FDPs from an initial yield of 3,658 titles identified was complicated by its division across the 2 papers. Two independent reviewers selected 291 titles from the initial yield, with a kappa score of 0.43 (indicating moderate agreement). Eighty titles were discarded after discussion. It was unclear how the review of the 211 abstracts, 81 full-text articles, and the final 19 articles was conducted. No kappa scores for agreement were reported. The updated review[24] identified 2 additional papers for inclusion. The method of this identification was not stated.

The 21 articles of the Pjetursson et al review[24] included data regarding 3,548 FDPs (6% metal-ceramic, 54% gold resin, 40% not reported). The authors of the Sailer et al review[16] selected 5 of these articles to assess failure events of metal-ceramic FDPs. The authors did not describe how or why these 5 articles were selected. The Sailer et al review[16] used complication data from all 21 articles for comparison with all-ceramic FDPs. It was not clearly stated that data from non–metal-ceramic FDPs were used. The use of this data from the entire cohort of "conventional" FDPs was contrary to the authors' stated aims.

Data Extraction and Assessment of Study Quality. Data were extracted independently by three reviewers using a data extraction form, with disagreements resolved through discussion. The level of agreement between reviewers was not reported. Descriptions of outcomes were sufficiently detailed to allow replication of the method. Survival was defined as the FDP remaining in situ at the examination visit with or without modification. Biologic complications included loss of vitality, caries, and loss of the FDP because of caries, periodontitis, or abutment fracture. Technical complications included loss of retention, ceramic chipping, marginal discoloration, and loss of the FDP because of framework fracture or ceramic fracture.

The results of any review are limited by the quality of the included studies.[30] The authors state that randomized controlled trials on this topic were unavailable, but do not discuss how the shortcomings of prospective or retrospective cohorts may have affected the validity of the results. The inclusion of studies with a short follow-up period (3 years for all-ceramic FDPs) was justified, and the impact that this may have had on the results was discussed.

Results Interpretation

Reporting of data heterogeneity was unclear. Heterogeneity of the extracted data was assessed with the Spearman goodness-of-fit statistic. *P* values were reported for the event of failure but not for the other 10 complications. Astute readers could detect the presence of heterogeneity of other events by examining notations in the tables. The possible reasons for heterogeneity and its impact on the review findings were not discussed.

Data were expressed as event rates (events per 100 FDP/abutment years) and summary event rate estimates (calculated with either standard or random-effects Poisson regression). Constant annual event rates were assumed, and the summary estimates were used to calculate the estimated 5-year survival/complication rate. The authors discussed the limitation of this statistical method. They acknowledged that all-ceramic FDPs had been in situ for less time than metal-ceramic FDPs. With the assumption that events occurred evenly during the observation period, the 5-year estimated survival was likely to favor overestimation of all-ceramic FDPs and disfavor underestimation for metal-ceramic FDPs.

The interpretation of the results was complicated by the use of dissimilar descriptives and outcome measures. The terms "FDP" and "FPD" were used interchangeably, but it was not clear whether they described identical entities. For example, Table 6 in the Sailer et al[16] study states "Estimated rate of FDPs lost due to ceramic fracture (per 100 FPD years)."

Furthermore, use of the term "metal-ceramic FDP" was discretely changed to "conventional FDP" partway through the systematic review. As stated previously, the authors used data from metal-ceramic FDPs to calculate the survival rate but used data from conventional FDPs to calculate the complication rates. The term "conventional" was not defined. It was unclear whether conventional FDPs included non–metal-ceramic FDPs. This lack of clarity was perpetuated by further errors in nomenclature. For example, the abstract states "frequencies of material fractures were significantly higher for all-ceramic FDPs (6.5%

Table 2 Reported Estimated Event Rates for Complications

	Conventional FDPs		All-ceramic FDPs		
	Summary estimate event rates (95% CI)*	Cumulative 5-y complication rates (95% CI)	Summary estimate event rates (95% CI)*	Cumulative 5-y complication rates (95% CI)	*P*
Loss of vitality of abutments	1.3% (1.0%–1.6%)	6.1% (4.9%–7.6%)	0.8% (0.6%–1.2%)	4.1% (2.8%–5.9%)	NS
All-ceramic FDPs: Caries of FDPs Conventional FDPs: Caries of abutments†	1.0% (0.5%–2.1%)‡	4.8% (2.3%–9.9%)‡	0.4% (0.0%–3.7%)‡	1.8% (0.2%–16.9%)‡	NS
FDPs lost due to caries	0.3% (0.2%–0.5%)	1.6% (1.1%–2.3%)	0.3% (0.0%–5.6%)‡	1.7% (1.7%–24.4%)‡	NS
FDPs lost due to periodontitis	0.1% (0.0%–0.1%)	0.4% (0.2%–0.7%)	0%	0%	NS
FDPs lost due to abutment fracture	0.2% (0.2%–0.3%)	1.0% (0.7%–1.3%)	0.2% (0.1%–0.9%)	1.2% (0.3%–4.6%)	NS
Loss of retention	0.7% (0.4%–1.1%)‡	3.3% (2.0%–5.3%)‡	0.5% (0.2%–0.9%)	2.3% (1.2%–4.6%)	NS
Ceramic chipping	0.6% (0.3%–1.4%)‡	2.9% (1.2%–6.8%)	2.9% (1.4%–6.3%)‡	13.6% (6.6%–26.9%)‡	< .001
Marginal discoloration			3.3% (0.8%–13.4%)‡	15.3% (4.0%–48.9%)‡	NR
All-ceramic FDPs: Loss of FDPs due to framework fracture Conventional FDPs: Rate of veneer or framework fracture†	0.3% (0.2%–0.6%)‡	1.6% (0.9%–2.9%)	1.4% (0.6%–3.0%)‡	6.5% (3.0%–13.8%)‡	< .0001
Loss of FDPs due to ceramic fracture			0.2% (0.0%–0.6%)	0.8% (0.0%–2.7%)	NR

CI = confidence interval; NS = not significant; NR = not reported.
*Data expressed as event rates (events per 100 FDP/abutment years).
†Comparison of dissimilar outcome measures by authors.
‡Random-effects Poisson regression used (heterogeneity assumed to be present, test for heterogeneity not reported).

Table 3 Reported Estimated 5-Year Survival Rates

	Metal-ceramic FDPs		All-ceramic FDPs		
	Summary estimate event rates (95% CI)*	Cumulative 5-y complication rates (95% CI)	Summary estimate event rates (95% CI)*	Cumulative 5-y complication rates (95% CI)	*P*
Failure	1.2% (0.7%–1.9%)†	NA	2.4% (1.2%–4.9%)†	NA	< .001
Survival	NA	94.4% (91.1%–96.5%)†	NA	88.6% (78.3%–94.2%)†	NR

CI = confidence interval; NA = not applicable. *P* values only reported for failure events.
*Data expressed as event rates (events per 100 FDP/abutment years).
†Random-effects Poisson regression used (test for heterogeneity, all ceramic: $P = .005$; metal-ceramic: $P = .0002$.).

and 13.6%) compared with those of metal-ceramic (1.6% and 2.9%) FDPs."[16] This is incorrect. This outcome for metal-ceramic FDPs was not calculated by the review and remains unknown. The figures 1.6% and 2.9% refer to "conventional" FDPs. This is but one instance of an inaccurate and misleading statement regarding metal-ceramic FDPs.

Interpretation of the results was further complicated by their presentation. The results for all-ceramic FDPs were discussed and tabulated in the Sailer et al review,[16] while the results for metal-ceramic FDPs were discussed and tabulated across all three reviews.[12,16,24] This complicated presentation also appeared to confuse the authors themselves, with two notable errors. Two events were measured differently by the separate reviews but considered identical for comparative and statistical purposes. The comparison of these dissimilar outcome measures represented a serious oversight by the authors. These were:

- The Pjetursson et al review[24] assessed the rate of caries of "abutments," while the Sailer et al review[16] assessed the rate of caries of "FDPs." An abutment is a single tooth; the FDP is the entire reconstruction, involving multiple teeth.
- The Pjetursson et al review[24] assessed the rate of "veneer or framework fracture," while the Sailer et al review[16] assessed the rate of "FPDs lost due to framework fracture." A statistically significant difference was reported.

Reported Results

The reported estimated event and 5-year rates for survival and complications are summarized in Tables 2 and 3. The annual failure rate of metal-ceramic FDPs was 2.11 times less than all-ceramic FDPs ($P < .001$). Of the 343 all-ceramic FDPs (mean time in situ: 3.8 years), the estimated annual failure rate was 2.4 per 100 FDP years (range: 1.2 to 4.9 per 100 FDP years), and the 5-year survival was 88.6% (range: 78.3% to 94.2%). Of the 1,163 metal-ceramic FDPs (mean time in situ: 8 years), the estimated annual failure rate was 1.2 per 100 FDP years (range: 0.7 to 1.9 per 100 FDP years), and the 5-year survival was 94.4% (range: 91.1% to 96.5%).

Heterogeneity was present for metal-ceramic and all-ceramic failure rates: five all-ceramic FDP events (caries, loss of FDP due to caries, ceramic chipping, marginal discoloration, and loss of FDP due to framework fracture) and four "conventional" FDP events (caries, loss of retention, ceramic chipping, veneer/framework fracture). Heterogeneity between studies was not surprising. Heterogeneity is commonly found when baseline risk, sociodemographic factors, outcome measures, and interventions differ.[31] In this review, interventions and treating operators (student vs specialist) differed, and it was likely that other methodologic differences were also present, contributing to heterogeneity.

The interventions included were zirconia, glass-ceramic, InCeram Zi, and InCeram Al (all-ceramic FDPs) and metal-ceramic, gold acrylic, and unclassified (metal-ceramic FDPs). These reconstructions have different properties and were likely to experience different complications. Also, the outcome of some of these interventions was reported during their developmental stage. In one instance, the 95% confidence interval for heterogenous caries data for all-ceramic FDPs spanned over 23% (range: 1.7% to 24.4%). The authors discussed complication trends for different all-ceramic FDPs but not for different conventional FDPs. Despite these variations, the data were pooled for analysis. This aggregation was unlikely to provide clinically relevant assessments of complication outcomes.

The treating operators included undergradutate students, postgraduate students, private dentists, and specialist prosthodontists. Their level of experience and clinical judgment differed and may have contributed to the heterogeneity.

The clinical relevance of the "survival" or "complication" definitions, and thus the measured outcomes, was not considered. This limits the external applicability of the data.

The conclusions stated in the abstract were supported by the results and related to the study aims; the conclusions stated in the text were not. The authors provided specific concluding advice regarding the replacement of posterior teeth, recommending zirconia as the all-ceramic FDP material of choice. This conclusion was not explored by the review and remains unsupported by the reported evidence.

Results, Walton[21]

Walton[21] published a prospective cohort study that provides further relevant evidence for the clinical query at hand. It was published in 2009 and thus not included in the 2007 systematic review by Sailer et al.[16]

Study Validity

The internal validity of a cohort study is associated with a clearly focused question, choice of study methodology, cohort recruitment, exposure and outcome, presence of confounding factors, and length and completeness of follow-up.

The prospective cohort study addressed a focused clinical question. Its PICO was:

- Patient: Patients in a private prosthodontic practice
- Intervention: Provision of single crowns or FDPs after the introduction of implant therapy
- Comparison: Provision of single crowns or FDPs prior to the use of implant therapy
- Outcome: Difference in prosthesis outcomes

The clinical question was explored through a prospective cohort study. It was a long-term observational study incorporating well-defined outcome measures to assess two patient cohorts who were treated during different eras (over a 20-year period). This is the optimal study design available to investigate such results, with no randomization, allocation concealment, or blinding possible.

Readers were provided with sufficient information to enable them to equate the included cohort with their own specific region. Conclusions as to whether the presented results would be applicable to their patients could be made. The patient sample was representative of patients referred to private prosthodontic practices in Australia. The patients were of nonspecific socioeconomic backgrounds, and the facility was not associated with a university or hospital.

Bias was minimized through the patient's exposure to treatment and assessment of the outcome. Exposure was defined as provision of the prosthesis,

with every patient receiving single crowns or FDPs during a specified time period sequentially included and followed. Outcome was defined by the six-field outcome classification (success, survival, repair, failure, lost to follow-up, death) system, which has been in use since 1997.[32] All prostheses were assigned an outcome, loss to follow-up was reported, and analysis was performed on an intent-to-treat basis. The prospective study assessed outcomes over a 5- to 10-year period. This time period would be suitable to ascertain the outcome of interest, although a longer follow-up would be of interest.

Possible confounding factors were accounted for. The time in situ for each group was equal. Follow-up was sufficient for adverse outcomes to occur, and groups were similar at the start of the trial (baseline data were reported). Groups were treated equally during the trial, and results were analyzed in subgroups where appropriate (tooth vitality, type, location). Modes of failure and complications were considered.

Overall, the results from this study had good internal validity.

Reported Results

Survival of each group was reported as 10-year estimated Kaplan-Meier cumulative survival and associated standard error. Group 1 included patients treated between 1989 and 1993 with outcomes reviewed in 1998. This group included 422 abutments and 189 FDPs. Group 2 included patients treated between 1997 and 2001 with outcomes reviewed in 2006. This group included 354 abutments and 142 FDPs.

Compared with group 1, patients in group 2 had a significantly improved 10-year survival for nonvital FDP abutments (group 1: 89% ± 3%, group 2: 96% ± 2%; $P = .049$). Within group 1, the 10-year survival of FDPs with vital abutments was significantly greater than those with nonvital abutments (vital: 97% ± 1%, nonvital: 89% ± 3%; $P = .001$). Within group 2, the 10-year survival of FDPs with vital and nonvital abutments was statistically identical (vital: 98% ± 1%, nonvital: 96% ± 2%; $P = .377$). Group 1 experienced 17 failures (4%) of 433 abutments, while group 2 experienced 8 failures (2.3%) of 354 abutments.

Discussion

Internal and External Validity

Systematic Review (Sailer et al[16]). The internal validity of the systematic review was compromised. It was likely that relevant studies were not identified by the search strategy and thus were not available for analysis. Inclusion criteria and independency of study selection were unclear. The data extraction method was structured, independent, and repeatable, but reviewer agreement was not reported.

The aim of the review was four-fold. The authors have adequately addressed the first three sections: namely, to assess the 5-year survival rates of all-ceramic FDPs, to assess the incidences of complications of all-ceramic FDPs, and to compare all-ceramic and metal-ceramic FDP 5-year survival rates. The authors failed to compare the incidence of complications of all-ceramic and metal-ceramic FDPs, and they did not acknowledge this divergence from the stated aims.

Interpretation of the results was complicated by distribution across three systematic reviews, nomenclature confusion, non–metal-ceramic FDP inclusion, multiple all-ceramic FDP presence, dissimilar outcome measure analysis, and nontransparent reporting of heterogeneity.

It is accepted that the definition of "survival" for systematic reviews is restricted by the included studies. However, the clinical relevance of the survival and complications, as defined in the systematic review, must be considered. For this review, survival was defined as "the FDP remaining in situ at the examination visit with or without modification." This was a broad definition. An FDP in situ could have required no or irregular minor repairs and remained esthetically and functionally sound or could have experienced significant complications and required an unacceptably high level of maintenance. Although both scenarios fulfill the "survival" criteria, the second FDP would likely be considered a failure by the patient (and the clinician). The impact of this definition on the results was not explored by the authors.

Although reporting complications improves the understanding of true clinical outcomes, the same complication could have different consequences. A small chip of veneering porcelain or a stained margin on a posterior tooth could be a "complication," while a large chip or stained margin on an anterior tooth compromising appearance would be a "failure." These dissimilar outcomes would be reported as identical complications. The impact of this classification on the results was not explored by the authors.

Overall, the external reliability was limited by the compromised internal validity, broad outcome definitions, inaccurate results, and incomplete examination of stated aims. With care, however, the results can be applied to clinical practice.

Cohort Study (Walton[21]). The prospective cohort study had good internal validity. It was well focused, comparing outcomes of metal-ceramic FDPs provided before and after the introduction of implant therapy. Patient cohorts were clearly defined, similar at baseline, and treated equally. Loss to follow-up was reported, and analysis was performed on an intent-to-treat basis.

Ten-year Kaplan-Meier cumulative survival with standard errors was reported. Metal-ceramic FDP survival rates were high and had significantly improved since the introduction of implants and the decreased use of structurally compromised abutments. These results offer significant insight for clinical decisions. The introduction of implant dentistry has provided an alternative treatment option for restoring edentulous spaces. FDPs were previously supported by both strong and structurally compromised abutment teeth. These structurally compromised teeth are now less frequently used as abutments, and, thus, the survival of FDPs has improved.

Current systematic reviews and studies often incorporated FDPs from the pre-implant era, when structurally compromised abutment teeth were likely utilized. It is likely that the provision of similar treatment, using abutment teeth with good structural integrity, will result in an improved survival of metal-ceramic FDPs when compared with the current results published in systematic reviews.

Clinical Applicability

The internal validity of the systematic review[16] was limited, and some results presented were confusing and inaccurate. Despite this, the data will provide guidance for clinicians. The study populations included patients from numerous locations and operators working within varied facilities (undergraduate, postgraduate, private, and specialist clinics). The incorporation of this broad patient base, however, is both advantageous and disadvantageous. It allows the results to be generalized to multiple treatment settings, but the obtained results will lack precision, with their magnitude unlikely to be directly applicable to any treatment setting in particular. Nevertheless, it was likely that the comparatively greater survival of metal-ceramic compared with all-ceramic FDPs would remain clinically relevant in any setting. The authors found that the estimated 5-year survival rate of metal-ceramic FDPs was significantly higher than all-ceramic FDPs, and that all-ceramic FDPs had a high incidence of technical failure. As stated, the difference between all-ceramic and metal-ceramic FDP complication rates was unable to be reported. Further studies to assess complication rates of metal-ceramic FDPs and of different all-ceramic FDP constructions would be clinically helpful.

The prospective cohort study[21] had good internal validity and reported clinically relevant outcomes. The patient population was similar to the clinical scenario (private prosthodontic practice, referred patient). This narrow patient base, however, has the opposite advantages and disadvantages to that of the systematic review.[16] Its generalizability is limited, but its applicability to a referral private prosthodontic practice has high precision. Despite the different external applicability, the conclusions from this study complemented that of the systematic review, reinforcing the good long-term clinical outcomes associated with metal-ceramic FDP reconstructions. The 10-year metal-ceramic FDP survival rates were high and had significantly improved compared with FDPs placed prior to the introduction of implant dentistry (and the decreased use of structurally compromised abutments). This indicated that metal-ceramic FDP outcomes were likely to have greater longevity than that reported by the systematic review.

Conclusion

In a patient with biologically and structurally sound abutment teeth, the provision of a metal-ceramic FDP was likely to have a significantly greater 5-year survival than an all-ceramic FDP. Differences in complications were not known, but the studies indicated that the incidence of complications of metal-ceramic FDPs were lower than that of all-ceramic FDPs. This evidence was directly applicable to the clinical scenario and will help guide the decision.

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Literature Abstract

Infective endocarditis: Rationale for revised guidelines for antibiotic prophylaxis

This article is an analysis of revised guidelines by professional societies for infective endocarditis prophylaxis. Infective endocarditis is an uncommon but serious condition that develops from cardiac endothelial damage and bacteremia from a precipitating event. Prevention of bacteremia through appropriate antibiotics could, in theory, reduce this. However, defining the patient population at high risk of endothelial injury and procedures at high risk of bacteremia has been a challenge for the various guidelines and revisions. At present, there is limited evidence for antibiotic prophylaxis for respiratory, gastrointestinal, and genitourinary procedures, and there is no evidence for dental procedures. Emergence of antibiotic resistance as well as risk of antibiotic-related adverse effects has led to an increasingly evidence-based approach to infective endocarditis prophylaxis. The guidelines of the American Heart Association (AHA, 2007), National Institute for Health and Clinical Excellence Guidance (NICE, 2008), and the British Society for Antimicrobial Chemotherapy (BSAC, 2005) show significant departure from traditional recommendations. The BSAC recommends prophylaxis for dental and nondental procedures (including gastrointestinal and genitourinary), the AHA recommends prophylaxis for only dental and respiratory procedures and not gastrointestinal or genitourinary, and NICE recommends prophylaxis for none of the procedures. The authors are optimistic that the newer guidelines will reduce the spread of antibiotic-resistant bacterial strains and their unintended consequences.

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