Canadian Agency for Drugs and Technologies in Health

RAPID RESPONSE REPORT: SUMMARY WITH CRITICAL APPRAISAL

TITLE: All-Ceramic Crowns Compared to Porcelain-Fused-to-Metal Crowns in Adults: A Review of Long-Term Clinical Effectiveness and Cost-Effectiveness

DATE: 23 September 2013

CONTEXT AND POLICY ISSUES

Considered the gold-standard in dental restorations, porcelain fused to metal (PFM) or metal-ceramic crowns have been available for more than 40 years.[1] They consist of a noble or base metal fused to a porcelain overlay.[2] PFM crowns have good mechanical properties and high fracture resistance, however they have often been criticized for their esthetic properties.[2]

All-ceramic crowns have historically been more esthetically pleasing, but less resistant to chips and fractures than the PFM alternative.[2] The major advances in ceramic technology that have occurred over the last 20 years have improved the failure rates and appeal of all-ceramic crowns, however it is still not clear whether or not the improvements have bridged the gap between the longevity of all-ceramic crowns and that of PFM crowns.[2]

In order to make evidence-based decisions regarding the reimbursement of dental crowns, policy makers require information on the long-term relative benefits and costs associated with the different dental crown materials. The objective of this report is to review the long-term (at least eight years) clinical and cost-effectiveness of all-ceramic dental crowns compared with PFM dental crowns, as well as to identify contextual considerations, such as access to health care, and dentist skill, that may influence their clinical and cost-effectiveness. This report is an update of a previous CADTH report.[3] This report focuses on longer-term follow up and addresses contextual considerations that were not considered in the previous report.

RESEARCH QUESTIONS

1. What is the long-term (eight years and longer) clinical effectiveness of all-ceramic dental crowns, compared to porcelain-to-metal dental crowns?

2. What is the long-term (eight years and longer) cost-effectiveness of all-ceramic crowns, compared to porcelain-to-metal dental crowns?

3. What are some contextual considerations for all-ceramic crowns or porcelain-to-metal dental crowns that may influence their respective clinical or cost-effectiveness?

KEY FINDINGS

Limited evidence from one non-randomized study and one Australian cost-effectiveness study suggests that porcelain-to-metal crowns may have a higher 10 and 15 year survival rate and may be more cost-effective after 10 years than all-ceramic crowns. No comparative information regarding the contextual considerations that may have an influence on the clinical and cost-effectiveness of different crown materials was identified. The authors of the included non-randomized study analyzed factors that had an effect on the longevity of crowns, but they did not report separate analyses for different crown materials.

METHODS

Literature Search Strategy

This report makes use of a literature search conducted for a previous CADTH report.[3] The original literature search was conducted December 6, 2012 on key resources including PubMed, The Cochrane Library (2012, Issue 12), University of York Centre for Reviews and Dissemination (CRD) databases, Canadian and major international health technology agencies, as well as a focused Internet search. Methodological filters were applied to a broad search of any type of dental crown to limit retrieval to health technology assessments, systematic reviews, meta-analyses, randomized controlled trials and economic studies. No filters were applied to a narrower search of articles comparing all-ceramic to metal-ceramic dental crowns. The initial clinical search was also limited to English language documents published between January 1, 2007 and December 6, 2012. The initial search for economic studies was limited to documents published between January 1, 2002 and December 6, 2012. For the current report, database searches were rerun on August 23, 2013 to capture any articles published since the initial search date. Additionally, the clinical search was expanded to include items published from 2002-2006. A search for guidelines was also conducted. The search of major health technology agencies was updated as well.

Rapid Response reports are organized so that the evidence for each research question is presented separately.

Selection Criteria and Methods

One reviewer screened citations and selected studies. In the first level of screening, titles and abstracts were reviewed for relevance. Full texts of any relevant titles/abstracts were retrieved, and assessed for inclusion. The final article selection was based on the inclusion criteria presented in Table 1.

Table 1: Selection Criteria

Population	Any patient 18 years or older who requires a crown
Intervention	All ceramic crowns (e.g., veneered, not veneered, glass-ceramic, all ceramic zirconia, lithium disilicate, alumina, etc.)
Comparator	Metal-ceramic crowns – AKA porcelain-fused to metal crowns (PFM).

Table 1: Selection Criteria	
Outcomes	**Clinical** Success rate (no further intervention required for duration of study),cracks, chips, fractures Longevity, durability including strength, hardness, brittleness, resistance to fracture Colour match Anatomic contour Occlusion Surface texture Proximal contact Wear of crowns Wear of opposing teeth (enamel) Wear on opposing dental work Tooth sensitivity Secondary caries Marginal integrity Tissue health Level of destruction of the tooth to prepare the crown **Cost** Cost-effectiveness Costs of professional and laboratory fees Costs of training Costs of repair/replacing crowns that fail **Contextual** High caries population High diabetes population Remote or isolated communities Dentist skill/technique Patient preference/acceptability Anterior versus posterior permanent teeth Study population: overall population living on urban and rural areas, with specifics for remote areas (if any) Public and private plans Canada and internationally
Study Designs	HTA, SR, RCT, NRS, Guidelines

HTA = health technology assessment; NRS = non-randomized study; RCT = randomized controlled study; SR = systematic review

Exclusion Criteria

Studies were excluded if they did not meet the inclusion criteria, were published prior to 2002, or did not report long-term (eight years or longer) outcomes. Additionally, studies were excluded if they did not directly compare PFM with all-ceramic crowns. Non-comparative studies may provide an indication of the survival of a particular crown type, but do not provide information on the relative effectiveness of different materials in similar populations or settings.

Critical Appraisal of Individual Studies

Critical appraisal of the included studies was based on study design. The non-randomized studies included in this review were evaluated using the SIGN50 checklist for cohort studies.[4] The methodological quality of the included cost-effectiveness study were assessed using the guidelines for appraisal of economic studies by Drummond et al.[5]

For the included studies a numeric score was not calculated. Instead, the strengths and limitations of the study were described narratively.

SUMMARY OF EVIDENCE

Quantity of Research Available

A total of 567 citations were identified in the updated literature search of the bibliographic databases, 564 of which were excluded at title and abstract screening based on their irrelevance to the questions of interest. The full text documents of the remaining three articles were retrieved and the articles included in the original report,[3] for which this is and update, were screened for relevance to this review. Two of the included articles from the original report, were retained for full-text review. Of the five articles examined in full text, three did not meet the inclusion criteria and were excluded, leaving one non-randomized study[6] and one cost-effectiveness study[7] included in this review.

Additional references of potential interest that did not meet the inclusion criteria, such as studies without a control group, narrative literature reviews, or that had fewer than eight years of follow-up data, are provided in Appendix 5.

Summary of Study Characteristics

Study Design

One non-randomized study[6] and one cost-effectiveness study met the inclusion criteria.[7] The non-randomized study examined patient records from a health insurance dataset for claims made in England and Wales between 1990 and 2002.[6] The cost-effectiveness study examined records for patients who received restorations in Australia prior to 1985 with at least 10 years of follow-up data.

Population

The non-randomized study examined the records of 21,809 patients older than 18 years of age, 45% of whom were between the ages of 30 and 39 years at the time of crown placement, and 54% of whom were female.[6]

The patient data for the cost-effectiveness study was based on patient records for restorations performed before 1985 who were followed for at least 10 years.[7] The mean age of the patients at the time of crown placement was 40.1 years ± 12 and there was an approximately equal distribution of males and females.

Interventions and Comparators

In their non-randomized study, Burke et al. evaluated 47,417 all-ceramic (porcelain jacket), porcelain fused to metal, or all-metal crowns (38,166 PFM crowns and 1,434 porcelain jacket crowns).[6] All-metal crowns were not relevant to this report. More crowns were placed on the maxillary arch rather than the mandibular arch and the maxillary incisor was the tooth most frequently crowned (followed by the first molar and second premolar). Differences in the placement of crowns based on the crown material were not reported.

Kelly et al. examined the cost-effectiveness of PFM and all-ceramic (porcelain jacket) crowns, using various amalgam restorations as reference cases.[7] A total of 212 PFM, 18 porcelain jacket, 269 Class I amalgam, and 57 Class IV amalgam restorations were examined. Most of the porcelain jacket crowns were placed on maxillary incisors and the PFM crowns were mostly placed on maxillary incisors or premolars.

Outcomes

The main outcome evaluated in the non-randomized study was crown survival[6] and the main outcome in the cost-effectiveness study was cost-effectiveness, reported as an incremental cost-effectiveness ratio (ICER) expressed as the net cost (in Australian dollars) for each percentage unit increase in restoration survival.[7]

Further detail regarding the characteristics of the included studies is included in Appendix 2.

Summary of Critical Appraisal

The primary strength of the Burke et al. non-randomized study (NRS) was the large sample size. A total of 47, 417 crowns (80% of which were PFM crowns) in 21,809 patients were examined for at least ten years.[6] The crown materials were not randomized and therefore, it is unknown if crown survival was mediated by patient-related factors or the location of the crown in the mouth and not simply the crown type. However, the authors do state that the placement of the crowns of different material-types in the different regions of the mouth were likely representative of general practice. Not all crown replacements were necessarily due to crown failure, some re-interventions may have been due to cosmetic reasons. The crowns in the study were fabricated prior to 2002, therefore, it is possible that the results are not generalizable to the materials that are currently used to fabricate dental crowns.

The primary strengths of the cost-effectiveness study were the discounting of costs and the inclusion of real dental prices.[7] The costs reported in the study, however, are also a limitation due to the fact that they were Australian costs in 1992 and may not be generalizable to current Canadian prices. The crowns examined by Kelly et al.[7] were fabricated prior to 1985, which may also affect the generalizability of the data, as dental materials have changed since then. The definition of survival was also not reported. As the crown survival results were based on a non-randomized study, the limitations of the clinical data presented in the study are similar to those of the Burke et al. study. For example, it is unknown if crown survival may have been influenced by the reason for selecting the type of restoration. Neither study reported the funding source

Further detail regarding the critical appraisal is included in Appendix 3.

Summary of Findings

What is the long-term (eight years and longer) clinical effectiveness of all-ceramic dental crowns, compared to porcelain-to-metal dental crowns?

10-year survival:
Both the non-randomized study[6] and the cost-effectiveness study[7] reported unadjusted 10-year crown survival. PFM survival was 62% in the NRS and 88.2% in the cost-effectiveness study whereas porcelain jacket survival was 48%[6] and 66.6%, respectively.[7] The difference was statistically significant in the NRS study ($P < 0.0001$) and statistical significance was not reported in the cost-effectiveness study.

15-year survival:
Fifteen year survival was reported in the cost-effectiveness study and was found to be 76.9% for PFM crowns and 66.6% for porcelain jacket crowns.[7] Statistical significance was not reported.

The only clinical effectiveness outcome reported in the included studies was crown survival. The authors of the non-randomized study noted that the need for re-intervention was more common in all-ceramic crowns but specific data were not provided. For further detail regarding the outcomes of interest, see Table 5 in Appendix 4.

What is the long-term (eight years and longer) cost-effectiveness of all-ceramic crowns, compared to porcelain-to-metal dental crowns?

Incremental cost-effectiveness ratios for PFM and porcelain jacket crowns were reported at 10 years and 15 years relative to Class I amalgam and to Class IV multi-surface resin composite restorations.[7] Class I amalgam restorations are considered the most universal or standard dental restoration. Ten year survival for Class I amalgam crowns was 85.8% and for Class IV multi-surface resin was 56.3% (versus 88.2% for PFM and 66.6% for porcelain jacket crowns). Fifteen year survival for Class I amalgam was 82.5% and for Class IV multi-surface resin was 47.7% (versus 76.9% for PFM and 66.6% for porcelain jacket crowns).

The ICER was expressed as the net cost (in Australian dollars) for each percentage unit increase in restoration survival. The lower ICER values indicate higher benefits.

10-year ICER:
Relative to Class I amalgam restorations, the 10-year ICER was 160.3 for PFM and -19.2 for porcelain jacket crowns.[7] The survival was shorter for porcelain jacket crowns, but the cost was not less. Relative to Class IV multi-surface resin composite restorations, the ICER was 11.9 for PFM and 34.3 for porcelain jacket crowns.

15-year ICER:
Relative to Class I amalgam restorations, the 15-year ICER for PFM was -49.6 and -17.0 for porcelain jacket crowns.[7] Relative to Class IV multi-surface resin composite restorations, the ICER was 9.2 for PFM and 13.8 for porcelain jacket crowns.

Further detail regarding outcomes of interest is included in Appendix 4 Table 5.

What are some contextual considerations for all-ceramic crowns or porcelain-to-metal dental crowns that may affect their respective clinical or cost-effectiveness?

No comparative evidence regarding contextual considerations that may influence the clinical or cost-effectiveness of all-ceramic crowns or PFM crowns was identified. The authors of the included non-randomized study analyzed factors that influence the longevity of all crowns placed in the study period (including all metal crowns). Some of these factors include tooth position, with shorter survival observed for crowns placed on maxillary teeth; dentist age, with longer survival observed with crowns placed by older dentists; and patient age, with shorter crown survival observed for older patients. The authors of this study did not report separate analyses for different crown materials, so it is unclear whether these factors may influence the survival of PFM or porcelain jacket crowns differently. A full list of outcomes considered, as well as the evidence identified, is available in Appendix 4, Table 5.

Limitations

One of the primary limitations of this review is the scarcity of evidence identified. No additional studies were identified in the updated literature search and therefore data from two studies was included. The available clinical evidence was not the result of randomized studies. Limited evidence regarding the comparative long-term clinical and cost outcomes of all-ceramic versus porcelain fused to metal crowns is available. Some additional non-comparative evidence and evidence for slightly shorter follow-up was identified and was is included in Appendix 5.

The year of fabrication for the dental crowns is another limitation. In the NRS, crowns were fabricated prior to 2002 and in the economic study, prior to 1985. As dental materials have been improving, the results of these studies may not be generalizable to current dental materials and crowns.

The cost-effectiveness information is further limited in that not only is it from Australia, and may not be generalizable to Canada, but also because the cost estimates are from 1992, and may not reflect current prices. Additionally, the study focused primarily on posterior crowns, which may limit the generalizability of the information to anterior teeth.

CONCLUSIONS AND IMPLICATIONS FOR DECISION OR POLICY MAKING

One non-randomized study and one cost-effectiveness study examining PFM and ceramic crowns were included in this review.

The authors of the non-randomized study found that PFM crowns had longer survival at 10 years than porcelain crowns. They also found that factors such as the age of the patient and patient payment exemption status influenced the longevity of crowns, with older or non-paying patients experiencing shorter crown survival. However, the authors did not present data based on the type of crown material and the data examined by the authors included all-metal crowns, therefore, it is unclear if this data can be extrapolated to draw specific conclusions regarding how these contextual considerations may have an effect on PFM or porcelain jacket crowns. The authors of the cost-effectiveness study also found PFM crowns to have longer survival than porcelain jacket crowns, at both 10 and 15 years.

In terms of cost-effectiveness at 10 and 15 years, PFM crowns were more cost-effective than porcelain jacket crowns. This was true when Class I amalgam restorations on all teeth and

Class IV multi-surface resin composite restorations on anterior teeth were used as reference cases.

Overall, limited evidence suggests that PFM crowns may have longer-term survival and may be more cost-effective after 10 years than porcelain jacket crowns. However, it is unclear if this information is generalizable to the current Canadian context. No evidence was identified to indicate that all-ceramic crowns have equivalent or superior clinical or cost-effectiveness compared with PFM crowns. No conclusions regarding contextual considerations can be presented due to the lack of information that presented evidence specific to the type of crown material. One study analyzed factors that influence the longevity of all crowns placed during the study period (including all metal crowns). Some of these factors include tooth position, with shorter survival observed for crowns placed on maxillary teeth; dentist age, with longer survival observed with crowns placed by older dentists; and patient age, with shorter crown survival observed for older patients. The authors of this study did not report separate analyses for different crown materials, so it is unclear whether these factors may influence the survival of PFM or porcelain jacket crowns differently.

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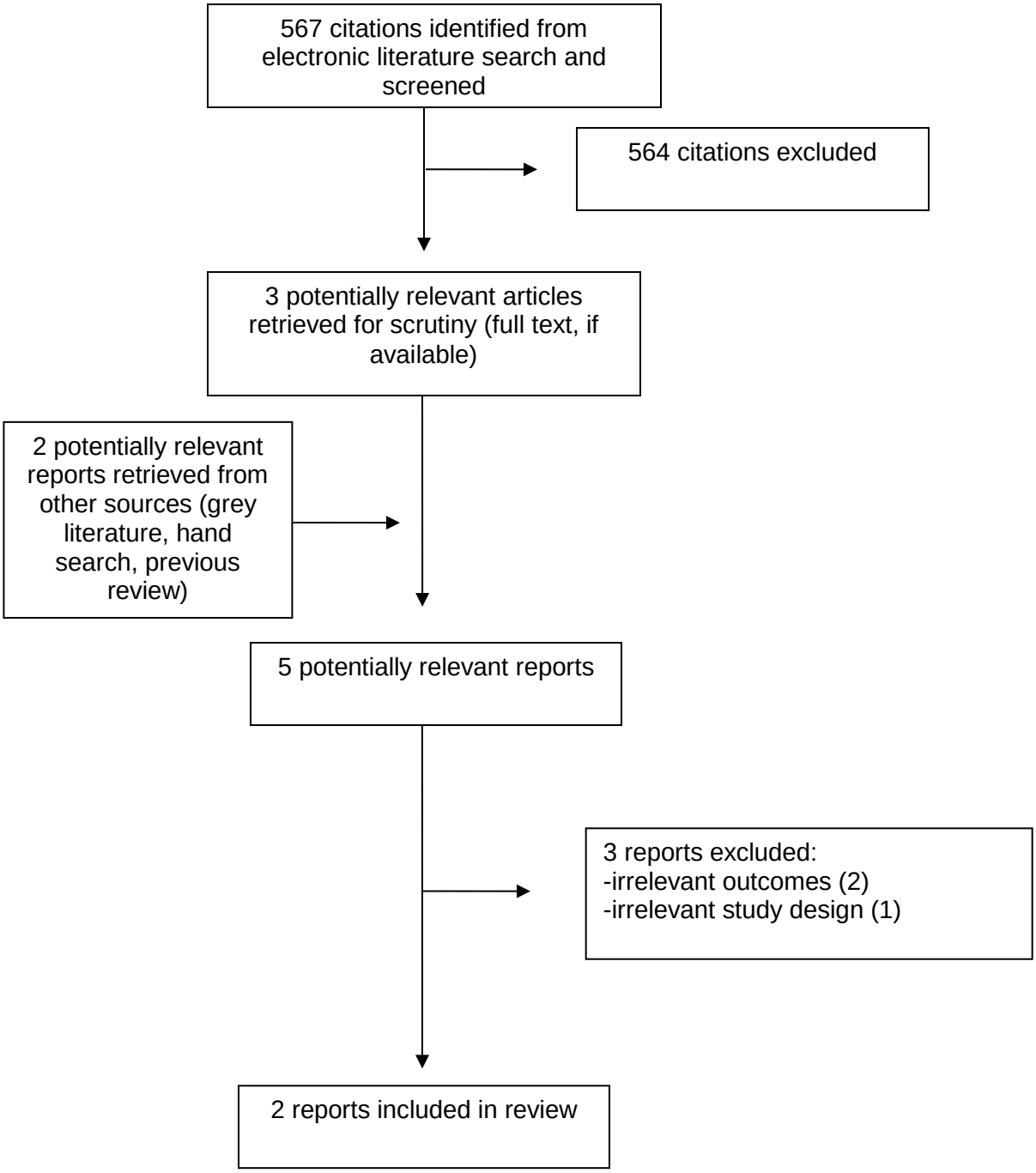
6. Burke FJ, Lucarotti PS. Ten-year outcome of crowns placed within the General Dental Services in England and Wales. J Dent. 2009 Jan;37(1):12-24.

7. Kelly PG, Smales RJ. Long-term cost-effectiveness of single indirect restorations in selected dental practices. Br Dent J. 2004 May 22;196(10):639-43.

APPENDIX 1: Selection of Included Studies



Appendix 2: Study Characteristics

Table 2: Characteristics of the included non-randomized study			
Study Objectives, Study Design	**Inclusion Criteria, Sample Size, Patient Characteristics**	**Intervention, Comparator**	**Clinical Outcomes**
Burke et al. 2009[6] – UK (Non-randomized trial)			
Consider the factors associated with the need for re-intervention on a crown, and the times to re-intervention. Retrospective non-randomized study	**Inclusion Criteria:** patients with • a data set was created by random selection from health insurance dataset, • consisted of crowns which have been placed, with their dates of placement and their dates, if any, of re-intervention • insurance claims between 1990 to 2002 **Sample size:** • 21,809 patients o A total of 47,417 crowns o Mean follow-up of 10 years **Patients characteristics:** 45% of patients were 30 to 39 years	**Intervention:** • All-porcelain crowns (N=1,434) **Comparators:** • Metal-ceramic crowns (N=38,166) • All metal crowns (N=7,817)	Survival rate of dental crowns. Survival defined as time from the date of payment claim for the restoration until another intervention or maintenance was needed on the restored tooth.

Table 3: Characteristics of the included economic study			
Study Objectives & Design	**Data collection/ Assumptions**	**Interventions**	**Outcomes**
Kelly et al, 2004[7] – Australia			
Determine the relative cost-effectiveness of alternative methods for restoring large tooth substance loss in adults.	• The study included was based on retrospective survival data of molar restorations placed in three private clinics with the participation of nine dentists • All restorations were placed before 1985 and followed-up for at least 10 years • Data were collected patients records • Survival analysis excluded (censored) crowns removed due to endodontic treatment or periodontal diseases • Restoration costs were discounted to the mean costs in South Australian metropolitan in 1992.	Posterior dental restorations: • Full gold crowns • Ceramo-metal crowns • Cast onlay • Porcelain jacket crowns • Class I amalgam • Class II amalgam • Class IV resin composite	Cost-effectiveness of the dental restorative treatment defined as the difference in the discounted costs incurred between treatment A and treatment B divided by the difference in their effectiveness (restoration survival). Lower values mean higher benefits derived. ICER expressed as the net cost (in Australian dollars) for each percentage unit increase in restoration survival. Effectiveness was based on restoration survival; however, survival rate was not defined in the report.

Appendix 3: Critical Appraisal of Included Studies

Table 4: Critical Appraisal	
Strengths	**Limitations**
Burke et al. 2009[6] – UK (Retrospective non-randomized study)	
• The study included a large sample size with a follow-up enough to evaluate the survival of dental crowns. • Although study not randomized, placement of the crowns of different material-types in the different regions of the mouth likely representative of general practice.	• The selection of restoration was not randomized, and the survival of crowns might be affected by the cause behind selecting the type of restoration. • Based on administrative data, limited information available regarding population details. • The study was based on restorations placed between 1990 and 2002, dental materials used in crown fabrication could have been changed considerably since the beginning data collection. This may affect the generalizability of the study results. • No statement of funding source • No statements regarding potential confounders • Power calculation not reported, confidence intervals not reported
Kelly et al, 2004[7] – Australia (Cost-effectiveness Study)	
• The cost-effectiveness analyses were based on real data obtained from three different dental practices. • Prices were adjusted (discounted) from the time of tooth restoration to the time when the study was conducted and differed based on the type of restoration.	• The selection of restoration was not randomized, and the survival of crowns might be influenced by the cause behind selecting the type of restoration. • The study was based on restorations placed before 1985, dental materials used in crown fabrication have been changed considerably since then. This may affect the generalizability of the study results. • No statement of funding source • Excluded opportunity costs of lost income and productivity • Payer perspective not explicitly stated

Appendix 4: Summary of Findings

Table 5: Evidence Summary		
Outcome	**Evidence**	**Comment**
CLINICAL		
Success rate (no further intervention required for duration of study)	No evidence identified.	Burke et al.[6] • All-ceramic crowns showed the least time to re-intervention
Cracks, chips, fractures	No evidence identified.	
Longevity, durability including strength, hardness, brittleness, resistance to fraction	Burke et al[6] – Percentage Survival after 10 years: • PFM: 62% • Porcelain Jacket: 48% (difference statistically significant, P<0.0001) Kelly et al, 2004[7] – Percentage 10-year survival: • PFM: 88.2% • Porcelain Jacket: 66.6% • Class I amalgam: 85.8% • Class IV multi-surface resin: 56.3% Kelly et al[7] – Percentage 15-year survival: • PFM: 76.9% • Porcelain Jacket: 66.6% • Class I amalgam: 82.5% • Class IV multi-surface resin: 47.7%	
Colour match	No evidence identified.	
Anatomic contour	No evidence identified.	
Occlusion	No evidence identified.	
Surface texture	No evidence identified.	
Wear of crowns	No evidence identified.	
Proximal contact	No evidence identified.	
Wear of opposing teeth (enamel)	No evidence identified.	
Wear on opposing dental work	No evidence identified.	
Tooth sensitivity	No evidence identified.	
Secondary caries	No evidence identified.	
Marginal integrity	No evidence identified.	
Tissue health	No evidence identified.	

Table 5: Evidence Summary		
Outcome	**Evidence**	**Comment**
Level of destruction of the tooth to prepare the crown	No evidence identified.	
ECONOMIC		
Cost-effectiveness	From Kelly et al.[7] 10-year ICER[a] relative to Class I amalgam [b]: • PFM: 160.3 • Porcelain Jacket: -19.1[c] (difference statistically significant) 15-year ICER relative to Class I amalgam [b]: • PFM: -49.6[c] • Porcelain Jacket: -17.0[c] (differences statistically significant) 10-year ICER (relative to Class IV multisurface resin composite restoration) for anterior restorations [b]: • PFM: 11.9 • Porcelain Jacket: 34.3 15-year ICER (relative to Class IV multisurface resin composite restoration) for anterior restorations [b]: • PFM: 9.2 • Porcelain Jacket: 13.8	Posterior restorations were the focus of the study. Kelly et al.[7] concluded that the anterior PFM crowns were more cost-effective than porcelain jacket crowns over the longer term.
Costs of professional and laboratory fees	No evidence identified.	Discounted cost of restorations in 1992 (Aus$): • PMF: 695.00 • Porcelain Jacket: 606.40 • Class I amalgam: 50.00 • Class IV resin composite: 82.0
Costs of training	No evidence identified.	
Costs of repair/replacing crowns that fail (travel time, cost for professional and lab fee)	No evidence identified.	Travel time not considered in Kelly et al.[7]
CONTEXTUAL		
High caries population	No evidence identified.	
High diabetes population	No evidence identified.	
Remote or isolated communities (access to health care, equivalent dentist skills and materials)	No evidence identified.	Burke et al.[6] found that patient attendance pattern had an effect on the longevity of crowns, but did not present data based on

Table 5: Evidence Summary		
Outcome	**Evidence**	**Comment**
		crown type.
Dentist skill/technique	No evidence identified.	Burke et.al[6] 10 year data, any crown: • Older dentists associated with 62% survival at 10 years • Male dentists associated with 63% survival at 10 years Kelly et al.[7] reported that all of the porcelain jacket crowns were inserted by a highly skilled dentist.
Patient preference/acceptability anterior (incisors and cuspids) versus posterior (bicuspids and molars) permanent teeth	No evidence identified.	Burke et al.[6] postulated that some all-ceramic crowns may be replaced for aesthetic reasons rather than performance or need for replacement.
Study population: overall population living on urban and rural areas, with specifics for remote areas (if any)	No evidence identified.	
public and private plans altogether, with specifics for public plans	No evidence identified.	Burke et al.[6] found that patient payment exemption status had an effect on the longevity of crowns but did not present data based on crown type.
Canada and internationally	No evidence identified.	Evidence identified was from England, Wales, and Australia, not from Canada.

Aus = Australian; ICER = incremental cost-effectiveness ratio; PFM = porcelain fused to metal

[a] ICER expressed as the net cost (in Australian dollars) for each percentage unit increase in restoration survival.

[b]lower values mean higher benefits

[c]survival was shorter than the class I amalgam, cost was not less

Appendix 5: Additional Information

Clinical Effectiveness – no control group, or irrelevant control group:

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