Marginal Adaptation of CAD/CAM Restorations: A Systematic Review

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Authors’ contributions

This work was carried out in collaboration among all authors. Author KA concept of study and statistics application. Author RAM literature search and review. Author BAF extracting relevant data and review writing. Author MLB review writing and final draft preparation. All authors read and approved the final manuscript.

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ABSTRACT

Background: Several treatment options are available for restorative dental treatment of moderate to large teeth defects. However, in recent years, improved computer-aided design and computer-aided manufacturing (CAD/CAM) technology show several advantages, including favorable esthetic results, conservative preparation techniques and cost-effectiveness hence the aim of the study was to search for the best available evidence in investigating whether CAD/CAM fabricated partial coverage restorations will show better marginal adaptation and provide an evidence-based clinically relevant statement.

Methodology: An extensive search was performed using four online databases. Search strategies were developed for each online database, the studies were reviewed by three independent authors, and inclusion/exclusion criteria were applied and the quality of the included studies was assessed.

Results: The initial search resulted in 998 studies from all the databases. Six clinical studies were identified as relevant to the research question and were included in the qualitative assessment.

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1. INTRODUCTION

Increasing demand for conservative dental treatments has raised the mandate for improving the manufacturing process of ceramic restorations [1]. The evolution in adhesion dentistry research has guided the development in this field [2,3]. Despite the frequent use of traditional impression techniques for fabrication of dental restoration, computer-aided design and computer-aided manufacturing (CAD/CAM) provide enhanced alternatives due to the speed of the process of fabrication [4].

In 1985, cameras were used in order to formulate multidimensional measurements, referring the data to a computer screen, and from there to a milling machine using computer numerical control, thus the beginning of CAD/CAM restorations [5]. CAD/CAM restoration offers ease of use and speed; as traditional impressions take longer compared to scanning, and the milling machine is on site, which means patients can have the restoration performed on the same day, CAD/CAM can potentially offer reduced cost of treatment [6]. A recent study showed that CAD/CAM-fabricated restorations demonstrate promising results with a survival rate of 90.4% [7].

A successful dental restoration depends on a number of characteristics, such as marginal adaptation, esthetics, biocompatibility and mechanical strength [8]. The most important of these is the marginal fit, which is known to predict the longevity of dental restorations as well as the overall success. In the case of a defective or inadequate marginal fit, negative outcomes are often observed, such as negative effects on the tooth structural integrity and the periodontal tissue, or damage to the restoration itself. Additionally, if a marginal discrepancy exists, it can cause microleakage, dissolving cement and accumulation of plaque leading to pulpal lesions and inflammation of the gingiva [9].

A review published in 2015 on the marginal adaptation of CAD/CAM technology consisted of a total of 55 studies, which revealed that in most of the studies a clinically correct marginal discrepancy (MD) range was shown by CAD/CAM restorations [10]. However, it was also observed that these results were influenced by the type of restorative material used. Similarly, another review on the performance of CAD/CAM restorations assessed the failure rates and overall survival rates. The results gathered by these researches showed a 2.17% failure rate of CAD/CAM restorations per year [1]. This raises the question about the quality of the restorations fabricated in CAD/CAM in a particular marginal fit, as it is a key criterion for evaluating the success of restorations and quality [11]. Marginal adaptation of CAD/CAM-fabricated restorations is our scope of investigation in this research.

2. MATERIALS AND METHODS

The aim of this study is to search for the best available evidence in investigating whether CAD/CAM-fabricated partial coverage restorations will show better marginal adaptation and provide an evidence-based clinically relevant statement. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were used to perform this systematic review [12]. A comprehensive search for relevant studies was conducted using PubMed, the Cochrane Library, Web of Science, and the American Dental Association Library for Evidence-Based Dentistry. These databases were used to search for relevant studies according to the inclusion criteria. The studies that met the inclusion criteria were reviewed and the data obtained were used to help in conducting clinical recommendations.

The research question is the following: For cavitated teeth that require partial coverage restoration, do CAD/CAM-ceramic-fabricated restorations show better marginal adaptation when compared to direct composite restorations after three months of follow-up? The components of the research question (PICOT) in this review are as follows:

**Population:** Adult patients with cavitated permanent teeth that need partial coverage restorations

**Conclusions:** Marginal adaptation of CAD/CAM-fabricated restoration shows excellent clinical outcomes in short-term observation periods. There is a need for clinical trials that compare the clinical outcomes of CAD/CAM-fabricated restoration to direct composite restorations.

**Keywords:** Composite restoration; CAD/CAM restorations; ceramic inlay; ceramic onlay ceramic restorations; e-max restorations; partial coverage restorations; inlay; onlay.
**Intervention:** CAD/CAM-fabricated restoration

**Comparator:** Direct composite restorations

**Outcome:** Well-adapted restorations and sealed cavo-surface margin

**Timing:** Three months of follow-up.

Research hypothesis: CAD/CAM-fabricated restorations show better marginal adaptation compared to direct restorations. The inclusion criteria were:

- Clinical trials
- Observational studies
- Adult patients
- Permanent teeth only
- Papers in English
- 3 months of follow-up
- Papers published after 01/01/2000

The exclusion criteria were:

- Studies on primary teeth
- Animal studies
- Less than 3 months of recall visit evaluation
- Papers published earlier than 2000

Calibration of the readers was performed by evaluating a pilot study. Three readers evaluated the study for risk of bias, and then strength of recommendation. The process of evaluation was completed using the revised risk of bias instrument [13] and the Ex-GRADE [14]. The same criteria of assessment were used for evaluating the included studies.

Ethical approval for the current review was obtained from the research center at Riyadh Elm University (FIRP/2019/46/105/102).

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**Fig. 1.** PRISMA flow chart


3. RESULTS

The initial search generated 998 studies from three databases, plus records identified through other sources. The search process is summarized in Fig. (1). After duplicate removal and applying the inclusion/exclusion criteria, 599 were further screened and the final search that matched the PICOT question was six studies. These studies were evaluated for quality of the evidence and strength of recommendation, and an average score was calculated for all the readers. The studies included in the bibliometrics are as follows:

1. Two-year clinical evaluation of Cerec 3D ceramic inlays inserted by undergraduate dental students [15]
2. Clinical performance of large, all-ceramic CAD/CAM-generated restorations after three years [16]
3. All-ceramic partial coverage restorations—Midterm results of a 5-year prospective clinical split mouth study [17]
4. Evaluation of two different CAD/CAM inlay-onlays in a split mouth study: 2-year clinical follow-up [18]
5. Polymer-infiltrated ceramic CAD/CAM inlays and partial coverage restorations: 3-year results of a prospective clinical study over 5 years [19]
6. The clinical performance of CAD/CAM-generated composite inlays [20]

The assessment of these studies for quality of the evidence and strength of recommendation did not reveal any bias and showed strong quality of evidence.

4. DISCUSSION

Failed direct dental restorations are a major concern for all dentists at the present time. The accurate selection of the restorative dental materials and techniques is an essential factor for improving the survival rate of these restorations [21]. A recent systematic review reported an 83% mean rate of survival for direct composite restorations in general [22]. The current study aims to investigate whether CAD/CAM-fabricated partial coverage restorations will show better marginal adaptation. The comprehensive review and analysis of the included studies was performed in two steps. Results from these clinical studies were incorporated into a data extraction sheet. Then a brief summary was obtained from all the included studies for a qualitative consensus.

Qualitative analysis performed for the included studies and interpretation of the results focused on intervention and measurement of the outcomes.

1. Two-year clinical evaluation of Cerec 3D ceramic inlays inserted by undergraduate dental students [15]. In this study, 50 dental students placed a total of 60 restorations for 40 participating patients. Cerec 3D CAD/CAM was used for fabrication of felspathic ceramic inlays. These restorations were evaluated at baseline, 6, 12 and 24 months using US Public Health Service (USPHS) criteria. The evaluation for marginal adaptation required replacement in a single case only. The 2-year study reported acceptable clinical results in a short-term evaluation span.

2. Clinical performance of large, all-ceramic CAD/CAM-generated restorations after three years [16]. This is a pilot clinical study where 58 large all-ceramic restorations were placed using a Cerec 2 CAD/CAM system. However, these restorations were not fabricated by taking a direct scan of the prepared teeth. A traditional impression of the preparation made then used the Cerec system to scan the mounted casts. Only one case showed a marginal defect after 9 months during the 3-year follow-up evaluation using the USPHS criteria.

3. All-ceramic partial coverage restorations—Midterm results of a 5-year prospective clinical split-mouth study [17]. 25 patients received 80 CAD/CAM-fabricated ceramic restorations (40 ceramic IPS e.max press and 40 leucite-reinforced glass–ceramic ProCAD blanks). After three years of observation of partial coverage ceramic restorations within this prospective clinical study, only one restoration required replacement because of occlusal fracture. No marginal discrepancies were detected when examined using the USPHS assessment criteria.

4. Evaluation of two different CAD/CAM inlay-onlays in a split-mouth study: 2-year clinical follow-up [18]
In this clinical study, 14 patients received 60 indirect inlay/onlay restorations (30 lithium disilicate ceramic and 30 hybrid ceramic) fabricated by Cerec Omnicam. Patients were evaluated for up to 2 years after cementation according to USPHS criteria, in addition to plaque index and gingival index. The study reported no marginal defects in either group and concluded that hybrid ceramic is a reliable option for inlay/onlay restorations.

5. Polymer-infiltrated ceramic CAD/CAM inlays and partial coverage restorations: 3-year results of a prospective clinical study over 5 years [19]

A prospective clinical trial was conducted in which 47 participants were provided with 103 inlays and partial coverage crowns. A traditional impression was taken, and then the cast was scanned by CAD/CAM to fabricated ceramic restorations using Cerec in Lab. The evaluation of these restorations was made using USPHS criteria, and during the 36 months of observation, the restorations showed no marginal discoloration or clinically unacceptable adaptation. The results indicated that polymer-infiltrated ceramics showed promising clinical outcomes during a period of three years of observation.

6. The clinical performance of CAD/CAM-generated composite inlays [20-22]

Two clinicians treated 43 patients with 80 indirect inlays (40 porcelain Vita Mark II and 40 resin-based composite Paradigm 3M ESPE). These restorations were placed on posterior teeth (37 molars and 43 premolars). The evaluation of these restorations was done according to USPHS criteria at 6 months, 1 year, 2 years and 3 years. The evaluation of marginal adaptation showed excellent clinical outcomes with no restoration showing crevice formation (Bravo score) after three years of follow-up.

The included clinical studies have shown that CAD/CAM-fabricated restoration produced favorable clinical results in short-term evaluations. The clinical recommendation encourages the use of partial indirect restorations for moderate to large defects. Although there was no direct comparison within these studies with direct restorations, the high survival rate indicates superiority of indirect restoration in marginal adaptation.

5. LIMITATIONS

There is a major limitation in this field of research due to the differences in materials used with the CAD/CAM systems. Moreover, the main limitation of this review is the absence of comparison with direct restorations, in addition to the small sample size within multiple studies of the current systematic review. Furthermore, the inclusion criteria restricted the search to studies published in English, which limits the inclusion of some relevant literature.

6. CONCLUSION

There is strong evidence to support the use of CAD/CAM-fabricated partial restorations in treating moderate to large teeth defects in posterior teeth. The success of CAD/CAM-fabricated restorations has been confirmed in short-term evaluations of up to 36 months. In particular, marginal adaptation of CAD/CAM-fabricated restoration shows excellent clinical results. The improvement in bonding techniques and the development in CAD/CAM systems support the shift to digital dentistry.

7. RESEARCH RECOMMENDATIONS

There is a need for clinical trials that compare the clinical outcomes of CAD/CAM-fabricated restoration to direct composite restorations. Additionally, there is a need for more clinical studies with longer observational periods.

7.1 Clinical Recommendations

The success of direct and indirect restoration depends on the accuracy of the dentist’s diagnosis and assessment of the case, in addition to the correct choice of dental materials. One of the main objectives of restorative treatment is preserving the remaining tooth structure. CAD/CAM-fabricated restoration shows promising clinical outcomes in conservative treatment of cases with moderate to large cavities.

CONSENT

It is not applicable.
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