Review Article

MECHANICAL PROPERTIES, OCCLUSAL FIT AND SUCCESS OF CAD/CAM DESIGNED CERAMIC ENDOCROWNS: A SYSTEMATIC REVIEW

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ABSTRACT

Today, end crowns are broadly used as alternatives to the traditional fixed partial and post-core dentures. Mechanically, a conventional endodontic fabricated cavity has minimal fractural resistance to a given tooth. On the other hand, ceramic endocrowns' thickness of the occlusal portion is usually between three and seven millimeters. Empirical studies have demonstrated that the fracture resistance of ceramic endocrowns intensifies when occlusal thickness increases. This systematic review aimed to determine the association between mechanical properties and occlusal fit to CAD/CAM Designed ceramic endocrowns' success rates. Systematic review and PRISMA meta-analysis guidelines were adopted to collect relevant studies with accurate information. The primary investigator described in detail the adopted research approach, inclusion, and exclusion criteria. Furthermore, the author explained the Cochrane risk of bias assessment of the selected studies in a tabulated format. 13 peer-reviewed articles were selected after a procedural screening based on the inclusion criteria. The findings and objectives of each study were tabulated for a straightforward interpretation of the outcome. The discussion provided insights into the topic based on the interpretation and critics of the empirical findings. In conclusion, CAD/CAM Designed ceramic endocrowns were found to be the most successful restoration tools in contemporary prosthodontics.

Key words: CAD/CAM Designed ceramic endocrowns, Occlusal fit, Mechanical properties, Success rates.

Introduction

In this systematic review, the association of occlusal fit, mechanical properties, and success rate of ceramic computer-aided design/computer-assisted manufacturing (CAD/CAM) endocrown is the point of interest in this systematic review. Mechanical properties of the ceramic endocrown are about the tensile strength, elasticity, hardness, fatigue limits, and others. The superior occlusal accuracy of the fabricated endocrowns is also of interest because it determines their success. Today, end crowns are broadly used as alternatives to the traditional fixed partial and post-core dentures [1]. Mechanically, a conventional endodontic fabricated cavity has minimal fractural resistance to a given tooth. On the other hand, ceramic endocrowns' thickness of the occlusal portion is usually between three and seven millimeters (mm). Empirical studies have demonstrated that the fracture resistance of ceramic endocrowns intensifies when occlusal thickness increases [1]. One is right to reason that when the mechanical properties and the occlusal fit are attained, the success rate of CAD/CAM Designed Ceramic Endocrowns is assured.

Ceramic restorations using ceramic CAD/CAM systems involve the use of feldspathic ceramic blocks [1]. Over the last decade, CAD/CAM technology has gained profound popularity and advances in the material used [2]. Spitznagel *et al*. (2018) explain that advancements in these technologies and ease of usage facilitated novel therapy concepts and ideologies for contemporary prosthodontics [3]. The different CAD/CAM ceramic restorative procedures are continuously transforming to address the augmented demands for long-lasting, aesthetic, and biocompatible prosthodontics. The latest polymer-infiltrated ceramic CAD/CAM blocks give the specialist a new option and add an innovative treatment approach to the restorations practice.

The high-edge stability of the CAD/CAM ceramic endocrowns facilitates the machinability of thin restoration layers [3]. Furthermore, industrially enhanced feldspathic ceramics are more applicable in CAD/CAM processes than other dental ceramic materials because they have better structural homogeneity and fracture. CAD-CAM endocrowns fabricated using flexible and malleable fused resin blocks are better choices to all-ceramic crowns because of marginal adaptation [4]. According to Sevimli *et al*. (2015), the comparable flexural strength advantages of these composite ceramic blocks and ferrule outcomes are significant for attaining the desired results [1]. Hassanzadeh *et al*. (2019) conducted a study to compare and evaluate the marginal and internal "adaptations of chairside CAD/CAM (CEREC) endocrowns and crowns fabricated from lithium

disilicate glass-ceramic (IPS e.max CAD), zirconia-reinforced lithium silicate glass-ceramic (VITA Suprinity), and hybrid ceramic (VITA Enamic) [2].” Their results showed that endocrowns had a significantly lower mesial axial wall and occlusal discrepancies than crowns, while distal axial wall revealed a significantly higher contrast. In addition, endocrowns’ floor discrepancy was significantly lower than crowns; however, type material showed no significant consequence [2]. From the discrepancy variations, a knowledge gap would be completed or enriched with additional insights after completing this systematic review.

Materials and Methods

The investigator adopts a systematic review methodology and meta-analyses (PRISMA) guidelines to complete the study. A systematic review involves collecting the evidence after appraising critically pertinent primary studies and extracting befitting data for analysis and inclusion [5]. The *Cochrane Handbook for Systematic Reviews of Interventions*, “Systematic reviews seek to collate evidence that fits pre-specified eligibility criteria to answer a specific research question” [5]. Ranganathan and Aggarwal (2020) outline six sequential steps for a systematic review [6]. The first step is stating the review question. The second step is listing the eligibility criteria, while the third step is comprehensive research. The fourth stage is the selection and identification of relevant studies. Data extraction and synthesis of the results are steps five and six, respectively [6]. These steps are observed in this study using Cochrane risk of bias assessment and PRISMA guidelines and flowchart.

Inclusion and exclusion criteria

Inclusion and exclusion criteria are significant for systematic review because they set limits on sample size, availability of relevant articles, quality of papers, and others [7]. **Table 1** provides inclusion and exclusion criteria for the current study.

Table 1. Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion criteria
• **Studies evaluating endocrowns** • **Language English** • **Studies from the year 2011 to 2021** • **Peer-review and scholarly literature** • **Full-texts that are extracted based on keywords** • **CAD/CAM Designed Ceramic Endocrowns**	• Animal teeth • Outdated studies 2010 backward • Non-peer-review, such as blogs or other website posts • Abstract-only search • Nonmonolithic endocrowns

PRISMA flowchart

Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) is an evidence-based set of records gathered for reporting in a meta-analysis and systematic reviews. PRISMA assists researchers to enhance the reporting of collected studies and reporting of systematic reviews [8]. It is viable for various types of research; such as randomized trials, evaluations of interventions, and systematic review [8]. It focuses on the documenting and reporting of reviews assessing the effects of interventions and a foundation for reporting systematic reviews with reasons [9]. **Figure 1** presents the PRISMA flowchart reporting the steps taken to identify eligible articles based on the inclusion and exclusion criteria. The articles were collected from databases Google scholar and screening entailed publication restrictions (2011 to 2021) and full articles.

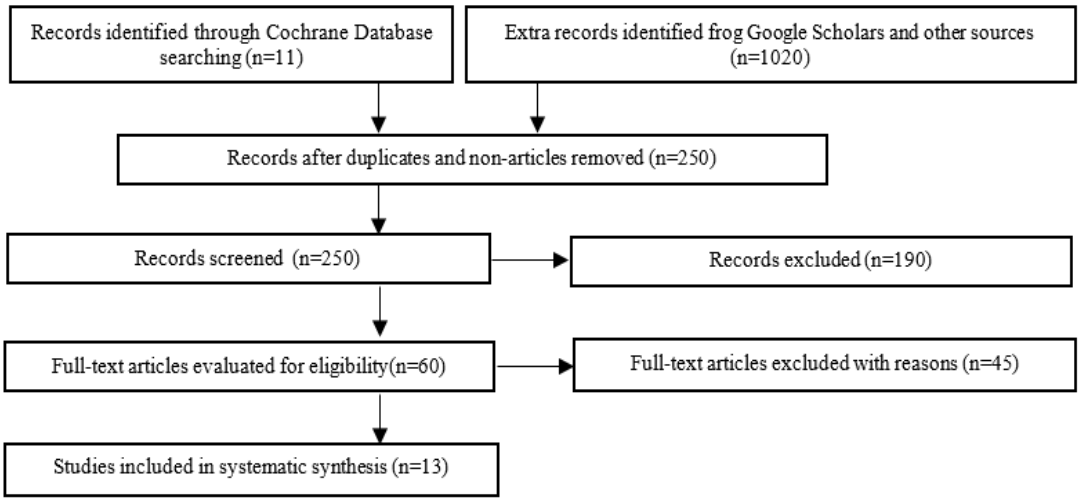

Figure 1. PRISMA Flowchart. (Source: Adapted from UNC (2021) [8])

Cochrane risk of bias assessment

Assessing risk of bias (RoB) is an integral part of Cochrane systematic reviews (CSRs). Systematic reviews entail collecting and synthesizing relevant studies meeting eligibility criteria set to minimize bias [10]. The primary investigator or author cautiously considers likely limitations of the incorporated studies. The assessment seeks to consider the extent to which the studies were suitable to answer the research question. However, RoB is an essential component of the Cochrane assessment procedure for systematic reviews [10]. Seven principles for evaluating Cochrane RoB are 1) not using quality scales, 2) concentrating on internal validity, 3) assessing in trial results, 4) judgment required, 5) theoretical and empirical domains considered 6) focus on data, and 7) report the specific outcome. Using quality scales makes it difficult to ascertain consistency or predictable assessment criteria [10]. Poor internal validity has high RoB and vice versa.

RoB is assessed based on the results, not methodological or reporting challenges. In a systematic review, a description of the details or lack is applicable for determining RoB. Knowledge and judgment are necessary elements of RoB assessment because they help discern various aspects of the content [10]. Empirical and theoretical considerations help identify the RoB based on the topic and design specific issues associated with the reviews. Data used in a study should focus on evaluating bias rather than reported results, which could have a high or low bias based on input. Lastly, the author should report specific assessments of risks of bias [10]. In assessing the RoB, the Cochrane tool or table engages in six domains, namely selection, detection, performance, reporting, attrition, and other bias [10]. To assess the current studies for this systematic review, the Cochrane RoB table is used as shown in **Table 2**. The research question is "what are the mechanical properties, occlusal fit, and success rate associated with CAD/CAM designed ceramic endocrowns?

Table 2. Cochrane RoB Table

Article	Bias	Judgment	Explanation/Comment
[11]	Self-reported outcomes (Detection bias)	High risk	Quote: "Endocrowns are a reliable alternative to post-retained restorations for molars and seem promising for premolars." Comment: records are responses given by participants whose binding is not fully described
[12]	Allocation concealment (selection bias)	Unclear risk	Comment: 37 patients and 47 restorations were included based on sampling with unclear or inadequate randomization
[13]	Incomplete outcome data (attrition bias)	High risk	Comment: Authors identified knowledge gaps for further studies to assess the longevity of CAD/CAM-designed ceramic restorations.
[14]	Blinding of participants (performance bias)	Unclear risk	Comment: A systematic review of studies whose participants could have been blinded; however, the authors did not describe the blinding effect.
[15]	Selective reporting (reporting bias)	High risk	Comment: a statistically significant difference finding does not give specific success rate metrics of a ME design.
[2]	Other bias	Low risk	Comment: the authors provide a comprehensive review of 72 CAD/CAM restorations and identify discrepancies between endocrown and crown with minimal bias
[3]	Selective reporting (reporting bias)	Unclear	Comment: Findings show CAD/CAM applications offer a normalized manufacturing procedure without a clear success rate of endocrown restorations outcome.
[16]	Blinding of participants (performance bias)	Unclear risk	Comment: Statistically significant differences demonstrate a variance in CAD/CAM materials performance; however, no description of a possible effect of participant blinding
[17]	Self-reported outcome (detection bias)	Low	Comment: study findings demonstrated that ME restoration design performs better than traditional endocrown with a minimum overall failure probability.
[18]	Allocation concealment (selection bias)	Unclear	Comment: Results showed a 98.66% of restorations with only 6 failures; however, no clear demonstration of participant randomization

[19]	Other bias	Low	Comment: the researchers observed randomization, inclusion criteria, self-reported findings, and other factors; hence, the low concern of other bias.
[1]	Incomplete outcome data (attrition bias)	High	Comment: reporting of findings is not well structured; thus, it is not easy to relate outcomes to the current study
[4]	Blinding of participants (performance bias)	Low	Comment: there is a detailed description of the methodology and participation.

Source: Adapted from Cumpston (2012) [20]

Results and Discussion

Using the search criteria, the search of the Cochrane database yielded 11 results, while Google Scholars had 1020 results. The first screening was based on duplicates and non-articles, leading to the remaining 250, further screened based on peer reviews and date specification criteria, leaving 60 full-text eligible articles. After reading abstracts, 13 articles had the most relevant content for this systematic review.

Table 3. Summary of findings from Selected Studies

Year	Author	Inclusion criteria	Objective	Findings
2021	Vervack, De Coster, and Vandeweghe	Full-text peer-reviewed article	To assess CAD/CAM restorations outcomes in a cohort study and evaluate satisfaction following restoration.	CAD/CAM showed satisfactory outcome endocrown restorations and overlays.
2020	Albelasy *et al*.	Full-text peer-reviewed article	The aim was to summarize scientific evidence of fatigue strength in vitro fracture of occlusal veneers using varied CAD/CAM materials thicknesses.	The authors established a correlation between the materials, fracture strength, and occlusal veneers withstood bite forces; however, the thickness should be standardized.
2020	Ansari, H. S. *et al*.	Full-text peer-reviewed article	To establish success rates of endocrowns ceramics in dental practice	Records indicated that endocrowns are desirable restorative instruments in dentistry.
2020	Ghoul *et al*.	Full-text peer-reviewed article	The purpose was to evaluate fracture resistance, stress concentration, and failure mode of a modified endocrown	Modified endocrown (ME) showed higher fracture resistance compare to traditional endocrown, and normal masticatory forces were recorded.
2019	Hassanzadeh *et al*.	Full-text peer-reviewed article	To compare and assess the marginal and internal adaptations of chairside CAD/CAM (CEREC) endocrowns and fabricated crowns	CEREC revealed lower mesial axial wall discrepancy to occlusal inconsistency in crowns; floor discrepancy was also significantly lower with no substantive effect on the material.
2019	Govare and Contrepois	Full-text peer-reviewed article	The purpose was to establish the reliability of endocrowns for restoration of damaged endodontically treated teeth (ETT	Results revealed that endocrown had an impressive restoration of extensively damaged ETT compared to post-retained foundations.
2018	Spitznagel, Boldt, and Gierthmuehlen	Full-text peer reviewed article	To establish the impact of advances in CAD/CAM technologies as contemporary prosthodontics.	Findings indicated that CAD/CAM applications provide a normalized manufacturing procedure with the reliable outcome for complex teeth-reinforced restorations.
2018	Zimmermann *et al*.	Full-text peer-reviewed article	To assess the fit of CAD/CAM ceramic endocrowns using a novel 3D assessment method for the intraoral scanning approach.	Results showed statistically significant variances in CAD/CAM materials even though the CAM uses an identical procedure.
2017	Gulec and Ulusoy	Full-text peer-reviewed article	To evaluate the outcome of two endocrown designs and CAD/CAM on failure probability and stress distribution of restorations on damaged ETT.	Findings showed that modified endocrown (ME) with VITA ENAMIC (VE) was the best restorative choice for premolar teeth with a massive coronal structural loss under increased occlusal loads.

2017	Fages *et al*.	Full-text peer-reviewed article	To analyze the clinical results of 447 monoblock ceramic chairside CAD/CAM reconstructions for more than seven years.	Findings indicated that the CAD/CAM complete ceramic endocrowns had a higher and favorable survival rate on molars.
2016	Botto, Barón, and Borgia	Full-text peer-reviewed article	The purpose was to present the retrospective scientific performance of selected endocrowns used in a single practice.	Results showed that endocrown is an aesthetic and conservative technique-sensitive process applicable for to restoration of damaged posterior ETT with a good functional and biomechanical performance and acceptable longevity.
2015	Sevimli, Cengiz, and Oruc 2015	Full-text peer-reviewed article	To assess the restoration of ETT despite the controversial discussions in the empirical findings	The result compared showed that endcrowns had a better mechanical performance at a cheaper cost and less clinic time.
2013	Ramírez-Sebastià *et al*.	Full-text peer-reviewed article	To evaluate and contrast the marginal adaptation between composite and ceramic CEREC crowns in ETT restored using endocrowns.	Results showed that fabricated CAD-CAM crowns using malleable composite resin blocks provide a superior choice to all-ceramic crowns.

The findings had some discrepancies in the materials used; however, the outcome showed that CAD/CAM ceramics endocrowns mechanical properties and occlusal fit for successful rate in modern prosthodontics.

Conclusion

In this study, the investigator found that CAD/CAM ceramics endocrowns are the most reliable contemporary prosthodontics because their mechanical properties and occlusal fitness facilitate a higher success rate than conventional crowns or other procedures. Zimmermann *et al*. (2018) explain that experts could use a broad range of CAD/CAM materials for a single-tooth replacement or restoration [16]. The mechanical properties of CAD/CAM materials determined the fabrication accuracy [16]. The mechanical properties could be linked to the significantly lower mesial axial wall and floor discrepancies. Nonetheless, Hassanzadeh *et al*. (2019) argue that type of material had little or no significant impact on reported differences [2]. Discrepancies notwithstanding, Fages *et al*. (2017) report that CAD/CAM full ceramic endocrowns have a much more favorable survival rate compared to conventional or other types of endocrowns [18]. This outcome emphasizes the significance of the mechanical properties of endocrowns.

On the subject of mechanical property, Ramírez-Sebastià *et al*. (2013) found that fabricated CAD/CAM crowns using flexible or malleable composite resin blocks provided better performance than all-ceramic ones crowns [4]. Endocrowns are superior to crowns; hence, CAD-CAM ceramic endocrowns offer a much superior success rate because of flexibility, strength, and occlusal fit using standardized thickness. Furthermore, ceramic endocrowns have better mechanical performance, less cost and clinic time, and a suitable aesthetic compared to conventional techniques. [1]. Spitznagel *et al*. (2018) support the findings by reiterating that CAD/CAM applications offer a standardized application process leading to predictable, reliable, and economically complex teeth-supported restorations [3]. They are more convenient and practical for restoring extensively damaged ETT than post-retained crown foundations [11]. CAD/CAM ceramic endocrown is a suitable tool for restorations when integrated with air abrasion, immediate dentin sealing (IDS), and 10-methacryloyloxydecyl dihydrogen phosphate (MDP)-containing adhesive procedures for marginal disintegration over a long period [12]. Mechanical property has a significant effect on CAD/CAM ceramic endocrown restoration success.

The correct choice of prosthodontics material significantly addresses the fracture strength. Hence, occlusal veneers are considered a fit for withstanding bite forces, while the thickness of the material remains standardized [13]. ME design has demonstrated higher fracture resistance [15]. Mainly ME with VE presenting the best restorative choice for teeth with extensive degradation of the coronal structure following high occlusal outcomes [17]. In short, endocrown remains a modern and aesthetic technique-sensitive procedure for the successful restoration of posterior ETT, particularly molars, with good longevity, ideal functional and biomechanical performance [19]. Endocrowns remain the desirable restorative instruments in dentistry with massive support from significant empirical findings and publications [14]. In conclusion, this systematic review has demonstrated that CAD/CAM ceramic endocrowns have a higher success rate because of occlusal fitness and mechanical properties, such as longevity, flexibility, and structural strengths.

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