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Original Article

Influence of Mechanical Properties and Occlusal Fit on the Success of CAD/CAM Ceramic Endocrowns

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ABSTRACT

Endocrowns have become widely accepted as an alternative to conventional fixed partial dentures and post-core restorations. From a mechanical standpoint, traditional endodontically treated cavities exhibit low fracture resistance. In contrast, ceramic endocrowns typically feature an occlusal portion ranging in thickness from 3 to 7 millimeters. Research suggests that increasing this occlusal thickness enhances the fracture resistance of ceramic endocrowns. This systematic review aimed to investigate the relationship between mechanical properties, occlusal fit, and the success rates of CAD/CAM-designed ceramic endocrowns. To ensure the reliability of the findings, the study followed systematic review protocols and adhered to PRISMA meta-analysis guidelines in selecting relevant literature. The principal investigator outlined the research methodology by specifying the inclusion and exclusion criteria. In addition, a Cochrane risk of bias assessment was performed and presented in a tabular format. After a rigorous screening process, 13 peer-reviewed studies met the inclusion criteria. A structured summary of the objectives and findings of each study facilitates a clear interpretation of the results. The discussion critically analyzed these empirical findings, offering valuable insights into the topic. Finally, the review concluded that CAD/CAM-designed ceramic endocrowns are one of the most effective restorative options in modern prosthodontics.

Keywords: Success rates, CAD/CAM Designed ceramic endocrowns, Mechanical properties, Occlusal fit

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Introduction

This systematic review examines the correlation between occlusal fit, mechanical properties, and the success rate of ceramic computer-aided design/computer-assisted manufacturing (CAD/CAM) endocrowns. The mechanical properties of these restorations include tensile strength, elasticity, hardness, and fatigue limits. Additionally, precise occlusal adaptation is essential, as it significantly influences the longevity and performance of endocrowns. In contemporary dentistry, endocrowns are widely recognized as viable alternatives to traditional fixed partial dentures and post-core restorations [1]. Endodontically treated cavities in conventional restorations generally have low fracture resistance, whereas ceramic endocrowns typically feature an occlusal thickness ranging between 3 and 7 millimeters (mm). Research has indicated that increasing the occlusal thickness enhances the fracture resistance of ceramic endocrowns [1]. Therefore, achieving optimal mechanical properties and occlusal fit is fundamental to ensuring the success of CAD/CAM Designed Ceramic Endocrowns.

The production of ceramic restorations using CAD/CAM systems relies on feldspathic ceramic

blocks [1]. Over the past decade, the widespread adoption of CAD/CAM technology has been accompanied by significant advancements in restorative materials [2]. As noted by Spitznagel et al. [3], these technological improvements and their user-friendly nature have contributed to the development of innovative treatment strategies in modern prosthodontics. The evolution of CAD/CAM ceramic restorative techniques continues to meet the increasing demand for long-lasting, aesthetic, and biocompatible prosthodontic solutions. The latest polymer-infiltrated ceramic CAD/CAM blocks have introduced new possibilities for specialists, offering an innovative approach to contemporary restoration practices.

The superior edge stability of CAD/CAM ceramic endocrowns allows for the precise machining of thin restoration layers [3]. Additionally, feldspathic ceramics that have undergone industrial enhancements are particularly well-suited for CAD/CAM applications compared to other dental ceramic materials, as they exhibit greater structural uniformity and fracture resistance. Endocrowns fabricated from flexible and malleable fused resin blocks offer superior marginal adaptation, making them a more favorable option than traditional all-ceramic crowns [4].

Sevimli *et al.* [1] highlighted that the comparable flexural strength of these composite ceramic blocks, along with the influence of ferrule effects, plays a crucial role in achieving optimal restorative outcomes. A study by Hassanzadeh *et al.* [2] assessed the marginal and internal fit of chairside CAD/CAM (CEREC) endocrowns and compared them with crowns made from lithium disilicate glass-ceramic (IPS e.max CAD), zirconia-reinforced lithium silicate glass-ceramic (Vita Suprinity), and hybrid ceramic (Vita Enamic). The findings indicated that endocrowns demonstrated significantly lower discrepancies in the mesial axial wall and occlusal regions compared to crowns, whereas the distal axial wall exhibited a noticeably higher contrast. Furthermore, the discrepancy at the endocrown floor was significantly lower than that of crowns, although the type of material used did not produce a statistically significant effect [2]. The observed variations in discrepancies suggest a need for further research to bridge existing knowledge gaps, which this systematic review aims to address.

Materials and Methods

The study follows a systematic review approach, adhering to meta-analysis (PRISMA) guidelines. A systematic review entails gathering and critically evaluating relevant primary studies before extracting suitable data for analysis and inclusion [5]. According to 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 [6] describe six key steps involved in conducting a systematic review. The process begins with formulating the research question, followed by defining the eligibility criteria. The third step involves conducting an extensive literature search, while the fourth focuses on identifying and selecting relevant studies. The fifth step includes extracting data, and the final step involves synthesizing the results [6]. This study follows these methodological steps, incorporating the Cochrane risk of bias assessment and utilizing PRISMA guidelines along with a flowchart to ensure a structured and transparent review process.

Inclusion and exclusion criteria

Establishing inclusion and exclusion criteria is essential in a systematic review, as it helps define the sample size, ensures the selection of relevant articles, and maintains the quality of the included studies [7]. **Table 1** outlines the specific inclusion and exclusion criteria applied in this study.

Table 1. Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
• Research focusing on endocrowns • Publications available in English • Studies published between 2011 and 2021 • Scholarly and peer-reviewed sources • Full-text articles retrieved using keyword-based searches • Investigations related to CAD/CAM-designed ceramic endocrowns	• Studies involving animal teeth • Research published before 2011 • Non-peer-reviewed sources, including blogs or general website content • Articles available only as abstracts • Endocrowns that are not monolithic

PRISMA flowchart

The preferred reporting items for systematic reviews and meta-analyses (PRISMA) is an evidence-driven framework designed to improve the transparency and consistency of reporting in meta-analyses and systematic reviews. PRISMA helps researchers enhance the clarity and comprehensiveness of study reporting in systematic reviews [8]. It is applicable across various research types, including randomized trials, intervention evaluations, and systematic reviews [8]. The framework emphasizes the proper documentation and presentation of reviews focused on intervention effects, providing a structured foundation

for systematic review reporting with clear justifications [9]. **Figure 1** illustrates the PRISMA flowchart, outlining the process followed to identify eligible studies based on the predefined exclusion and inclusion criteria. The articles were sourced from databases like Google Scholar, and the screening process involved publication restrictions (2011 to 2021) and full-text availability.

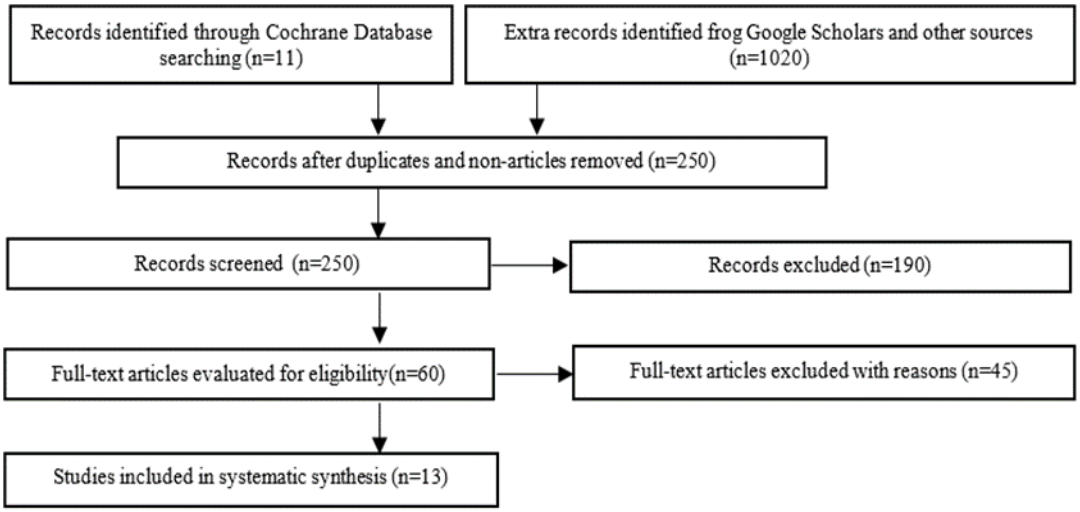

Figure 1. PRISMA flowchart (Source: Adapted from UNC [8]).

Cochrane risk of bias assessment

Evaluating the risk of bias (RoB) is a crucial element in Cochrane systematic reviews (CSRs). These reviews involve gathering and synthesizing relevant studies that meet predefined eligibility criteria to minimize bias [10]. The primary investigator carefully examines potential limitations within the included studies. The goal of this assessment is to evaluate how well the studies address the research question. RoB remains a vital component of the Cochrane evaluation process for systematic reviews [10]. 7 key principles for assessing Cochrane RoB include: 1) avoiding the use of quality scales, 2) focusing on internal validity, 3) evaluating trial results, 4) making judgments based on evidence, 5) considering both theoretical and empirical aspects, 6) emphasizing data, and 7) reporting specific outcomes. The use of quality scales complicates the ability to achieve consistency or predictability in assessments [10]. Poor internal validity is associated with a higher RoB, and the opposite is true as well.

Risk of bias (RoB) is evaluated based on the outcomes, rather than issues related to methodology or reporting. In a systematic review, the presence or absence of specific details is crucial for determining RoB. Expertise and judgment are key factors in the assessment process, as they help distinguish different aspects of the included studies [10]. Both theoretical and empirical considerations are vital for identifying RoB, especially when addressing topic-specific and design-related challenges within the reviews. The data used in research should prioritize evaluating bias, rather than relying solely on the reported results that could carry varying levels of bias depending on the input. Finally, the author must provide a detailed report on the specific RoB assessments [10]. The Cochrane tool or table is utilized to assess RoB across six domains: selection, detection, performance, reporting, attrition, and other biases [10]. For the studies included in this systematic review, the Cochrane RoB table is applied, as seen in **Table 2**. The research question guiding this review 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]	Bias due to self-reported outcomes (detection bias)	High risk	Quote: "Endocrowns provide a dependable option compared to post-retained restorations for molars and show potential for use in premolars." Comment: The records represent responses from participants, but the details of their binding have not been thoroughly explained.
[12]	Bias from allocation	Unclear risk	Comment: A total of 37 patients and 47 restorations were included, but the sampling method lacked clear or sufficient randomization.

	concealment (selection bias)		
[13]	Bias from incomplete outcome data (attrition bias)	High risk	Comment: The authors highlighted areas of limited understanding, suggesting the need for additional research to evaluate the long-term performance of CAD/CAM-designed ceramic restorations.
[14]	Bias from lack of blinding of participants (performance bias)	Unclear risk	Comment: This systematic review includes studies where participant blinding was possible, but the authors didn't provide details regarding the impact of blinding.
[15]	Bias from selective reporting (reporting bias)	High risk	Comment: The identification of a statistically significant difference does not provide precise success rate metrics for an ME design.
[2]	Other types of bias	Low risk	Comment: The authors present an extensive analysis of 72 CAD/CAM restorations, highlighting differences between endocrowns and crowns with minimal bias.
[3]	Bias from selective reporting (reporting bias)	Unclear	Comment: The findings indicate that CAD/CAM applications provide a standardized manufacturing process, but the success rate of endocrown restorations remains unclear.
[16]	Bias from lack of blinding of participants (performance bias)	Unclear risk	Comment: Statistically significant differences reveal variability in the performance of CAD/CAM materials, yet there is no mention of how participant blinding might have influenced the results.
[17]	Bias due to self-reported outcomes (detection bias)	Low	Comment: The study results showed that the ME restoration design outperforms the traditional endocrown, exhibiting a lower overall failure probability.
[18]	Bias from allocation concealment (selection bias)	Unclear	Comment: The results indicated that 98.66% of restorations were successful, with only six failures; however, there was no clear indication of how participants were randomized.
[19]	Other types of bias	Low	Comment: The researchers considered randomization, inclusion criteria, self-reported outcomes, and other elements, leading to minimal concern regarding other biases.
[1]	Bias from incomplete outcome data (attrition bias)	High	Comment: The presentation of findings lacks clear organization, making it difficult to connect the outcomes to the present study.
[4]	Bias from lack of blinding of participants (performance bias)	Low	Comment: The methodology and participant details are thoroughly explained.

Source: Adapted from Cumpston [20]

Results and Discussion

Using the specified search criteria, a search of the Cochrane database returned eleven results, while Google Scholar provided 1020 results. The initial screening removed duplicates and non-articles, narrowing the pool to 250, which were then further filtered based on peer review status and publication date, leaving 60 full-text articles. After reviewing the abstracts, 13 articles were selected as the most relevant for inclusion in 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 evaluate the outcomes of CAD/CAM restorations in a cohort study and assess satisfaction after the restoration process.	CAD/CAM demonstrated positive results for endocrown restorations and overlays.
2020	Albelasy *et al*.	Full-text peer-reviewed article	The objective was to consolidate scientific findings on the fatigue strength and in vitro fracture of occlusal veneers made from different CAD/CAM material thicknesses.	A correlation was found between the materials used, fracture strength, and the ability of occlusal veneers to withstand bite forces; however, standardization of thickness is recommended.

2020	Ansari *et al*.	Full-text peer-reviewed article	The goal was to determine the success rates of ceramic endocrowns in dental clinical applications.	Records suggested that endocrowns are highly favored as restorative tools in dentistry.
2020	Ghoul *et al*.	Full-text peer-reviewed article	The objective was to assess the fracture resistance, stress distribution, and failure patterns of a modified endocrown.	The modified endocrown (ME) exhibited greater fracture resistance compared to traditional endocrowns, with normal masticatory forces recorded.
2019	Hassanzadeh *et al*.	Full-text peer-reviewed article	The goal was to compare and evaluate the marginal and internal fit of chairside CAD/CAM (CEREC) endocrowns and conventionally fabricated crowns.	CEREC showed lower mesial axial wall discrepancies and improved consistency in occlusal crowns, with floor discrepancies being significantly reduced and no major impact on the material.
2019	Govare and Contrepois	Full-text peer-reviewed article	The aim was to determine the reliability of endocrowns for restoring teeth that have undergone endodontic treatment (ETT).	Results demonstrated that endocrowns were highly effective in restoring severely damaged ETT when compared to post-retained foundations.
2018	Spitznagel, Boldt, and Gierthmuehlen	Full-text peer reviewed article	The goal was to assess the impact of CAD/CAM technological advancements in modern prosthodontics.	Findings revealed that CAD/CAM technologies offer a standardized manufacturing process with reliable outcomes for complex tooth restorations.
2018	Zimmermann *et al*.	Full-text peer-reviewed article	The objective was to evaluate the fit of CAD/CAM ceramic endocrowns using a new 3D assessment method applied to intraoral scanning.	The study showed significant differences in CAD/CAM material performance, despite the use of the same manufacturing procedure.
2017	Gulec and Ulusoy	Full-text peer-reviewed article	The aim was to compare two endocrown designs and CAD/CAM technologies concerning failure probability and stress distribution on restorations of damaged ETT.	The modified endocrown (ME) using Vita Enamic (VE) was identified as the optimal restoration choice for premolars with a significant coronal loss under high occlusal forces.
2017	Fages *et al*.	Full-text peer-reviewed article	The purpose was to analyze clinical outcomes from 447 monoblock ceramic chairside CAD/CAM restorations over more than seven years.	CAD/CAM complete ceramic endocrowns were found to have higher and more favorable survival rates on molars.
2016	Botto, Barón, and Borgia	Full-text peer-reviewed article	The goal was to present a retrospective analysis of the performance of selected endocrowns used in a single dental practice.	Endocrowns were found to be an aesthetic, conservative, and technique-sensitive approach for restoring damaged posterior ETT, offering good functional performance, biomechanical stability, and acceptable longevity.
2015	Sevimli, Cengiz, and Oruc	Full-text peer-reviewed article	The objective was to assess the restoration of ETT, amidst ongoing debates regarding empirical findings.	Comparisons showed that endocrowns provided better mechanical performance at a lower cost and with reduced clinical time.
2013	Ramírez-Sebastià *et al*.	Full-text peer-reviewed article	The aim was to compare the marginal adaptation of composite and ceramic CEREC crowns in ETT restored using endocrowns.	Results indicated that CAD/CAM crowns made from malleable composite resin blocks were a superior option compared to all-ceramic crowns.

While there were some inconsistencies in the materials used, the results demonstrated that CAD/CAM ceramic endocrowns exhibit favorable mechanical properties and occlusal fit, contributing to their success rate in contemporary prosthodontics **(Table 3)**.

Conclusion

In this investigation, the researcher concluded that CAD/CAM ceramic endocrowns are the most dependable choice in modern prosthodontics due to their mechanical properties and occlusal fit, resulting in a higher success rate compared to traditional crowns or alternative procedures. Zimmermann *et al.* [16] highlight that a wide variety of CAD/CAM materials

can be used for single-tooth restorations or replacements. The accuracy of fabrication is influenced by the mechanical properties of the CAD/CAM materials [16], which also correlate with notably lower mesial axial wall and floor discrepancies. However, Hassanzadeh *et al.* [2] suggest that the material type has minimal or no notable effect on the observed differences. Despite these discrepancies, Fages et al. [18] found that CAD/CAM full ceramic endocrowns exhibit a considerably higher survival rate than conventional or other types of endocrowns, underscoring the importance of the mechanical properties of endocrowns.

Ramírez-Sebastià *et al.* [4] demonstrated that CAD/CAM crowns made from flexible or malleable composite resin blocks outperformed all-ceramic crowns in terms of performance [4]. CAD/CAM ceramic endocrowns are superior to traditional crowns, offering higher success rates due to their strength, flexibility, and occlusal fit with standardized thickness. In addition, ceramic endocrowns provide better mechanical performance, lower costs, reduced clinic time, and enhanced aesthetics compared to conventional methods [1]. Spitznagel *et al.* [3] confirm these findings, emphasizing that CAD/CAM applications ensure a standardized process, resulting in predictable, reliable, and cost-effective restorations for teeth-supported structures. These restorations are more efficient and practical for repairing extensively damaged endodontically treated teeth (ETT) compared to post-retained crown foundations [11]. Furthermore, CAD/CAM ceramic endocrowns are effective when used with air abrasion, immediate dentin sealing (IDS), and MDP-containing adhesive procedures, ensuring long-term marginal stability [12]. The mechanical properties of CAD/CAM ceramic endocrowns play a crucial role in the success of these restorations.

The selection of the appropriate prosthodontic material plays a crucial role in enhancing fracture strength. As a result, occlusal veneers are regarded as effective for enduring bite forces, with the material thickness remaining standardized [13]. The modified endocrown (ME) design has been shown to offer superior fracture resistance [15], particularly when ME is paired with Vita Enamic (VE), making it the optimal restorative choice for teeth with significant coronal structural loss, especially under high occlusal forces [17]. Overall, endocrowns represent a contemporary, aesthetically appealing, and technique-sensitive approach for successfully restoring posterior endodontically treated teeth (ETT), particularly molars, with excellent longevity and optimal functional and biomechanical outcomes [19]. Supported by extensive empirical research and literature, endocrowns continue to be a preferred restorative option in modern dentistry [14]. In conclusion, this systematic review confirms that CAD/CAM ceramic endocrowns offer higher success rates due to their occlusal fit and mechanical properties, including longevity, flexibility, and structural integrity.

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