Review of Marginal Adaptation and fracture resistance of Computer Aided Design/Computer Aided Manufacturer (CAD-CAM) Fabricated Endo-crowns

ABSTRACT

Background: Zirconia-based restorations have become more popular in dentistry during the last two decades. Patients choose metal-free restorations, preferring materials with similar attributes to natural teeth and similar light scattering characteristics, resulting in a nice esthetic appearance. Restoring a root canal treated teeth is one of the hot topics today.endo crown materials can be either; feldspathic, glass-ceramic, monolithic hybrid ceramic or composite material**.** Considering the marginal gap of endocrown, an important cause of failure of treatment, the current study evaluated the marginal gap of CAD-CAM concocted endo-crowns.

Materials and Method: This research is an analysis systemic review study was conducted between January 2020 and October 2021. We followed the PRISMA principles and recorded this systematic review using the PROSPERO database to find and identify published literature related to the marginal adaptation of CAD-CAM-fabricated endocrown. The search will include all relevant articles through the end of 2021. Finally, 24 papers on marginal clearance and fracture resistance in coronary arteries were reviewed.

Results: The electronic database search yielded 98 studies that were relevant. After cross-referencing, further seven studies were added. After a full-text analysis and duplicate reduction, 74 of the 98 articles were eliminated. 5 clinical (prospective) studies, 19 in vitro studies were found.

Conclusion: This analysis of the recent literature on the marginal seating integrity and fracture resistance of CAD/CAM made-up endo-crowns showed that the endo-crown had superior marginal seating integrity than classical full crown. CAM/CAM showed statistically significant higher mean fracture resistance than MAD/MAM.

*Keywords:*CAD-CAM, Dental Material, Endo-Crowns, Fracture Resistance, Marginal Adaptation

1. INTRODUCTION

Zirconia-based restorations have become more popular in dentistry during the last two decades. Patients choose metal-free restorations, preferring materials with similar attributes to natural teeth and similar light scattering characteristics, resulting in a nice esthetic appearance. [1] restoring a root canal treated teeth is one of the hot topic today. [2] Endo crown materials can be either; feldspathic, glass-ceramic, monolithic hybrid ceramic or composite material.[3] the computer aided systems deliver a substitute to traditional methods for fabricating prosthesis, minimizing the cost and time efficient.[4] In endocrowns we will not need to for crown lengthening and post holding core to make the provisional restoration.[5] The intraoral scan, designing the prosthesis, setting the milling parameter and the restorative material shrinkage affects the exactness of the endocrown fabricated by CAD/CAM.[6] Although computer aided systems have improved; still the scanning and milling the restorations for complicated cases remain challenging.[7]The longevity of any prosthesis reliant on its marginal adaptation to the tooth.[8] Inaccurate marginal fit can result in accumulation of plaque and cement washout consequently, the risk of carious lesions, periodontal disease. Endodontic inflammation can cause adverse consequences on the health of the abutments, and altering the subgingival microflora, indicating the onset of gingival disease. [9] The marginal fit is the most important factor of a successful restorations. It includes both vertical and horizontal gaps. [10,11] The gap on the margins indicates the distinction of the crowns. A clinically relevant measurements of the gap is unknown in laboratory studies. They observed, however, that on the arithmetic mean data, erraticism less than 5 µm can be caused by a drop from 230 to 50 measurements. Analyzing standard errors revealed values less than 3 µm that were slowly increasing, suggesting there was no consistent effect on results quality. A lower number of measurements led to an increase in standard errors and divergent variances. At the most 50 measurements on gap to define it as a gap or cementation conditions. Based on their findings, 50 measurements clinically consider as data about gap size, that used currently in vitro studies.[12] As part of the USPHS criteria method, a tooth is inspected by explorer, a published article in 1971 clarified how inter examiner calibration can be developed, as how a tooth be pictorial acceptable using the USPHS criteria.[13] Previous in vitro studies have demonstrated that a range of 85 to 247 µm before cementation on marginal gap of computer aided restoration is expected.[14] There have been a lot of studies that have found marginal discrepancies between CAD / CAM systems both in vitro and in vivo studies [15,16] A 120 µm of marginal gab is clinically adequate for successful restorations, according to Mclean and Von Fraunhofer.[17] Considering the marginal gap of endocrown, an important cause of failure of treatment, the current study evaluated the marginal gap of CAD-CAM concocted Endo-crowns.

2. MATERIAL AND METHODS

The PRISMA principles were followed, and the PROSPERO database was used to record this systematic review (258869). To reach and identify the published literature related a marginal adaptation of a CAD-CAM concocted endo-crowns, two independent teams conducted a comprehensive search using Cohen's kappa agreement for title selection (0.82), abstract selection (0.77), and full-text selection (0.65). Each group was comprised of two analysts who directed a consolidated hunt dependent on distinct and concurred together upon consideration and avoidance rules. On the off chance that any of the groups can't concede to which article to pick, an outsider (fifth scientist) will settle on an ultimate choice. The search includes all appropriate articles by the end of 2021. In total of, (98) papers were established. Only in-vivo and in-vitro studies on endocrowns marginal gap and fracture resistance were counted in analysis. Excluding the case reports, case series, pilot studies,

review articles, and laboratory studies aimed at evaluating the characteristics of endocrowns. Finally, 24 articles on marginal gap and fracture resistance of endocrowns were investigated.

Inclusion criteria

The research covers the period from 2013 up to 2021, English language and mainly based on in vitro and in-vivo study.

Exclusion criteria

Excluded the cohort, case control, case report and case series study design and all none English resources.

Scientific assessment

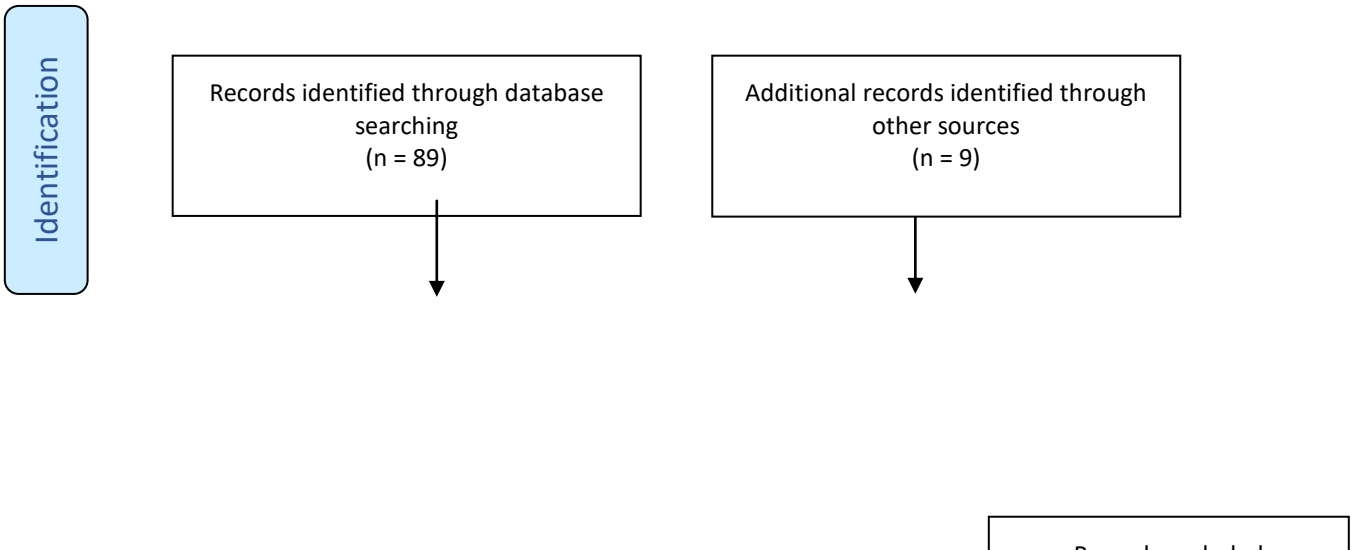
The Critical Appraisal Skills Program (CASP) tool for systematic reviews and Centre for Evidence-Based Medicine (CEBM) had been used in this systematic review to evaluate the scientific merit of the full texts. CASP checklist contains 12 questions to help the reader make sense of a Systematic Review. Each of them will be critically appraised by using (CASP) and (CEBM) by one of the researchers.

3. RESULTS AND DISCUSSION

The electronic database search yielded 98 studies that were relevant. After cross-referencing, further seven studies were added. After a full-text analysis and duplicate reduction, 74 of the 98 articles were eliminated. 5 clinical (prospective) studies, 19 in vitro studies were found.

Being conservative in tooth preparations help to preserve the tooth vitality and decrease sensitivity after. Conversely, there is no research assess the tooth structure detached during preparations.

Fig 1: PRISMA Flow Diagram



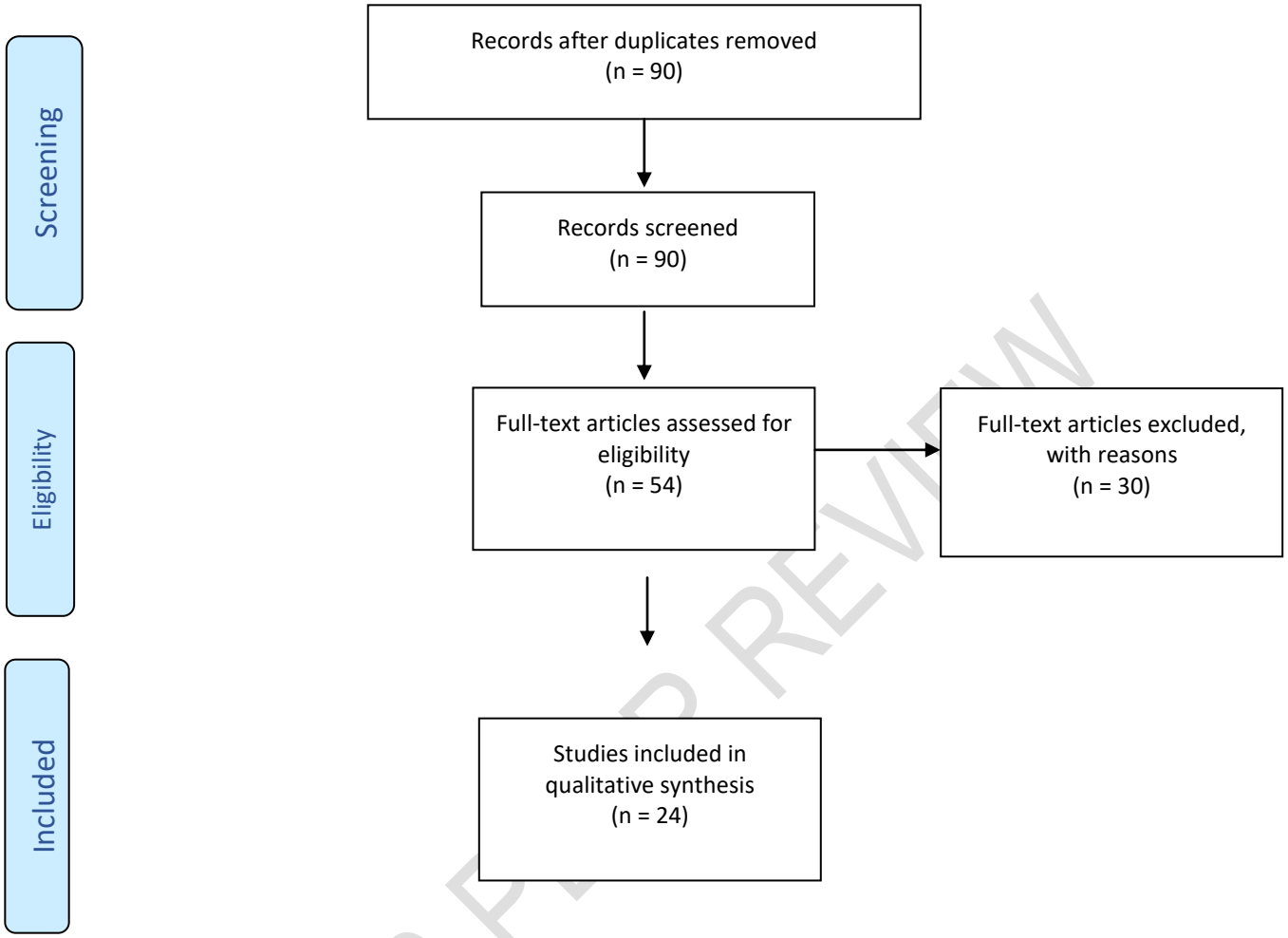


Table 1. Demographic Characteristics of Studies Results

Country	Type of Study	Year of publication	Reference
Turkey	In-vitro Study	2013	(YILDnIZ et al., 2013)
Egypt	In-vitro Study	2013	(Al Shehhi and Fattouh, 2013)

UAE	In-vitro Study	2015	(El-Damanhoury et al., 2015)al
India	In-vitro Study	2015	(Rajan et al., 2015)
Iran	In-vitro Study	2015	(Jalali et al., 2015)
Japan	In-vitro Study	2016	(Giovanni Tommaso Rocca et al., 2016)
UAE	In-vitro Study	2016	(Gaintantzopoulou & El-Damanhoury, 2016)
Albania	In-vitro Study	2017	(Memarian et al., 2017)
Turkey	In-vitro Study	2017	(Bankoğlu Güngör et al., 2017)
Egypt	Clinical Trail	2017	(Darwish et al., 2017)
Egypt	In-vitro Study	2018	(Taha et al., 2018)
Egypt	In-vitro Study	2018	(Taha et al., 2018)
Egypt	In-vitro Study	2018	(Abo El Fadl et al., 2018)
China	Clinical Trial	2018	(Zou et al., 2018)
Egypt	Clinical Trail	2019	(Soliman, 2019)
Egypt	In-vitro Study	2019	(Korsel, 2019)
Switzerland	In-vitro Study	2019	(Zimmermann et al., 2019)
Lebanon	In-vitro Study	2020	(El Ghoul & Salameh, 2020)
China	Clinical Trail	2020	(Wang et al., 2020)
Brazil	In-vitro Study	2020	(Dartora et al., 2021)
India	In-vitro Study	2021	(Huda et al., 2021)
China	In-vitro Study	2021	(Zheng et al., 2021)
Jordan	Clinical Trial	2021	(El-Ma'aita et al., 2021)
Egypt	Clinical Trial	2021	(tammam, 2021)

Table 2. Summary of included studies

Title	Objectives of Study	Type of Tooth	No of Samples/ Group	Restoration Material	Marginal Adaptation Result (Mn ±SD)
1) Marginal-internal adaptation and fracture resistance of CAD/CAM crown restoration	The purpose of this study was to investigate the marginal and internal adaptation of CAD/CAM crowns fabricated using two commercial brands of partially stabilized zirconia systems, IPS ZirCAD and Lava Frame.	Maxillary second pre molar	50	1-IPS ZirCAD zirconium oxide blocks. 2-Lava zirconium oxide blocks .	Marginal adaptation for both materials showed insignificant differences.
2) Marginal accuracy and fracture resistance of CAD/CAM versus MAD/MA M endo-crwons	The purpose of this study was to compare marginal accuracy befor and after cementation and fracture resistance of CEREC endo-crwons with the manually milled endocrowns	Mandibular pre molars	20	1-classic CEREC all ceramic crown 2- zirconia crowns	Marginal adaptation after cementation was statistically significant.
3) Fracture Resistance and Microleaka ge of Endocrowns Utilizing Three CAD-CAM Blocks	This study assessed marginal leakage and fracture resistance of computer-aided design/computer-aided manufacturing (CAD/CAM) fabricated ceramic crowns with intracoronal extensions into the pulp chambers of endodontically treated teeth (endocrowns)	Permanent Maxillary Molars	30 extracted human permanent maxillary molars were endodontica lly treated	feldspathic porcelain (CEREC Blocks [CB], Sirona Dental Systems GmbH, Bensheim, Germany), lithium disilicate (e.max [EX], IvoclarVivadent, Schaan, Liechtenstein), or resin nanoceramic (Lava Ultimate [LU], 3M ESPE, St Paul, MN, USA).	There was no significant difference between mean fracture resistance of EX and CB. Additionally, the mean dye penetration values of LU (2.80 ± 0.19 mm) were found to be significantly higher (p<0.05) than those of CB and EX (1.111 ± 0.185 and 1.91 ± 0.14 mm, respectively), which were also found to be significantly different.
4) Effect of Preparation Depth on the Marginal and Internal Adaptation of Computerai ded Design/Co	to evaluate the effect of cavity preparation depth and intraradicular extension on the marginal and internal fit and of resin-ceramic CAD/CAM endocrown restorations.	Three first mandibular right molars	three tested groups	1- Micro-XCT polymerinfiltrated . 2-ceramicnetwork material. 3-endocrowns 4-CEREC AC CAD/CAM system.	marginal fit of the three groups tested proved to be significantly better than internal fit evaluated by analyzing the internal gap width in various measuring positions.

	mput er-assisted Manufactur e Endocrowns					
5)	Evaluation of marginal fit and internal adaptation of zirconia copings fabricated by two CAD - CAM systems	to check the marginal fit and internal adaptation of commonly used CAD CAM systems namely CERAMILL and CEREC - In Lab MC XL.	20 identical samples of typodont mandibular first molar	20 groups into two groups of 10 each	1- CERAMILL system 2- CEREC -In Lab MC XL system. 3- zirconia	The marginal adaptation of CEREC was found to be superior to CERAMILL and Both the CEREC -In Lab MC XL and CERAMILL copings demonstrated internal adaptation and marginal fit within acceptable discrepancy range.
6)	Comparison of Marginal Fit and Fracture Strength of a CAD/CAM Zirconia Crown with Two Preparation Designs	to compare the marginal adaptation and fracture resistance of a zirconia-based all-ceramic restoration with two preparation designs	Twenty-four mandibular premolars	two groups (n=12);	1- zirconia (Cercon) 2- stereomicrosco pe. 3-Cercon Eye Scanner 4- DeguDent 5- dual selfetch resin cement	No difference in the marginal gaps of the two groups. Less aggressive preparation of proximal and lingual finish lines for the preservation of tooth structure in all ceramic restorations does not adversely affect the marginal adaptation
7)	The influence of FRCs reinforceme nt on marginal adaptation of CAD / CAM composite resin endocrowns after simulated Fatigue loadind	To evaluate the marginal adaptation of endodontically treated molars restored with CAD / CAM composite resin endocrowns either with or without reinforcement by fibre reinforced composites (FRCS) , used in different configurations . 32 human endodontically treated molars were cut 2 mm over the CEJ	Molars	8g	Composite resin	The marginal quality of FRC reinforced CAD/CAM resin composite restorations õn molars was investigated in vitro. before and after fatigue loading. Within the limitations of the present study it can be concluded that their adaptation to enamel and dentin significantly remaining satisfactory at the end of the simulation. The presence of different kinds of FRCS of the cavity did not influence these results.
8)	Marginal Adaptation and Internal Fit of Posterior 3 - Unit Zirconia FPDs Fabricated with Different CAD /	compare the accuracy of zirconia FPDS fabricated by different laboratory CAD/CAM system	Premolar Molars	12g	Zirconia	Within the limitations of this in vitro study, it can be con- cluded that; in an ideal preparation, an acceptable marginal gap could be reached in three-unit zirconia FPDS fabricated by different manufacturers. However, CAD/CAM systems could influence the internal fit of those FPDS

	CAM Systems					
9)	Evaluation of the in vitro effects of cervical marginal relocation using composite resins on the marginal quality of CAD / CAM crowns	To evaluate the effect of cervical margin relocation (CMR) for crowns designed using CAD / CAM technol ogy , and made of pre - cured resin or lithium disilicate , before and after ermomech loading	Molar premolar	20G 40S	Composite	The null hypothesis was accepted, since no statistically significant differences were found in marginal quality before and after thermomechanical cycling ($p > 0.05$).
10)	Fracture strength of CAD/CAM fabricated lithium disilicate and resin nano ceramic restorations used for endodontica lly treated teeth	to evaluate and compare the fracture strength and failure modes of endocrowns, zirconia post, and fiber post supported restorations and predict the clinical outcomes of six different prostheses used for endodontically treated teeth.	maxillary central incisors	Sixty	1- (ZrRNC) 2- (FbRNC) 3- (ZrLDS) 4- (FbLDS) 5- (EndoRNC) 6- (EndoLDS).	fracture of the restoration with or without post were generally observed. The failure modes of endocrowns were noted as tooth fractures while no tooth fracture was noted for post-core restorations.
11)	Fracture resistance and failure modes of polymer infiltrated ceramic endocrown restorations with variations in margin design and occlusal thickness	to assess the effect of varying the margin designs and the occlusal thicknesses on the fracture resistance and mode of failures of endodontically treated teeth restored with polymer infiltrated ceramic endocrown restorations.	Root canal treated mandibular molars	divided into four groups (n = 8)	1- fabricated polymer infiltrated ceramic endocrowns (ENAMIC blocks).	Endocrowns with shoulder finish line had significantly higher mean fracture resistance values than endocrowns with butt margin. the results were not statistically significant regarding the restoration thickness.
12)	Assessment of marginal adaptation and fracture resistance of endocrown restorations utilizing different machinable blocks subjected to thermomech anicalaging	To assess the marginal adaptation and fracture resistance of computer aided design/computer aided manufacturer (CAD-CAM) fabricated endocrowns restoring endodontically treated molars using different machinable blocks with thermomechanical loading protocols.	Mandibular Molars	Forty Molars divided into 4 groups	Lithium disilicate ceramics, polymer infiltrated ceramics, zirconiareinforced lithium silicate ceramics and resin nanoceramics	Statistically significant increase of the marginal gap values for all the tested materials but the type of tested material did not affect the marginal gap. Before cementation (μm) .14 NS After cementation (μm). 42 NS

13) EVALUATION OF MARGINAL GAP OF CAD/CAM CROWNS MILLED FROM TWO CERAMIC MATERIALS	To evaluate and compare the marginal gap of CAD CAM crowns milled from two ceramic materials.	First maxillary molars	Sixteen Molars divided into two groups	ceramic material Emax CAD (Lithium disilicate glass ceramics) Vita suprinity (Zirconia reinforced lithium silicate ceramic)	CAD group (Lithium disilicate glass ceramics) showed significantly higher marginal gap values (M=95.4, SD=8.27) in comparison with Vita suprinity group (Zirconia rein- forced lithium silicate ceramic) (M=75.47, SD=8.9)
14) Clinical performance of CAD/CAM-fabricated monolithic zirconia endocrowns on molars with extensive coronal loss of substance.	To clinically evaluate computer-aided design/ computer-aided manufacturing (CAD/CAM)- fabricated molar endocrowns after 6 months and 1, 2, and 3 years of clinical service.	Molars	289 patients with 321 molars	Monolithic zirconia restorations	None of the 289 endocrowns failed during the observation period. The high clinical rating criteria (97.2%) and the high satisfaction percentage (98.0%) remained prac- tically unchanged (P > 0.05) throughout the followup assessments at 6 months and after 1, 2, and 3 years.
15) Marginal Adaptation of Lithium Disilicate Endocrowns with Different Cavity Depths and Margin Designs.	to study effect of different preparation designs on the marginal adaptation of lithium disilicate endocrowns.	mandibular molars	Twenty human mandibular molars were divided into 2 groups	Lithium Disilicate	All marginal adaptation values lie within the clinically accepted ranges. The shoulder finish line marginal configuration has superior marginal adaptation than those with butt joint marginal configuration.
16) EFFECT OF CAD/CAM TECHNOLOGY SYSTEM AND TIMING OF DENTIN SEALING APPLICATION ON HYBRID CERAMIC ENDO-CROWNS MARGINAL FIT	to determine the influence of CAD/CAM system type and immediate dentin sealing (IDS) on the marginal fit of hybrid ceramic endocrowns.	lower molars	Forty molars divided in to 4 groups	1-CEREC in-lab system 2-DOF system	All marginal gap values were acceptable value of restorations. there is a significant effect of the CAD \CAM system and the timing of dentin sealing application on the marginal fit.
17) Three-Dimensional Digital	to evaluate the fit of endocrowns fabricated from different CAD/CAM	maxillary right first molar	3 groups	1-zirconia-reinforced lithium silicate ceramic.	Statistically significant differences were found both within and among the test

	Evaluation of the Fit of Endocrowns Fabricated from Different CAD/CAM Materials Zimmerman n,	materials using a new 3D evaluation method with an intraoral scanning system.			2- leucite-reinforced silicate ceramic. 3- resin nanoceramic.	groups in marginal fit and axial fit. For occlusal fit , no statistically significant differences were found within all three test groups
18)	Marginal and Internal Adaptation of Lithium Disilicate Endocrowns Fabricated By Heat-Pressable and Subtractive Techniques	To evaluate and to compare the marginal and the internal fit of milled (MLE) and heat-pressed lithium disilicate endocrowns (PLE).	Mandibular Molars	Thirty Molars	1- MLE: endocrowns were milled using LDS blocks and a 5-axis milling machine. 2- PLE: endocrowns were heat-pressed using lost wax technique and LDS ingots.	significant interactions were recorded between fabrication technique and region ($p < 0.05$), F (1.97, 27.69) = 5.462. Group MLE displayed significantly smaller gaps than PLE in all regions ($p < 0.001$). The largest gap was observed at the pulpal floor in both groups. The internal gap was significantly larger than the marginal gap in MLE group ($p < 0.001$), while no statistically significant difference was observed in PLE group ($p = 0.082$).
19)	Mechanical behavior of endocrowns fabricated with different CAD-CAM ceramic systems	To evaluate the mechanical behavior of endodontically treated teeth restored with ceramic endocrowns made by using different computer-aided design and computer-aided manufacturing (CAD-CAM) systems.	Mandibular Molars	Sixty Human Molars into 4 groups	1- leucite-based glass-ceramic (LC group) 2- lithium disilicate-based glass-ceramic (LD group), 3- glass-ceramic based on zirconia-reinforced lithium silicate (LSZ group). 4- monolithic zirconia (ZR group).	Statistically significant differences among the groups were observed ($P<.05$). The outcomes of the LC, LD, and LSZ groups were similar (1178 N, 1935 N, and 1859 N) but different from those of the ZR group (6333 N). The LC and LD groups had a higher ratio of restorable failures, while LSZ and ZR had more nonrestorable failures.
20)	Clinical efficacy of ceramic versus resin-based composite endocrowns in Chinese adults: study protocol for a randomized controlled trial.	The main objective is to compare the clinical efficacy of resin-based bloc and ceramic endocrowns in treating endodontically treated molars by assessing the marginal adaptation of restorations fabricated with a chairside CAD/CAM system (Dentsply Sirona, Bensheim, Germany). The minor objectives include evaluating the wear, radiographic examination, patient's view, and re-currence of caries between the study groups during the	Molar.	156 adults between 18 and 75 years old. One Molar for Each Individual.	- resin-based bloc and ceramic endocrown according to a random number table.	Marginal Adaptation is not significant. assessed by clinical and radiographic examination according to Likert scales of 5 terms. Some items are evaluated quantitatively, others visually. The worst score of all items is retained as The overall score of the restoration, thus resulting in a single (ordinal) primary outcome.

	same period and looking for the prognostic and influen-cing factors of the related effects.				
21) Resistance against Fracture in Teeth Managed by Root Canal Treatment on Restoring with Onlays, Inlays, and Endocrowns : A Comparativ e Analysis	To compare the fracture resistance in teeth managed by root canal treatment after restoring with different types of onlays, inlays, and endocrowns prepared with hybrid ceramics and pulp chambers restored with fiber-reinforced composite and resin composite that were radiopaque, light-cured, and flowable.	Mandibular Molars	252 Extracted Molars, 6 groups consisted of 42 specimens	- Group 1 intact teeth without any access cavity(control group). - Group 2 teeth with endocrown and empty pulp chamber. - Group 3 teeth with MOD onlay prepared with hybrid ceramics and pulp chamber filled with flowable, light-cured, radiopaque resin composite. - Group 4 teeth with MOD onlay and pulp chamber filled with fiber-reinforced composite. - Group 5 teeth with MOD inlay and pulp chamber filled with flowable, light-cured, radiopaque resin composite. - Group 6 teeth with MOD inlay and pulp chamber filled with fiber-reinforced composite. Inlay, onlay, and endocrowns were prepared with computer-aided design (CAD) and computer-aided machine (CAM) using hybrid ceramics.	Marginal adaptation is not significant. (is not mentioned) Fracture strength was found to be maximum in the intact teeth group followed by the endocrown. The fracture strength was minimum in the inlay group. The fracture strength was intermediate in the onlay groups.
22) Biomechani cal behavior of endocrown restorations with different CAD-CAM	to compare and evaluate the stress distribution, failure probability, and fracture resistance of endodontically treated teeth restored with endocrowns from CAD-CAM milling blocks including ceramic,	First Mandibular Molars.	30 molar-Endocrowns Fabricate (model duplicatd)	CAD-CAM blocks: - Vita Suprinity (VS), - IPS e.max CAD (EMX), - Vita Enamic (VE),	Marginal adaptation is not significant. (is not mentioned)

	materials: A 3D finite element and in vitro analysis	polymer- infiltrated ceramic (PICN), and composite resin.			- Lava Ultimate (LU), - Grandio blocs (GR).	
23)	Endocrowns Clinical Performanc e and Patient Satisfaction: A Randomize d Clinical Trial of Three Monolithic Ceramic Restorations	to assess the survival of endocrowns made from three different monolithic ceramic materials, and to evaluate patient satisfaction.	Molars	53 patients (60 root canal treated molar teeth). 3 material groups. 48 patients were available for assessment after 2 years	1- lithium disilicate-reinforced glass-ceramic, 2- mono- lithic zirconia 3- polymer infiltrated hybrid ceramic. Predefined cementation pro-tocols were used.	Marginal adaptation is not significant. (is not mentioned) Kaplan-Meier survival estimate among all groups was 90.9% with no statistically significant difference between the groups (p = 0.17). Three zir-coniaendocrownsdebonded after 9, 10 and 13 months (82.4% survival rate), while 2 hybrid ceramic endocrowns chipped/fractured (89.5% survival rate). Lithium dis-ilicateendocrowns had a 100% survival rate. The Kruskal Wallis test revealed no statistically significant difference between the groups in the USPHS criteria ratings and the radiographic assessment (P>0.05).
24)	Clinical evaluation of monolithic Zirconia (5Y), Lithium Disilicate and modified PEEK CAD-CAM endocrown materials,3-year clinical prospective study	To conclude clinically, if endocrowns are a dependable substitute to post-retained restorations for significantly broken endodontically treated teeth and which restorative materials are proficient customized for constructing endocrowns.	Randomized Molars and Premolars	40 patients 3 groups	- lithium disilicate, monolithic zirconia Endocrowns bonded by adhesive dual-cured luting resin composite.	Marginal adaptation is not significant. (Is not mentioned) An examination period of 3 years, endurance ratios were 94.87 %. one restoration replaced due to clinically improper failure and another after debonding rebonding again. There is an increase of Charlie ratings at 36 months in marginal fit among cases Zirconia 6 (50%), the best material was lithium disilicate, translucent zirconia, and PEEK material respectively.

Discussion More conservative treatment techniques for restoring endodontically treated teeth, such as endocrowns, have been presented as a result of recent improvements in adhesive dentistry, because a macro retentive design is no longer a need when there are adequate tooth surfaces for bonding.[18]Most of the studies of CAD/CAM evaluate the system itself or the milling tool. Only four papers focused on the differences between a classical full crown and endocrown.

Studies by Al Shehhi and Fattouh on 2013, Sağlam et al on 2013 and Carlos et al. on 2013 showed endocrown has a superior marginal adaptation than a classical full crown, However, Al Shehhi and Fattouh, 2013 stated that; there is no a statically difference in the margin gap

among the endocrown and a conventional full crown group. [19–21] Also there is other study shown the marginal adaptation of CAD/CAM endocrown had superior marginal seating than a classical full crowns.[22]

Most of the studies have been done in the last few years since 2013-2021, had focused on in vitro designs. There was 18 vitro study and 5 clinical trials. The 5 clinical trials were talk about endocrown fit with using different material and technique. This research arrived to that endocrown with using accurate design of CAD/CAM and properties of material give very satisfaction result. (Soliman, Kholoud) Shown that endocrown with shoulder marginal configuration has superior adaptation than those with butt joint configuration using 90 shoulder marginals with 4mm cavity depth show higher mean value the different was significant than 2mm depth Using Butt-joint margin configuration with 4mm cavity depth show higher mean value the different was non-significant than 2mm cavity depth.[23] Zirconia endocrowns on molars with prevalent tooth structure loss give a good result.[24]

The majority of studies identified substantial variations in marginal adaptation and materials between the CERAMILL system, CEREC -In Lab MC XL system, and zirconia groups.[25] In addition classic CEREC all ceramic crown, zirconia crowns.[26] However monolithic zirconia restorations (Y. Zoua, J. Baib, J. Xiangc, 2018) [27] found no statically difference in marginal adaptation among the materials.

No statically difference in marginal seating and preparation designs. [28,29] Other study showed the chamfer finish line has less micro leakage because the silicone weight. The crowns fabricated withCeramil system was significantly higher than that fabricated by Zirconia system, due to the differences in the silicone weight as the prostheses made up based on the commendation of each system.[30]

Only three studies focused at marginal adaption and Cavity Depths. According to the results acquired, each marginal adaption value falls within a clinically acceptable range during the study conducted by Soliman 2019. Individuals with marginal shoulder finish line configurations adapt slightly better than individuals with marginal butt joint configurations.[23]

Gaintantzopoulou and El-Damanhoury on 2016; also shown that intracoronal and extra showed significant differences in marginal gap (MG) and marginal discrepancy (MD) values, with marginal discrepancy standard being greater in both situations (p, 0.001). The preparation was held at a 2.0 mm intracoronal height (group intracoronal) , to achieve a overall stature of 3 mm, a consistent intra radicular allowance of 1 mm was conducted in the second master die (group extra), In the third master die, a 2.0 mm interradicular allowance was added to achieve an overall intracorneal stature of 4 mm (group inter radicular allowance).[29] However, there is other study shown the marginal adapted well to enamel and dentin. Variable types of FRCS were not affected by the cavity.[31]

There were only few studies testing the fracture resistance of CAD/CAM endo-crowns were found, with the LAVA ULTIMATE ENDOCROWN having significantly higher fracture resistance than the E-MAX and CEREC BLOCK endo-crowns in the 2015 research. However, more microleakage is possible with this substance.[29]

Al Shehhi and Fattouh on 2013; examined the fracture resistance of CAD/CAM and MAD/MAM endo-crowns. Furthermore, this study revealed that the CAD/CAM endo-crown had greater fracture resistance than the MAD/MAM endo-crown. [19] Another study examined the marginal and internal adaptability of CAD/CAM crowns IPS ZirCAD and LAVA

FRAME crown restoration cemented with two different adhesive systems. The mean of load to failure of the two crowns (IZC & L) cemented with Multilink was higher than the crowns cemented by Variolink. The change, however, was not statistically significant.[28]

4. CONCLUSION

This analysis of the recent literature on the marginal seating integrity and fracture resistance of CAD/CAM made-up endo-crowns showed that the endo-crown had superior marginal seating integrity than classical full crown. CAM/CAM showed statistically significant higher mean fracture resistance than MAD/MAM. This suggests that, as compared to conventional manufacturing methods, CAD/CAM systems improve the average quality of prosthesis marginal adaptation and fracture resistance. However, due to the insufficient number of clinical investigations on the marginal adaption and fracture resistance of CAD/CAM made-up endocrown restoration and the wide variation in results between protocols, more in-vivo studies it is recommended.

ACKNOWLEDGEMENTS

Special thanks to the Deanship of Scientific Research (DSR) and the Faculty of Dentistry at King Abdulaziz University, Jeddah, for supporting this project.

FUNDING

This study has not received any external funding.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interests.

REFERENCES

1. Denry I, Kelly JR. State of the art of zirconia for dental applications. Dent Mater. 2008 Mar;24(3):299-307.

2. Dietschi D, Duc O, Krejci I, Sadan A. Biomechanical considerations for the restoration of endodontically treated teeth: a systematic review of the literature--Part 1. Composition and micro- and macrostructure alterations. Quintessence Int. 2007 Oct;38(9):733–43.

3. Rocca GT, Saratti CM, Poncet A, Feilzer AJ, Krejci I. The influence of FRCs reinforcement on marginal adaptation of CAD/CAM composite resin endocrowns after simulated fatigue loading. Odontology. 2016 May 1;104(2):220–32.

4. Korsel A. Effect of CAD/CAM Technology System and Timing of Dentin Sealing Application on Hybrid Ceramic Endo-crowns Marginal Fit. Egypt Dent J. 2019;65(4):3617–25.

5. Afshar MK, Mahgoli H, Nokar S, Bahrami M. Marginal and Internal Adaptation of Zirconia Endocrowns - A Literature Review. J Evol Med Dent Sci. 2019;8(46):3488–91.

6. Beuer F, Schweiger J, Edelhoff D. Digital dentistry: an overview of recent developments for CAD/CAM generated restorations. Br Dent J. 2008 May;204(9):505–11.

7. Rekow ED, Silva NRFA, Coelho PG, Zhang Y, Guess P, Thompson VP. Performance of dental ceramics: challenges for improvements. J Dent Res. 2011 Aug;90(8):937–52.

8. Hunter AJ, Hunter AR. Gingival margins for crowns: A review and discussion. Part II: Discrepancies and configurations. J Prosthet Dent. 1990;64(6):636–42.

9. Özen J, Sipahi C, ﷺb lar A. The Effect of Aged Dental Ceramics on Gingival Cell Viability. In 2006.

10. Harada A, Nakamura K, Kanno T, Inagaki R, Örtengren U, Niwano Y, et al. Fracture resistance of computer-aided design/computer-aided manufacturing-generated composite resin-based molar crowns. Eur J Oral Sci. 2015;123(2):122–9.

11. Mounajjed R, M Layton D, Azar B. The marginal fit of E.max Press and E.max CAD lithium disilicate restorations: A critical review. Dent Mater J. 2016 Dec;35(6):835–44.

12. Groten M, Axmann D, Pröbster L, Weber H. Determination of the minimum number of marginal gap measurements required for practical in-vitro testing. J Prosthet Dent. 2000 Jan;83(1):40–9.

13. McLean JW, von Fraunhofer JA. The estimation of cement film thickness by an in vivo technique. Br Dent J. 1971 Aug;131(3):107–11.

14. Mou S-H, Chai T, Wang J-S, Shiau Y-Y. Influence of different convergence angles and tooth preparation heights on the internal adaptation of Cerec crowns. J Prosthet Dent. 2002 Mar;87(3):248–55.

15. Denissen H, Dozić A, van der Zel J, van Waas M. Marginal fit and short-term clinical performance of porcelain-veneered CICERO, CEREC, and Proceraonlays. J Prosthet Dent. 2000 Nov;84(5):506–13.

16. Fasbinder DJ, Dennison JB, Heys D, Neiva G. A clinical evaluation of chairside lithium disilicate CAD/CAM crowns: a two-year report. J Am Dent Assoc. 2010 Jun;141 Suppl:10S-4S.

17. Tinschert J, Natt G, Mautsch W, Spiekermann H, Anusavice KJ. Marginal fit of alumina-and zirconia-based fixed partial dentures produced by a CAD/CAM system. Oper Dent. 2001;26(4):367–74.

18. Goodacre CJ, Campagni W V, Aquilino SA. Tooth preparations for complete crowns: An art form based on scientific principles. J Prosthet Dent [Internet].

2001;85(4):363–76. Available from: https://www.sciencedirect.com/science/article/pii/S0022391301577513

19. Al Shehhi MO, Fattouh M. Marginal accuracy and fracture resistance of CAD / CAM versus MAD / MAM endocrowns. 2013;(29):1–7.

20. Sağlam G, Cengiz S, Karacaer Ö. Marginal adaptation and fracture strength of endocrowns manufactured with different restorative materials: SEM and mechanical evaluation. Microsc Res Tech. 2021;84(2):284–90.

21. Carlos RB, Thomas Nainan M, Pradhan S, Roshni Sharma, Benjamin S, Rose R. Restoration of Endodontically Treated Molars Using All Ceramic Endocrowns. Case Rep Dent. 2013; 2013:1–5.

22. El Ghoul W, Salameh Z. Marginal and Internal Adaptation of Lithium Disilicate Endocrowns Fabricated By Heat-Pressable and Subtractive Techniques. J Prosthodont. 2020 Jul 1;30(6):509–14.

23. Soliman K. Marginal Adaptation of Lithium Disilicate Endocrowns with Different Cavity Depths and Margin Designs. Al-Azhar Dent J Girls. 2019;0(0):0–0.

24. U Y, Bai J, Xiang J. Clinical performance of CAD/CAM-fabricated monolithic zirconia endocrowns on molars with extensive coronal loss of substance. Int J Comput Dent [Internet]. 2018;21(3):225–32. Available from: http://www.ncbi.nlm.nih.gov/pubmed/30264051

25. Rajan BN, Jayaraman S, Kandhasamy B, Rajakumaran I. Evaluation of marginal fit and internal adaptation of zirconia copings fabricated by two CAD - CAM systems: An in vitro study. J Indian Prosthodont Soc. 2015;15(2):173–8.

26. Marginal accuracy and fracture resistance of CAD/CAM versus MAD/MAM endocrowns.

27. Bai J, Zou Y, Bai J, Xiang J, Zou Y. Clinical performance of CAD/CAM-fabricated monolithic zirconia endocrowns on molars with extensive coronal loss of substance. Vol. 21, International Journal of Computerized Dentistry. 2018.

28. YILDnIZ C, VANLIOĞLU BA, EVREN B, ULUDAMAR A, ÖZKAN YK. Marginal-internal adaptation and fracture resistance of CAD/CAM crown restorations. Dent Mater J [Internet]. 2013;32(1):42–7. Available from: https://www.jstage.jst.go.jp/article/dmj/32/1/32_2012-148/_article

29. Gaintantzopoulou MD, El-Damanhoury HM. Effect of preparation depth on the marginal and internal adaptation of computer-Aided design/computerassisted manufacture endocrowns. Oper Dent. 2016 Nov 1;41(6):607–16.

30. Ha SJ, Cho JH. Comparison of the fit accuracy of zirconiabased prostheses generated by two CAD/CAM systems. J Adv Prosthodont. 2016;8(6):439–48.

31. Rocca GT, Daher R, Saratti CM, Sedlacek R, Suchy T, Feilzer AJ, et al. Restoration of severely damaged endodontically treated premolars: The influence of the endo-core length on marginal integrity and fatigue resistance of lithium disilicate CAD-CAM ceramic endocrowns. J Dent. 2018 Jan 1;68:41–50.