

UCUENCA

Facultad de Odontología

Especialidad en Rehabilitación Oral y Prótesis Implanto Asistida

RESISTANCE OF CAD/CAM COMPOSITE RESIN AND CERAMIC
OCCLUSAL VENEERS TO FATIGUE AND FRACTURE IN WORN POSTERIOR
TEETH: A SYSTEMATIC REVIEW

Trabajo de titulación previo a la
obtención del título de
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Resumen:

El objetivo de esta revisión sistemática es sintetizar y analizar la evidencia científica que evalúe el rendimiento mecánico en términos de resistencia a la fractura y fatiga de las carillas oclusales elaboradas con bloques de resina compuesta CAD/CAM y bloques de cerámicas de disilicato de litio CAD/CAM en dientes posteriores con desgaste severo. Hoy en día las carillas oclusales se consideran como una alternativa para el tratamiento de dientes posteriores con desgaste severo. Si bien existe evidencia científica que demuestra el buen desempeño de las carillas oclusales de disilicato de litio, ahora existen más materiales que son menos frágiles y tienen un módulo de elasticidad más similar a la dentina que las cerámicas, como los bloques de resina CAD/CAM. Por lo tanto, es importante identificar qué tipo de material es mejor para restaurar dientes con defectos de desgaste oclusal, que puedan brindar un mejor desempeño clínico. Esta revisión siguió la guía PRISMA. La búsqueda fue conducida en PubMed, Embase, Web of Science, Scopus, Cochrane, Open Gray, Redalyc, DSpace, Grey Literature Report y fue complementada por una búsqueda manual, sin limitación de tiempo o idioma, hasta enero de 2022. Los estudios que evaluaron la resistencia a la fractura y a la fatiga de carillas oclusales con bloques de resina compuesta CAD/CAM y bloques de cerámica de disilicato de litio CAD/CAM fueron seleccionados. La evaluación de la calidad de los artículos a texto completo fue analizada de acuerdo a los criterios CONSORT modificado para estudios in vitro. Inicialmente, se identificaron 400 artículos. Después de eliminar los duplicados y aplicar los criterios de selección, 6 estudios fueron incluidos en la revisión sistemática. Las carillas oclusales de

bloques de resina compuesta CAD/CAM tienen similar rendimiento mecánico en términos de resistencia a la fractura y a la fatiga que las carillas oclusales de bloques de cerámica de disilicato de litio CAD/CAM.

Palabras clave: Resina compuesta. Cad-cam. Cerámica. Tasa de supervivencia. Desgaste dental.

Abstract:

The aim of this systematic review is to summarize and analyze the scientific evidence evaluating the mechanical performance of Computer Aided Design, Computer Aided Manufacturing (CAD/CAM) composite resin and CAD/CAM lithium disilicate ceramic occlusal veneers, in terms of fatigue and fracture resistance, on severely worn posterior teeth. Currently, occlusal veneers are an alternative for treating worn posterior teeth. Even though there is scientific evidence demonstrating the good performance of lithium disilicate occlusal veneers, there are now more materials that are less brittle and have a modulus of elasticity more similar to dentin than ceramics, such as resin CAD/CAM blocks. Therefore, it is important to identify which type of material is best for restoring teeth with occlusal wear defects that can provide better clinical performance. This review followed the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines. We performed a search in the Pubmed, Embase, Web of Science, Scopus, Cochrane, Open Gray, Redalyc, Dspace, and Grey Literature Report databases, supplemented by a manual search, without time or language limitation, until January 2022, for studies evaluating the fatigue and fracture resistance of CAD/CAM composite resin

and ceramic occlusal veneers. The quality of the full-text articles was analyzed according to the modified CONSORT criteria for in vitro studies, and 400 articles were initially identified. After removing duplicate studies and applying the selection criteria, the systematic review finally included 6 studies. The CAD/CAM composite resin occlusal veneers have similar mechanical performance in terms of fatigue and fracture resistance as CAD/CAM lithium disilicate occlusal veneers.

Keywords: Composite resin, Cad-cam, Ceramics, Survival rate, Tooth wear.

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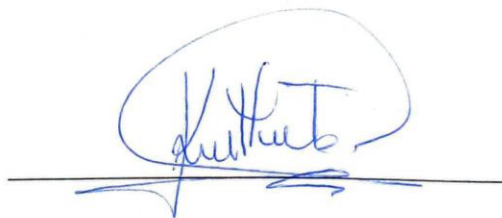
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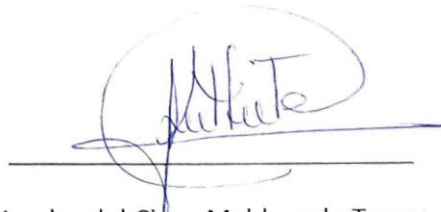
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A handwritten signature in blue ink, appearing to read 'K. Maldonado', is written over a horizontal line.

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INTRODUCTION

In the first clinical study¹ measuring tooth wear in young patients, the authors observed a mean annual occlusal wear of enamel of 29 microns in molars and 15 microns in premolars. A 2015 report² estimated that the mean maxillary incisor crown height at 10 years of age, 11.94 mm, decreased to 10.93 mm in patients aged 70 years, corresponding to a loss of 1.01 mm (1010 microns) in 60 years. The wear was greater in the mandibular incisors, with the mean crown height at 10 years of age of 9.58 mm decreasing to 8.12 mm in patients aged 70 years, for a loss of 1.46 mm (1460 microns) in 60 years. These values correspond to a physiological annual wear rate of 16.8 microns for the maxillary incisors and 24.3 microns for the mandibular incisors².

It is important to distinguish between severe tooth wear and pathological tooth wear. The latter refers to atypical wear for the patient's age that causes pain or discomfort, functional problems, or deterioration of the esthetic appearance and that, if it progresses, can lead to undesirable complications of increasing complexity². Instead, severe tooth wear is related to substantial loss of tooth structure, with dentin exposure and significant loss ($\geq 1/3$) of the clinical crown³. However, not all cases of severe tooth wear can be considered pathological, especially among elderly people, where in most cases it is not atypical. According to an epidemiological study conducted in 2016, the estimated prevalence of erosive tooth wear in children and adolescents was 30.4%⁴. The most recent European consensus on the management of severe tooth wear³ recommends using indices such as the Basic Erosive Wear Examination (BEWE)⁵, and the Tooth Wear Evaluation System (TWES)⁶ for

diagnosis. Severe tooth wear can be attributed to excess consumption of carbonated beverages, a high-acid diet, gastric diseases, anorexia, bulimia, teeth grinding, use of highly abrasive pastes, or a combination of two or more of these factors^{7 8 9 10 12}. These factors can affect the patient in several ways, such as via loss of vertical dimension, sensitivity due to dentin exposure, poor esthetics, and neuromuscular disorders^{7 11 12}.

Restorative alternatives have been sought to solve these problems, such as the placement of metal-free crowns; however, although this technique has shown a high survival rate (92% at 5 years and 85.5% at 10 years)¹³, it requires mechanical retention, necessitating the removal of more dental tissue, including healthy tissue. Thanks to improved dental materials and adhesive techniques, the indications for crowns have decreased^{14 15}. Thus, occlusal veneers have been considered a viable option to treat posterior tooth wear, as they require minimal tooth preparation, from 0.4 mm to 0.6 mm at the level of the developmental groove and 1 mm to 1.3 mm at the tip of the cusp, largely preserving healthy dental tissue. Because of the bonding characteristics of these materials and the more intuitive preparation guided by anatomical considerations, there is sometimes no need to remove any dental tissue^{16 17 18}.

Advances in CAD/CAM technology and bonding procedures (immediate dentin sealing)^{19 20} have allowed the fabrication of thin occlusal veneers without affecting their performance¹⁶. Although there is scientific evidence showing the good performance of lithium disilicate occlusal veneers^{21 22}, less brittle materials with a modulus of elasticity close to that of dentin are also available, such as composite

resin^{17 19 23}. Several studies, most of them in the laboratory setting, have evaluated the mechanical properties of occlusal veneers using universal test machines and mastication simulators under physiological and/or pathological occlusal loading conditions^{19 23 24 25}. However, there is no up-to-date systematic review allowing the clinician to decide which material is best for restoring teeth with occlusal wear. Therefore, the aim of this systematic review is to summarize and analyze the scientific evidence evaluating the mechanical performance, in terms of fatigue and fracture resistance, of CAD/CAM composite resin and lithium disilicate ceramic occlusal veneers in severely worn posterior teeth.

MATERIALS AND METHODS

Registration protocol

This systematic review was conducted according to the PRISMA guidelines²⁶, is shown in a supplementary file S1 Table. In addition, the review has been registered in the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY), doi number: 10.37766/inplasy2021.10.0036. <https://inplasy.com/inplasy-2021-10-0036/>

Search strategy

The search intended to address the question: In posterior teeth with severe tooth wear, can occlusal veneers made from CAD/CAM composite resin blocks perform better mechanically than CAD/CAM lithium disilicate occlusal veneers in terms of fatigue and fracture resistance? The research question was developed as per the population, intervention, comparison, and outcome (PICO).

Three independent researchers (K.M., J.E., and D.A.) conducted an exhaustive electronic search in 5 databases: Pubmed, Scopus, Cochrane, Embase, and Web of Science, to identify relevant articles published up to January 2022. Medical Subject Headings (MESH), Embase subject headings (EMTREE) and free terms were used without limits in terms of language or year of publication. The search strategy is described in a supplementary file S2 Table. To identify other potentially relevant articles, a manual search was performed by two researchers (K.M. and J.E.) in the bibliographic citations of the included articles and in the following journals: Dental Materials, Journal of Dental Restoration, Journal of Dentistry, Journal of Oral Rehabilitation, Journal of Oral Esthetic and Restorative Dentistry, Dental Materials Journal, Journal of Material Sciences. The search for grey literature was performed by K.M. and J.E. in the Open Gray, Redalyc, dspace, and Grey Literature Report databases.

Eligibility criteria

Inclusion Criteria: The present systematic review included studies on the indirect restoration of worn posterior teeth with machined materials, comparing CAD/CAM composite resin and ceramic materials and evaluating mechanical properties such as fatigue and fracture resistance. This review included randomized controlled trials, nonrandomized controlled trials, and in vitro studies.

Exclusion Criteria: Studies investigating CAD/CAM restorations on endodontically treated teeth, as well as crown, inlay, onlay, and implant restorations, case reports, literature reviews, expert opinions and systematic review were excluded.

Screening and selection

Studies were selected in duplicate and independently by two researchers (K.M. and J.E.) based on their titles and abstracts. If a decision on inclusion could not be made because of insufficient data in the title and abstract, the complete manuscript was obtained. Articles in which both researchers agreed were selected. The articles selected for full-text reading were evaluated in duplicate and independently by two researchers (K.M. and J.E.). Any disagreement about the eligibility of the included studies was resolved by discussion and consensus or by a third reviewer (D.A.). Only papers that met all eligibility criteria were included.

The modified CONSORT tool²⁷ was used to assess the methodological quality of the articles in the included studies in terms of their correct implementation and the structure of the abstract, introduction, methods, results, discussion, and funding S3 Table.

Data extraction

A data extraction protocol was defined and evaluated by two of the authors (K.M. and J.E.). Data were extracted independently from full-text articles, using a standardized form in electronic format (Office Excel 2016 software, Microsoft Corporation, Redmond, WA, USA). The information was classified according to the authors, year, study design, sample size, type of material, objectives, test machine used, and conclusions Table 1.

Table 1. Summary of the studies included in the systematic review

Author, year	Type of study	Material	Sample size	Objectives	Testing machine	Conclusions
Andrade et al ²⁵ 2018	In vitro	IPS e.max CAD Vita Enamic Lava Ultimate	70 human third molars	To evaluate, in vitro, the influence of CAD/CAM restorative materials (IPS e.max CAD, Vita Enamic, and Lava Ultimate) and their thickness (0.6 mm and 1.5 mm) on the fracture resistance of teeth restored with occlusal veneers.	Cyclic Mechanical Loading: (ER-11000 (Erios, São Paulo, SP, Brazil) cycling machine. Fracture Resistance Testing: Universal testing machine DL-2000 (EMIC, São Jose dos Pinhais, PR, Brazil)	The occlusal veneers of IPS e.max CAD, Vita Enamic, and Lava Ultimate, obtained fracture resistances similar to those of sound teeth.
Al-Akhali et al ²⁷ 2017	In vitro	LD (lithium disilicate [e.max CAD]) PI (polymer-infiltrated ceramic [Vita Enamic])	64 human maxillary first premolars	To evaluate the influence of thermodynamic loading on the durability and fracture resistance behavior of occlusal veneers fabricated from different biomedical dental CAD/CAM materials.	Cyclic loading fatigue: Dual-axis computerized chewing simulator (Willytec, Feldkirchen-Westerham, Germany) Fracture resistance testing: universal testing machine (Zwick Z10/TN2A, Zwick, Ulm, Germany)	All materials tested may be considered as a viable treatment for restoring the occlusal surfaces of posterior teeth.
Al-Akhali et al ³¹ 2019	In vitro	LD (lithium disilicate [e.max CAD]) PI (polymer-infiltrated ceramic [Vita Enamic])	64 human maxillary first premolars	To evaluate the influence of thermomechanical fatigue loading on the fracture strength of minimally invasive occlusal veneer restorations fabricated from different CAD-CAM materials and bonded to human maxillary premolars using self-etching bonding technique.	Cyclic loading fatigue: Dual-axis computerized chewing simulator (Willytec) Fracture resistance testing: universal testing machine (Zwick Z10/TN2A; Zwick)	Thermomechanical fatigue generally decreased the survival rate and fracture strength of all tested CAD-CAM materials when bonded to enamel using self-etching technique.
Heck et al ³² 2019	In vitro	IPS e.max CAD Lava Ultimate CAD/CAM	84 human molars	The aim of this study was to determine whether ceramics or nanoceramic composites with an ultrathin layer thickness of 0.3–0.5 mm could be used to restore pressure-loaded occlusal dentin and enamel defects.	Fatigue simulations: computer-controlled chewing simulator (MUC 2; Willytec GmbH, Gräfenberg, Germany)	IPS e.max CAD and Lava Ultimate CAD/CAM are recommended for the treatment of occlusal tooth loss with ultrathin veneers.
Magne et al ²¹ 2010	In vitro	IPS e.max CAD Paradigm MZ100 blocks	30 human maxillary molars	To assess and compare the fatigue resistance of composite resin and ceramic posterior occlusal veneers.	Fatigue testing: Masticatory forces were simulated using closed-loop servohydraulics (Mini Bionix II; MTS Systems Corp, Eden Prairie, Minn)	CAD/CAM composite resin posterior occlusal veneers had significantly higher fatigue resistance when compared to ceramic occlusal veneers.
Schlichting et al ¹⁹ 2011	In vitro	Lithium disilicate e.max CAD Paradigm MZ100 blocks XR experimental blocks (reinforced with short polyethylene fibers) (Kerr Corp)	40 human maxillary molars	To assess the influence of CAD/CAM restorative material (ceramic vs. composite resin) on the fatigue resistance of ultra-thin occlusal veneers	Fatigue testing: Masticatory forces were simulated using closed-loop servohydraulics (Mini Bionix II; MTS Systems Corp, Eden Prairie, Minn)	CAD/CAM composite resin ultra-thin occlusal veneers significantly increased the fatigue resistance when compared to the ceramic ones.

Risk of bias assessment

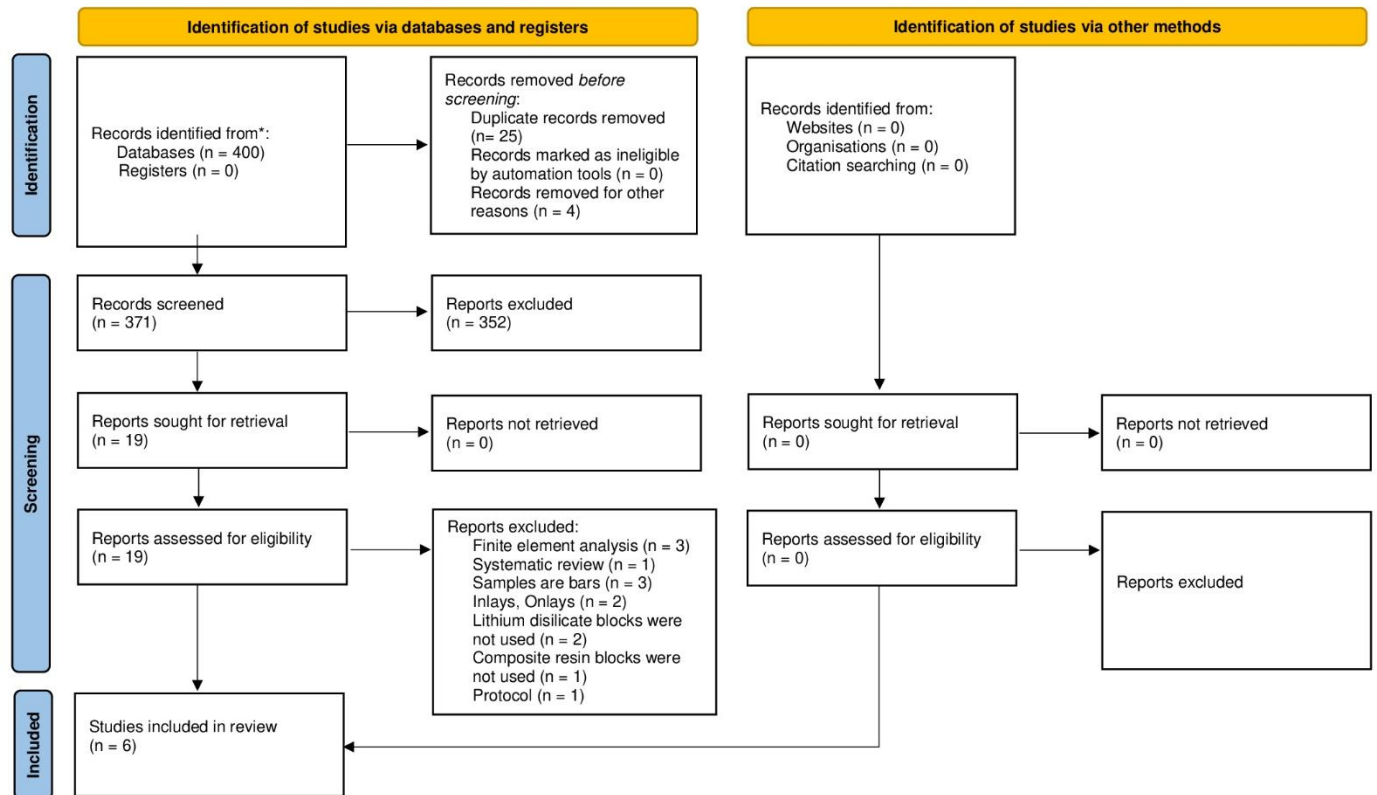
Two authors (K.M. and J.E.) independently assessed the risk of bias of the studies included in this review based on a previous study²⁸. The following parameters were evaluated: tooth randomization, use of teeth free of caries or restorations, use of materials following manufacturers' instructions, use of teeth with similar dimensions, tooth preparation by the same operator, description of sample size calculations, and blinding of the testing machine operator. If the author reported the parameter, the article received a yes (Y) for that specific parameter; if the information was not found, the article received a no (N). Articles reporting 1 to 3 items were classified as high risk of bias, 4 or 5 items as medium risk of bias, and 6 or 7 items as low risk of bias. Disagreements about the risk of bias were resolved by consensus. If a consensus could not be reached, a third author (D.A.) intervened.

REVIEW RESULTS

Search and selection

A flowchart of the PRISMA statement summarizing the selection process is shown in Figure 1. The search yielded 400 studies, of which 25 duplicates were removed. Another 4 studies were removed because they were book chapters, and 352 were excluded because they did not meet the eligibility criteria. The remaining 19 studies were subjected to a full-text review; 3 studies were removed because they involved finite element analyses, 1 study was a systematic review, and 9 studies did not meet the inclusion criteria. Therefore, a total of 6 studies were included in the systematic review; 3 examined fracture resistance^{23 25 29}, and the other 3 examined fatigue resistance^{17 19 30}.

PRISMA 2020 flow diagram for new systematic reviews which included searches of databases, registers and other sources



*Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers).

**If automation tools were used, indicate how many records were excluded by a human and how many were excluded by automation tools.

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 2021;372:n71. doi: 10.1136/bmj.n71. For more information, visit: <http://www.prisma-statement.org/>

Risk of bias assessment

Of the 6 included studies, 2 were at medium risk of bias^{23 25}, and 4 were at high risk of bias^{17 19 29 30}. The results are described in Table 2. according to the parameters considered in the analysis. The risks of bias most commonly identified among the studies were a lack of blinding of the testing machine operator, no description of the sample size calculation, and tooth preparation by the same operator.

Table 2. Risk of bias considering aspects reported in the materials and methods section

Study \ Parameter	Teeth randomization	Teeth free of caries or restoration	Materials used according to the manufacturer's instructions	Teeth with similar dimensions	Teeth preparation performed by the same operator	Sample size calculation	Blinding of the operator of the testing machine	Risk of bias
Andrade et al ²⁵ 2018	Y	Y	Y	Y	N	N	N	Medium
Al-Akhali et al ²⁷ 2017	N	Y	Y	Y	N	Y	N	Medium
Al-Akhali et al ³¹ 2019	Y	Y	Y	N	N	N	N	High
Heck et al ³² 2019	N	Y	Y	Y	N	N	N	High
Magne et al ²¹ 2010	N	Y	Y	N	N	N	N	High
Schlichting et al ¹⁹ 2011	N	Y	Y	N	N	N	N	High

Abbreviations: Y: Yes, N: No

Report of main findings

The characteristics of the materials used in the studies included in this systematic review are shown in Table 3. The fracture resistance of CAD/CAM occlusal veneers was evaluated in three studies^{23 25 29}, two of them had restorations of the same thickness and used termocycling^{25 29}. The results indicate that there is no statistically significant difference

between the use of CAD/CAM composite occlusal veneers and CAD/CAM lithium disilicate veneers, Table 4.

On the other hand, fatigue resistance was evaluated according to the survival rate in three investigations^{17 19 30}, in one study there was no statistically significant difference³⁰, however, in two studies the survival rate was higher in CAD/CAM composite resin occlusal restorations, Table 5.

According to the results of this study, the use of CAD/CAM composite and lithium disilicate occlusal veneers in worn posterior teeth is recommended. Due to the heterogeneity and risk of bias of the studies, a quantitative analysis cannot be performed.

Table 3. Materials tested in the studies included

Material	Classification	Manufacturer	Composition
IPS e.max cad	Lithium disilicate based glass-matrix ceramic	Ivoclar Vivadent AG, Liechtenstein	SiO ₂ 57.0 – 80.0%, Li ₂ O 11.0 – 19.0%, K ₂ O 0.0 – 13.0%, P ₂ O ₅ 0.0 – 11.0%, ZrO ₂ 0.0 – 8.0%, ZnO 0.0 – 8.0%, Al ₂ O ₃ 0.0 – 5.0%, MgO 0.0 – 5.0%, Colouring oxides 0.0 – 8.0%
Lava Ultimate	Resin Nanoceramic	3M ESPE, USA	Silica nanomers (20 nm), zirconia nanomers (4-11 nm), nanocluster particles derived from the nanomers (0.6-10 nm), silane coupling agent, resin matrix (Bis-GMA, Bis-EMA, UDMA, and TEGDMA)
Vita Enamic	Hybrid ceramic (Glass ceramic in a resin interpenetrating matrix)	VITA Zahnfabrik, Germany	The inorganic ceramic content is 86 wt% (Silicon dioxide 58 – 63 %, Aluminum oxide 20 – 23 %, Sodium oxide 9 – 11 %, Potassium oxide 4 – 6 %, Boron trioxide 0,5 – 2 %, Zirconia < 1 %, Calcium oxide < 1 %). The organic polymer content is 14 wt% (UDMA and TEGDMA)
Paradigm TM MZ100 Block for CEREC	Zirconia-silica ceramic in a resin interpenetrating matrix	3M TM ESPE	Paradigm MZ100 block material contains 85 wt% ultrafine zirconia-silica ceramic particles that reinforce a highly crosslinked polymeric matrix. The polymer matrix consists of bisGMA and TEGDMA

Table 4. Fracture resistance in Newtons [N], means, standard deviations (SD), and medians of the studies included.

Study	Variables				Antag onist materi al	Results					
						Mean fracture resistance values in Newton (N)	Without thermomechanica l loading (N)		After thermomechanica l loading (N)		
	Materi al	Restoratio n thickness	Cyclic Mechanic al Loading	Thermoc ycling			Mean ±SD	Median	Mean ±SD	Media n	
Andra de et al ²⁵ 2018	IPS e.max CAD	0.6mm	200 N using 1,000,000 cycles at 1 Hz frequency in distilled water at 37°C.	No thermoc ycling was performe d.	A metal sphere with a diamo ter of 6 mm was used.	3067 +- 933					A significantly higher fracture resistance was obtained for IPS e.max CAD 1.5 mm than for the other experimental groups (p= 0.027). There was no significant difference between Vita enamic, Lava ultimate and IPS e.max CAD 0.6mm (p=0.05). The fracture resistance of the sound teeth (3991 N) did not differ significantly from that of the experimental groups (p= 0.199).
		1.5mm				4995 +- 855					
	Vita Enami c	0.6mm				2973N+- 635					
		1.5mm				3540N+- 986					
	Lava Ultima te	0.6mm				3384 +- 922					
		1.5mm				3584+- 954					
Al- Akhal i et al ²⁷ 2017	e.max CAD	0.5mm	1200000 mechanica l chewing cycles. A vertical load of 98 N was applied	Between 5 and 55°C in distilled water with a 30 sec dwell time at each temperat ure with a total of 5,500 thermal cycles at a loading cycle frequenc y of 2.4 Hz	Steatit e ceram ic balls with a 6-mm diamo ter (Hoec hst Ceram Tec, Wunsi edel, Germ any) were used as antago nists		1408.8 +- 215.8	1335	1545.0 +- 175.2	1560	Thermodynamic loading increased the fracture resistance significantly for Vita enamic (P≤0.031). Without thermodynamic loading, Lithium disilicate, showed significantly higher fracture resistance than Vita enamic (P≤0,015). After thermodynamic loading, no statistically significant difference was found between the groups (P≤0.291).
	Vita Enamic						1018.5 +-155.5	1005.0	1321.0 +-269.1	1310.0	

Al-Akhal i et al ³¹ 2019	e.max CAD	0.5mm	1200000 mechanica l chewing cycles. A vertical load of 98 N was applied	Between 5 and 55°C in distilled water with a 30 sec dwell time at each temperat ure with a total of 5,500	Steatit e ceram ic balls with a 6-mm diamo ter (Hoec hst Ceram Tec, Wunsi edel, Germ any) were used as antago nists		806.1 +- 186.9	782.5	470.8 +- 428.2	328.5	Thermomechanical fatigue significantly reduced the fracture strength of Vita enamic (P=.047). Lithium disilicate did not have a significant reduction of the fracture strength after thermomechanical fatigue. With thermomechanical fatigue, no statistically significant difference was found among the groups.
	Vita Enami c			thermal cycles at a loading cycle frequenc y of 2.4 Hz			767.1 +- 130.9	769.5	349.9 +- 350.5	98.0	

Abbreviations: N: Newton; S: standard deviation

Table 5. Fatigue resistance of groups presented based on survival rate in percentages (%).

Study	Material	Restoration thickness	Antagonist material	Cyclic Mechanical Loading	Survival rate	Results
Heck et al ³² 2019	e.max CAD	0.3mm - 0.5mm	As antagonistic specimens, 5 mm Degussit-balls (highly compacted oxide ceramic; FRIALIT, Mannheim, Germany) were used.	1000000 masticatory cycles with a loading force of 50N and 100 N and a frequency of 1 Hz	100%	There was no significant difference between the IPS e.max CAD and Lava Ultimate CAD/CAM (p = 0.317) .
	Lava Ultimate			1000000 masticatory cycles with a loading force of 50N and a frequency of 1 Hz.	95%	
Magne et al ²¹ 2010	IPS e.max CAD	1.2mm at the central groove	A 7-mm-diameter composite resin sphere (Z100; 3M ESPE) postpolymerized at 100oC for 5 minutes was used.	Cyclic load was applied at a frequency of 5 Hz, and 1400 N at a maximum of 185000 cycles	30%	There was higher fatigue resistance of MZ100 compared to EMAX (p=.002)
	Paradigm MZ100				100%	
Schlichting et al ¹⁹ 2011	IPS e.max CAD	0.6mm at the central groove	A 7-mm-diameter composite resin sphere (Z100; 3M ESPE) postpolymerized at 100oC for 5 minutes was used.	Cyclic load was applied at a frequency of 5 Hz, and 1400 N at a maximum of 185000 cycles	0%	There was higher fatigue resistance of MZ100 compared EMAX (p<.001). XR was also significantly stronger than EMAX (P<.001) but not different from MZ100 (p=.03).
	Paradigm MZ100				60%	
	XR experimental blocks				100%	

Abbreviations: N: Newton, Hz: Hertz

SUMMARY

This systematic review shows that CAD/CAM composite resin occlusal veneers have fracture resistance values ranging from 1018.5 N to 3584 N, even thin veneers (0.5-1.5 mm), exceeding the maximum bite force in patients without parafunctional habits (424 N to 630 N)²³. These results are consistent with those of a systematic review³¹ advising the use of CAD/CAM composite resin occlusal veneers less than 1-mm thick and lithium disilicate veneers from 0.7- to 1.5-mm thick. Maeder et al³² evaluated different materials; among them, Vita Enamic, with a thickness of 0.5 mm, needed a load (800 N) higher than the maximum bite force to produce a crack in the veneer. Therefore, this material reaches high values of fracture resistance, which can be related to its composition, consisting of a hybrid structure with two interpenetrated ceramic and polymeric networks, resulting in a Weibull modulus of 20, in relation to the fracture range, reliability, and strength of the material³³. Ioannidis et al³⁴ also reported that 0.5 mm-thick Vita Enamic occlusal veneers have load capacity values above the normal force intervals. Johnson et al¹⁶ compared CAD/CAM composite resin occlusal veneers, such as the Lava Ultimate vs Paradigm MZ100, with thickness of 0.3, 0.6 and 1 mm, and obtained fracture resistance results higher than normal masticatory forces, even at the minimum thickness of 0.3 mm. Therefore, minimum thickness, nonceramic occlusal veneers could be considered a restorative alternative in patients with a normal masticatory load; however, under excessive loads in patients with parafunctional habits (780 N to 1120 N), complications may occur such as restoration dislodgment and fracture^{16 23}.

In terms of fatigue resistance, CAD/CAM lithium disilicate and composite resin occlusal veneers such as IPS e.max CAD and Lava Ultimate, respectively, with a thickness of 0.3-0.5 mm showed no statistically significant differences. In the studies of Magne et al¹⁹ and Schlichting et al¹⁷, Paradigm MZ100 occlusal veneers with thicknesses of 1.2 mm and 0.6 mm showed higher resistance values than IPS e.max CAD, applying a final load of 1400 N in both studies. The results of these studies suggest that higher flexural strength is not necessarily equal to a higher load resistance¹⁹. According to the studies included in this systematic review, CAD/CAM composite resin occlusal veneers have a survival rate between 95 and 100% despite their lower flexural strength than lithium disilicate. For example, lithium disilicate has a flexural strength of 360-440 mpa, compared to MZ100, which has a flexural strength of 150 mpa^{17 19 35} (neither of which is correlated with the respective survival rate), and the Lava Ultimate and Vita Enamic blocks, which show flexural strength values of 200 mpa and 150-160 mpa, respectively²³. The elastic modulus of Lava Ultimate (13 gpa) and Vita Enamic (30 gpa), close to that of dentin (20.3 gpa), can influence restoration performance²³, since the elasticity of dentin compensates for the stiffness of enamel, cushioning it against masticatory forces. Thus, stress distribution within a restored tooth during mastication depends on this property^{36 37}. However, it should be noted that thermocycling was not performed in the studies of Magne et al¹⁹ and Schlichting et al¹⁷.

In vitro studies using thermocycling are of great importance, as the procedure allows simulation of the physiological conditions and temperature changes in the oral environment, which can cause physicochemical alterations in dental materials^{25 32 38}. The

study of Al-Akhali et al²⁹ evaluated restoration survival by using thermocycling for 1200000 cycles, which simulates 5 years of clinical service^{39 40}, obtaining low survival values for both the Vita Enamic and IPS e.max CAD blocks with a survival rate of 37.5% and 50%, respectively. However, the authors of the study consider that the self-etch protocol used the reduced fracture resistance of the CAD/CAM composite resin and lithium disilicate ceramic blocks. Therefore, enamel etching is required when placing occlusal veneers, since a self-etch technique results in an insufficient and unstable bond between the veneer and the tooth²⁹. Self-etch adhesive systems produce a very superficial enamel etching, with reduced microporosity for resin infiltration, while orthophosphoric acid creates a porous enamel surface 5- to 50-µm deep. This poor etchability of self-etching adhesive systems on enamel can lead to pigmentation at the enamel margins, which may affect esthetics and also could be responsible for restoration dislodgement, marginal leakage, and secondary caries, because self-etching does not achieve lasting adhesion to the enamel. Therefore, self-etching adhesive systems should be preceded by selective enamel etching with orthophosphoric acid^{41 42 43 44 45}.

Occlusal veneers have been proposed as an alternative to full-coverage restorations for the treatment of worn posterior teeth, as they have shown satisfactory mechanical properties in several studies^{17 21}. Glass-ceramic is one material used in their manufacture, demonstrating several advantages, such as color stability, biocompatibility, durability, favorable translucency, chemical stability, reduction in the accumulation of bacterial plaque, and adequate marginal adjustment, but also disadvantages, such as chipping,

porosity and microstructural defects^{30 46 47 48 49 50}. CAD/CAM composite resin blocks have advantages such as low wear of the opposing teeth, a dentin-like elastic modulus, low cost, and the possibility of repair; some disadvantages are their greater water absorption, along with chemical and mechanical degradation^{23 51 52}.

When analyzing the fatigue and fracture resistance of CAD/CAM composite resin and CAD/CAM lithium disilicate blocks, both materials can be considered suitable for treatment of occlusally worn teeth in thicknesses from 0.5 mm to 1.5 mm using an etch-and-rinse bonding procedure. However, these results should be interpreted with caution, as the present review showed some limitations. Most of the included studies show a high risk of bias, as they do not explain whether the extracted teeth were prepared by the same operator, and only one study mentioned the sample size calculation²⁵. Additionally, variables such as the number of cycles, the load applied, and veneer thickness are not the same in all the included studies. It should also be noted that no clinical trials were found in the search, as all included studies were performed in vitro. Therefore, there is difficulty in simulating the oral environment, although only two studies^{25 29} used thermocycling, and it is recommended that clinical studies be conducted with long-term follow-up. In turn, it is suggested that the methodology of future studies be standardized. Although the studies included in this review compare CAD/CAM lithium disilicate blocks (IPS e.max CAD, Ivoclar Vivadent, Liechtenstein) with CAD/CAM composite resin blocks (Lava ultimate, 3M ESPE; Vita Enamic, VITA Zahnfabrik, Germany; Paradigm™ MZ100 Block, 3M ESPE), it should be noted there are more CAD/CAM composite resin materials such as Grandio Blocs (Voco,

Germany), with high filler content (86 % w/w), yielding a high elastic (18 gpa) and flexural (290 mpa) modulus while showing a fracture resistance of 2500 N, exceeding even the bite force in patients with parafunction^{53 54}. Another material notable for its properties is Brilliant Crios (Coltène AG; Switzerland), showing an elastic modulus of 10 gpa and a fracture resistance of 1255 N with a thickness of 1 mm⁵⁰. However, to date, there are no studies comparing occlusal veneers created from these materials with those constructed from lithium disilicate. Due to the wide heterogeneity of the included studies, a meta-analysis could not be performed.

CONCLUSIONS

CAD/CAM composite resin occlusal veneers have similar mechanical performance in terms of fatigue and fracture resistance as CAD/CAM lithium disilicate veneers.

CAD/CAM composite resin and lithium disilicate CAD/CAM occlusal veneers are recommended for use on worn posterior teeth. CAD/CAM composite resin occlusal veneers are economical and repairable, and CAD/CAM lithium disilicate occlusal veneers have better color stability and less plaque accumulation. The indicated thickness of CAD/CAM composite resin and lithium disilicate occlusal veneers is 0.5 to 1.5 mm. An etch-and-rinse or self-etch adhesive system with selective etching of the surface of the dental substrate should be used. Randomized clinical studies on this topic are suggested.

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Statements

Not applicable

Conflict of interests

None exist

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SUPPLEMENTARY FILES

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	3-4
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	6-7
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	8
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	9-10
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	8-9
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	8-9
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	10
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	10
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	12-13
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	
Reporting bias	14	Describe any methods used to assess risk of bias due to missing results in a synthesis	

Section and Topic	Item #	Checklist item	Location where item is reported
assessment		(arising from reporting biases).	
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	13-14
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	14
Study characteristics	17	Cite each included study and present its characteristics.	11-12
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	15
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	17-19
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	20-23
	23b	Discuss any limitations of the evidence included in the review.	23
	23c	Discuss any limitations of the review processes used.	23
	23d	Discuss implications of the results for practice, policy, and future research.	23-24
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	8
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	8
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	
Competing interests	26	Declare any competing interests of review authors.	2
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	

S2 Table. Search Strategy

PubMed (MEDLINE) (((((((((tooth erosion[MeSH Terms]) OR (tooth wear[MeSH Terms])) OR (dental wear[MeSH Terms])) OR (tooth erosion)) OR (tooth wear)) OR (dental wear)) OR (occlusal erosion)) AND (((((((Computer-Aided Design[MeSH Terms]) OR (composite resins[MeSH Terms])) OR (tabletop)) OR (resin composite block)) OR (occlusal veneer)) OR (cad cam)) OR (composite resins))) AND (((((((Computer-Aided Design[MeSH Terms]) OR (ceramics[MeSH Terms])) OR (tabletops)) OR (lithium disilicate)) OR (occlusal veneers)) OR (lithium disilicate ceramic)) OR (ceramic))) AND (((((survival rate[MeSH Terms]) OR (fracture strength)) OR (survival rate)) OR (fracture resistance)) OR (fatigue)))
Scopus ALL (tooth AND erosion OR tooth AND wear OR dental AND wear OR tooth AND erosion OR tooth AND wear OR dental AND wear OR occlusal AND erosion) AND (KEY (computer-aided AND design OR composite AND resins OR tabletop OR resin AND composite AND block OR occlusal AND veneer OR cad AND cam OR composite AND resins)) AND # 5 AND (survival OR fracture AND strength OR survival AND rate OR fracture AND resistance OR fatigue)
Cochrane “Tooth wear” AND “Composite restorations” AND “Ceramic Restorations” AND “Fatigue”
Embase P #1 'tooth erosion '/exp OR 'tooth wear ' OR 'wear tooth '/exp OR 'dental wear ' OR 'dental erosion '/exp OR 'tooth disease ' OR 'worn teeth '/exp AND [embase]/lim I #2 'composites resin '/exp OR 'computer aided design/computer aided manufacturing ' OR 'indirect restorations'/exp OR 'occlusal veneers ' OR 'table tops ' OR 'overlay ' OR 'CAD/CAM ' AND [embase]/lim C # 3 'Ceramics '/exp OR 'lithium disilicate ' OR 'occlusal veneers OR 'table tops' OR 'overlay' AND [embase]/lim O # 4 'mechanical properties' OR 'fracture toughness' OR 'surface wear' OR 'fatigue' OR 'rate survival' OR 'fatigue resistance' AND [embase]/lim #1 AND #2 AND #3 AND #4
Web of science P#1 Dental wear or Dental erosion OR tooth wear OR tooth erosion OR severe tooth wear I#2 Occlusal veneers OR tabletops OR indirect restorations OR overlay OR composite resin OR composite CAD CAM C#3 Ceramics OR lithium disilicate OR glass ceramics OR indirect restoration O#4 fatigue resistance OR fracture resistance OR survival rate OR mechanical properties. #1 AND #2 AND #3 AND #4

Modified Consolidated Standards of Reporting Trials (CONSORT) checklist for reporting in vitro studies of dental materials.						
Item	Studies					
	Andrade et al ²⁵ 2018	Al-Akhali et al ²⁷ 2017	Al-Akhali et al ³¹ 2019	Heck et al ³² 2019	Magne et al ²¹ 2010	Schlichting et al ¹⁹ 2011
1 Abstract	YES	YES	YES	YES	YES	YES
2a Introduction (Background)	YES	YES	YES	YES	YES	YES
2b Introduction (Objectives)	YES	YES	YES	YES	YES	YES
3 Methods (Intervention)	YES	YES	YES	YES	YES	YES
4 Methods (Outcomes)	NO	NO	NO	NO	NO	NO
5 Methods (Sample size)	NO	NO	NO	NO	NO	NO
6 Methods (Randomization: Sequence generation)	NO	NO	YES	NO	NO	NO
7 Methods (Allocation concealment mechanism)	NO	NO	NO	NO	NO	NO
8 Methods (Implementation)	NO	NO	NO	NO	NO	NO
9 Methods (Blinding)	NO	NO	NO	NO	NO	NO
10 Methods (Statistical Methods)	YES	YES	YES	YES	YES	YES

11 Results (Outcomes and estimation)	YES	NO	NO	YES	NO	NO
12 Discussion (Limitations)	YES	NO	YES	NO	YES	YES
13 Other information (Funding)	NO	YES	YES	YES	YES	YES
14 Other information (Protocol)	NO	NO	NO	NO	NO	NO