EGYPTIAN DENTAL JOURNAL
www.eda-egypt.org

Vol. 70, 2625:2635, July, 2024

Print ISSN 0070-9484 • Online ISSN 2090-2360

Fixed Prosthodontics and Dental Materials

Submit Date : 07-05-2024 • Accept Date : 30-06-2024 • Available online: 10-07-2024 • DOI : 10.21608/EDJ.2024.287559.3029

FRACTURE RESISTANCE OF OCCLUSAL VENEERS FABRICATED FROM DIFFERENT TYPES OF CAD/CAM MATERIALS: AN IN-VITRO STUDY

Lydia Amir Fouad Ibrahim*, Hany Halim Nasr** *and* Omnia Nabil***

ABSTRACT

Aim: The aim of this study was to evaluate the effect of different CAD/CAM materials (Lithium disilicate glass ceramic, polymer infiltrated ceramic network and Machinable resin composite) on the occlusal veneers' fracture resistance.

Materials and Methods: A Mandibular first molar of a typodont model was prepared into flat occlusal veneer preparation, then it was duplicated using rubber base duplicating material to obtain 21 epoxy resin dies. Also, the prepared tooth was scanned, occlusal veneer design was done then milled to obtain 21 occlusal veneers. Occlusal veneers were divided into three groups based on the material of construction: Group (LD): IPS e.max® CAD, Group (VE): Vita Enamic® and Group (BC): BRILLIANT Crios®. The 21 occlusal veneers were bonded using DUO-LINK UNIVERSAL™ adhesive resin cement to their corresponding dies. Then a vertical compressive load was applied on the restorations using the universal testing machine. The maximum load and the failure mode were recorded. After testing for normality. Data were statistically analyzed at significance level ($P \leq 0.05$).

Results: Comparison between the three groups using One Way ANOVA test demonstrated that Group (VE) (1863.18 N) had the highest fracture resistance followed by Group (BC) (1697.17 N) then Group (LD) (1035.23N). Also, Group (LD) and (VE) had repairable failure mode while Group (BC) had both repairable and irreparable failure moode.

Conclusions Groups (LD), (VE) and (BC) can withstand forces more than the physiologic masticatory forces. Also, Vita Enamic can provide satisfactory fracture resistance and a repairable failure mode for the posterior occlusal veneers.

KEYWORDS: Lithium disilicate, Polymer infiltrated ceramic network, Machinable resin composite, Fracture resistance, occlusal veneers.

* Master Degree in Fixed Prosthodontics Department, Faculty of Dentistry, Cairo University.
** Professor in Fixed Prosthodontics Department, Faculty of Dentistry, Cairo University.
*** Lecturer in Fixed Prosthodontics Department, Faculty of Dentistry, Cairo University.

INTRODUCTION

The main objective of restorative dentistry is to preserve natural tooth structure. Unfortunately, the coronal tooth structure loss that is accompanied by unfavorable dietary or oral habits represents a critical issue in prosthodontics[1]. The consequences of such loss are in the form of unstable occlusion, sensitivity, loss of vertical dimension of occlusion and incisal edge chipping which can affect both the function and esthetic aspects.[2]

Earlier the commonly used protocol to restore the worn dentition was full coverage restorations which required the elimination of the healthy tooth structure to accommodate the preparation design[3-4]. Nowadays, with the great shift in concept towards conservatism and protection of the maximum amount of healthy tooth structure, occlusal veneers have gained popularity.[5]

Even though restorations made of direct composite resin are often used for worn dentition treatment, but utilizing indirect restorations may offer better predictability due to the advancements in the adhesive bonding, which allowed the use of these non-retentive occlusal veneers with promising performance.[6]

The innovations in the CAD/CAM dental technology including the advanced scanning possibilities, the highly efficient designing software and the variety in milling protocols have made the production of high-quality dental restorations an easily done job.[7]

One of the most essential fields of esthetic dentistry is the CAD/CAM technology. This technology is seen as a revolution and has allowed the development of numerous materials. The dentist using the chairside system has access to three different types of materials supplied in the form of blocks: glass ceramic, ceramic/glass-polymer (hybrid ceramic), and resin composite. These materials have the advantage of being bondable to the tooth structure which is of crucial importance in occlusal veneers.[8]

Lithium disilicate glass ceramics have higher flexural strength compared to feldspathic and leucite-reinforced ceramics, owing to their favorable mechanical properties.[9] They are commonly used to create monolithic restorations, such as full coverage crowns, inlays, and onlays and can be used successfully to produce posterior occlusal veneers.[10] Lithium disilicate glass ceramics could be produced by pressing or milling[11]. CAD/CAM Lithium disilicate glass ceramics blocks are manufactured under controlled surroundings that reduce the development of voids and defects within the restoration.[12]

Hybrid ceramics in which a polymer material is infiltrated in the ceramic network structure, have mechanical properties that lie between ceramics and resin composites and are assumed to combine the advantages of both materials.[13]

Moreover, the ease of milling and less susceptibility of chipping during milling result in better marginal adaptation[14], together with the advantage of cancelling the need of crystallization after milling.[15]

Hybrid ceramics have comparable modulus of elasticity to the natural tooth structure which result in less wear to the opposing dentition[16], in addition to their superior esthetic qualities and the ability to be easily repaired intra-orally.[17]

This material also has reduced brittleness and hardness in comparison to lithium disilicate, thus may provide favorable properties when applied in reduced thickness. All these advantages make the hybrid ceramics a competitive alternative to the conventional glass ceramic.[18]

Machinable resin composite materials have been enhanced in their mechanical characteristics over the conventional composite material by applying heat polymerization under high pressure which led to a degree of conversion and increases their density. They also consist of organic and inorganic parts (ceramic or glass).[19-20]

Ordinarily, they are used to produce inlays and onlays. Advantages of CAD/CAM composite are being easily milled, can be produced at low thicknesses to accommodate conservative tooth preparations and repair potentiality.[19]

Another advantage over the hybrid ceramics is that the repaired composite blocks had a better bonding performance.[21-22]

The mechanical properties of these three materials differ, and accordingly it is important to investigate whether these variations would affect the survival rate of occlusal veneers.

Therefore, the aim of the present study was to evaluate the effect of Lithium disilicate glass-ceramic (IPS e.max® CAD, Ivoclar Vivadent, USA), Polymer infiltrated ceramic network (VITA ENAMIC®, VITA Zahnfabrik, Germany) and Machinable resin composite (BRILLIANT Crios®, Coltène, Switzerland) on the fracture resistance of occlusal veneers. The null hypothesis was that there would be no significant difference between the three tested materials in the fracture resistance of occlusal veneers.

MATERIALS AND METHODS

Sample size calculation

Sample size calculation was performed with 0.05 alpha, 95% confidence interval and 90% power, rendering seven samples in each group, calculated based on the results of **Egbert JS, et al**.[23]

Sample grouping:

21 samples were divided into three groups according to the type of the veneer material as follows:

Group LD: (n=7) Lithium disilicate glass-ceramic (IPS e.max® CAD, Ivoclar Vivadent, USA).

Group VE: (n=7) Polymer infiltrated ceramic network (VITA ENAMIC®, VITA Zahnfabrik, Germany).

Group BC: (n=7) Machinable resin composite CAD (BRILLIANT Crios®, Coltène, Switzerland).

Sample preparation:

A mandibular first molar of a Typodont model (NISSIN Dental Model, Kyoto Japan) was selected for the occlusal veneer preparation. An addition silicon putty index (Elite HD +Zhermack SPA, Italy) was taken before the preparation to ensure standardization and was cut buccolingually. The occlusal surface preparation was done manually using diamond wheel stone (OKO Dental, Germany). Putty index was used to check the amount of reduction which was 1.5 mm at cusp tip and 1 mm at fossa **Figure (1)**. Preparations were polished with Sof-Lex spiral wheels (3M, USA) and EVE Diacomp plus occluflex (EVE, Germany). The prepared typodont tooth was replicated to obtain 21 epoxy resin replicas. Replication was done by placing the prepared typodont tooth in a glass container. Equal proportions of (REPLISIL Silicone Rubber 22 N) were mixed and poured into glass container to create a mold, then epoxy resin (KEMAPOXY 150, Egypt) was poured immediately into the silicon mold to obtain the replicas. **Figure (2).**

Fig. (1) Flat occlusal preparation

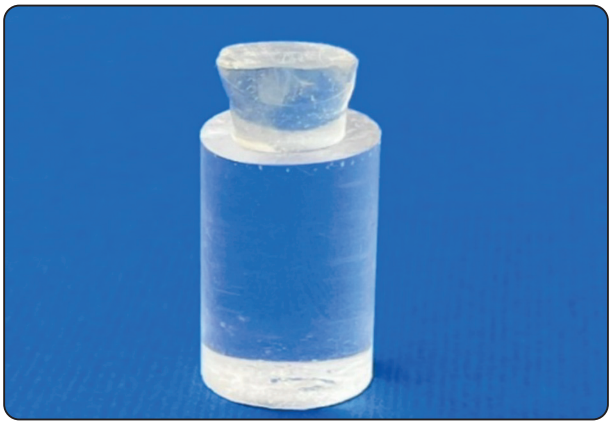


Fig. (2) The duplicated epoxy resin dies.

Occlusal veneers were fabricated using CAD/CAM system. First the prepared typodont tooth was scanned directly on the cast using an intraoral scanner (Primescan, Dentsply Sirona, Germany), then model images obtained by the scanner were exported as STL files and were sent to EXOCAD software (EXOCAD GmbH, Germany) for designing. Onlay restoration of mandibular first molar tooth was selected.

Ceramic thickness was standardized at 1mm at the central fossa and spacer thickness was set at 30μm. Once designing of occlusal veneers regarding position, shape and contour was completed. The CAD file of virtual design was exported to the 5-axis milling machine Imes-icore 150i pro (Coritec, Germany), The milling procedure was entirely automated with the grinding diamond bur in a wet milling mode. The procedure was repeated to end up with 21 occlusal veneers, then all the occlusal veneers were checked over the typodont tooth and the corresponding duplicated teeth for proper seating.

Outer surface treatment of the occlusal veneers was performed as recommended for each material. Group (LD) samples were crystallized and glazed in the programat EP 3010 furnace (Ivoclar Vivadent, USA) at the recommended firing program after the application of IPS e.max ceram crystal/glaze paste (Ivoclar Vivadent, USA) on their outer surface. While Group (VE) was finished and polished using the Vita Enamic kit (VITA Zahnfabrik, Germany). Also, Group (BC) was finished and polished by using Diatech kit (Coltène, Switzerland).

Surface treatment:

The epoxy resin dies were etched with Bisco phosphoric acid 37% (Bisco, Schaumburg) for 30 seconds then rinsed with water for 60 seconds, dried with air, then Bisco universal bonding agent (Bisco, Schaumburg) was applied with a brush for 15 seconds, air thinned then light polymerized (Elipar LED curing unit, 3M ESPE) for 20 seconds.

The fitting surface of Group (LD) was etched using Bisco Porcelain Etch (Bisco, Schaumburg) 9.5% hydrofluoric acid ceramic etching gel for 20 seconds, rinsed and air-dried, then Bisco porcelain's primer (Bisco, Schaumburg) was applied for 60 seconds then air-dried for 5 seconds. The same protocol was used for Group (VE) except that etching time was extended to 60 seconds.

The fitting surfaces of Group (BC) were sandblasted by air abrasion (Optident, Ltd) using 50µm aluminum oxide particles under a standardized pressure of 2 bar at a distance of 10mm for 5 seconds.

Cementation

DUO-LINK UNIVERSAL™ adhesive resin cement (Bisco, Schaumburg) was utilized to cement the occlusal veneers on the epoxy resin duplicates. Then a custom-made loading device was used to apply a 3 kg of constant occlusal load for 30 seconds, excess cement was removed after tack curing for 2 seconds (Elipar LED curing unit, 3M ESPE) then light polymerization of all surfaces was done for 40 seconds on each surface.

Fracture resistance Test

Every sample was mounted individually on a computer-controlled universal testing machine

(Model 3345; Instron Industrial Products, Norwood, MA, USA) with a load of 5 kg. Fracture test was done with a compressive load using a metallic rod with round tip (5.8 mm diameter) attached to the upper compartment of testing machine, this load was applied occlusally and moved at crosshead speed of 1mm/min with tin foil sheet in-between to achieve uniform stress distribution.

Failure Mode:

Failure mode analysis of all the samples was done using magnifying loupes at 3.5x (Eighteenth Brilliance, China).

Failure mode was categorized according to **(Guess et al., 2014)**[24]. Failure Mode I: extensive crack formation only in the restoration. Failure Mode II: fracture involving only the restoration. Failure Mode III: crack/fracture involving both the restoration and the die above the cementoenamel junction. Failure Mode IV: longitudinal fracture of the restoration and the die (Catastrophic fracture). Failure modes (I, II, III) are considered repairable modes, while failure mode (IV) is an irreparable mode.

Statistical analysis:

Statistical analysis was performed with SPSS 20®, Graph Pad Prism® and Microsoft Excel 2016. All quantitative data were checked for normality by using Shapiro Wilk and Kolmogorov Normality test and presented as means and standard deviation (SD) values. One Way ANOVA test for overall comparisons and Tukey`s Post Hoc test were used for multiple comparisons. The level of significance was set to (P≤0.05).

RESULTS

Fracture resistance test

One Way ANOVA test revealed that Group (LD) was significantly lower than Group (VE) with Mean ± SD (828± 266.15) as P=0.003, Group (LD) was significantly lower than group (BC) with Mean ± SD (661.95± 220.4) as P=0.01, Group (VE) was insignificantly higher than Group (BC) with Mean ± SD (166± 244.3) as P=0.73, presented in **Table (1,2), Figure (3).**

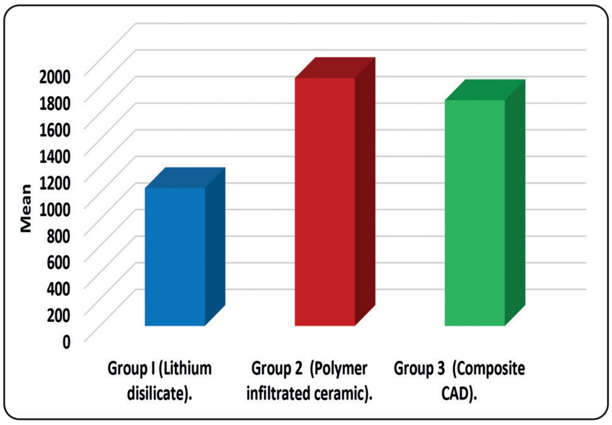


Fig. (3) Bar chart showing mean values of all groups.

Failure Mode analysis:

For all the tested groups, the most common failure mode was (II), followed by failure mode (I), failure mode (IV) then failure mode (III), illustrated in **Table (3), Figure (4)**

TABLE (1) Mean (M) and standard deviation (SD) of all groups and overall comparison between them using One Way ANOVA test

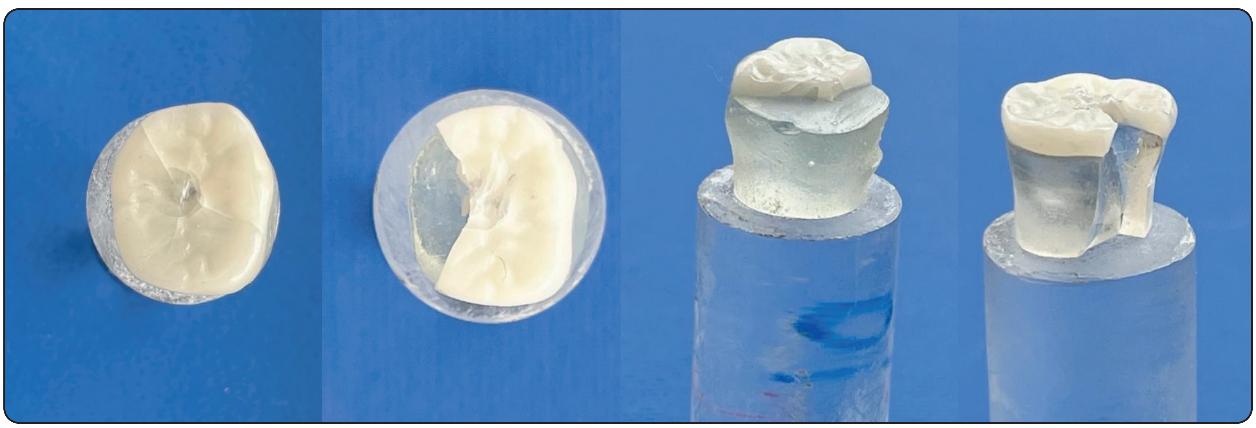
	M	SD	P value
Group (LD)	1035.23 N (a)	154.57 N	0.003*
Group (VE)	1863.18 N (b)	437.01 N	0.01*
Group (BC)	1697.17 N (b)	543.19 N	0.73*

TABLE (2) Mean difference and standard error of difference between each 2 groups and multiple comparisons using Tukey`s Post Hoc test:

		MD	SE	P value	95% CI	
					L	U
Group (LD)	**Group (VE)**	828.0	266.15	0.003*	-1390	-265.5
	Group (BC)	661.95	220.4	0.01*	-1341.19	-17.30
Group (VE)	**Group (LD)**	828.0	266.15	0.003*	-1390	-265.5
	Group (BC)	166	244.3	0.73	-396.4	728.4
Group (BC)	**Group (LD)**	-661.95	220.4	0.01*	-1341.19	17.30
	Group (VE)	166	244.3	0.73	-396.4	728.4

TABLE (3) Failure modes of the tested materials (expressed in numbers):

	Failure Mode I	Failure Mode II	Failure Mode III	Failure Mode IV
Group (LD)	1	6	-	-
Group (VE)	2	4	1	-
Group (BC)	1	4	-	2



Mode I Mode II Mode III Mode IV

Fig. (4) Failure mode analysis Mode I: extensive crack formation only in the restoration. Mode II: fracture involving only the restoration. Mode III: crack/fracture involving both the restoration and the die above the cementoenamel junction. Mode IV: longitudinal fracture of the restoration and the die (Catastrophic fracture).

DISCUSSION

Massive tooth wear has increased over the past years which causes inefficient chewing ability, impaired tooth surface and destruction of the dental structure stability.[25]

Occlusal veneers have been established as a minimally invasive substitute to treat tooth wear instead of using full-coverage restorations as a treatment option. Its main characteristic is regaining the chewing abilities with optimum conservation of the vital tooth structure particularly after teeth wear or trauma.[26]

In the present study occlusal veneers were fabricated from three different materials: Lithium disilicate (IPS e.max CAD, Ivoclar Vivadent, USA), Polymer infiltrated ceramic network (Vita Enamic, VITA Zahnfabrik, Germany) and Machinable resin composite (Brilliant Crios, Coltène, Switzerland) to test their fracture resistance.

In previous studies, the proven competence of lithium disilicate material has been demonstrated, which encouraged its use in restoring worn teeth using a more conservative approach.[27] It is considered as an adaptable metal-free material due to its favorable esthetic and mechanical properties.[28]

Due to the high fracture resistance of lithium disilicate glass ceramic, occlusal veneers could be fabricated at thickness (1–1.5mm). Also, they are biocompatible, and they have superior adhesive bonding strength, accordingly they are used when a significant occlusal correction is required or when teeth have been extensively abraded.[28]

Polymer infiltrated ceramic network materials represent a recent advancement of CAD/CAM materials that have been developed to utilize the benefits of the composite resins with reduced brittleness, high edge stability and increased fracture resistance added to the distinctive esthetic properties of the ceramic materials. Their mechanical characteristics are midway between that of adhesive ceramics and highly filled composites.[29]

The third material chosen in the study was machinable resin composite material which has been enhanced in the last ten years.[30] In comparison to porcelain, CAD/CAM resin composite overlays were shown to have superior fatigue resistance.[31] Their low abrasiveness to the opposing teeth and low elastic modulus which is close to the natural teeth, allows more absorption of functional stresses than glass ceramics.[3] Their excellent machinability, high edge stability and reduced brittleness mitigated some of the drawbacks seen in ceramic/glass-ceramic blocks.[32]

In the current study, standardization of all steps was carried out to ensure uniformity of all samples. A typodont lower first molar tooth was used instead of natural teeth, as natural teeth represent great variations in anatomy, form, age and storage time after extraction making it difficult to standardize tooth preparation.[33] Also, the CAD/CAM technology used in the study aided in standardization.

Occlusal veneers were prepared with a flat design, that is considered a conservative approach as it follows the biomimetic perspective.[34] Also, this design allows more uniform distribution and reduction of stress as the number of prepared walls decreases.[35]

Duplication of the prepared typodont tooth using epoxy resin was done to get 21 replicas. Because it was easier to standardize and make dies using materials like epoxy resin[36], as they have modulus of elasticity close to the natural dentin.[37]

Scanning of the prepared typodont tooth was done by Primescan, then data was sent to EXOCAD software to design the occlusal veneer. This virtual design was saved and used to produce all restorations with exactly the same dimensions for standardization. Cement space was set at 30µm since that would serve for optimum cement thickness and would allow passive fit of the ceramic restoration.[38]

To ensure precise milling of the occlusal veneers, the IMES icore 5-axis milling machine was used, **Bosch et al., (2014)**[39] stated that five-axis milling results in high trueness and permits a more effective milling of surfaces near to the insertion axis. Moreover, a better outcome could be obtained as small angles and steep walls could be machined from different directions.

Crystallization/Glazing of Group (LD), finishing and polishing of Groups (VE) and (BC) were done to increase surface smoothness and restoration strength because this technique would decrease the size of the surface defects, acting against crack propagation, thus increasing the fracture resistance of the materials.[40]

DUO-LINK Bisco adhesive resin cement was used, this is a dual cure cement that has the ability to enhance the polymerization of the inaccessible areas to light,[41] allowing optimum bonding that will strengthen the weaker ceramic restorations.[42]

Static loading of fracture was used to determine whether the restorative material is appropriate for clinical use and to determine the practical longevity of all-ceramic restorations.[43]

The results of the fracture resistance of Groups (LD), (VE) and (BC) were (1035.23±154.57N), (1863.18±437.01N), (1697.17±543.19N) respectively. The null hypothesis was rejected because the tested materials had statistically different fracture strengths.

The present results showed that Group (VE) had higher mean fracture resistance values than Group (LD) which was statistically significant (P=0.003). This was in agreement with **Maeder et al., (2019)**[44] who stated that polymer infiltrated ceramic network with fracture resistance (2239 ± 493N) could withstand higher masticatory forces than Lithium disilicate occlusal veneers with fracture resistance (1851 ± 631N). Also, **Tribst et al., (2018)**[45] found as well that polymer infiltrated ceramic network occlusal veneers produced lower stress concentration in the restoration structure than lithium disilicate.

Also, the present results showed that Group (BC) had significantly higher mean fracture resistance values than Group (LD) (P=0.01) which is in agreement with **Emam and Aleem, (2020)**[46] who found that CAD/CAM composite resin occlusal veneers (1033 ± 135.7N) had higher fracture resistance than Lithium disilicate ones (518 ± 74.1N), which was explained by **Schlichting et al., (2011)**[3] that this might be due to the close resemblance between the elastic moduli of dentin and composite, which justifies its higher fracture resistance than lithium disilicate.

There was no significant difference between Group (VE) and (BC) (P=0.73) which was in agreement with **Egbert et al., (2015)**[23] who found no significant difference between Paradigm MZ100 and Vita Enamic. Group (VE) matched the fracture strength of the Group (BC). From the authors point of view, this might be due to the resin content presented in both materials which allowed absorption of functional stresses while Group (LD) had the lowest mean fracture resistance because they didn't contain resin content, so they are brittle. Also, Group (VE) had the highest mean fracture resistance because the cracks primarily spread via the ceramic network and the polymer/ceramic interface, then they form polymer deformation bridges across the crack, this would increase crack propagation resistance.[45]

The fracture resistance of the three tested materials exceeded the normal masticatory forces (600-900N[3]), so occlusal veneers could be fabricated from the tested materials without fracture.

Failure modes of the occlusal veneers were analyzed to test the repairability of the tested materials.[13] The tested groups were mostly showing cracks within the restoration (Mode I) and fracture of the restoration only (Mode II) which meant that occlusal veneer restorations when fractured, might cause minute damage to tooth structures that would enhance the longevity of the tooth by the restoration replacement,[23] instead of losing the tooth itself. One sample in Group (VE) showed fracture in the restoration and die above the cementoenamel junction which is also repairable. While two samples within Group (BC) revealed longitudinal fracture of the restoration and the die (Mode IV). The high fracture resistance of the material might cause less force distribution along the tooth axis resulting in residual stress exceeding the restoration elasticity limit consequently the die was fractured.

Limitations of the current study were obtaining fractures in vertical direction under static loads whereas clinical forces are dynamic in nature. It was a laboratory investigation study therefore there were no oral environmental conditions such as the absence of the intra-pulpal pressure that could impact the adhesion quality to dentin and cause debonding. Also, aging wasn't done in this study to check the material's fatigue resistance.

The study's clinical implication showed that Vita Enamic occlusal veneer restorations are considered a promising alternative to the conventional IPS e.max CAD in terms of fracture resistance.

CONCLUSIONS

Within the limitations of the study, the following could be concluded:

1. The tested CAD/CAM materials had fracture resistance higher than the normal range of the masticatory forces.
2. Vita Enamic occlusal veneers combined the advantage of the highest fracture resistance together with the repairable failure mode.
3. The best failure mode was achieved by Lithium disilicate (IPS e.max CAD) occlusal veneers.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Ethics

This study protocol was approved by the ethical committee of the faculty of dentistry- Cairo university, approval number [4-5-21].

REFERENCES

1. Abrahamsen, T. C. The worn dentition—pathognomonic patterns of abrasion and erosion. International dental journal, 2005;55(S4), 268-276.
2. Cardenas-Sallhue, H., Delgadillo-Avila, J., & Alvarado-Menacho, S. Functional Aesthetic Rehabilitation of a Patient with Dental Biocorrosion: A Case Report. Chin J Dent Res, 2020;23(3), 215-220.
3. Schlichting, L. H., Maia, H. P., Baratieri, L. N., & Magne, P. Novel-design ultra-thin CAD/CAM composite resin and ceramic occlusal veneers for the treatment of severe dental erosion. The Journal of prosthetic dentistry,2011; 105(4), 217-226.
4. Magne, P., Stanley, K., & Schlichting, L. H. Modeling of ultrathin occlusal veneers. Dental materials, 2012;28(7), 777-782.
5. Dietschi, D., & Spreafico, R. Evidence-based concepts and procedures for bonded inlays and onlays. Part I. Historical perspectives and clinical rationale for a bio substitutive approach. Int J Esthet Dent, 2015;10(2), 210-27.
6. Hardan, L., Mancino, D., Bourgi, R., Cuevas-Suarez, C. E., Lukomska-Szymanska, M., Zarow, M., & Haikel, Y. Treatment of tooth wear using direct or indirect restorations: a systematic review of clinical studies. Bioengineering, 2022;9(8), 346.
7. Stromeyer, S., Wiedemeier, D., Mehl, A., & Ender, A. Time efficiency of digitally and conventionally produced single-unit restorations. Dentistry Journal, 2021;9(6), 62.
8. Marchesi, G., Camurri Piloni, A., Nicolin, V., Turco, G., & Di Lenarda, R. Chairside CAD/CAM materials: current trends of clinical uses. Biology, 2021;10(11), 1170.
9. Phark, J. H., & Duarte Jr, S. Microstructural considerations for novel lithium disilicate glass ceramics: A review. Journal of Esthetic and Restorative Dentistry, 2022;34(1), 92-103.

10. Sartori, N., Tostado, G., Phark, J., & Lin RDuarte, S. CAD/CAM High Strength Glass-Ceramics. Quintessence of Dental Technology, 2015;38, 39-54.

11. Anadioti, E., Aquilino, S. A., Gratton, D. G., Holloway, J. A., Denry, I., Thomas, G. W., & Qian, F. 3D and 2D marginal fit of pressed and CAD/CAM lithium disilicate crowns made from digital and conventional impressions. Journal of Prosthodontics, 2014;23(8), 610-617.

12. Giordano, R. Materials for chairside CAD/CAM–produced restorations. The Journal of the American Dental Association, 2006;137, 14S-21S.

13. Albelasy, E., Hamama, H. H., Tsoi, J. K., & Mahmoud, S. H. Influence of material type, thickness and storage on fracture resistance of CAD/CAM occlusal veneers. Journal of the mechanical behavior of biomedical materials, 2021; 119, 104485.

14. Chavali R, Nejat AH, Lawson NC. Machinability of CAD CAM materials. J Prosthet Dent, 2017;118 (2):194-9.

15. De Kuijper, M. C., Gresnigt, M. M., Kerdijk, W., & Cune, M. S. Shear bond strength of two composite resin cements to multiphase composite resin after different surface treatments and two glass-ceramics. The international journal of esthetic dentistry, 2019;14(1), 40-50.

16. He, L. H., & Swain, M. A novel polymer infiltrated ceramic dental material. Dental materials, 2011;27(6), 527-534.

17. Awada, A. & Nathanson, D. Mechanical properties of resin ceramic CAD / CAM restorative materials. J. Prosthet. Dent; 2014;1–7.

18. Stappert CF, Att W, greds T, Strub JR. Fracture resistance of different partial coverage ceramic molar restorations: an in vitro investigation. J Am Dent Assoc 2006;137-:514-522.

19. Awada, A., & Nathanson, D. Mechanical properties of resin-ceramic CAD/CAM restorative materials. The Journal of prosthetic dentistry, 2015;114(4), 587-593.

20. J. Nguyen, V. Migonney, N. D. Ruse, and M. Sadoun, Resin composite blocks via high-pressure high-temperature polymerization," Dental Materials, 2012;28(5) 529–534.

21. ELSAKA, Shaymaa E. Repair bond strength of resin composite to a novel CAD/CAM hybrid ceramic using different repair systems. Dental materials journal, 2015, 34.2: 161-167.

22. El Zohairy, A., Hafez, A., & Amr, H. Repair potentiality of CAD/CAM composite block and hybrid ceramic block by direct resin composite restoration with and without surface treatment. Egyptian Dental Journal, 65(1-January (Fixed Prosthodontics, Dental Materials, Conservative Dentistry & Endodontics), 2019;551-562.

23. Egbert J. S., Johnson A. C., Tantbirojnc D., Versluisd A. Fracture strength of ultrathin occlusal veneer restorations made from CAD/CAM composite or hybrid ceramic Materials. Oral science international, 2015;12(2): 53-58.

24. Guess, P. C., Schultheis, S., Wolkewitz, M., Zhang, Y., & Strub, J. R. Influence of preparation design and ceramic thicknesses on fracture resistance and failure modes of premolar partial coverage restorations. The Journal of prosthetic dentistry, 2013;110(4), 264-273.

25. Turker, I., & Kursoglu, P. Wear evaluation of CAD-CAM dental ceramic materials by chewing simulation. The Journal of. Advanced Prosthodontics, 2021;13(5), 281.

26. Ladino, L.G., Sanjuan, M.E., Valdéz, D.J. and Eslava, R.A. Clinical and Biomechanical Performance of Occlusal Veneers: A Scoping Review. Journal of Contemporary dental practice, 2021;22(11): 1327–37.

27. Al-Zordk, W., Saudi, A., Abdelkader, A., Taher, M. and Ghazy, M. Fracture Resistance and Failure Mode of Mandibular Molar Restored by Occlusal Veneer: Effect of Material Type and Dental Bonding Surface. Materials, Jan, 2021;14(21):6476.

28. Zarone, F., Di Mauro, M.I., Ausiello, P., Ruggiero, G. and Sorrentino, R. Current status on lithium disilicate and zirconia: a narrative review. BMC Oral Health, 2019;19(1): 134.

29. Marchesi, G., Camurri Piloni, A., Nicolin, V., Turco, G. and Di Lenarda, R. Chairside CAD/CAM Materials: Current Trends of Clinical Uses. Biology, 2021;10(11): 1170.

30. Mainjot, A.K., Dupont, N.M., Oudkerk, J.C., Dewael, T.Y. and Sadoun, M.J. From artisanal to CAD-CAM blocks: State of the art of indirect composites. Journal of dental Research, 2016;95: 487–95.

31. Magne, P., & Knezevic, A. Simulated fatigue resistance of composite resin versus porcelain CAD/CAM overlay restorations on endodontically treated molars. Quintessence International, 2009;40(2).

32. Lucsanszky, I. J., & Ruse, N. D. Fracture toughness, flexural strength, and flexural modulus of new CAD/CAM resin composite blocks. Journal of Prosthodontic, 2020;29(1), 34-41.

33. Alghazzawi, T. F. Advancements in CAD/CAM technology: Options for practical implementation', journal of prosthodontic research, 2016;60(2), pp. 72–84.

34. Abdelhameed A. M., Abd-El Aziz M. H. and Hamza T. A. In vitro study to evaluate the effect of different material types and preparations on the fracture resistance of occlusal veneers. Al-Azhar Journal of Dental Science, 2018;21(1): 65-71.

35. Huang X., Zou L., Yao R., Shuyi W., Yan L. Effect of preparation design on the fracture behavior of ceramic occlusal veneers in maxillary premolars. J Dent, 2020; 97:103346

36. Nawafleh, N., Hatamleh, M., Elshiyab, S. and Mack, F. Lithium Disilicate Restorations Fatigue Testing Parameters: A Systematic Review. Journal of Prosthodontics, 2016; 25: 116-26.

37. Chen C., Trindadec F. Z., Jagerb N. D., Kleverlaanb C. J., Feilzerba A. J. The fracture resistance of a CAD/CAM Resin Nanoceramic (RNC) and a CAD ceramic at different thicknesses. Dental Materials, 2014; 30(9):954–962

38. Kale, E., Seker, E., Yilmaz, B., & Özcelik, T. B. Effect of cement space on the marginal fit of CAD-CAM-fabricated monolithic zirconia crowns. Journal of prosthetic dentistry, 2016;116(6), 890-895.

39. Bosch, G., Ender, A., & Mehl, A. A 3-dimensional accuracy analysis of chairside CAD/CAM milling processes. Journal of prosthetic dentistry, 2014;112(6), 1425-1431.

40. Mores, R. T., Borba, M., Corazza, P. H., Della Bona, Á., & Benetti, P. Influence of surface finishing on fracture load and failure mode of glass ceramic crowns. The Journal of prosthetic dentistry, 2017;118(4), 511-516.

41. Sasse M., Krummel A., Klosa K., Kern M. Influence of restoration thickness and dental bonding surface on the fracture resistance of full-coverage occlusal veneers made from lithium disilicate ceramic. Dent Mater., 2015;31(8):907-915.

42. Al-Akhali M., Chaar M. S., Elsayed A., Samran A., Kern M. Fracture resistance of ceramic and polymer-based occlusal veneer restorations. J. Mech. Behav. Biomed. Mater. 2017;74: 245-250.

43. Gürpınar B., Celakil T., Baca E., Evlioğlu G. Fracture resistance of occlusal veneer and overlay C AD/CAM restorations made of polymer-infiltrated ceramic and lithium disilicate ceramic blocks. Ege Üniversitesi Diş Hekimliği Fakültesi, 2020;41(2):131-142.

44. Maeder, M., Pasic, P., Ender, A., Özcan, M., Benic, G.I. and Ioannidis, A. Load-bearing capacities of ultra-thin occlusal veneers bonded to dentin. Journal of the mechanical behavior of biomedical materials, 2019;95: 165-71.

45. Tribst J.P., Dal Piva A.M., Penteado M.M., Borges A.L., Bottino M.A., Influence of ceramic material, thickness of restoration and cement layer on stress distribution of occlusal veneers. Brazilian oral Research, 2018;29:32.

46. Emam Z. N. and Aleem N. A. Influence of different materials and preparation designs on marginal adaptation and fracture resistance of CAD/CAD fabricated occlusal veneers. Egyptian Dental Journal, 2020; 66.1-January (Fixed Prosthodontics, Dental Materials, Conservative Dentistry & Endodontics): 439-452.