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Original Article

Fracture Resistance of CAD-CAM Occlusal Veneers Fabricated from Different Materials with Two Different Thicknesses: An In-Vitro Study

Maram G. Abd El-Kawy[1], Rabab M. Ibraheem[2], Hanaa S. Nassar[2]
[1] Fixed Prosthodontics Department, Faculty of Dentistry, Ahram Canadian University, Egypt
[2] Fixed Prosthodontics Department, Faculty of Dentistry, Cairo University, Egypt

Email: maram_gamal@ dentistry.cu.edu.eg

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Abstract

Purpose: The purpose of this study was to evaluate the fracture resistance of occlusal veneers constructed from Lithium Disilicate (IPS e-max CAD), Zirconia reinforced Lithium Silicate (Celtra Duo) and Resin Matrix ceramics (Shofu) materials with two restoration thicknesses. **Materials and Methods**: 42 Human 2 nd mandibular molars were selected and fixed into epoxy resin transparent blocks. Teeth were divided into 2 groups (n=21) according to the occlusal thickness: conventional 1.5mm and thin 1mm. Samples were divided into three subgroups (n=7) according to the ceramic material: subgroup(A); Lithium Disilicate (IPS e-max CAD), subgroup (B); zirconia lithium silicate (Celtra Duo) and subgroup (C); Hybrid ceramics (Shofu HC). All prepared teeth were Scanned with Omnicam scanner. Designing was done by cerec 3D software version 4.5. CEREC MCXL 4-Axis machine was used for milling of occlusal veneers. All restorations were thermally aged for 100000 cycles. All specimens were subjected to a compressive load to fracture of 5000N using a computerized universal testing machine. **Results:** Results of the one-Way ANOVA test showed that the highest mean fracture values were for IPS e-max CAD. Comparison between the two tested thicknesses showed non-significant difference as $P>0.05$. Comparison between the different materials showed significant difference as $P<0.05$. **Conclusion**: Both conventional and thin occlusal veneer thickness presented fracture resistance mean values that exceed the range of clinical acceptability.

Keywords: occlusal veneers, CAD CAM, Fracture resistance, thermocycling, Thickness.

I. INTRODUCTION

Non-carious tooth surface loss (TSL) or tooth wear (TW) is becoming an increasingly significant factor affecting the long-term health of the dentition. TSL may result subsequently in widespread exposure of dentine with hypersensitivity, an unsightly appearance of the teeth and reduced masticatory function. The costs of treatment and rehabilitation may then be considerable. With the advances in CAD/CAM (computer aided design/Computer aided manufacturing) technology, materials and resin cement the loss of dental structure can be minimized using conservative preparations. Several studies have evaluated fracture and fatigue resistance of restorations made in ceramics or composite resin of different thicknesses. Owed to their ability to form adhesive bond with tooth enamel, occlusal veneers perform well despite the low ceramic thickness, and fractures rarely occur [(1), (2)]

Occlusal veneers are a contemporary restorative approach indicated for teeth with occlusal wear. They are considered as an important therapeutic modality to recover the occlusal vertical dimension of patients with great occlusal wear related to a parafunctional habit or physiological processes such as erosions. The main advantage of occlusal veneers is the recovery of the masticatory function with maximum preservation of dental structure being a conservative option to traditional onlays and complete coverage crowns. Occlusal veneers represent a conservative alternative to traditional onlays and complete coverage crowns for the treatment of severe erosive lesions in the posterior dentition **[3], [4]**

In the last decades, several advancements were done in the field of ceramic material as well as CAD/CAM technology that allows the clinicians to choose from a wide variety of ceramic materials with their differences in terms of mechanical and optical properties to fulfil every clinical situation. Zirconia reinforced lithium silicate (ZLS) is not as rigid as lithium di silicate and the crystal reinforcement make this material tougher than feldspathic ceramics due to its high glass content. It contains 8-10% zirconium oxide (ZrO2) by weight. This very fine microstructure allows a high flexural strength, at the same time providing a high percentage of glassy matrix, thus leading to good optical, milling, and polishing properties. ZLS ceramics are provided in either a fully or a partially crystallized state and can be processed, either by using the hot-pressing or CAD-CAM techniques. The performance of CAD/CAM hybrid composite resin restorations have also increased in last years through a superior bond to underlying structure resulting in appropriate stress transfer, low abrasiveness of opposing teeth lead to enamel preservation as well as low elastic modulus allowing absorption of functional stresses. Their development offers the advantage of great esthetics, exceptional polish-ability and high strength **[5]**. The aim of the present study was to evaluate the effect of two occlusal veneers thicknesses: conventional 1.5 mm and thin 1mm using three different ceramic materials IPS e.max CAD, CeltraDuo and Shofu HC on the fracture resistance of bonded occlusal veneers. The null hypothesis of this study was that there would be no difference regarding the fracture resistance of occlusal veneers made of different ceramic materials with two different thicknesses.

II. MATERIALS AND METHODS

1. Sample Size Calculation and Samples Grouping

Sample size was calculated based on the results of previous study by **Andrade., et al (2018) [6]** using G*Power version 3.1.9.2. When an alpha (α) level of 0.05 (5%), a beta (β) level of 0.05 (5%), i.e., power=95% were used, the effect size (f=0.806) was estimated. Accordingly, sample size (n) was found to be a total of 42 samples. The forty-two samples were randomly divided into two groups (n=14) according to thickness of occlusal veneer conventional 1.5mm and thin 1mm. Each group was subdivided into three equal subgroups (n=7) according to ceramic material used. Materials were lithium disilicate (IPS e-max CAD), zirconia reinforced lithium silicate (Celtra Duo) and resin hybrid ceramic (SHOFU HC).

2.Teeth Selection, Fixation and Periodontal Simulation

42 sound mandibular 2nd molars that defect and caries free with no previous restoration or root canal treatment were selected in this study. All teeth with previous restorations or fractures were excluded. A digital caliper (Mitutoyo IP 65, Kawasaki, Japan) was used to confirm the comparable dimensions of selected teeth; the distance between the height of contours of buccal and lingual surfaces was (10±1mm), while the mesio-distal dimensions were (8±1.5 mm) at contact area level. Tissues and calculus deposits were removed with an ultrasonic scaler. Teeth were cleaned and disinfected by immersing them in a 5 % sodium hypochlorite solution for 15 minutes and then storing them in distilled water at room temperature. For creating mold former, a mix of a silicone duplicating material was done 30 gm base to 30 gm catalyst in a hexagonal embodiment with a square box in the center, to get a hexagonal silicone mold with a hollow square center. Silicon mold left to be hardened for 24 hours. An ivomat pressing device was used to eliminate any voids and remnants of the mold former. Then a mix of resin transparent liquid with its corresponding hardener with a ratio 2 :1 was done at the center of the silicone mold former. A 0.2 mm of soft pink wax was added around root of the tooth and the tooth was dipped into the epoxy resin mix before hardening. It was left for

hardening for 48 hours. Adental surveyor was used with centralizing wo different thicknesses. tool for ensuring centralization of tooth position into the block. Each tooth was inserted to a level 2mm below the CEJ. After complete polymerization, tooth was removed from the block and wax was eliminated by hot water. Followed by light body silicone impression material injection into the space to simulate periodontal ligament then, the tooth was replaced again into the block.

3. Randomization of the samples

Randomization software (www.random.org) was used for generation of random sequence of all the study samples. Software was utilized twice first to allocate the 42 samples into two groups according to restoration thickness, second randomization was done to further allocate the samples into 3 subgroups according to material used for occlusal veneer construction. Allocation ratio was 1:1.

4. Blinding

This study was double blinded where the outcome assessor and statician were blinded to both thickness of restoration and type of material used to avoid detection bias. On the other hand, operator and CAD/CAM specialist were not blinded due to variation in sample preparation and designing on CAD/CAM software.

5. Biogeneric copy

To allow checking accurate amount of reduction of the study samples by superimposition of the pre and post operative image of tooth, a Biocopy mode on cerec 4.5 CAD/CAM software was used **Figure (1)**. In addition, to allow for better control over occlusal morphology of the final restoration.

Figure (1): Superimposition of the pre and post operative image of tooth

6. Teeth Preparation

In order to ensure a uniform and equal amount of occlusal reduction for each tooth, silicon index from addition silicone putty impression material was made before teeth preparation to check the uniformity and the amount of preparation. All preparation was performed by the same operator using the exact same sequence for each to ensure standardization. All teeth received standardized preparation using a veneer preparation kit (Intensive Modular veneer kit DR. A Schöler, Biel). High-speed handpiece was held horizontal and perpendicular to the long axis of the tooth with copious water coolant. Four depth grooves were made in the occlusal surface following tooth anatomy with a coarse diamond 3-wheel stone with a 0.8 mm diameter .Then these depth grooves were connected by removing enamel portions in between them with a round-ended cylindrical diamond green stone .The occlusal preparation was finished with a fine-grit diamond red stone ,then chamfer finish line was prepared on the top of the axial wall 1mm from the occlusal surface by using tapered red stone with a non-cutting guide pin at its tip and finished with a fine-grit yellow stone. The prepared surfaces were then polished with non-abrasive rubber points. **Figure (2)**

Figure (2): Teeth Preparation For occlusal veneer

7. Occlusal veneers construction

CAD/CAM occlusal veneers were fabricated using CEREC AC system with Omnicam (Dentsply Sirona GmbH, Bensheim, Germany). Omnicam intra oral scanner was used to scan all the prepared teeth. The CEREC 3D software (version 4.5, Sirona Dental Systems GmbH, Bensheim, Germany) was used for designing the occlusal veneers restorations. Standardized restoration design with similar occlusal surface anatomy was done by using biogeneric reference feature in CEREC software.

All restorations were milled with 4-axis wet milling and grinding machine MCXL (Dentsply Sirona, Bensheim, Germany) **Table (1)** After milling is complete, sprues were cut and finished with diamond finishing stones. For IPS e-max CAD and Celtra Duo groups, the milled specimens were crystallized and glazed in Programat P310 ceramic furnace (Ivoclar Vivadent Inc., New York, USA) following crystallization and glazing parameters provided by the manufacturer. While the specimens of SH group were finished and polished using ZiLMaster Kit (SHOFU Dental GmbH, Ratingen), Germany) according to manufacturer instructions. Finally, the thicknesses of all specimens were checked and verified using the digital caliper.

8. Bonding procedure

All occlusal veneers were cleaned with an ultrasonic cleaner for 3 minutes, while the prepared teeth were cleaned for 15 seconds with ultrasonic cleaner then rinsed thoroughly with water for 15 seconds. The intaglio surface of each IPS e.max CAD and CeltraDuo restoration was etched with 9.5 % hydrofluoric acid gel (Porcelain Etchant 9.5%. BISCO, USA) for 20 seconds, then rinsed thoroughly and dried with oil free compressed air. Then, a silane coupling agent (Porcelain Primer Bis-silane, BISCO – USA) was applied for 60 seconds and air dried before cementation. For Shofu HC restorations, a special primer (HC Primer, SHOFU Dental, Ratingen, Germany) was used, which was left for 30 seconds then air dried. The prepared surfaces of all teeth samples were etched with 37% phosphoric acid etchant gel (Etch- 37™. BISCO – USA) for 30 seconds, rinsed and air dried. Then, the surfaces were coated with two successive layers of bonding agent (All-Bond Universal. BISCO – USA) using a micro brush, air thinned syringe, and light cured for 20 seconds.

All occlusal veneers were cemented to their corresponding teeth samples using dual-cured adhesive resin cement (Duo link dual cure self-etch resin cement. BISCO, USA) and 1kg load was applied vertically by a specially designed loading device **Figure (3).** After spot curing with light curing unit (Elipar™, 3MESPE, USA), the excess cement was removed, then light curing was done for 40 seconds to each surface. All specimens were stored in distilled water at 37°C for 48 hours prior to thermal cycling.

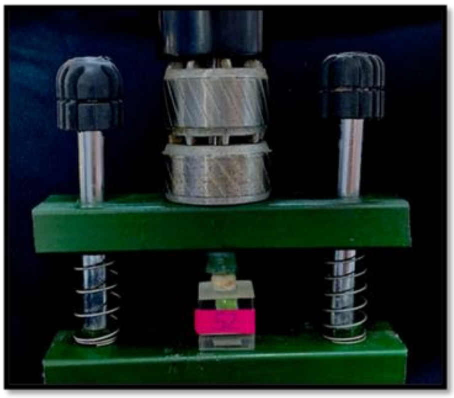

Figure (3): customized loading device

9.Thermocycling

All specimens were subjected to thermal aging in a water bath of a thermal cycling simulation device (Thermocycler THE-1100, SD sd-mechatronic, Germany). Thermocycling was 10000 cycles, which are equivalent to one year between 5 º C and 55 º C with 20 s dwell time and transfer time for 10 s to simulate temperature fluctuations found in the oral cavity. All samples were stored in distilled water in an incubator at 37 ◦C for one week prior to mechanical testing.

10. Fracture resistance test

Occlusal veneers were subjected to the fracture resistance test, where each one was individually mounted on a computer-controlled universal testing machine (Model 3345; Instron Industrial products, Norwood, MA, USA) with a load cell of 5 KN The fracture test was done by the compressive mode of 5 KN load applied occlusally using a metallic rod with a spherical tip 5 mm in diameter .The spherical tip was attached to the upper movable compartment of the testing machine, travelling at a cross head speed of 1 mm/min. The samples were secured to the lower fixed compartment of the testing machine by tightening screws. A tin foil sheet 0.5 mm was positioned over the occlusal surface of the restoration during fracture test in order to prevent stress concentration **Figure (4).** Data were collected using computer software (Bluehill Lite Software Instron® Instruments).

Table (1): materials used for construction of occlusal veneers

Material	Brand name	Manufacturer	Main Composition	Batch number
Lithium disilicate ceramics LT / A1 / C14	IPS E.-max CAD	Ivoclar Vivadent, Schaan, Liechtenstein	SiO2 (57–80%), Li2O (11-19%), K2O (0–13%), P2O5 (0–11%), ZrO2 (0–8%), Zn O (0–8%) and coloring oxides (0–12%)	626390X36081
Zirconia reinforced lithium silicate ceramics LT /A1 / C14	Celtra Duo	Dentsply Sirona, Germany	58% Sio2and 5% P2O5 1.9% Alumina. 10.1% crystallized Zirconium Dioxide, and 1% Terbium Oxide and 2.0% Ceria	16004372
Resin Matrix Ceramics LT/A3.5 /M	Shofu Block HC	Dental GmbH, Ratingen, Germany	UDMA, TEGDMA 39% weight, Sio2, Zro2, Fillers 61% weight	1220025

Figure (4): Fracture resistance test using Instron universal testing machine

11. Failure mood determination

Imaging of the fractured samples for fractographic analysis was performed using a-Photographic Examination: The fracture surfaces of each restoration were documented with photographs of Fractographic analysis featured with eye lens (20 x) b- Microscopic Examination: Scanning Electron Microscope Model Quanta 250 FEG (Field Emission Gun) (FEI company. Eindhoven, Netherland attached) (Energy Dispersive X-ray Analyses), with accelerating voltage30 K.V., magnification of 45X and 280X with resolution of Gun.1nm were used. Fracture behavior of the samples observed by SEM and classified into two modes: where repairable fracture which was represented by two types: adhesive failure and adhesive-cohesive failure and non-repairable fracture which observed as catastrophic failure.

Statistical analysis

Statistical analysis was performed with SPSS 20®, Graph Pad Prism®, and Microsoft Excel 2016. All data were explored using Shapiro wilk and Kolmogorov test. Comparison between both 2 groups (different thicknesses) was performed by using independent t test. Comparison between 6 groups (different ceramic types with different thicknesses) was performed by using One Way ANOVA followed_by Tukey`s Post Hoc test for multiple comparisons. Two Way ANOVA test was used to compare the effect of different variables on fracture resistance. It was revealed that the significant level *(P-value)* was shown to be insignificant as *P-value* > 0.05, which indicated that data originated from normal distribution (parametric data).

III. RESULTS

1. The effect of different occlusal thickness regardless of the material

Regardless of the material type comparison between the two thicknesses was done using independent t test which showed a non-significant difference as $P>0.05$. The mean fracture load for thickness 1.5 mm was (1809.34±644.79N) and for thickness 1mm was (1680.79±450.91N) **Table (2)**.

2. The effect of different material regardless of the occlusal thickness

Regardless of the thickness comparison between the different materials using One Way ANOVA test showed significant difference as $P<0.05$. The highest mean fracture load was for Emax CAD (2430.89 ±253.58N), then CeltraDuo (1521.60±272.19N) and the lowest mean fracture load was for Shofu (1282.71±191.96N).

3. Comparison between all groups

The effect of different variables on mean fracture resistance was performed using Two-way ANOVA analysis followed_by Tukey`s Post Hoc test for multiple comparisons **Figure (5)**. By comparing thicknesses, there was no statistically significant difference between mean fracture loads. By comparing ceramic materials, there was a statistically significant difference between mean fracture loads. while interactions between them showed significant effect on the fracture resistance (P value < 0.0001).

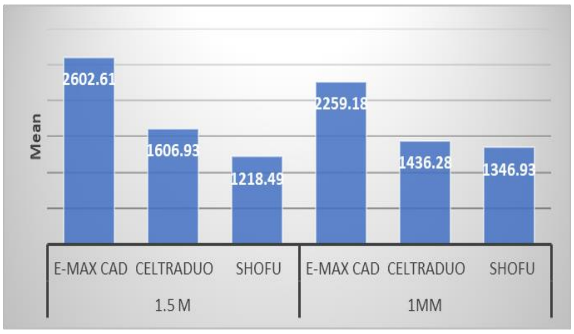

Figure (5): Bar chart showing Mean and standard deviation of all ceramic groups at both thicknesses

4.Fractographic analysis of fractured samples

In IPS e-max CAD fractographic analysis revealed: adhesive -cohesive failure was found in 17% of specimens **Figure (6), (7)**. Adhesive failure was found 50% of the samples while catastrophic was found 33% of specimens. In Celtra Duo fractographic analysis revealed that adhesive-cohesive failure was found in 85%, adhesive failure was found in 15%, while catastrophic failure was found in 0% of specimens. In Shofu fractographic analysis revealed that adhesive -cohesive failure was found in 100%, adhesive failure was found in 0% while catastrophic failure was found in 0% of specimens.

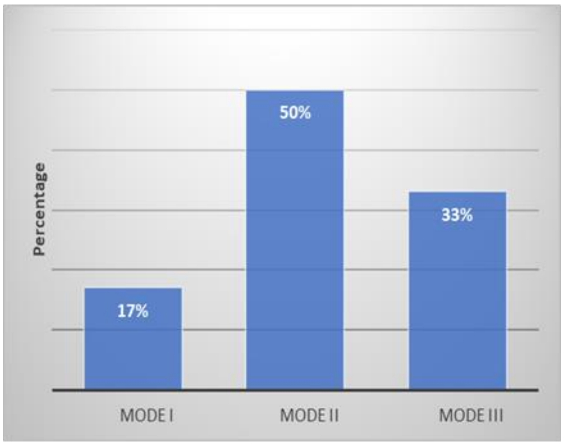

Figure (6): Bar chart showing percentages of different modes of failure in IPSE-max Cad

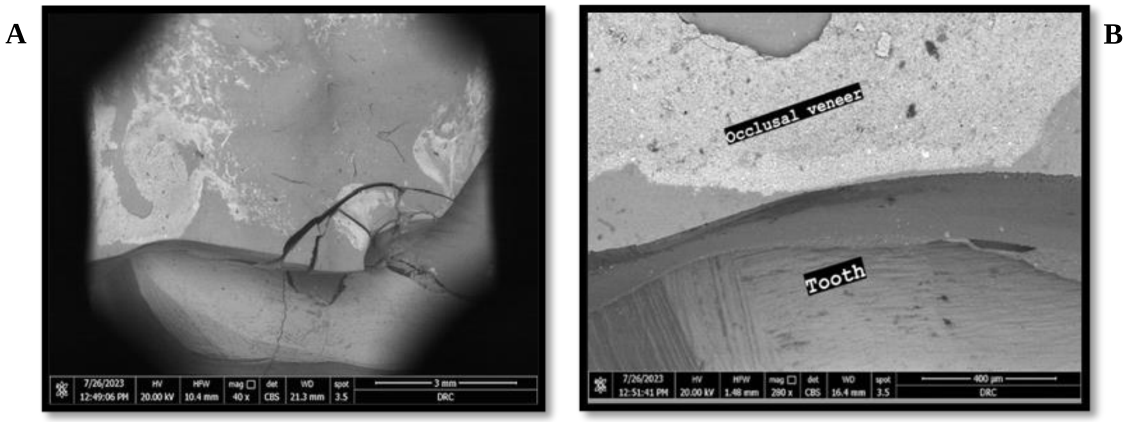

Figure (7): Scanning electron microscope images, showing the failure patterns (adhesive-cohesive failure) at different magnification **A**: 45X **B:**280X

Thickness	N	M	SD	Difference (Independent t test)				
				MD	SEM	95% CI		*P* value
						L	U	
1.5 mm (n=21)	21	1809.34	644.79	128.5	171.7	-475.6	218.5	0.45
1 mm (n=21)	21	1680.79	450.91					

IV. DISCUSSION

The development of stronger materials in combination with CAD/CAM techniques and innovative adhesive technology made a more conservative approaches should be considered. CAD/CAM technology was chosen in this study because of its ability to control the thickness and anatomy of restorations during the fabrication process, as well as its high aesthetic qualities. It also allowed for the standardization of fit of the restorations as well as the mechanical qualities of the restorative materials. [(7)]

Three materials were chosen in this study. IPS E.max CAD was used due to its esthetic nature, impressive strength, and ease of use, IPS e.max CAD has been increasingly used over the years. The fully crystalized form of IPS e.max CAD has been shown to possess a recorded flexural strength of above 360 MPa Zirconia reinforced lithium silicate ceramics (CeltraDuo) used in this study as the incorporation of zirconia of about 8-10 % by weight improves the mechanical properties of the material and result in material with flexural strength of (262-370) MPa. Hybrid ceramics have been introduced to the market with the idea of combining the positive aspects of both composites and ceramics. **Mohamed and Nassar., (2022)** [(8)] reported that Shofu HC as a CAD/CAM resin hybrid ceramic material provides fast milling and polishing, and high flexural strength together with high elasticity which allows stress absorption.

Natural teeth were chosen for this study to stimulate the clinical situation. Natural teeth possess elastic properties, bonding ability, and strength, which is better able to mirror the clinical conditions. All teeth were stored in distilled water during the study to prevent them from drying out and as the fracture resistance of all-ceramic restorations depends on the modulus of elasticity of the chosen abutment material. The epoxy resin blocks were used for fixation of teeth to allow proper handling. In addition to simulate bone surround the teeth. Adental surveyor was used with centralizing tool for ensuring proper positioning of the tooth sample in the block. A light body silicone material was injected around root of tooth to simulate periodontal ligament which can affect the fracture resistance testing results [(9), (10)]

A Biogeneric copy design mode was used on CAD CAM software. Teeth were scanned twice, first time scanned before preparation and the second image was taken after preparation. Then, two images were superimposed over each other to determine amount of reduction and to copy parts of the occlusal morphology in the final restoration. Preparations were also done with the use of depth cutters diamond stones, and putty index that was taken before preparation to allow for rechecking after preparation. All the preparation steps were done by a single operator to standardize preparation protocol for all samples.

A thickness of 1.5mm was chosen as control in this study because of the usual recommendation for porcelain restoration thickness is 1.5 to 2.0 mm. However, thickness of 1mm was chosen in this study as intervention as a more conservative option for teeth that are already weakened by tooth wear. **Albelasy *et al.*, (2020)** [(11)] stated that lithium disilicate glass ceramic showed more favourable results in terms of fracture strength of occlusal veneers at a thickness of 0.7–1.0 mm. In order to standardize cementation protocol, a custom loading device was used to apply a constant load of 1 kg parallel to the long axis of each tooth as it was used in **El-sharkawy *et al*., (2022)** [(12)] and **Zamzam *et al.*, (2021)** [(13)]. As recommended by the manufacturer, the load was applied for 10 minutes to allow the standardized load application on the cement during curing.

Based on the results of this study, the null hypothesis was partially rejected as the fracture resistance of occlusal veneer was dependent on the material type. Because there was a statistically significant difference between different materials used for construction of occlusal veneers. On the other hand, there was no statistically significant difference between the two tested occlusal veneer thicknesses conventional 1.5 and thin 1mm.

Results of our study revealed that comparison between the different materials irrespective to the thickness showed significant difference as *P<0.05*. The highest mean fracture load was for IPS e-max CAD (2430.89 ±253.58 N), followed by CeltraDuo (1521.60±272.19 N) and the lowest mean fracture load was for Shofu HC (1282.71±191.96 N). The results of our study were in accordance with **El-Saka *et al*., (2016)** [(14)] who reported that there was a statistically significant difference in the fracture behaviour between IPS e-max CAD and CeltraDuo occlusal veneers. This could be attributed to the incorporation of zirconia filler to the composition of ZLS that makes some sort of stiffness in the material that decreases fracture resistance. Also, these results were in agreement with **Mostafa *et al*., (2023)** [(17)] who evaluated the fracture resistance of occlusal veneers fabricated from two ceramic materials IPS E-max CAD and Lava Ultimate and two thicknesses 0.5mm and 1mm after thermocycling. It was concluded that IPS Emax CAD veneers had a significantly higher fracture load value than Lava Ultimate veneers. This is explained by the microstructural analysis of lithium disilicate glass ceramics and resin matrix ceramics. The high value of fracture resistance in IPS e-max CAD can be attributed to the high number of interlocking, needle-like crystals that are embedded in its glassy matrix of lithium disilicate. However, the microstructural analysis of resin matrix ceramic material showed that is composed of interconnected networks: a dominant ceramic and a polymer. Moreover, flexural strength of IPS e-max CAD and resin matrix ceramics is 360 MPa and 150 MPa respectively.

In contrast to our study **El-sayed and El-Basty., (2021)** [(15)] who compared fracture resistance between IPS e.max CAD and CeltraDuo occlusal veneers fabricated from CAD wax technique, they reported that there was no statically significant difference between both materials regarding the fracture resistance. This may be attributed to different construction techniques used. These results were also in disagreement with **Zhang *et al*., (2021)** [(16)] who made their study on glass and hybrid ceramic crowns and found no significant difference between them in terms of fracture resistance. This inconsistency might be due to different restoration thicknesses, different bonding protocols and lack of thermocycling simulation in their study.

Comparison between the two tested thicknesses irrespective to the ceramic material type in this study showed non-significant difference as *P*>0.05. The mean fracture load for conventional thickness 1.5 mm (1809.34±644.79N) and for thin thickness 1mm (1680.79±450.91N). The mean fracture loads of tested samples were beyond the mean reported maximum masticatory force. Therefore, it could be assumed that all the tested specimens could withstand the maximum intraoral posterior masticatory forces. Our results were in agreement with **Al-Belasy *et al*., (2020)** [(11)] who reported that lithium silicate-based glass ceramics showed more favourable outcomes in a thickness of 0.7–1.0 mm. Fracture resistance values in all the included studies exceeded maximum bite forces in the posterior region. Occlusal veneers can withstand bite forces in the posterior region, whereas the measurement of thickness should be standardized in order to have fair comparison. Also, These results were in agreement with **El Sharkawy *et al*., (2022)** [(12)] who compared the fracture resistance of occlusal veneers made from IPS e.max CAD, Vita Suprinity and VitaEnamic at two thicknesses 1mm and 1.5mm. It was concluded that occlusal thickness changes not affected significantly the fracture resistance of occlusal veneers. Occlusal veneers fabricated from the three tested materials with 1mm and 1.5mm thicknesses, revealed values of fracture resistance above normal posterior masticatory forces.

In contrast to our study **Zahran *et al*., (2023)**[(18)] who analysed the effect of different thicknesses of ceramic occlusal veneers 1mm and 0.5mm with different surface treatments on fracture resistance . It was reported that increasing the occlusal veneers thickness increased the fracture resistance regardless of the type of surface conditioning performed. The fracture resistance of occlusal veneers is significantly affected by different thicknesses. This can be attributed to using different thicknesses and surface treatments.

One of the limitations of this study is the in vitro model. In vitro studies attempt to mimic clinical conditions, but they will never be able to accurately reflect real-life clinical situations. In addition, the fracture load applied to the restoration during testing was vertical and static which does not imitate clinical loading situations having vertical and lateral components. Also, using natural teeth which may have some natural variations can affect the standardization. Using only one resin cement in this study can also be considered as one of the limitations of this study. Further studies are needed to study the impact of different bonding protocols and cements on the fracture behaviour of the tested materials and to evaluate the fracture resistance after cyclic loading. Clinical studies are required to test the effect of different occlusal veneer thickness on the clinical behaviour of the tooth-restoration complex.

V. CONCLUSION

Within limitations of this in vitro study, the following conclusions could be drawn as follows: conventional thickness 1.5 mm showed a non-significant fracture resistance compared to thin thickness 1mm for all materials. IPS e-max CAD showed the highest significant fracture resistance compared to CeltraDuo and Shofu. Considering the fracture pattern, the most detected mode was the adhesive-cohesive failure mode. Both conventional and thin occlusal veneer thickness presented fracture resistance mean values with the three tested materials within the range of clinical acceptability.

Conflict of interest: Authors declare no conflict of interest.

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Ethics: This study protocol was approved by the ethical committee of the faculty of dentistry-Cairo university on :26/1/2021, approval number 1512.

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