Effect of Thickness and Glass Ceramic Materials on the Fracture Resistance of Biomimetic Occlusal Veneers

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Abstract

Background: Glass ceramics occlusal veneers are one of the currently used conservative options for repairing excessive occlusal surface tooth loss by using adhesive techniques, allowing limited reduction of the tooth structure.

Methods: Extracted premolar teeth (n=28) were collected, randomized according to materials into two groups (n=14): E-Max CAD and Cetra Duo then randomized into subgroups (n=7) according to occlusal veneer thicknesses 1 mm and 1.5 mm. Teeth were reduced then sealed by dentine bonding agent. Construction of the occlusal veneers was done by CAD/CAM milling machine. Occlusal veneers were cemented by dual core resin cement. All veneers were exposed to thermocycling and cyclic loading then loaded till failure by universal testing machine, failure mode was assessed using digital microscope. The impact of ceramic type, thickness, and their interactions on fracture resistance was investigated using a two-way ANOVA test. Failure mode data were obtained. The significance level was set at P ≤ 0.05.

Results: Two-way ANOVA showed that ceramic type (P-value = 0.221) and thickness (P-value = 0.704) had no statistically significant influence on fracture resistance with mean values of 1573.3 N and 1542.9 N for E-Max CAD 1 mm and 1.5 mm thickness respectively. For Cetra Duo mean fracture resistance values were 1518.4 N and 1343.7 N respectively. The majority of the samples exhibited Fracture in restorations only.

Conclusion: Both glass ceramic materials performed equally well at 1 mm and 1.5 mm thicknesses. Favourable failure with fracture of restoration only and no damage to the tooth structure with glass ceramic occlusal veneers.

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1 Introduction

Occlusal surface tooth structure loss can result from a variety of physiological or chemo-mechanical reasons, including wear, erosion, and attrition. This loss of sound tooth structure might lead to occlusal disharmony, impaired function and aesthetic failure which may require drastic and difficult treatment procedures, such as purposeful endodontic treatment or full crown preparation; however, these options are known to be an invasive procedure to tooth structure 1.
Treatment is achieved by; treating the cause and avoiding further deterioration. And according to the degree of destruction, a further restorative step could be taken \(^2\). With the advancement of adhesive bonding systems, conservative dentistry is now one of the utmost important topics in clinical esthetic and restorative dentistry as the usage of adhesive techniques allows limited reduction of the tooth structure \(^3,4\).

Glass ceramic materials have good adhesive quality, enhanced surface finish and outstanding optical properties \(^5-7\). Nowadays, one of the commonly used glass ceramics is lithium disilicate glass ceramic. Lithium disilicate glass ceramic is indicated for partial crowns, inlays, and onlays. Evidence based literature showed that lithium disilicate ceramic restorations are an adequate enamel substitute; however, this mainly depends on the material’s strength, thickness and on the optimal bonding to the underlying dental tissues. In addition, Lithium disilicate glass ceramic also offers good aesthetics, flexural strength and mechanical properties \(^8-11\).

New classes of glass ceramics have recently been developed are zirconia reinforced lithium silicate (ZLS) ceramics which are characterized by having elevated translucency and strength (370 MPa). The flexural strength is comparable to that of lithium disilicate (360 MPa), and in order to enhance the mechanical features of the (ZLS) ceramic’s glass matrix, 10% zirconia fillers were added into it \(^12,13\). New innovative ceramic restorative products, advances in milling technology, and the presence of enhanced adhesive systems all allow for a more conservative approach to repairing damaged teeth. As a result, partial coverage restorations are progressively substituting full coverage restorations in clinical practise \(^14\).

Occlusal veneers could be defined as the following: an extra coronal restorations that require guidance by interocclusal clearance, an adhesive-retained prosthetics that fully cover the occlusal surface or as form of minimally invasive tooth preparation for detrimentally worn teeth \(^15\). The key benefit of occlusal veneers is restoring mastication while also conserving dental structure, this concept supports the biomimetic approach that is leading in the field of dentistry nowadays \(^16-20\).

Controversy is still present regarding the most suitable thicknesses of occlusal veneers to obtain maximum longevity and success, while also taking into consideration the manufacture’s recommendations regarding different ceramic materials. The usual required thickness is from 1-2 mm to achieve optimum mechanical and optical properties \(^19\).

Planar preparation design for occlusal veneers has grown in popularity as a conservative treatment option for severely worn dentition \(^21-26\). Immediate dentine sealing proved to be an effective way to improve bond strength in cases of tensile bond strength and shear bond strength \(^27-29\). Other advantages of immediate dentine sealing are patient comfort, less dentine sensitivity with temporary restoration, protection from bacterial and fluid leakage, and also reduction of post cementation sensitivity \(^28\). The most favorable substrate for dentine bonding is freshly cut dentine after preparation when dentine is still free from contamination \(^30-32\).

In vitro aging, including thermocycling and dynamic loading, is critical in testing new dental materials in conditions similar to the intraoral environment and aging conditions \(^33-35\). Furthermore, it is a more important predictor for the clinical longevity of ceramic restorations than static loading \(^36\).

The aim of the present study is to assess the fracture resistance of zirconia reinforced lithium silicate in comparison to lithium disilicate glass ceramic occlusal veneers at two thicknesses after thermo-mechanical aging. The null hypothesis of the current research is that there will be no significant difference regarding the fracture resistance of occlusal veneers fabricated with two materials following thermo-mechanical aging. The other null hypothesis is that there will be no significant difference concerning the fracture resistance of occlusal veneers made of two thickness following aging.

2 Materials & Methods

A power analysis determined that there was sufficient power to test the null hypothesis statistically. Using a 95% power and an effect size of \((f=0.806)\) determined based on the findings of Andrade, J. P., et al,
the predicted sample size was found to be a total of 28 samples with seven for each subgroup. Sample size calculation was performed using GPower version 3.1.9.2.

The research ethics committee of the Faculty of Dentistry of October University for Modern Sciences and Arts approved this in-vitro study (ETH17) on extracted human premolar teeth which were collected from the Outpatient Clinic of the Department of Oral Surgery Faculty of Dentistry of October University for Modern Sciences and Arts. Each patient signed the informed consent after an overview regarding the research purposes. The teeth were extracted for orthodontic or periodontal reasons.

### 2.1 Materials

The materials used in this study are tabulated in (Table 1)

#### Table 1. Materials used

<table>
<thead>
<tr>
<th>Material</th>
<th>Commercial Name and Manufacturer</th>
<th>Composition</th>
</tr>
</thead>
</table>
| Lithium Disilicate              | Emax CAD (Ivoclar Vivadent, Schaan, Liechtenstein) | Oxides: 57.0 – 80.0%
SIO₂: 11.0 – 19.0%
K₂O: 0.0 – 13.0%
P₂O₅: 0.0 – 11.0%
ZrO₂: 0.0 – 8.0%
ZrO₂: 0.0 – 8.0%
Al₂O₃: 0.0 – 5.0%
MgO: 0.0 – 5.0%
Coloring Oxides: 0.0 – 8.0% |
| Zirconia reinforced Lithium Disilicate | Celtra Duo | Oxides: 58.0%
SIO₂: 18.5%
ZrO₂: 10.1%
Teberium oxide: 1%
Ceria: 2%
Alumina: 1.9%
P₂O₅: 5% |
| Resin Cement                    | Multilink Speed (Ivoclar Vivadent, Schaan, Liechtenstein) | Monomer matrix (Di-
methacrylate and acidic monomers) Inorganic fillers: barium glass, ytterbium trifluoro-
copolymer and silicon dioxide
Additional fillers: catalysts, stabilizers and colour pigments. |

#### Table 2. Specimen preparation

28 human maxillary premolars were collected divided according to material into two main groups (A) Lithium disilicate glass ceramics (IPS emax CAD) and (B) zirconia-reinforced lithium silicate (Celtra Duo). Groups were further split into four subgroups i.e. 7 for each subgroup according to occlusal veneers thicknesses (A-1) 1 mm and (A-2) 1.5 mm, (B-1) 1 mm and (B-2) 1.5 mm.

The teeth were inspected using 10x magnification microscope to ensure the lack of any cracks. The teeth were selected to be as similar as possible in BL & MD dimensions (± 0.5 mm) which was measured using a digital calliper (Digital Calliper, Adoric, CHINA). The selected teeth were washed then kept in purified water at room temperature which was routinely changed every week during the duration of the study. Silicon moulds were made by mixing its components (ecosi+, Dentaurum, Germany) according to manufacturer’s instructions to make a cube with dimensions of 2x2 cm. To enable accurate vertical centralization of each tooth following the long axis of the block Mold, a custom-made paralleling technique using disc and mandrill was used. The tooth was
dipped once in wax heater (Fencia, China) with molten wax.

Each sample was placed into the mold and mounted into a surveyor (Paraflex, Bego, Bremen, and Deutschland) to assure the centralization and parallelism with the long axis with epoxy block. The epoxy resin mixing was done on a vibrator (Powerful Lab Oscillator Square Orbital Shaker, fencia, China), poured into the epoxy mold, and finally inserted into vacuumed pressure-polymerization unit with a pressure of 4.5 bars and duration of 12 hours in order to remove all air bubbles and complete resin polymerization. The samples were subjected to boiling water for melting the wax, and then light body was injected in the epoxy block to fill the space left by the melted wax.

A custom milling machine (AF30 Nouvag, Switzerland) was used to standardize the teeth reduction. A custom-made attachment was designed to hold the high-speed handpiece horizontal to the sample with water coolant perpendicular to the milling platform. The occlusal reduction was set at 1 mm (Fig. 1) and 1.5 mm (Fig. 2) measured from the fissure using guided preparation with series of stones for 1 mm depth two wheel stone (Tiefenmarkierer depth marker 834A(000) ÖkoDENT Gruppe, Germany) after that the depth were connected with double cone stone (Dia.doppelkegel 811 (038) C FG, Öko DENT Germany ) for the extra 0.5 mm to gain the 1.5 mm the same steps are repeated with additional three wheel stone ( Tiefenmarkierer depth marker 834 (552) Öko DENT Gruppe Germany) and the double cone was used again to connect the depth cuts. Before preparation, an index made of putty was made for each tooth to confirm the amount of reduction.

Cusp inclination angle was set as 144 degrees same angulation of the double cone stone where each preparation was photographed and measured by virtual protractor to check cusp inclination.

Drying of the prepared surfaces for easy identification of exposed dentin surfaces was done. Dentin is distinguished by its glossy look, whilst the enamel is frosty. Phosphoric acid 37 percent was used to etch the freshly cut and uncontaminated surfaces (META ETCHANT, META BIOMED, and Korea). Rinsing was thorough, followed by cautious air drying without dehydrating for three to five seconds. The bonding mediator (Adper single bond 2, 3M ESPE, USA) was added to the exposed dentine with a dental loupe and a mild brushing motion for at least 15 seconds before being cured for 20 seconds, then the addition of a coating of glycerine gel and another 10 seconds of light curing before the glycerine layer was eliminated by rinsing.
2.3 Occlusal veneer restoration designing

Each tooth preparation was scanned with the aid of an intraoral scanner (TRIOS 3, 3Shape, Copenhagen, Denmark). The occlusal veneer restorations were designed with 50 μm virtual spacer using CAD-software (Exocad GmbH, Darmstadt, Germany). To achieve a uniform ceramic thickness, the veneers were semi-anatomically shaped. The restoration thickness was uniform across all groups, ranging from 1 mm to 1.5 mm depending on the group. A milling machine with five axis was used for milling the restorations (CORITEC 250i, Imes-Icore, Germany). The E-Max CAD restorations were subjected to crystallization cycle in a furnace (Programat EP 3010, Ivoclar Vivadent. Schaan, Liechtenstein), followed by glazing (GC AMERICA INC, USA). The Celtra DUO groups were subjected to firing cycle following to manufacturer’s instructions, and then subjected to a glaze cycle.

IPS E-Max CAD veneers were etched with a 9% hydrofluoric acid gel for 20 seconds whereas the Celtra DUO for 30 seconds then cleaned with water spray for 60 seconds, and thoroughly dried with air. Silane was implemented to the pre-treated surfaces and left for 60 seconds. The sealed dentin was cleaned with 29 μm alumina intraoral air abrasion (Aquacare Single, Velopex International, UK) at 10 mm intervals under 2 bar pressure till the surface became dull. Following that, the preparation surface was conventionally conditioned for 30 seconds with 37% phosphoric acid, thoroughly washed, and dried. The bonding agent was coated on prepared surfaces and left uncured till applying the luting resin.

Dual cured luting resin cement (Panavia F 2.0) was mixed as per manufacturer’s instruction and applied to the surface of the prepared teeth. Each restoration was gently allowed to sit on its prepared tooth, and a continuous weight of 1 kg was adapted to the occlusal surface of the restoration for one minute using a customized loading apparatus to provide steady uniform standardized weight for all specimens during cementation. Extra cement was removed with a brush before covering the margins with Panavia F 2.0 Oxyguard II (Kurary) and 20 seconds light curing at 5 mm intervals on each surface of the restoration. To ensure complete curing, the restorations were kept in distilled water at a temperature of 37 °C for a week.

2.4 Thermocycling and mechanical aging procedure

To mimic oral conditions, the samples were thermocycled (Thermocycler THE-1100, SD mechatronik, Germany) 10000 times in distilled water between 5 and 55 degrees Celsius with a 30 second stay at each temperature. The sample was then subjected to cyclic mechanical loading to simulate a year of clinical service cycles at 5 kg load; each epoxy block was secured with an Allen key within the chewing simulator chamber (Chewing Simulator CS4, SD Mechatronik, Feldkirch-Westerhan, Germany) to stabilise it during cyclic loading. A 6 mm diameter ceramic ball was positioned to first contact the supporting cusp and after that slide down for 0.3 mm to simulate the antagonistic tooth. Following aging the samples were checked by magnifying loupes 3.5 x with LED light. All samples survived the chewing simulator cycles without cracks.

2.5 Fracture resistance and fracture mode testing

A stainless-steel bar ending with a 6-mm-diameter ball was attached on the main fissure centre of a universal testing machine (Model 3345, Canton, Massachusetts, USA), and load was put evenly to both cusps at a cross-head speed of 1 mm/min until fracture. In order to prevent local stress concentration among the veneers and the bar, and 0.5-mm tin foil was used. The fracture loads for each specimen were automatically recorded in Newtons (N) using testing software. Following fracture resistance test, samples were visually examined using digital microscope with 30x magnification (U500x digital microscope, Guangdong, China) to decide the failure mode. The failure modes were classified as follows14: Mode I: Restoration fracture (Fig. 3), Mode II: Restoration and enamel fracture, and Mode III: Restoration, enamel, and dentine fracture.
2.6 Statistical analysis

To determine normality, the Kolmogorov-Smirnov and Shapiro-Wilk analyses were used. Data on fracture resistance indicated a parametric distribution. The data was obtainable in the form of a mean and standard deviation (SD). The effect of ceramic type, thickness and their interactions on fracture resistance was investigated using a two-way ANOVA test. The mode of Failure was represented as frequencies and ratios. To compare the groups, the Fisher’s exact test was used. Failure modes were compared within each group, the Chi-square test was used. P 0.05 was chosen as the significance level. IBM SPSS Statistics for Windows, Version 23.0, was used for statistical analysis.

3 Results

Ceramic type (irrespective of thickness) had no statistically significant influence on mean fracture resistance (P-value = 0.221, Effect size = 0.062), according to the findings. At 1 mm and 1.5 mm thicknesses, there was no statistically significant difference between ceramic types (P-value = 0.704, Effect size = 0.006) and (P-value = 0.176, Effect size = 0.075), correspondingly. The interaction among the two variables did not have a statistically significant impact on mean fracture resistance (P-value = 0.482, Effect size = 0.021) (Table 2).

In terms of failure modes, there were no statistically significant differences between groups (P-value = 0.707, Effect size = 0.313). There was a statistically significant difference in failure modes within each group (P-value = 0.257, P-value = 0.059), and P-value = 0.102, respectively. All samples in the (IPS E-Max CAD - 1.5 mm) group demonstrated failure mode I (Table 3), (Fig. 4).

<table>
<thead>
<tr>
<th>Failure mode</th>
<th>IPS e.max CAD - 1 mm</th>
<th>IPS e.max CAD - 1.5 mm</th>
<th>Celtra Duo - 1 mm</th>
<th>Celtra Duo - 1.5 mm</th>
<th>P-value</th>
<th>Effect size</th>
</tr>
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<tr>
<td>Mode I</td>
<td>5</td>
<td>71.4</td>
<td>7</td>
<td>100</td>
<td>6</td>
<td>85.7</td>
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<tr>
<td>Mode II</td>
<td>2</td>
<td>28.6</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>143</td>
</tr>
<tr>
<td>Mode III</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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*: Significant at P ≤ 0.05

Table 3. Comparison among different failure modes

The majority of the samples scored Mode I which is fracture of restoration only and showed different categories: Category (a) 3 samples presented extensive crack formation, category (b) 16 samples presented partial restoration fracture and category (c) 4 samples presented complete fracture of the restoration with debonding. 4 samples scored Mode II which is fracture of restoration and enamel. One sample scored Mode III (catastrophic) which is fracture of restoration and enamel and dentine.

Figure 4. Bar chart representative to failure modes percentage distribution
4 Discussion

Both null hypotheses for this study were accepted; as there was no statistically significant difference in fracture resistance between occlusal veneers made of two materials and two thicknesses following thermo-mechanical aging.

Innovation in dental ceramic materials along with recent advances in bonding materials and protocols, such as immediate dentin sealing supports the idea of minimal invasive treatments. With the aim of saving as much as possible of remaining sound tooth structures, especially in cases of compromised dentition such as in severe dental wear. This study aims to determine zirconia reinforced lithium silicate occlusal veneers fracture resistance compared to IPS E-Max CAD at two thicknesses (1 mm and 1.5 mm) following thermo-mechanical aging.

Human natural teeth were chosen for this investigation to stimulate the clinical scenario. To replicate the periodontal membrane, (0.2 – 0.3 mm) thick light body silicone elastomeric material was applied around the roots of the teeth to simulate physiological tooth mobility. Planar occlusal veneer preparation was chosen in the current study, a standardized reduction was done using a custom milling machine. The angle of the stone was measured by an online virtual protractor and found to produce an inclination angle of 144 degrees. The substrate in this study was dependent on the amount of reduction as 1 mm reduction resulted in less dentine exposure and more enamel substrate while the 1.5 mm reduction resulted in more dentine exposure but all exposed dentine was sealed with immediate dentine sealing.

Immediate dentine sealing was performed on freshly cut dentine immediately following preparation, while the dentine was still free of contamination. Overlapping composite shrinkage and resulting occlusal forces put the relatively weak early dentin bonding in directly placed adhesive restorations to testing. However, due to the postponed restoration placement and delayed occlusal loading in immediate dentin sealing; dentin bond can be established without stress resulting in markedly better restoration adaptation.

In the current study, Trios 3 by 3 Shape was used for the scanning of the preparation. 1 mm thickness was chosen as most of the published literature advocate it, while, 1.5 mm thickness was used as an intervention because the common endosystem for porcelain restoration thickness is usually from 1.5 mm to 2.0 mm. Furthermore, when repairing moderate to severe tooth wear, the vertical dimension of occlusion may need to be increased. The luting cement Panavia F20 was used as unbiased cement for bonding with E-Max CAD and Celtra DUO as each material manufacture recommends their cement to be used in order to get the desired bond and flexural strength.

The results showed that the type of ceramic materials regardless of the thicknesses as seen in (Table 2) showed no statistically significant difference. This could be explained by the similarity of the composition and the slight differences in the microstructure, as the microstructure in E-Max CAD is composed of 70% fine-grain lithium disilicate crystals embedded in 30% glassy phase. Whereas Celtra Duo comprises of approximately 58% crystals with additional 10% zirconium dioxide to create a unique fine-grained structure of (0.5 – 1 μm) in length leading to four times smaller lithium silicate crystals which increases the glass phase. The substrate that was used in this study was mainly enamel in the 1 mm preparation depth to provide superior bonding strength than dentine moreover, the 1.5 mm preparation depth showed exposure of dentine which is sealed immediately with dentine bonding agent that been proven to increase the bonding strength. The mean value for E-Max CAD with 1 mm and 1.5-mm thicknesses was (1573 N and 1542.9 N) respectively. The mean value for Celtra DUO at 1 mm and 1.5-mm thickness was (1518.4 N and 1343.7 N) consequently as seen in (Table 2). In clinical literature, it is reported that the normal force at the premolar region varies from 222 to 445 N but from 520 to 800 N during clenching. Therefore, these results are within the clinically accepted limit. Our results come in with agreement with some studies, and disagreement with other research studies whom reported significant difference between the ceramic groups. These differences might be attributed to different testing variables such as bonding protocol, aging, and different testing parameter.

The IPS E-Max CAD group showed no statistical significant difference with different thicknesses (1 mm, 1.5 mm), this came with agreement with Albelasy et al. (2020). The Celtra Duo group showed also no statistical significant difference with different thicknesses (1 mm, 1.5 mm), this came with agreement with Abbas et al. (2020). Other studies reported also that increasing the thickness of the occlusal veneers did not impact the fracture resistance, while other reported differently.

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Regarding the failure mode; the majority of the samples scored mode I as seen in (Table 3, Fig. 4), where there is fracture of restoration only. It represented a cohesive fracture of the material because the tensile stresses are focused on the ceramic which is considered a more favorable outcome with no damage to the tooth structure. Mode I exhibited different categories which might be due to time dependent failure during testing as the force increases by time and tensile stress building up in the occlusal veneers. 3 samples failed early showing only extensive crack formation and survival without any chipped fragments and this was described as mode I category (a). As time increases mode I category (b) appear as a partial fracture of the occlusal veneer in 16 samples (Fig. 3) furthermore, four samples out of twenty-eight samples showed mode I category (c) which might be due impaired bonding within the resin – restoration interphase (adhesive failure).

Mode I may also be explained by the fact that when restoring enamel (elastic modulus is 84.1 GPa) with glass ceramic (elastic modulus of IPS e.max CAD is 95 GPa, while Celtra Duo is 70 GPa) compared to dentine (elastic modulus is 18.6 GPa) a reduction in principal stresses within enamel and dentine occurs allowing less stress transfer. This outcome indicates that occlusal veneers with these materials can protect the natural tooth structure. These positive outcomes are consistent with minimally invasive dentistry principles. As veneers can be replaced, failures that do not cause tooth structure damage increase the durability and prognosis of the restored teeth.

Mode II failure (repairable) which is the fracture of the occlusal veneers and enamel was seen in four samples only. The transfer of stresses to the weakest link which is dentine the main bonding substrate and the presence of mostly of enamel at the periphery sites with higher bond strength and minimal transfer of stress to the tooth is the rational reason for this type of failure. The variation of enamel thicknesses in natural teeth may also contribute to this. Only one sample exhibited mode III failure (irreparable) in group (A-2) Celtra duo with 1.5 mm occlusal veneer thickness which is fracture in occlusal veneer and enamel and dentine (catastrophic failure) which is not significant. It might have happened due to unseen or developing crack which was not obvious at beginning of the study and the applied forces along with aging caused the crack to spread. Both glass ceramic materials performed equally well at 1 mm and 1.5 mm thicknesses regardless of the substrate involved. The clinical implications of this study are that biomimetic occlusal veneer preparation using different glass ceramics with variable thicknesses can show high rates of success.

Occlusal veneers fabricated on maxillary premolars made of lithium disilicate ceramic and zirconia reinforced lithium silicate with 1 mm or 1.5 mm, maybe demonstrating fracture resistance exceeding the recommended values when restoring worn teeth therefore, this restoration could be used as an alternative to full coverage restoration thus fulfilling the new concept of defect-oriented restoration. Both glass ceramic materials performed equally well at 1 mm and 1.5 mm thickness regardless of the substrate involved. No need to increase the thickness of occlusal veneers as manufactures recommended or (reduction depth) if the vertical dimension loss is 1 mm to reach the recommended thickness of the glass ceramic. In case of dentine involvement immediate dentine sealing approach can have a positive impact on the fracture resistance of occlusal veneers by enhancing bonding.

Limitations

In vitro studies attempt to mimic clinical conditions, but they will never be able to accurately reflect real-life clinical situations. The limited number of tested samples and the use of distilled water rather than artificial saliva during dynamic loading present limitations in the current study. Aging was limited to one year, in most published work performed longer periods between (2.5-5 year). Only uniform ceramic thicknesses with semi anatomic design were tested, anatomic design with different thicknesses may account for different results.

5 Conclusions

1- Glass ceramic occlusal veneers had no effect on the fracture resistance of occlusal veneers.
2- Using 1- and 1.5-mm thickness had no consequence on the fracture resistance of table tops veneers.
3- Favourable failure with fracture of restoration only and no harm to the tooth structure with glass ceramic occlusal veneers in the dominant mode of failure.
Fracture Resistance of Biomimetic Occlusal Veneers

Authors’ Contributions

K.A. made a substantial contribution to the conceptual design of the manuscript and led to the methodology, data collection, compilation of results, and discussion sections. D.W. and A.S. designed the models and helped interpret the results. K.A. contributed to the data collection and draft manuscript preparation. A.S. contributed to the writing of the manuscript. N.F. and A.W. contributed to the critical review of the manuscript for its intellectual content. All authors read and approved the final manuscript.

Conflict of interest

The authors declare that they hold no competing interests.

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