Abstract

The present investigation was done to measure fracture strength and microleakage of laminate veneers. Thirty maxillary anterior teeth were selected and divided into three equal groups (10 teeth for each design). Design {A}; teeth were prepared with feather edge, Design {B}; teeth prepared with 2 mm incisal reduction without palatal chamfer and, Design {C} 2mm incisal reduction with 1mm palatal chamfer. In-ceram laminate veneers were constructed with three different preparation designs and cemented on its corresponding prepared teeth with resin cement, then the tested specimens were thermocycled for 48 hours then the fracture strength was measured using Lloyd testing machine at cross-head speed of 0.5 mm/min. The microleakage were measured using stereomicroscope for fifteen specimens. The results were statistically analysed using ANOVA and student “t” test. It was concluded that highest fracture strength was found in design {B} and microleakage was found to be higher in cervical margin than incisal in the three different designs and highest in palatal margin of design {C} than design {A} and design {B}. 

Introduction

Using laminate veneer tooth structure as possible will preserve healthy tooth structure, facilitate superior periodontal health, facilitate cementation with minimal hydrolytic behavior, preserve the pulp’s health, and facilitate easier performance of oral hygiene for the patient (1). Several new all-ceramic materials and techniques have been developed to provide many desirable characteristics such as: translucence, fluorescence, biocompatibility, high compressive strength, and coefficient of thermal expansion similar to that of tooth structure (2).

The Desirable properties of the ideal restorative material is the one that have a perfect and complete seal of the restoration’s margins. The interface between restoration and dental substrate can result in secondary decay, marginal discoloration, and pulps(3). Clinically, absence of secure adaptation is usually denoted by microleakage(4,5).

The clinical result of 546 tetracycline-stained teeth restored with a porcelain laminate veneer system for aesthetic reasons. The color of the veneers was stable and no evident staining was found(6). The long term survival of anterior porcelain laminate veneers placed with and
without incisal porcelain coverage. It was concluded that the survival estimate were 95.8 % for veneers with incisal porcelain coverage and 85.5% for those without incisal coverage. The difference was not statistically significant.

Discolored, fractured, malformed and malposed teeth can be changed and restored to achieve esthetics. Laminate veneering is a conservative method of restoring the appearance of discolored teeth and teeth with diastemas in the mid line.

The variations in veneer preparation removing little tooth structure, removing all of the facial enamel and most of the mesial and distal enamel. The amount of tooth reduction of labial surface for laminate veneer should be 0.5/0.75 mm, which allows the preservation of enamel and enhances strong bonds.

The extent and thickness of enamel in the gingival area of anterior teeth does not permit a reduction of 0.5 mm without extending into the dentin.

Fabrication of all ceramic veneers is difficult to achieve an overall thickness of 0.5 mm, or less. It is necessary to accommodate the additional thickness or accept over contoured restorations.

It was found that, remaining dentin thickness had an important influence on the bond strength of the dentin bonding system. Dentin bond strengths have been shown to decrease during bonding to deep dentin. It is difficult to obtain high bond strength to dentin near to the pulp rather than dentin near to the dentino-enamel junction.

Various clinical techniques have been advocated, to achieve a uniform reduction as grooves as depth guide. It was concluded that the three different techniques not differ significantly.

With regard to the incisal edge preparation of lamination veneer, 4 preparation designs have been described. Window, in which the veneer is taken close but not to the incisal edge.

Feature, in which the veneer is taken up to the height of the incisal edge but the edge is not reduced. Butt-joint, in which a bucco–palatal bevel is prepared across the full width of the preparation. Incisal overlap, in which the incisal edge is reduced in the veneer preparation extend on to the palatal tooth surface.

**Fracture strength**

Some investigators studied fracture load and mode of failure of ceramic veneers with different preparations as no incisal reduction, 2mm incisal reduction without palatal chamfer (butt joint), 1mm incisal reduction and 1 mm height palatal chamfer . It was concluded that ceramic veneers with feathered incisal edge were the strongest, the palatal chamfer did not provide increased strength for ceramic veneers, and the ceramic veneers with incisal butt joint offered several clinical advantages such as tooth preparation, ceramic veneer fabrication , manipulation insertion. It was concluded that, a fracture resistance of teeth prepared using three different designs similar to that of natural teeth. Also these cracks may occur before or after the cementation procedures.

Ceramics always contain a large number of preexisting cracks. They are caused by the condensation, melting and cintering process by differences in the coefficient of thermal expansion between cores and veneers and by grinding and abrasion, result of further loading, polymerization shrinkage and thermo-cycling.

Composite resin polymeraization shrinkage may prevent surface flaws. The use of resin–based luting material may reduce the potential for crack propagation by healing surface flaws.

It was found that, laminate veneers after five years of clinical service, teeth were prepared in incisal over lap with palatal chamfer design and 1.5mm bucco-lingual thickness. The laminates were able to mask the incisal discolorations. Minimal marginal staining was detectable along palatoincisal margins of the laminate restorations.
The strength of ceramic materials is limited by the presence and distribution of structural defects. An increase of crystalline content of a glass-ceramic is accompanied with an increase of the strength. The alignment of elongated grains parallel to the surface is will achieve the greatest resistance to crack propagation through the core material (24).

Resin-composite luting cements provide an intact adhesive interface between the cements and porcelain, the polymerization shrinkage will have a (pulling-in) effect on the ceramic towards the cements. So the resin eliminating ceramic defects, ensure a strong interface between the resin composite luting cements and porcelain (25).

Adhesive bonding of tooth, ceramic and luting composite, and the fracture resistance of the ceramic are key factors of resistance for the long term success of the extended veneer technique (26).

Moreover, composites with a low viscosity show better flow properties thereby reducing the stress created within the material during early setting (27).

The highly viscous cement performed statistically significantly better at dentin \ composite margins than the low viscose cement, they also stated that polymerization stress within the luting cement could not be completely compensated for by large luting spaces (28).

Investigator studied the effect of two preparation design (window and incisal overlap) of incisal edge preparations on microleakage to ceramic laminate veneer. It was concluded that, incisal overlap type showed more leakage at incisal edge than window (28).

Some researchers proved that, the seal of the self-adhesive resin- based cement is comparable to cements that are used for sealing dentin, whereas this cement appears to benefit from the use of a conventional conditioner, such as phosphoric acid, or a strong self-etching adhesive system when cementing to enamel (29).

The bond strength of resin to ceramic increases with increasing ceramic surface roughness caused by acid etching or sandblasting and silanization with silane coupling agents (30).

**MATERIALS AND METHODS**

The material used in this study are listed in table (1):

**Speciements preparation**

Thirty anterior maxillary teeth were selected with homogenous width and length and prepared to receive laminate veneer where each ten teeth were prepared with one of the three different designs used in this study Fig. (1) which are:

<table>
<thead>
<tr>
<th><strong>Material name</strong></th>
<th><strong>Type</strong></th>
<th><strong>Manufacturer</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vita In-Ceram</td>
<td>Glass infiltrated alumina (In-Ceram)</td>
<td>Vita Zahnfabrik-Bad Sakengin, Germany</td>
</tr>
<tr>
<td>Relay X- ARC</td>
<td>Dual cure resin cement</td>
<td>3M ESPE-st. pual,MN USA</td>
</tr>
<tr>
<td>ALPHA-ETCH 37</td>
<td>37% phosphoric acid etchant</td>
<td>Dental technology-USA</td>
</tr>
<tr>
<td>Adper Single bond 2</td>
<td>Two steps total etch adhesive</td>
<td>3M ESPE-st. pual,MN USA</td>
</tr>
<tr>
<td>Porcelain Etch Gel</td>
<td>9.6% Hydrofluoric acid</td>
<td>pulpdent corporation oakalnd. USA</td>
</tr>
</tbody>
</table>
A. Feather in which the veneer is taken up to the height of the incisal edge but the edge, is not reduced.

B. 2mm incisal reduction without palatal chamfer (butt joint)

C. 2mm incisal reduction with 1mm height palatal chamfer.

Dimples were made to fill the entire labial surface, and then chamfer stone* was used to prepare the labial surface by joining the dimples in mesio-distal direction with a chamfer finish bur and extended proximally 1mm in mesial and distal directions forming clear chamfer finish lines.

The palatal surfaces were prepared to 1.5mm depth.

The prepared teeth were refined and polished to remove contour irregularities, internal line angels and bur striations.

Fifteen teeth from groups (A, B& C) were used for fracture strength test and other fifteen teeth from group (A, B&C) were used for marginal microleakage test, five teeth for each subgroup.

Then, impressions for the prepared teeth were taken with a poly vinyl-siloxane impression material** using perforated plastic trays. The teeth were then cleaned and stored in distilled water at room temperature.

Laminate veneers were constructed for all prepared teeth as recommended by the manufacturer.

Cementaion procedure

The fitting surface of the laminate veneer were treated using sandplasting with 50 Mm Al2O3 particles*** at a maximum of 2 bars and then they were ultra sonically and steam cleaned using distilled water. Laminate veneers were subjected to etching using 9.6% hydrofluoric acid gel for sixty seconds followed by thoroughly rinsing with water and drying with the air syringe.

Prepared teeth were etched with phosphoric acid 37% for 30 seconds in enamel and 15 seconds in dentin. The thickness of in-ceram veneers were measured to 1.5mm with clipper.

Cementaion

All veneers were cemented with slight finger pressure until seating and excess material was removed with foam pellets.

The cemented samples of the three groups were stored in humidor at 37°C for 48 hours, and then they were thermocycled for 3000 cycles altering between 5°C and 55°C with 30 seconds dwell times in each water bath using thermostatistically water bath**** for 48 hours.

Measurements

(1) Fracture strength test

The specimens were statically loaded in Lloyd testing machine***** at across head speed of 0.5 m m/min until fracture of the veneer or the tooth occurred.

Each sample was mounted in Lloyded testing machine at 45 degree to the long axis using a specially designed testing device until fractured (Fig. 2).

The load at the fracture of each specimen was recorded in Newton (N), entered into a Microsoft Excel spreadsheet program, and imported into an SPSS statistical program.

The results were analyzed statistically using analysis of variance and student “t” test.

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* Sf-41, Mani, Japan
** Aqiasil monophase, dentsply caulk, USA
*** Korox , Bego , Bremen ,Germany
**** Etica Equipamento cientificos , São Paulo , SP , Brazil
***** Instron , High Wycombe , UK
Measurement of microleakage

Tooth and laminate were entirely covered with nail varnish, except the margins of the restoration. The teeth were stored in 0.5% dye solution* for 8 h at (37°C) and were then cleaned.

The crowns of teeth and its laminate were then embedded in acrylic resin blocks to avoid shipping of the laminate, then sectioned 2 mm below the cervical line with the help of a water-cooled diamond disk**.

The extent of the dye penetration (in millimeters) was measured with a stereo microscope*** at 30 X magnification.

RESULTS

(I) Results of fracture strength test

The mean load of fracture strength of all groups were recorded in table(2) and represented in fig (3). Statistically there was a significant difference in the fracture strength between the groups.

The highest mean failure load was recorded with the specimens prepared with design {B} (524.56±63.07 N), while the lowest mean failure load was recorded with design {C} (440.56± 46.21 N). Statistically, using multiple comparison (Tukey) tests, there was a significant difference in fracture strength between the three designs.

* Lishman Stain- Labstain – Egypt.

** Diamond 100/ 80 Top Dent , Swiss made.

*** Olympus Dp 10 , Japan.
TABLE (2) Descriptive Table for fracture strength results of In – Ceram laminate veneers with the three tested preparation designs in Newton (N).

<table>
<thead>
<tr>
<th>Design</th>
<th>Mean value</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A)</td>
<td>460.93</td>
<td>± 58.56</td>
</tr>
<tr>
<td>(B)</td>
<td>524.56</td>
<td>± 63.07</td>
</tr>
<tr>
<td>(C)</td>
<td>440.56</td>
<td>± 46.21</td>
</tr>
</tbody>
</table>

TABLE (3) Descriptive table for the marginal microleakage results in mm of In-Ceram laminate veneers with the three tested preparation designs.

<table>
<thead>
<tr>
<th>Margin</th>
<th>Design (A)</th>
<th>Design (B)</th>
<th>Design (C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cervical</td>
<td>2.30± 0.46</td>
<td>2.33 ± 0.55</td>
<td>2.42± 0.56</td>
</tr>
<tr>
<td>Incisal</td>
<td>1.26 ± 0.35</td>
<td>0.91 ± 0.24</td>
<td>2.27± 0.52</td>
</tr>
</tbody>
</table>

FIG. (3) Bar chart of the mean value of fracture strength results in N for In-Ceram laminate veneers with the three tested preparation designs.

II) Results of microleakage

The mean value of microleakage standard deviations of the three preparation designs of tested specimens are shown in table (3) and represented in Fig. (4).

The results were analyzed statistically using analysis of variance (ANOVA) test, student “t” test, and multiple comparison (Tukey) test.

For design A, B and C, the highest mean value of marginal microleakage was recorded at the cervical margin, while the lowest mean value of marginal gap was recorded at the incisal margins. Statistically, there was a significant difference between the marginal microleakage of cervical margin and the marginal microleakage of the incisal margins ( P < 0.05 ).

FIG. (4) Bar Chart of the mean value of marginal microleakage in mm of In-Ceram laminate veneers with the three tested preparation designs.

FIG. (5) A Photograph showing microleakage at the cervical margin of In-Ceram laminate veneer in design (A) at magnification 30X.
DISCUSSION

Laminate veneering is a conservative method of restoring the appearance of discolored, pitted teeth and teeth with midline diastemas.

The laminate veneers placed on the enamel layer of the labial surface of the restored teeth. The preparation must be at least 1.5 mm of thickness which is necessary to accommodate the additional thickness.

Uniform reduction was done by using dimples as a guide for amount of tooth removal.

The butt-joint incisal configuration for In-Ceram laminate veneered showed the lowest marginal leakage at the incisal margin, this may be attributed to preservation of a peripheral enamel layer around all margins, also, this design established an easy path of insertion of the laminate during cementation (31).

The occurrence of microleakage along the interface has been related to pulpal problems, hypersensitivity, and secondary caries (32). Microleakage has generally been evaluated with in vitro models with dye penetration studies being the most employed tests. The high diffusion of dyes employed, due to the small size of particles and mild acidity may cause light etching, this accordance with result of Tay and Pashley (33).

The margin configuration were different at the cervical, and incisal, therefore, it was decided to use a linear measurement by millimeters instead of scoring method.

Marginal leakage was studied as it is an important factor affecting the longevity of dental restorations. Microleakage usually has been evaluated with invitro models using methylene blue.

Marginal microleakage mean values were found to be higher in the cervical margin in design {A} and {B}, while, the incisal margin in the same designs exhibit the lowest mean value of marginal microleakage. This phenomena can be explained by that the dentinal tubules orientation is a perpendicular to the cervical margin and their diameter and density is increased as a function of pulp proximity. Also the enamel at the cervical margin is thinner than that of incisal margin, and the diameter and density of dentinal tubules decreased incisally. This finding is in agreement with that of studies by Andree. et al (34).

Window technique of preparation of porcelain laminate veneer is not accepted in case of In-Ceram laminate veneer due to weakening the enamel at the incisal edge.

The influence of cement lute, thermo cycling and surface preparation on the strength of a porcelain laminate

![FIG. (6) A photograph showing microleakage at the cervical margin in design (B) In-Ceram laminate veneer at magnification 30 X.](image6)

![FIG. (7) A photograph showing microleakage at the PALATAL margin in design (C) In-Ceram laminate veneer at magnification 30 X.](image7)
veneering material, may help to strengthen porcelain surfaces.\(^\text{[25]}\)

It may be contributed that the overlapped preparation showed stress to be more distributed in the tooth, and that the forces had to be sustained to a greater extent by the veneer itself. This is in agreement with Hui et al.\(^\text{[35]}\).

In this study, it was found that design (C) with palatal chamfer was the weakest one, this may create a thin extension of ceramic in an area of maximum tensile stress. The palatal surface in the form of a long chamfer has been shown to be a possible cause of failure, because of maximum tensile stresses in the palatal concavity. This in agree with Gordon J.\(^\text{[21]}\).

Specimens to simulate the angle intra orally as the mandibular incisors directed toward the maxillary incisors at this angle as stated by Kevin et al.\(^\text{[36]}\).

The fracture strength of ceramic restoration may be affected by many factors as, cracks that present in the ceramics as a result of cementation. Gary et al.\(^\text{[22]}\) stated that, postoperative cracks are reported as a possible cause of fracture and a crack can start from a defect, growing very slowly under further load until fails.

### SUMMARY AND CONCLUSIONS

This study was directed to evaluate fracture strength and microleakage of In-Ceram laminate veneers, with three different preparation designs. {A} Feather, in which the veneer is taken up to the heigt of the incisal edge but the edge, is not reduced, {B} 2 mm incisal reduction without palatal chamfer (butt joint ) and {C} 2mm incisal reduction with 1 mm height palatal chamfer laminate veneers were cemented using resin cement on each group of prepared teeth. The cemented laminate veneers were subjected to thermocycles for 48 hours, then the fracture strength and microleakage were measured.

Fracture strength was measured by L loyed testing machine at a cross head speed of 0.5 mm/min until fracture of the veneer or the tooth occurred. Load was applied at 45 degree to the long axis of tested specimens. Marginal microleakage was measured by dye penetration at the interface using stereo microscope at cervical and incisal margins.

**Within the limitation of this study, it was concluded that**

1. Highest mean values of fracture strength in design {B} in comparison with designs {A} and {C}.
2. Marginal microleakage was found to be higher in the cervical margin while, the incisal margin exhibited the lowest mean value of microleakage for In-Ceram laminate veneer with the three preparation designs.
3. The marginal microleakage was found to be higher in the palatal margin of design {C} than the other two designs.

**REFERENCES**


