

EFFECT OF TOOTH SURFACE LOSS ON COLOR STABILITY AND STRENGTH OF WRAP AROUND CERAMIC VENEERS

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ABSTRACT

Introduction: Ceramic veneers are increasing worldwide.

Objective: Evaluate the effect of surface loss on color stability and strength of ceramic veneers.

Methods: 40 incisors were divided into 4 groups; A: the incisal third was removed, B: one third was removed, C: one half was removed D: intact tooth. Teeth of (A, B and C) were restored with composite. Teeth received ceramic veneers. Fracture resistance and color were evaluated.

Results: Fracture resistance showed no significant difference between the 4 groups, while one half surface loss affected the color stability.

Conclusion: The results suggested full ceramic coverage when loss is one half.

INTRODUCTION

Achieving the good esthetic results especially with ceramic veneers is probably the most challenging task encountered by dental practitioners and ceramist today. Ceramic veneers are indicated for teeth with moderate discoloration, restoration of traumatized, fractured, worn dentition and abnormal tooth anatomy^{3,4}. Oral injuries are the second most common body injury in pre-school age children and the sixth most common body injury among 7-30 year-olds. The prevalence of these injuries has increased in the last 10-20 years. Out of these, 83%

with acute tooth injuries were younger than 20 years.

1 It is estimated that about 1 out of every 4 persons up to the age of 18 sustain a traumatic dental injury in the form of an anterior crown fracture. Coronal fractures of permanent incisors represent 18-22% of all traumas to dental hard tissues. Out of these, 96% involve maxillary incisors (80% central incisors and 16 % lateral incisors)⁵. Numerous techniques have been developed for the reconstruction of injured teeth with the evolution of newer materials and different schools. These include: Full coverage crowns- resin crowns, steel crowns, ceramic crowns,

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laminate veneers, & resin composite build-up with or without pins.

Dentoalveolar traumas are commonly caused due to falls, fights, accidents etc in children and adolescents^{4,6}. Fractures because of trauma usually occur in maxillary anterior teeth⁷ and these fractures subsequently lead to aesthetic, functional and phonetic problems which represent a big challenge for the dentist. In the past methods such as resin crowns, stainless steel crowns and pin retained inlays have been used with varying degree of success⁸. Over the years more recent aesthetic techniques such as porcelain laminate, veneers, all ceramic crowns, reattachments, direct composite build up have largely replaced the older techniques.

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 dentin⁹. It is difficult to obtain high bond strength to dentin near to the pulp rather than dentin near to the dentino-enamel junction¹⁰.

In search for more durable aesthetics, porcelain veneers have been introduced. Several studies have proven their long time prognosis in-vivo and high level of patient acceptance¹¹⁻¹⁷. The failure rate ranged in these studies ranged between 0%¹¹ and 33%¹⁸. Additionally, in-vitro studies demonstrated long term retention of porcelain veneers¹⁹⁻²¹.

Yet, there are limited studies concerning the prognosis of veneers in relation to the amount of surface loss of the anterior teeth accordingly the ceramic veneers color stability and fracture resistance. Thus, this study was conducted to evaluate the effect of surface loss on the fracture resistance and the color stability of wrap around ceramic veneers also to quantitatively evaluate the color difference (ΔE) from standard (ceramic veneers cemented on intact teeth), when three different amount of tooth structure has been removed.

METHODOLOGY

Specimens preparation

Forty caries and restoration-free human maxillary central incisors of approximate sizes were collected. The teeth were cleaned and sterilized in an autoclave at 121°C, 15 Psi for 40 minutes. They were then mounted 2mm below the cement-enamel junction (CEJ) in an auto-polymerized acrylic resin (Vertex- Dental B.V., The Netherlands) blocks with a size of 10mm x 10mm x 20 mm. Teeth were divided into four groups of ten teeth each according to surface tooth loss (Fig1):

Group A: The incisal third of tooth was removed parallel to cemento-enamel junction and tooth was restored using composite resin (Z350,3M ESPE,USA).

Group B: One third of the tooth was removed obliquely and tooth was restored using composite resin.

Group C: One half of the tooth was removed obliquely and restored by composite resin.

Group D: The tooth was intact.

All composite restorations in all designs were made from the same color shade.

All teeth were prepared to receive a wrap around design of ceramic laminate veneer.

Standardized tooth preparation

Three horizontal surface depth cuts were made on facial surface of tooth using roundend taper diamond bur with guiding pin # 8881 P (Komet, Brasseler, Germany) on a parallelometer (Amann Girschbach, Germany) with half of the facial Surface acting as a control, the other half was reduced to 0.6 mm uniformly, similarly the other half of the facial surface was prepared to a uniform depth of 0.6 mm. The preparation was carried out in two planes, proximal finishing line was kept labial to proximal

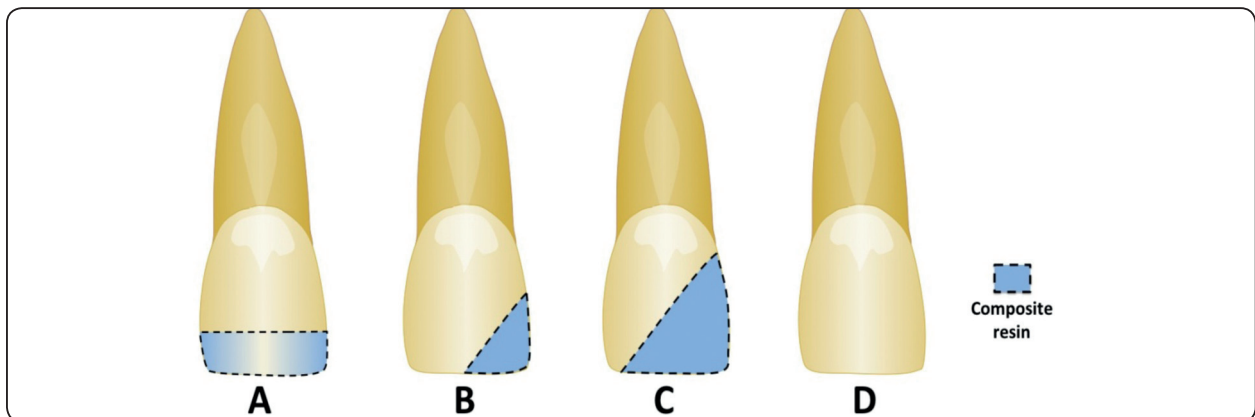


FIG. (1): Grouping of the samples according to the amount of tooth loss.

contact area of the tooth and chamfer finish line was prepared.

Fabrication of ceramic veneers Laboratory Steps

All dies were mounted individually in scanner (Zenotec scan, Wieland Dental + Technik GmbH & Co. Germany) where they were scanned and a CAD veneer was designed for all samples individually. STL file was exported to CAM wet milling machine (Zenotec Select, Wieland Dental + Technik GmbH & Co. Germany). Six IPS e.max CAD (Ivoclar Vivadent AG, Schaan / Liechtenstein) blocks were mounted in the milling machine for milling. After milling all veneers, they were cut off the block using round-end taper diamond bur # S6856 314 018 (Komet, Brasseler, Germany) and then cleaned using air blows and sintered in a ceramic oven (Zenotec Fire Cube, Wieland Dental + Technik GmbH & Co. Germany) using fast sinter program for sintering single-unit restorations (total cycle time approx. 3h). Discs were then collected ultrasonically cleaned and each assigned to its corresponding tooth.

Cementation of Ceramic Veneers

After try-in, inner surface of veneer was cleaned with 9.5% of HF gel (Ultradent, South Jordan, UT 84095, USA) for 40 Sec. and saline coupling agent (Ultradent, South Jordan, UT 84095, USA) was applied on etched ceramic surface and excess was

blown away by gentle blow of air. All silanated veneers were left to dry for 10 Sec. The prepared tooth surface was cleaned and 37% Phosphoric acid was applied for 15 sec & rinsed with water for 10 sec. Then single step bonding agent was applied on teeth and dried for 5 Sec. Dual cure resin cement (Rely X Veneer, 3M ESPE, USA) was applied on the inner surface of veneer, then all veneers were positioned on its corresponding tooth. The same shade color for the luting cement was used for all tested veneers in the different designs. Flash curing using LED curing light (Elipar S10, 3M ESPE, USA) for 1 second, then excess cement was removed using universal scaler (Hue-Friedy, Chicago, USA). Final curing was done 10 sec for labial and palatal surfaces.

All samples were stored in distilled water at room temperature for 48 hours. All samples were thermocycled for 1000 cycles between 5° and 55° with dwell time of 30 seconds at each temperature.

Measurements

Color measurements were taken firstly before applying the fracture strength test for the same 40 specimens.

(1) Color measurements

For color stability test; color was documented for each veneer first then all veneers were placed in a coffee solution for 15 days then the color was

again documented for each veneer to detect the ΔE^* . Color measurements were made using an 'Easy Shade' Vita probe spectrophotometer (Vita Easy Shade, Vita, Germany). Spectrophotometers measure CIE-L*a*b* values giving a numerical representation of a 3D measure of color. The L* describes the lightness of the object being assessed, a* value defines the color on the red-green axis and b* on the yellow-blue axis 20. The specimens were submitted to color readings. The readings were made against a standard white background (Standard for 45°, 0° Reflectance and Color Garder Laboratory Inc. Maryland, EUA). To determine the total color change (ΔE^*), the formula below was used: $\Delta E^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$; where ΔL^* is the variation of L*, Δa^* is the variation of a*, and Δb^* is the variation of b*. ΔE^* were obtained in this study for the four groups tested. Values obtained for ΔE^* were subjected to statistical analysis in SPSS 17.0 for Windows (SPSS Inc., Chicago, IL, EUA) with a significance level of 0.05 ($p \leq 0.05$) using Duncan's Multiple Range Test.

(2) Fracture strength test

For the purpose of the fracture strength test, the 40 specimens were statically loaded in Lloyd testing machine (Fig2) at across head speed of 0.5 m m/min until fracture, which was confirmed by a sudden drop of measurement in the testing machine. Each sample was mounted in L loyed testing machine at



FIG (2): Lloyd testing machine

135 degrees to the long axis of the tooth to simulate the average angle of contact between maxillary and mandibular incisors in class 1 occlusion, using a specially designed testing device. The load at the fracture of each specimen was recorded in Newton (N), the obtained values were converted into MegaPascal units (MPa), according to the following equation: $FS = F/A$ (N/mm²) or (MPa) Where FR= Fracture strength. F = Breaking load in Newton. A = Area of bonding interface = Πr^2 Where r = radius in mm and $\Pi = 3.14$. The results of fracture strength testing were recorded, tabulated and statistically analyzed using Duncan's Multiple Range Test.

RESULTS

(1) Results of fracture strength test

The mean load of fracture strength of all groups were recorded in table (1) and represented in (Fig. 3). Statistically there was no significant difference at $p \leq 0.05$ in the fracture strength between the four groups. The highest mean failure load was recorded with the specimens prepared with design D (control) group as they recorded $231 \pm (11.4)$, while the lowest mean failure load was recorded with design C (one half of the tooth was removed obliquely) group $208 \pm (9.4)$.

TABLE (1) Descriptive statistics of fracture strength results of the ceramic veneers of the four groups measured in MPa

Groups	N	Mean	SD	DT
The incisal third of tooth was removed	10	224	$\pm (18.4)$	ab
One third of the tooth was removed obliquely	10	215	$\pm (10.4)$	abc
one half of the tooth was removed obliquely	10	208	$\pm (9.4)$	abcd
Intact tooth (control)	10	231	$\pm (11.4)$	a

S.D. = Standard deviation. DT = Duncan's Multiple Range Test for the effect of Surface treatment. Means with the same letter are not significantly different at $p \leq 0.05$

(2) Results of color measurements:

The results for ΔE^* are shown in Table 2. There were significant differences between the ΔE^*3 obtained for group C (one half of the tooth was removed obliquely) when compared with ΔE^*1 , ΔE^*2 and ΔE^*4 . Group C presented more color change (higher ΔE^*) than the other three groups at ($p \leq 0.05$). The results revealed also that there were no statistically significant differences between the three designs (The incisal third of tooth was removed, one third of the tooth was removed obliquely and Intact tooth (control) ΔE^* (ΔE^*1 , ΔE^*2 and ΔE^*4) at $p \leq 0.05$.

TABLE (2) Descriptive statistics of color measurements ΔE^* results of the ceramic veneers of the four groups

Groups	N	Mean of ΔE^*	SD	DT
The incisal third of tooth was removed	10	0.736	$\pm(0.154)$	b
One third of the tooth was removed obliquely	10	0.703	$\pm(0.098)$	bc
one half of the tooth was removed obliquely	10	2.107	$\pm(0.427)$	a
Intact tooth (control)	10	0.607	$\pm(0.141)$	bcd

S.D. = Standard deviation. *DT* = Duncan's Multiple Range Test for the effect of Surface treatment. Means with the same letter are not significantly different at $p \leq 0.05$

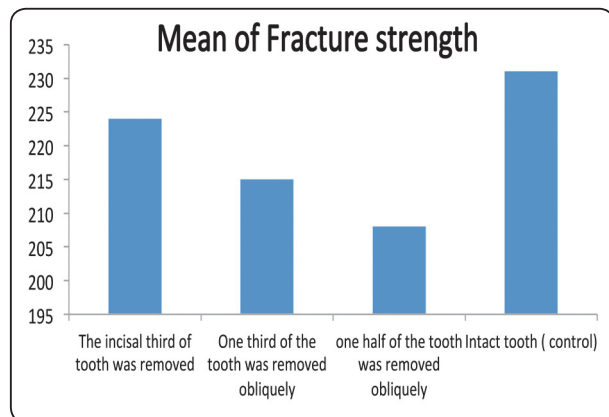


FIG. (3): Mean Values of fracture strength among the four different designs of tooth loss

DISCUSSION

With the great emphasis placed on esthetics by today's society, the color stability of esthetic restorative materials gains critical importance.

According to the literature, color alteration occurs in the first 300 hours of the aging process, as the composites water sorption stops with the saturation and stabilization of the polymeric chains²²⁻²⁴. In this study, the immersion in a staining solution was conducted for 15 days to achieve the total color change expected. The optical behavior of esthetic materials can be measured by visual or photographic techniques, even though they are highly subjective²⁵. Electronic devices have been developed to eliminate the subjectivity of the human eye, such as colorimeters and spectrophotometers²⁶.

The final color of translucent ceramic restorations is determined by the thickness of the porcelain, the thickness and color of the luting agent and the color of the underlying tooth structure²⁷⁻²⁹. In the present study, the effect of the underlining composite material restoring the three different designs of tooth loss on the color stability of the ceramic veneers was evaluated.

In this study, the higher ΔE^* was obtained in relation to the greater amount of tooth loss, therefore a large amount of composite material was exposed to color change. This finding was in accordance with some authors, who suggested that the yellowing of a material over time could be related to the exposition of Bis-GMA-based material to ultraviolet light and heat³⁰. As composite materials age, the water sorption characteristics of the resin monomers may contribute to differences in the degree of color stability³¹. While for the other two designs of tooth loss, no significant differences were recorded between them and the intact tooth. This finding could be attributed to the fact the IPS e.max Press is approximately 70% lithium disilicate glass ceramic, with its main component being SiO_2 . In the lithium disilicate glass ceramics, the main

crystalline phase consists of elongated lithium disilicate ($\text{Li}_2\text{Si}_2\text{O}_5$) crystals, building a scaffold of many small interlocking needle-like crystals that are randomly oriented and with a length ranging from 3 to 6 μm . The second crystalline phase consists of a lower volume of lithium orthophosphate (Li_3PO_4). This structure can provide translucent material that might be helpful for the polymerization process of resin cement³².

On the other hand, the influence of cement lute, thermo cycling and surface preparation on the strength of a porcelain laminate veneering material, may help to strengthen porcelain surfaces³³. 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 al³⁴.

Thermocycling with temperature changing from 5°C to 55°C was also performed. This is often reported by other authors in order to evaluate the long-term success of restorations³⁵⁻³⁷. This is in accordance to Palmer et al.³⁸ who reported minimum and maximum temperatures intraorally between 1.0°C and 58.5°C and suggested a range of 0°C to 67°C for the thermocycling tests of dental materials.

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 al³⁹ 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.

The three different amount of tooth loss applied in this study on the maxillary incisors didn't show significant difference in the fracture resistance of the veneers. These results were in accordance with Baratieri et al⁴⁰, and Camillo D'Arcangelo et al⁴¹, who suggested that the conservative veneer preparation within the enamel do not significantly

influence the fracture resistance of maxillary incisors.

Furthermore, the relation of the long axis of the tooth to the operating load renders the physiological load of upper incisors particularly disadvantageous⁴². Loney et al⁴³ showed that different load angles result in different fracture strengths. The horizontal section of the load has much more influence on maxillary incisors than the vertical section⁴⁴. Thus, in the present study, the load was applied at a 45° angle^{45,46} to simulate a worst-case scenario⁴⁷.

Moreover, previous research¹⁹ reported fractures of veneers bonded on teeth with large composite resin restorations. The lower adhesion to the large composite resin and exposed dentin surfaces was considered the most likely reason for these failures. The authors therefore concluded that the presence of composite resin restorations had a negative influence on the overall clinical performance but did not increase the loss of veneers.

But, the results obtained in this study showed that there was no statistical significant difference in the fracture resistance strength between porcelain veneers applied on intact tooth and those applied on composite restorations to replace three different design of tooth loss. And these results were in accordance with Marco et al⁴⁸ and Peumans et al⁴⁹, who suggested that ceramic laminate veneers bonded to silica-coated and silanized, existing, aged composite restorations presented higher fracture strengths (255 to 330 N) than the veneers adhered to enamel and dentin, they also concluded in their study that among the 42 failures, only 3 occurred in teeth with resin restorations, and no significant association could be observed between failure and presence of a restoration.

CONCLUSIONS

- 1- The amount of tooth loss affects the mean of ΔE values, with higher values for loss of half of the tooth structure.

- 2- Under the circumstances of this study, when luting cement and veneers material were the same, the fracture resistance was not affected by the amount of tooth loss.

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