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Original Research

# Comparative evaluation of fracture resistance of Ceramic Veneer with three different incisal design preparations - An In-vitro Study

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***Abstract:***

**Background:** Ceramic veneer fracture has occurred mainly at the incisal edge of the veneer because of greater stress. This study compares and evaluates the fracture resistance ceramic veneers with three different incisal preparations.

**Materials & Methods:** 15 human permanent maxillary central incisor extracted were selected which were divided into three groups of 5 each having a different Incial design Preparation. **Group 1**: No Incisal reduction with facio- incisal bevel, **Group 2**: 1 mm incisal reduction with butt joint, **Group 3**: 1 mm incisal reduction with 1 mm height of Palatal chamfer. It was found that Group III had greater fracture resistance as compared to Group I and Group II. Group I had least fracture resistance as compared to Group II and III. Group II had greater fracture resistance as compared to Group I but less than Group III.

**Results:** Ceramic veneer with 1mm incisal reduction with 1mm height of palatal chamfer showed highest fracture resistance as compared to 1mm incisal reduction with butt joint and no incisal reduction with facial-incisal bevel, in order to achieve better esthetic and functional results.

**Conclusion:** The palatal chamfer margin results in preservation of some peripheral enamel layer, which eliminates the micro leakage at the palatal margin-restoration interface and also effectively counteracting shear stress. This design provides a definite seat for cementation.

***Key Words:*** Ceramic veneer, esthetics, fracture resistance, incisal design

## 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.[1,2]

Ceramic veneers are contraindicated for edge - to - edge and cross bite occlusal relationships because of excessive stress during function. However, 'Friedman' reported that ceramic veneers not only provide suitable esthetic, but also reliable functional strength.[3] Therefore, they can be used to provide anterior guidance by restoring appropriate incisal length.

Newer bonding techniques and material have improved the bond strength of ceramic veneer to dentin.[4] Clinical cohesive ceramic fractures have occurred mainly at the incisal edge of the veneer because of greater stress.[5] It was believed that a palatal chamfer was necessary to strengthen ceramic veneers. Unfortunately, most of the data regarding the clinical behavior of different tooth preparation designs originated from anecdotal reports. It remains controversial, whether different tooth preparation design can affect fracture strength of ceramic veneers or whether one configuration of tooth preparation is superior to another. Hence attempt was made to study and compares the fracture resistance ceramic veneers with three different incisal preparations.

## Materials and Methods

The materials selected for the fabrication of ceramic veneers were presented in Table I & II

Twenty Five human extracted permanent maxillary central incisors were selected with normal crown anatomy and similar in sizes and shapes irrespective of age, sex or side. Teeth were cleaned and stored in normal saline water at room temperature from the day of extraction until the testing.

Fifteen teeth were divided into three groups of 5 each having a different Incial design preparation as following (Figure - 1)

Table I: Materials used for the fabrication of ceramic veneers.

| Material | Manufacturer |
|---|---|
| Polyvinyl siloxane impression material (putty & Light body) | 3 M express |
| Type IV (die stone) | Ultra rock |
| Die spacer | True fit |
| Duplicating paste | Vita hi – Ceram |
| Refractory die materials, Mixing liquid | Vita Dur Vest |
| Ceramic powder | Vita Duralpha |
| Dentine shade (B2), Enamel shade (EN1) | Vitapan Classic |
| Glaze (Akzent powder, liquid), Modellng liquid | Vita |


Figure 1

Group 1: No incisal reduction with facio- incisal bevel
Group 2: 1 mm incisal reduction with butt joint
Group 3: 1 mm incisal reduction with 1 mm height of Palatal chamfer

Table II: Materials used for the cementation ceramic veneers.

| Material | Manufacturer |
|---|---|
| Ceramic enchant – (HF, 9.5% buffered) | Utlradent |
| Silane coupling agent (scotch bond ceramic primer) | 3 M dental product |
| Bonding agent (syntac single bond adhesive) | Vivadent |
| Enamel etchant (37%phosphoric acid etchant) | 3M dental products |
| Dual cure resin cement (variolink II) | Vivadent |
| Acrylic resin (self cure acrylic resin) | Acryl an |

**Standardized tooth preparation:**

Three horizontal surface depth cuts were made on facial surface of tooth using depth guiding bur with half of the facial Surface acting as a control, the other half was reduced to 0.5 mm uniformly with chamfer end bur, similarly the other half of the facial surface was prepared to a uniform depth of 0.5 mm. The preparation was carried out in two planes, proximal finishing line was kept labial to proximal contact area of the tooth and chamfer finish line was prepared.

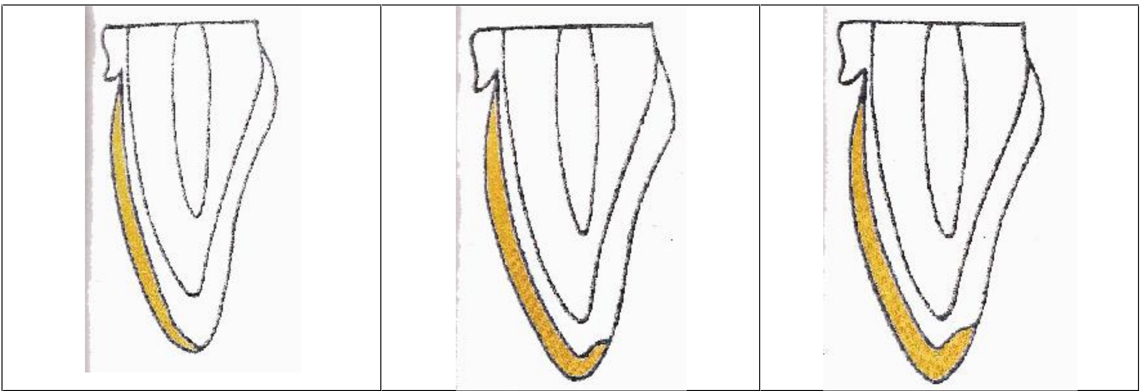
**Incisal reduction:**

This cross-sectional study was planned to assess dental health status of sensory impaired and blind children in an Institute aged 6 to 20 years children. Before the onset of the study, official permission and ethical clearance was obtained from both the Institutes.

**Group - I:** No incisal reduction, 0.5 mm facio incisal surface of the tooth was reduced and 0.2 mm bevel was placed at the expense of the labial surface (Figure 2.)

**Group - II:** 1 mm of incisal edge was reduced uniformly the incisal finishing line was prepared having a 75 degree incline towards the lingual surface of the tooth and butt joint finishing line was prepared. (Figure 2)

**Group - III:** 1mm of incisal edge was reduced chamfer finishing line was prepared on the palatal surface of the tooth with round end tapered diamond bur was held parallel to the lingual surface of the tooth with its end



| Group - I | Group - II | Group - III |
|---|---|---|

Figure 2


**Figure 3:** Master Dies

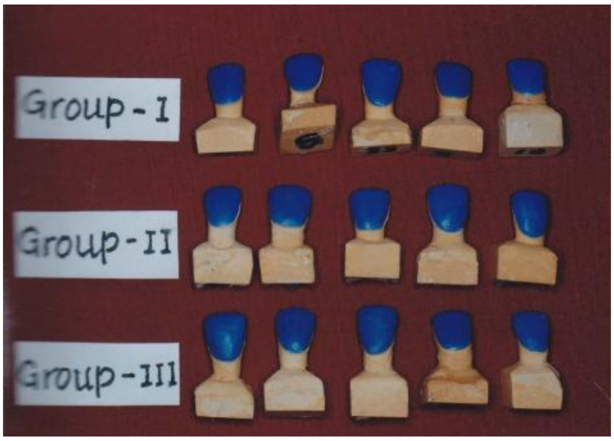



**Figure 4:** Master Dies with Wax Pattern

**Figure 5:** Putty index for ceramic build up

forming a chamfer 0.5 mm deep and 1 mm from reduced incisal edge (i.e. 1 mm height of palatal chamfer). (Figure 3)

**Impression of the prepared teeth and making a master die:**

Impression of the individual tooth was made in a stock tray. Two steps (putty/wash) impression technique was used, impression was made with polyvinysiloxane putty impression material (3M ExpressTM) with cellophane sheet as a spacer. Light body impression material (3M ExpressTM) was injected around the prepared tooth and into the set putty impression. Tooth was seated into the tray without applying excessive pressure until the material completely sets. The impression was poured in die stone (Ultrarock) and master dies were fabricated (Figure 3)

**Fabrications of putty index for porcelain build up:**

Wax pattern of 0.5 mm thickness was made on the master die with S-U Inlay wax; thickness was measured with Iwansons gauge. In Group II and III incisal edge was increased by 1mm. Then putty index was made with polyvinylsiloxane putty impression material, which consists of two parts; one upper and one lower with orientation groove. (Figure 4, 5)

**Fabrication of ceramic veneers Laboratory Steps:**

One coat of die spacer (True-fit) was applied on the master die with 1mm short of the margin. VITA Hi-Ceram duplicating paste was used for duplication of master die. Vitadurvest refractory die material was used for refractory die fabrication.

After die was hardened margins were outlined with VITA Marker (refractory market). Then the surface of the refractory die was sealed with Vitaakzent glaze and die was fired.

Ceramic powder and liquid were mixed according to


**Figure 6:** Cementation of ceramic veneer

manufacturer instructions. Dentin and enamel was built up by layering technique. Build up was done with proper condensation method. Putty index was used for ceramic build up.

Greatest part of refractory die materials was removed with a round bur No. 8, remaining was carefully removed by blasting with glass beads at a pressure of 2.3 bar (30-40 psi), taking care not to damage the margin. Then veneers were tried on prepared tooth for margin accuracy and fit.

**Cementation of Ceramic Veneers:**

After try-in, inner surface of veneer was cleaned with 9.5% of HF get for 60 Sec. and silane coupling agent was applied on etched ceramic surface and allowed to dry for 5 Sec. The prepared teeth 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 (variolink IITM) was mixed according to the manufacture instructions and applied on the inner surface of veneer and positioned it on the teeth. Excess cement was removed and it was cured as per manufacture instructions. (Figure 6)

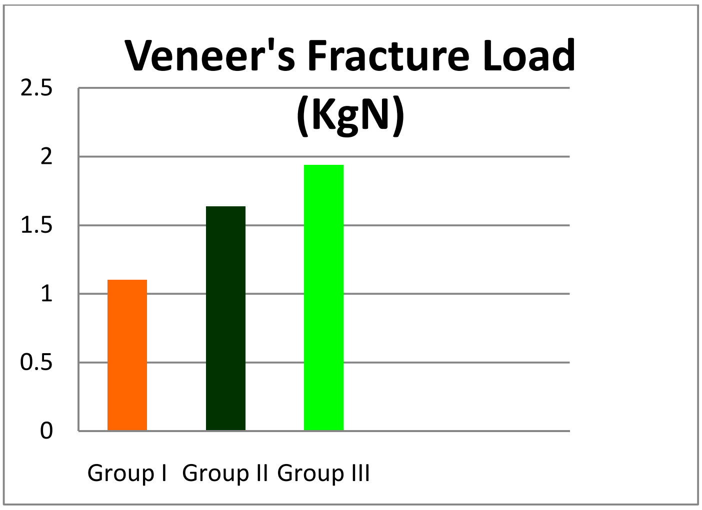
**Specimen testing for fracture resistance of ceramic veneers**

The 15 maxillary incisors were prepared with three different incisal design preparation and mounted in acrylic resin jig at specific dimension that would fit in Instron - universal testing machine. The tooth was mounted at an angle of 900 with horizontal plane. All specimens were embedded up to 2mm below CEJ. The load was applied at a distance of 2.5mm from the incisal edge, at an angle of 1350 to the lingual surface of the tooth. A customized plunger with rounded tip was attached to the instron machine and load was applaid at a cross head speed of 0.5 mm/minute. The fracture loads(KgN) was determined using a universal testing machine (Instron). (Figure 7)

**Figure 7:** Instron. universal testing machine

| Table III: Fracture load of ceramic veneers fabricated with different incisal design preparations. | | |
|---|---|---|
| **Preparation designs** | **No. of Samples** | **Veneers Fracture load (KgN)** |
| **Group I** (No incisal reduction with incisal bevel) | 1 | 0.58 |
| | 2 | 0.61 |
| | 3 | 0.60 |
| | 4 | 0.65 |
| | 5 | 0.64 |
| | Total | 3.08 |
| | Mean (X) | 0.616 |
| | S.D. | ± 0.0288 |
| **Group II** (1mm incisal reduction with Butt joint) | 1 | 1.01 |
| | 2 | 1.02 |
| | 3 | 0.83 |
| | 4 | 0.80 |
| | 5 | 0.83 |
| | Total | 4.49 |
| | Mean (X) | 0.898 |
| | S.D. | ± 0.1076 |
| **Group III** (1mm incisal reduction with 1 mm height of the Palatal Chamfer) | 1 | 1.09 |
| | 2 | 0.90 |
| | 3 | 0.83 |
| | 4 | 0.91 |
| | 5 | 0.93 |
| | Total | 4.66 |
| | Mean (X) | 0.93 |
| | S.D. | ± 0.0960 |

| Table IV: Difference in the mean value of fracture load of ceramic veneers between three different groups. | | | |
|---|---|---|---|
| | Group I & II | Group I & III | Group II & III |
| Mean Difference | 0.282 | 0.316 | 0.034 |
| S.E. (±) | ± 0.0556 | ± 0.0501 | ± 0.0721 |
| 't' | 5.0719 | 6.3061 | 0.4722 |
| Significance | P<0.001 | P<0.001 | NS: P>0.05 |




**Graph 1:** Fracture Load of Ceramic Veneers With Three Different Incisal Design Preparations.

**Results**

Group I: No incisal reduction with facio incisal bevel
Group II: 1mm incisal reduction with Butt Joint
Group III: 1mm incisal reduction with 1mm height of the Palatal Chamfer

**Statistical analysis**

Group I and Group II had significant difference (P<0.01) in the mean value of fracture resistance of ceramic veneers. Similarly Group I and Group III (1mm incisal reduction with palatal chamfer) also had significant difference (P<0.01) in the mean value of fracture resistance of ceramic veneers. Group II and Group III had no statistically significant difference (P>0.05) (Table III & IV and Graph1) Group III had greater fracture resistance as compared to Group I and Group II. Group I had least fracture resistance as compared to Group II and III. Group II had greater fracture resistance as compared to Group I but less than Group III.

**Discussion**

'Friedman' reported that fracture alone accounted for 67% of the total failure recorded for ceramic veneers during clinical observation over a period of 15 years.[3] Different tooth preparation designs for ceramic veneers were proposed considering the brittle nature of the porcelain.[6] 'Horn' gave the 'intra enamel' or 'window' preparation design for porcelain veneers, considering the conservative tooth preparation but major disadvantage of this design was the unaesthetic finish line of the veneer near incisal edge of the tooth.[7] Clyde, Gilmour and Hui et al described feather edge tooth preparation; incisally with 0.5 - 1mm bevel preparation and intra enamel tooth preparation in which 1 mm of incisal edge is preserved and also to overlapped incisal edge tooth preparation.[8] Weinberg suggested a 1 mm incisal reduction with rounded line angjle for improved translucency of the veneer.[9] Sheet and Taniguchi described a tooth preparation with a chamfer for adequate porcelain thickness and with a rounded incisal edge and lingual heavy chamfer.[10] A survey carried out by Brunton and Wilson in England showed that the two commonly followed philosophies of ceramic veneer preparation are facio-incisal bevel and incisal wrap preparation.[11]

Finite element analysis evaluations confirmed the importance of having a sufficient bulk and minimum composite resin cement thickness to reduce the thermal and polymerization shrinkage and the stress applied to the ceramic veneer.[12] It is critical for the dentist to understand that tooth preparation design can affect the longevity of veneer.

Other studies that compared fracture strength of different designed for ceramic veneers tested the specimen by loading the veneer - tooth system directly at the incisal edge and in a direction parallel to the long axis of the tooth. The orthognathic interincisal angle being 135 degree, stresses that affects maxillary ceramic veneers during mastication and protrusive mandibular excursions are not usually directed parallel to the long axis of a tooth.[13]

Both functional and parafunctional lodes applied on palatal surface move the ceramic veneers facially. Ceramic is more susceptible to failure when exposed to tensile loads. For these reasons, in our study only the horizontal component of load applied by mandibular incisors on the palatal surface of maxillary incisors was considered when positioning specimen for testing with an instron machine.[14] Thus veneers were loaded at 90 degree angle to the long axis of the tooth. This angle also prevented the instron crosshead from sliding along the palatal surface of natural teeth. Clinical study have reported that ceramic veneers bounded to mandibular incisors exhibited a lower fracture rate because of the less destructive nature of compressive load applied on veneers incisal edges.[15,16] Most clinical fracture has occurred on ceramic veneers bonded to maxillary incisor, so our study was designed to reproduce a similar clinical condition.

In the study, it was found that among the three Groups, Group III (1 mm incisal reduction with 1mm height of palatal chamfer) had the highest fracture resistance and is stronger than Group I and II. However, statistically no significant difference was found between Group II and III (P>0.05) [Table III, IV & Graph 1]. The increase in the fracture resistance was due to an increase in available bonding surface area. The 1mm incisal reduction and rounded incisal edge accentuate the bucco-lingual width and palatal chamfer develops a bound at right angle to the direction of potential displacement of the tooth. This design prevents the torque of the incisal porcelain to the underlying tooth surface. The resultant fracture is seen usually at the junction of the labial and incisal plane. The palatal chamfer margin result in preservation of some peripheral enamel layer, which eliminates the micro leakage at the palatal margin-restoration interface and also effectively counteracting shear stress. This design provides a definite seat for cementation.

Group II (1mm incisal reduction with butt joint) recorded fracture resistance greater than Group I and the difference was statistically significant (P<0.001). Butt joint incisal configuration still permits the preservation of peripheral enamel layer around all margins. The orientation of enamel rods at the palatal surface of central incisors approaches a 90 degree angle with the long axis of the tooth. It is necessary to remove both prismatic and interprismatic mineral crystals to produce more effective enamel etched surface. Tooth preparation with a palatal finish line at an angle with tooth surface larger than 90 degree and without excessive reduction of the thickness of the palatal ceramic at the tooth restoration margin can be better achieved with the butt joint incisal design.

Group I (No incisal reduction with facio incisal bevel) showed least fracture resistance as compared to Group II & III. The incisal edges of the prepared teeth were thin and also it does not provide a definite path of placement while cementation.

The ceramic veneer design of Group II & Group III also allow characterization of the incisal third of the restoration as compared with Group I.

Incisal design preparation of 1 mm incisal reduction with 1 mm height of the palatal chamfer gives better esthetic and functional result and hence, it must be advocated.

## Conclusion

Within the limitation of this study, the following conclusions were drawn:

1. Veneer with no incisal reduction with facio-incisal bevel preparation had least fracture resistance as compared to the other-incisal preparations.
2. Fracture resistance of veneers with 1mm incisal reduction with butt joint preparation was greater than facial-incisal bevel preparation.
3. Ceramic veneer with 1mm incisal reduction with 1mm height of palatal chamfer showed highest fracture resistance as compared to 1mm incisal reduction with butt joint and no incisal reduction with facial-incisal bevel, in order to achieve better esthetic and functional results.

Ceramic veneers not only provide suitable esthetics but also, if well designed, provides reliable functional strength.

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