ORIGINAL ARTICLE

Relation between fracture load and tooth preparation of ceramic veneers

– an in vitro study

Prasanth V, Harshakumar K, Lylajam S, Chandrasekharan Nair K¹, Sreelal T²

Department of Prosthodontics, Government Dental College, Trivandrum, Kerala, ¹Department of Prosthodontics, AECS Maaruti College of Dental Sciences and Research, Bangalore, Karnataka, ²Prosthodontics, Sree Mookambika Institute of Dental Sciences, Tamilnadu

Correspondence to : prasanthvmds@gmail.com

Abstract

Fracture is the major clinical failure modality of ceramic veneers. Effect of tooth preparation on the strength of ceramic veneers still remains a controversial issue. Purpose of the study: Our in-vitro study was aimed at exploring the possible association between tooth preparation and strength of ceramic veneers. Materials and Methods: Forty extracted human central incisors were divided into four groups. First group was given ‘feather edge design’. ‘Butt joint’ and ‘palatal chamfer’ designs were given for the other two groups. Fourth group was the control. Epoxy resin was used as the mounting medium. Teeth were prepared, veneers were made and cemented. Vertical force was applied until fracture was noted. Failure load and mode of failure were analyzed. Result and conclusion: Statistical analysis revealed that veneers prepared in teeth with ‘feather edge’ preparation design were the strongest followed by teeth with ‘incisal butt joint’ and ‘palatal chamfer’ designs. But in situations which demands incisal reduction, ‘incisal butt joint’ design was the design of choice.
Introduction

Ceramic veneers have become a popular dental procedure since its introduction because they provide excellent esthetics. They have a predictable clinical survival rate. Ceramic veneers are indicated for the management of non-carious surface defects, masking discoloration of teeth, repair of structural defects, replacement of defective resin composite veneers and for managing traumatized, fractured or worn dentition.\textsuperscript{1,2,3,4} Mal-positioned teeth can also be managed to some extent by ceramic veneers. Criteria for case selection include static / dynamic occlusal relationship, periodontal / oral health status, tooth discoloration, extent of caries and restorations, quality of tooth, motivation level and expectations of patient and oral habits.

Veneers are contra indicated in edge to edge and cross bite occlusal relationships. Patients with heavy occlusion, extreme facio version of teeth, poor oral hygiene, severe dentinal demineralization or tooth fluorosis are poor candidates for ceramic veneers.\textsuperscript{5,6}

Delamination, inadvertent pulp damage, periodontal irritation and unnatural appearance are the possible complications. Damaged ceramic veneers cannot be repaired. Acidulated phosphate fluoride and stannous fluoride are contra indicated because they can damage both ceramic veneers and resin composite silica. Stabilization of veneers is difficult during try-in procedure because there is no tenso-frictional grip.\textsuperscript{7,8}

Ceramic veneers are color stable and life like. It maintains surface luster for a long period. It has higher resistance to abrasion and staining. Deleterious effects of alcohol, medications and other solvents are ineffective on ceramic veneers. Veneers are extremely biocompatible. It requires less chair side time for tooth preparation.

But the relation between strength and various teeth preparation designs of ceramic veneers are still under question. This study was designed to clear these doubts.

Aims and objectives of the study

- To measure the fracture load of ceramic veneers made in teeth with three different designs of preparation.
- To evaluate whether a ‘palatal chamfer’ or ‘incisal butt joint’ design is ideal for preparations requiring incisal reduction.
- To evaluate whether incisal reduction is mandatory in all clinical situations.
• To clinically evaluate various designs for easiness in tooth preparation, manipulation and cementation.

Materials and Methods

Selection of teeth

Forty extracted human maxillary central incisors of the same size were selected. Maxillary central incisors were selected because veneers are commonly indicated on them.9 The exclusion criteria included carries, attrition, abrasion, erosion, fractures and restorations. Teeth were cleaned and stored in distilled water at room temperature from the day of extraction until testing. Teeth were randomly divided into four groups of ten each. Different designs of preparation were done for the first three groups while the fourth was the control.

• Group I – Feather edge design without incisal reduction.

• Group II – Incisal butt joint without palatal chamfer. 2mm incisal reduction.

• Group III – 1 mm incisal reduction plus 1 mm palatal chamfer.

• Group IV – Un-restored intact teeth. Control group.

Mounting of teeth (Figure 1)

Forty pre-fabricated plastic base formers of standard size were selected (table 1). Epoxy resin was used to mount the teeth. Mounting was done in such a way that long axis of each tooth was perfectly vertical. Tooth placement was clinically judged by two persons to avoid error in mounting.10 Mounting was up to 2 mm below cemento-enamel junction (CEJ) to simulate biologic width.

Figure 1. Mounted Specimens

Table 1. Materials Used
## Preparation of teeth (Figure 2)

Labial surfaces of teeth were prepared uniformly to make veneers of uniform thickness. A 0.3mm reduction was done at the cervical third and 0.5mm at the middle and incisal thirds of each specimen. Preparation was extended as far proximally as possible taking into consideration the contact areas. This will ensure more area for bonding. Air rotor hand piece with water spray was used for preparation. Self limiting depth cutting discs of 0.3mm and 0.5mm were used to define the depth cuts. 1.2 mm chamfer bur and finishing bur were also used. Tooth preparation was restricted in enamel alone and was devoid of any sharp line angle. Cervical finish lines were created in CEJ to ensure uniform veneer length.

### Material

<table>
<thead>
<tr>
<th>Material</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epoxy resin</td>
<td>Fevite, Pidilite Industries Ltd.</td>
</tr>
<tr>
<td>Burs</td>
<td>K G Sorensen, Brazil</td>
</tr>
<tr>
<td>Wax</td>
<td>Hindustan Waxes, India</td>
</tr>
<tr>
<td>Auto-polymerizing resin</td>
<td>Acralyn R, Asian acrylates</td>
</tr>
<tr>
<td>Air rotor handpiece</td>
<td>NSK</td>
</tr>
<tr>
<td>Impression material</td>
<td>Accurate Mono, Germany</td>
</tr>
<tr>
<td>Die material</td>
<td>Lamina Vest, Shofu Inc.</td>
</tr>
<tr>
<td>Porcelain</td>
<td>Shofu Inc.</td>
</tr>
<tr>
<td>Etchant</td>
<td>Shine Etch etching gel, USA</td>
</tr>
<tr>
<td>Resin cement</td>
<td>Calibra, Densply</td>
</tr>
<tr>
<td><strong>Instron machine (UTM Model 1011)</strong></td>
<td>Instron Corporation</td>
</tr>
</tbody>
</table>

*Health Sciences 2013;2(3):JS002A  An Open Access Peer Reviewed E-Journal*
Impression making

Wax spacer of 2mm thickness was adapted around the mounted teeth. This will ensure uniform thickness of impression material. A stop was provided in the incisal edge region. Auto-polymerizing acrylic resin was used to make the special tray. Wax spacer was removed, multiple perforations were made, tray adhesive was applied and impression was made in medium viscosity non-aqueous elastomeric impression material. Impressions were inspected and evaluated.

Veneer preparation

Die stone was used to pour the cast. Stone dies were recovered from impressions and two coats of die spacer were painted 0.5mm short of the finish lines of the preparations. Two coats of die lubricants were then applied to each die. Ceramic veneers were then prepared.

Cementation of veneers

Each specimen was etched with 37% phosphoric acid gel for 15 seconds and then was washed thoroughly for 30 seconds with water. Bonding surface was inspected for the characteristic frosted appearance. Bonding agent was applied and various
designs of veneers were cemented with light cured resin cement.\textsuperscript{15,16}

\textbf{Specimen testing}

Universal testing machine (Instron Machine) was used to find out the fracture load. 1mm cross head speed was utilized for the testing. Plunger tip applied force on the incisal edge of each specimen. Force was gradually applied along the long axis of tooth until failure by fracture occurs. Fracture load and the macroscopic failure mode were analyzed. Following criteria were used to assess the failure macroscopically (Figure3).

\textit{Tooth}

1. Intact tooth
2. Either cracked or fractured tooth

\textit{Veneer}

1. Intact veneer
2. Fractured veneer

\textit{Tooth-Veneer Junction}

1. Intact junction / No debonding
2. Complete or partial debonding

During the entire clinical exercise the operator evaluated the easiness in tooth preparation, veneer manipulation and cementation. Surface quality changes were more frequent in the composite veneer veneers than on ceramic veneers.\textsuperscript{17}

\textbf{Figure 3. Failed specimens}

\textbf{Statistical analysis}

A one way analysis of variance (ANOVA) was performed for the transformed data. Failure mode frequencies were analyzed with chi-square test. SPSS software (Statistical Program for Social Sciences) was used for analysis.

\textbf{Results}

Fracture load and mode of failure of ceramic veneers with three different preparations were analyzed. Group I included feather edge patterns while group II and III included incisal butt joint and incisal wrap around with palatal chamfer designs. Unprepared intact teeth included in group IV were the controls.
The mean fracture load and standard deviation of all the four groups are given in table 2. Table Results of one way ANOVA comparing fracture loads of different designs are given in table 3. Table 4, 5 and 6 have the results of chi square evaluation of frequency of veneer fracture, tooth fracture and debonding.

### Table 2. Mean fracture load (in Newton) and standard deviation of fracture loads

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>780</td>
<td>6.89</td>
</tr>
<tr>
<td>II</td>
<td>586</td>
<td>5.98</td>
</tr>
<tr>
<td>III</td>
<td>340</td>
<td>7.85</td>
</tr>
<tr>
<td>IV</td>
<td>1072</td>
<td>15.18</td>
</tr>
</tbody>
</table>

### Table 3. Results of one way ANOVA comparing fracture loads

<table>
<thead>
<tr>
<th>Group</th>
<th>Sum of squares</th>
<th>Mean square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between groups</td>
<td>5302920</td>
<td>1767640</td>
<td>18823.45**</td>
</tr>
<tr>
<td>Within groups</td>
<td>1502.500</td>
<td>93.906</td>
<td>(p &lt; 0.01)</td>
</tr>
<tr>
<td>Total</td>
<td>5304423</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 4. Frequency of failure modality of veneers

<table>
<thead>
<tr>
<th>Group</th>
<th>Intact (No)</th>
<th>Fractured (No)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>10</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>II</td>
<td>10</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>III</td>
<td>7</td>
<td>3</td>
<td>10</td>
</tr>
</tbody>
</table>

Chi square 8.75, Probability 0.035, ✓ 0.05 (P < 0.05), df 8

### Table 5. Frequency of failure modality of teeth

<table>
<thead>
<tr>
<th>Group</th>
<th>Intact (No)</th>
<th>Fractured (No)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>8</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>II</td>
<td>10</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>III</td>
<td>9</td>
<td>1</td>
<td>10</td>
</tr>
</tbody>
</table>

Chi square 11.752, Probability 0.0076, ✓ 0.05 (P < 0.01), df 8
Table 6. Frequency of debonding of veneers

<table>
<thead>
<tr>
<th>Group</th>
<th>Debonding (No)</th>
<th>No Debonding (No)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>10</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>II</td>
<td>8</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>III</td>
<td>2</td>
<td>8</td>
<td>10</td>
</tr>
</tbody>
</table>

Chi square 17.50, Probability 0.008, $\chi^2$ 0.05 (P < 0.01), df 6

Clinical evaluation revealed that the feather edge design offered easiest tooth reduction, handling and cementation procedures. Palatal chamfer design was the most difficult in this aspect.

**Interpretation of Results**

Mean fracture loads of group I, II, III and IV were 780, 586, 340 and 1702 Newton respectively. One way ANOVA revealed that all the groups differ significantly from each other at 1% level. Thus all the groups have highly significant differences in their respective fracture load. Chi square evaluation of frequency of veneer failure modality (n=10 per group) revealed significance at 5% level. Chi square evaluation of frequency of teeth failure modality (n=10 per group) revealed significant results at 1% level. Veneer tooth interface was also observed. Chi square evaluation of frequency of debonding revealed significant differences at 1% level.

**Discussion**

Tooth preparation for ceramic veneers should be restricted to enamel alone because if dentine is exposed, bond strength will be reduced. Chances of micro leakage are also more. Maxillary incisors where selected for this study because more number of fractures were seen in veneers prepared on maxillary incisors.\(^9\) Ideal veneer thickness is three times that of luting cement.

Since progressive load application was done, there was no need for simulating periodontal ligament.\(^9\) A soft medium at the tooth epoxy junction would have been necessary only if the impact fracture test was performed. Two persons clinically observed the vertical positioning of teeth during mounting.

The orthognathic inter-incisal angle is 135 degrees. The effect of horizontal component of incising force can be studied by applying force palataly. But since the shear forces and compressive forces are maximum under the
vertical component of incising force, in this study a vertical load application was preferred. This in addition helped to find out the design of choice for patients with minimum horizontal overlap. The need for instructing patients to control incising hard foods can also be substantiated.

Many teeth preparation designs were proposed by various authors. We are of the view that the veneer design patterns should be classified according to the need for incisal edge reduction.

- Involving incisal reduction (butt joint design, palatal chamfer design)
- Without incisal reduction (window and feather edge preparations)

It is critical for the operator to understand whether tooth preparation can affect longevity of ceramic veneers. Various authors have preferred various designs.\(^{15,16}\) Jacopo Castelnuovo et al. studied various designs and derived a conclusion that both feather edge preparation and preparation involving incisal butt joint were superior to the rest.\(^9\) They concluded that the design with palatal chamfer did not have any advantages. The butt joint design offered easy preparation, fabrication and cementation. Here the fracture load was analyzed under horizontal force component. So it was necessary to evaluate the effects under vertical component of forces also before reaching a definite conclusion. But surprisingly few investigators believed that the tooth preparation has no special role to play in the success of veneers.

The evaluation of clinical advantages suggests that the feather edge and butt joint designs offer advantages in tooth reduction, veneer preparation and cementation. Window preparation was not attempted because it offers poor esthetics.

Fracture resistance under vertical component of force is maximum for feather edge design followed by incisal butt joint and palatal chamfer. Palatal wrap around design did not offer neither clinical nor mechanical advantages. So in cases where there is necessity for incisal reduction, butt joint design should be preferred to palatal chamfer design. If incisal reduction is not necessary, feather edge design should be considered.

But many other studies indicated that the palatal chamfer design is superior because it adds to the strength of the porcelain.\(^{15}\) Interestingly, some studies supported the palatal chamfer designs and even incisal overlap designs.\(^3, 5, 6\) Results of our totally disagrees with these observations and is more or less in accordance with the observations of Jacopo Castelnuovo et al.\(^9\)

In patients with minimum horizontal overlap the feather edge design is more
suited because vertical component of force is more here. Palatal wrap around design should not be attempted here because it offers poor fracture resistance under vertical loading.

**Summary and Conclusions**

Forty extracted human maxillary central incisors were mounted using epoxy resin. They were randomly divided into four groups; I, II, III and IV. Teeth were prepared for ceramic veneers. Feather edge design, incisal butt joint design and palatal chamfer design were done on group I, II and III respectively.

Group IV which included unprepared teeth was the control. Ceramic veneers were prepared and cemented with visible light curable resin cement. Fracture load and mode of failure of all teeth were evaluated.

Within the limits of our study the results were analyzed and following conclusions were drawn.

- An association between design of tooth preparation and fracture load of ceramic veneers was demonstrated. Feather edge design offered better fracture resistance followed by incisal butt joint design and palatal chamfer design.
- In conditions where incisal reduction is required as in case of fracture of incisal edge, butt joint design is ideal.
- Incisal reduction should not be done unless it is specifically indicated.
- Feather edge design offered easy tooth preparation, veneer fabrication and cementation.

**References**


