Evaluation of the stress concentration of different incisal ridge preparations of porcelain veneers  
(Finite element analysis)

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ABSTRACT

Background: Porcelain veneers are under a great deal of stress which may lead to clinical failure as fracture or detachment. This study examined whether different finishing lines and lingual shoulder preparations in the incisal area of the maxillary central incisor affect the bond of the porcelain veneers.

Materials and methods: A two-dimensional finite element model was made. Location and magnitude of maximum Von Mises stresses were calculated in porcelain veneer. Six types of preparations were drawn as: incisal overlap of 0.5mm, 1mm and 1.5mm depth and lingual shoulder, and incisal overlap of 0.5mm, 1mm and 1.5mm depth without shoulder preparation.

Results: Stress formation is maximum in the incisal edge region. All the lingual shoulder preparations presented better stress distribution than the non shoulder preparations.

Conclusion: Stress is distributed more evenly when the tested preparation possesses a good thickness of porcelain and the more the surface area with incisal overlap the less possibility of bond failure.

Key words: Porcelain veneer, stress distribution, finishing line.

INTRODUCTION

Porcelain veneers may be used for many treatment modalities as for treating discoloured teeth or teeth with minor loss of the incisal edge. (1, 2)

The success rate of porcelain veneers was clinically ranges from 75-100%. Factors affecting long term success of porcelain veneers are age, gender of the patient and fabrication techniques. Therefore, failure in porcelain veneers seems to be associated with changes in bonding condition and / or the magnitude of incisal load.

The most recent adhesive techniques have given high bonding strength, therefore improving bond of the porcelain veneer efficiently to the tooth structure.

The marginal design of the finishing line was studied to verify the stress concentration by the use of 2 dimensional finite element analysis, but none clearly emphasized on the effect of incisal porcelain thickness and lingual shoulder preparation on stress distribution.

The purpose of this study was to examine the distribution of stresses in porcelain veneers in different incisal preparations with and without lingual shoulder preparation.

MATERIALS AND METHODS

The finite analysis was conducted using the ANSYS 5.4 finite element package (Swanson Analysis System, Housten, Pennsylvania).

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interface between the veneer and the tooth structure (Figure 1).

Table 1: Materials’ properties.\(^{(8)}\)

<table>
<thead>
<tr>
<th>Material</th>
<th>Esthetic Modulus (GPa)</th>
<th>Poisson’s Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Porcelain</td>
<td>70</td>
<td>0.19</td>
</tr>
<tr>
<td>Composite cement</td>
<td>6</td>
<td>0.4</td>
</tr>
<tr>
<td>Resin</td>
<td>5</td>
<td>0.4</td>
</tr>
<tr>
<td>Enamel</td>
<td>84</td>
<td>0.33</td>
</tr>
<tr>
<td>Dentin</td>
<td>19</td>
<td>0.31</td>
</tr>
</tbody>
</table>

RESULTS

Table 2 and figures 1-8 present the stress distribution picture along the porcelain veneer-tooth interface. Different stress concentrations are seen in the different points evaluated and are as follows:

Point 1: The incisal reduction with lingual shoulder preparations were comparable (0.2, 2 and 2) but preparations without shoulder showed more and unequal degrees of stress distribution (8,8 and 2MPa)

Point 2, 6 and 7: The more incisal reduction with lingual shoulder preparations the less stress accumulation and the same picture was seen in preparations without shoulder but with higher stress values.

Point 4: Very high and comparable stress values were found in all the preparations except 1.5 mm incisal reduction with lingual shoulder preparation which was less (190 MPa compared with 217 MPa).

Point 5: Very high and comparable stress values were found in all the preparations except in 1 mm and 1.5 mm incisal reduction with lingual shoulder preparationand 1.5 mm incisal reduction with shoulder which was less (185-204 MPa compared with 214 MPa).

By dividing the porcelain veneer to 3 segments, it is evident that the labial segment (Points 1, 2 and 3) show the least stress concentration (maximum 8, 31 and 140 MPa respectively). The incisal segment (Points 4 and 5) presented the highest stress concentration (maximum 217 and 214 MPa respectively). The lingual segment (Points 6-10) presented another stress concentration picture (maximum 204, 170, 137, 121 and 125 MPa).

Points 3, 8, 9 and 10: The more incisal reduction with lingual shoulder preparations the less stress accumulation and the same picture was seen in preparations without shoulder but with comparable stress values.
DISCUSSION

The use of veneers to replace enamel during rehabilitations is recommended. \(^{(12)}\) Regarding Restorative Dentistry

Point 1, lingual shoulder preparations produced more wrap around the incisal ridge surface area which decreased the dislodging force on Point 1 (the middle of the labial wall).

The stress distribution picture of Points 2, 6 and 7 are comparable and show that the surface area of lingual shoulder is directly related to better stress distribution. This is in compliance with the results of Magne and Douglas (1999) \(^{(10)}\)

Preparations with lingual shoulder and shallow incisal overlap (0.5 and 1 mm) have less surface area and wrap around incisal ridge therefore higher stress is seen.

Points 3, 8, 9 and 10 shared the same stress distribution. The thickness of the porcelain distributes the force. The force is at 90 degrees with the wall of the incisal porcelain which makes these points under compression and little value of the wraparound the incisal ridge. This agrees with the result of Sorrentino et al. (2009) who stated that compressive stresses were concentrated on the external surface of the buccal side of the veneer close to the incisal margin. \(^{(13)}\)

Point 4 is the touching point with the force with maximum stress concentration reaching 217 MPa which comparable with the results of Chander and Padmanabhan (2009) \(^{(14)}\). In this point, the 1.5 mm incisal reduction with lingual shoulder preparation has the least stress concentration because it has the most thickness of porcelain therefore stress is distributed more evenly in the porcelain.

The stress concentration in Point 5 showed that the more thickness of the porcelain and surface area distributes the stress.

From the segmental picture of the stress concentration of porcelain veneers, it is evident that the lingual area needs reinforcement because it is under considerable stress \(^{(12)}\)

REFERENCES


Figure 8: Distribution of stress in different points of the porcelain veneer preparation