Metal ceramic (MC) systems are one of the oldest bilayer dental restorative systems that are in use since 1960s. Owing to their wide grown popularity and high survival rates, these material systems are studied extensively. However, with the focus on aesthetics rising, MC systems are slowly being replaced by all ceramic systems. One of such all ceramic systems is porcelain-veneered lithium disilicate (PVLD) system. This is a new system that has not been studied much, both clinically and computationally.

Results

Table 1: Material Combination

<table>
<thead>
<tr>
<th>Model</th>
<th>Veneer: Core</th>
<th>Bilayer System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 1</td>
<td>2:1</td>
<td>MC</td>
</tr>
<tr>
<td>Model 2</td>
<td>1:1</td>
<td>MC</td>
</tr>
<tr>
<td>Model 3</td>
<td>1:2</td>
<td>MC</td>
</tr>
<tr>
<td>Model 4</td>
<td>2:1</td>
<td>PVLD</td>
</tr>
<tr>
<td>Model 5</td>
<td>1:1</td>
<td>PVLD</td>
</tr>
<tr>
<td>Model 6</td>
<td>1:2</td>
<td>PVLD</td>
</tr>
</tbody>
</table>

• Slow cooling resulted in lower stresses. Some of the stress contours are shown in Fig. 8.
• Longer clinical follow-ups of PVLD crowns are needed to validate all these conclusions.
• Maximum residual stress located at central fossa for PVLD and MC, but not in PVLD system. Table 2 shows the stresses in different models.

Fig. 8: Stress Contour for slow cooling in MC system: (a) Model 1 (V: 17.56/C: 18.43); (b) Model 2 (V: 27.18/C: 27.59); (c) Model 3 (V: 17.56/C: 20.73). PVLD system: (d) Model 4 (V: 10.38/C: 16.06); (e) Model 5 (V: 10.17/C: 14.24); (f) Model 6 (V: 8.99/C: 12.70).

Fig. 7: Transient stress for slow cooling in MC system: (a) Model 1 (V: 17.56/C: 18.43); (f) Model 6 (V: 26.53/C: 14.07).

Materials and Methods

a) Thermomechanical properties

In this study, MC system had Emax.Ceram/Metal and PVLD system had Emax.Ceram/Metal and PVLD system had max. Emax. Ceram/vexen.CAD as veneer and core layer for the bilayer dental restoration. Thermal conductivity, density, specific heat, coefficient of thermal contraction (CTC), Young’s modulus of each of these materials were measured at different temperatures (Fig. 2-a-d).

Materials and Methods

b) Validation of VFEA

Bilayer plates of PVLD material system were fabricated and residual stresses in the emax.Ceram layer were measured by the Vickers indentation method (4.9 N for 5 s). Similar plates were then modeled in ABAQUS and VFEA was carried out. Simulated results were then compared with experimental data that showed an excellent match.

Fig. 3: VFEA experimental verification plot

Vicker’s indentation method (4.9 N for 5 s).

Materials and Methods

c) Viscoelastic finite element analysis of axisymmetric crowns

1/4th of the 3D axisymmetric bilayer crown models were run in ABAQUS, for different veneer to core ratios and cooling rates, for each material system.

Fig. 4: Finite element model of full dental crown and 1/4th simulated model, with appropriate boundary conditions.

Conclusions

- PVLD system showed lower stress than MC in both veneer and core layers in all conditions simulated.
- Slow cooling resulted in lower stresses.
- Decrease in veneer thickness decreased amount of stress in MC, but not in PVLD system.
- Maximum residual stress located at central fossa for PVLD and in the cusp area for MC crowns, affecting final failure mode.
- Longer clinical follow-ups of PVLD crowns are needed to validate all these conclusions.

Acknowledgement

This work was sponsored by funding from the United States National Institute of Dental & Craniofacial Research, National Institutes of Health (Grants Nos. 1R01 DE026279 and R01DE026772).