Marginal Fit of Polymethyl Methacrylate Provisional Restorative Material after Polymerization at Different Water Temperatures and after relining: A Comparative Study

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ABSTRACT

Background and objectives: Good fit at the margins of provisional crowns is essential to maintain gingival health and to protect teeth from physical, chemical, bacterial, and thermal injuries. Use of water at the time of curing of provisional crown and relining are advised to get best the marginal fit.

The purpose of this study is to compare marginal fit after complete polymerization at room temperature followed by relining and after polymerization at different temperatures of water of provisional restorative material [polymethyl methacrylate (PMMA)].

Materials and methods: Eight provisional crowns of PMMA for groups A, A1, A2, and A3 were made using a precisely machined brass metal die simulating unprepared tooth and prepared tooth. The marginal fit of provisional crowns measured using stereo-microscope (0.5×10× magnification) at four different points to have 32 measurements in each group in micrometers (µm).

Results and conclusion: Intragroup comparison showed a statistically significant difference in marginal gap of all PMMA at 5 minutes of curing time and 10 minutes of storage time. Order of marginal gap was A3<A1<A2<A. The relining of provisional crowns showed the best marginal fit of all groups.

Keywords: Marginal fit, Polymethyl methacrylate, Storage time.

INTRODUCTION

Fabrication of fixed restorations requires numerous clinical laboratory steps that are time consuming. For biologically acceptable fixed prosthodontic treatment, it is vital that the prepared teeth be protected by means of an interim restoration till the time definitive prosthesis can be delivered. Interim restorations are useful for diagnostic purposes, providing a template for defining tooth contour to identify an optimum treatment outcome and for evaluating the potential consequences from an alteration in the vertical dimension of occlusion. Thus, the provisional restoration is an important step during prosthodontic treatment.

Good fit at the margins of a provisional crown is essential to maintain gingival health and to protect tooth from physical, chemical, bacterial, and thermal injuries. Temperature rise in polymerization of autopolymerizing resin can damage the pulp; therefore, provisional crowns should be removed from the prepared tooth after initial polymerization.

Various techniques are employed to improve the marginal fit of provisional crowns fabricated by direct technique, like curing of provisional crowns in water during final polymerization and relining. Crowns polymerized in 20°C and 30°C water are shown to have mean vertical marginal gap approximately three times smaller than those polymerized in 30°C air. Also, relining has been recommended at the time of fabrication to compensate for polymerization shrinkage of the resin, to improve marginal fit. It is important to know time-saving chair-side procedure and material for achieving good marginal fit using available techniques. Therefore, the present study is carried out to compare polymethyl methacrylate (PMMA) provisional restorative materials for marginal fit after complete polymerization at room temperature followed by relining and after polymerization at 20°C and 30°C water temperatures.

MATERIALS AND METHODS

- Matrix material – Aquasil (Dentsply Int. USA) polyvinyl siloxane putty impression material.
- Polymethyl methacrylate – DPI tooth molding powder.
- Unprepared die simulating unprepared tooth.
- Prepared brass die with 6° taper and shoulder margin simulating prepared tooth.
- Metal top simulating an impression tray to hold impression matrix.
- Custom-made seating device with 500 gm weight (Modified Surveyor).

Software used: Image-Pro analysis
Specimens

Provisional crowns were fabricated simulating direct technique of fabrication from provisional restorative material, PMMA, which is divided into four groups according to the method of curing and relining, for comparison of better marginal fit of crowns.

Precisely machined brass metal die simulating unprepared tooth and prepared tooth was made. Die simulating the prepared tooth was made with 1 mm shoulder margin and 6° taper (Fig. 1).

A metal top simulating an impression tray was made fitting over the master die with an internal dimension 3 mm larger than the external dimension of the unprepared die for providing space for the impression material.

A custom-made seating device was made by modifying surveyor for making an impression of the unprepared die and for making provisional crowns on the prepared die. A 0.5 kg load was attached for standardization of seating of metal top on die under constant pressure (Fig. 2).

Silicone matrix was used for fabricating direct temporary crowns using Vinyl-polysiloxane impression material (Putty consistency).

Fabrication of Provisional Crowns and Grouping of Prepared Provisional Crown Samples

The PMMA material (Dpi tooth molding powder with monomer) was mixed according to manufacturer’s instructions (1 gm polymer to 0.5 mL liquid). The material was poured in the rubber base impression matrix that was seated over the prepared tooth die and a constant load of 0.5 kg was applied with custom weight device.

Fabrication of Provisional Crowns Group A: For the control group, provisional crowns were reseated and allowed to complete polymerization at room temperature (Fig. 3).

Fabrication of Provisional Crowns Group A1, A2: The crowns were allowed to polymerize in a water bath (Rotek Water bath with Thermometer) at 20°C (group A1) and 30°C (group A2) for 5 minutes (Fig. 4).
Fabrication of Provisional Crowns Group A3: Prepared crowns were vented, crown in this group had 0.5 to 1 mm of acrylic resin trimmed from the margin, and approximately 0.5 mm of internal relief was provided to allow sufficient space for new resin addition. The PMMA was mixed and poured in vented crowns (Figs 5 and 6).

Eight provisional crowns were made in each group with PMMA provisional material. (Fig 7). All the crowns in all the groups were finished and polished.

The test die with crown was tilted to 90° for measurement of marginal discrepancy (in micrometers) using stereomicroscope, trinocular charge-coupled device camera, and Image-Pro analysis with 0.5×10× magnification (Fig. 8).

RESULTS

Results are expressed in means.

Mean was calculated using analysis of variance (ANOVA) to measure marginal gap of provisional crowns in micrometers (µm). Post hoc test was used for testing the statistical significance in PMMA (A, A1, A2, and A3). The significance of comparison was evaluated in terms of p values.

Table 1 shows mean marginal gap of groups A, A1, A2, and A3 fabricated from PMMA provisional crown and bridge material. Also, the table shows the minimum and maximum readings in each group with standard deviation (SD).

A marginal gap of PMMA crowns ranges from the maximum value in group A (106.29 µm) to minimum value in group A3 (48.03 µm).

There was a statistically highly significant difference between groups of PMMA (p<0.001).

Table 1: Descriptive statistics showing the mean marginal discrepancy and SD values of PMMA group and one-way ANOVA test

<table>
<thead>
<tr>
<th>Group (PMMA)</th>
<th>Number of samples</th>
<th>Measurements (n)</th>
<th>Mean ± SD (µm)</th>
<th>Minimum value (µm)</th>
<th>Maximum value (µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>8</td>
<td>32</td>
<td>106.29 ± 22.5966</td>
<td>65.37</td>
<td>153.85</td>
</tr>
<tr>
<td>A1</td>
<td>8</td>
<td>32</td>
<td>60.56 ± 19.15</td>
<td>25.64</td>
<td>116.09</td>
</tr>
<tr>
<td>A2</td>
<td>8</td>
<td>32</td>
<td>74.7 ± 18.43</td>
<td>40.54</td>
<td>116.09</td>
</tr>
<tr>
<td>A3</td>
<td>8</td>
<td>32</td>
<td>48.03 ± 10.95</td>
<td>28.67</td>
<td>69.04</td>
</tr>
</tbody>
</table>

SD: Standard deviation; ANOVA: Analysis of variance
Table 2: Post hoc analysis for intragroup comparison in PMMA group

<table>
<thead>
<tr>
<th>Comparison between groups</th>
<th>p-value</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>A and A1</td>
<td>0 (p &lt; 0.001)</td>
<td>HS</td>
</tr>
<tr>
<td>A and A2</td>
<td>0 (p &lt; 0.001)</td>
<td>HS</td>
</tr>
<tr>
<td>A and A3</td>
<td>0 (p &lt; 0.001)</td>
<td>HS</td>
</tr>
<tr>
<td>A1 and A2</td>
<td>0.013 (p &lt; 0.05)</td>
<td>S</td>
</tr>
<tr>
<td>A1 and A3</td>
<td>0.035 (p &lt; 0.05)</td>
<td>S</td>
</tr>
<tr>
<td>A2 and A3</td>
<td>0 (p &lt; 0.001)</td>
<td>HS</td>
</tr>
</tbody>
</table>

HS: Highly significant; S: Significant; comparison shows marginal fit in micrometers for A3 is best among all the groups. The marginal gaps were in the following order: A3 < A1 < A2 < A.

Table 2 shows post hoc analysis for intragroup comparison in the PMMA group. There was a statistically highly significant difference in the marginal gap between groups of PMMA. Post hoc analysis between groups A1–A2 and A1–A3 showed statistically significant difference in marginal gap (p < 0.05).

The comparison showed marginal fit in micrometers, the marginal gap was in the following order: A3 < A1 < A2 < A.

DISCUSSION

Provisional restorations are used for testing esthetic requirements and diagnostic occlusal changes. Other functions of provisional restorations are the protection of prepared tooth to cover exposed dentin, prevention of sensitivity, subsequent caries, and pulpal pathology.

Provisional restorations require accurate marginal adaptation and cleansable contours for the purpose of maintenance of oral hygiene and improving the health of gingival margin before fabrication of definitive prosthesis. In addition, poorly adapted interim restorations cause mechanical irritation to surrounding tissues, leading to passage of fluids and bacteria into the gap and enhance plaque accumulation, so one of the most important requirements for interim restoration is good marginal adaptation.

Techniques used for fabrication of provisional restorations are as follows:
- Direct technique
  - Using various matrices: Curing on prepared tooth or removal technique
  - On/off technique
- Indirect technique
- Combination technique
- Relining (vent and relining technique)

The maximum acceptable marginal gap size includes a wide range of values from 50 to 120 µm. Direct technique was preferred because it requires less chair-side time and reduces cost and does not require laboratory support. Autopolymerizing PMMA first appeared around 1940 and remains the most frequently used material for fabrication of interim restorations. So, in the present study, a direct technique for fabrication of provisional crown was used with PMMA provisional material and compared for marginal fit.

The fabrication of the provisional restorations using direct technique presents two major problems, namely, presence of free residual monomer and the exothermic heat released during polymerization of the materials by addition polymerization.

Zach and Cohen stated that thermal rise of 10°F is sufficient to cause irreversible damage to pulpal tissues.

In the present study, control group provisional crowns after initial polymerization of resin, matrix was removed from prepared die to allow final curing and complete polymerization of provisional restorative material at room temperature in air as advised in Removal technique to reduce rise of intrapulpal temperature as stated by Lui et al.

Polymerization shrinkage invokes a chemical mechanical dimensional and thermal change that increases marginal discrepancy. Volumetric polymerization shrinkage for PMMA is 6%. To overcome this polymerization shrinkage in direct technique, PMMA material provisional crowns are recommended to complete their polymerization in 20°C to 30°C water.

Ehrenberg et al reported that in hot temperature or by using lower water temperatures for polymerization, deterioration of marginal gap increases because of dimensional contraction. Thus, for good marginal fit and for completing polymerization of provisional crowns, use of hot water and water temperature below 20°C is not recommended.

Another method to increase initial marginal adaptation of provisional crown is relining in order to compensate for polymerization shrinkage and to improve initial retention. Relining of provisional crowns was not compared previously with the technique of completing polymerization of crowns in water for better marginal fit.

Dhillon et al stated that polymerization of provisional crowns in 20°C to 30°C water temperature gives good marginal fit without need for relining. Thus, the aim of the present study conducted to compare the relining of provisional crown at room temperature with curing of provisional crowns at 20°C and 30°C water temperature and control group for obtaining good marginal fit, by simulating direct technique of fabrication of PMMA provisional restorative material.
As can be seen from Graph 1 when the intragroup comparison was carried out in PMMA groups, control group A (complete polymerization of provisional crowns at room temperature in air) showed higher marginal gap than the other groups (A1, A2, and A3). There is statistically highly significant difference in marginal gap of group A compared with groups A1, A2, and A3, which gives p = 0.000 (p < 0.001).

In the present study, the largest marginal gap is found in control group crowns polymerized in air (group A). This could be because during final polymerization of provisional material in matrix, there is no supporting material against the internal surface of crown, thus shrinkage occurs toward center of crown and decreases the diameter of provisional crown, resulting in incomplete seating and more marginal gap.17

The improved marginal fit of provisional crowns polymerized at 20°C (group A1) and 30°C (group A2) can be due to two reasons:5

1. Water acted as supporting medium during polymerization
2. Possible compensation of polymerization shrinkage by means of hygroscopic expansion of resin

Group A1 showed better marginal fit than group A2. This can be explained by the fact that less water temperature compensates for polymerization shrinkage of PMMA crown.

The marginal gaps for different groups are in the order (PMMA) A3 < A1 < A2 < A. Group A3 with relined crowns performed best in terms of marginal adaptation. This reduced marginal discrepancy can be attributed to the reason that relining layer of resin was supported by hardened provisional crown.

Some limitations of the present study were the absence of multiple brands of provisional materials and influence of luting cement on the marginal gap of provisional crowns.

CONCLUSION

Within the limitations of this study, the following conclusion can be drawn:
Marginal gaps of crowns made of PMMA group are in order of A3 < A1 < A2 < A, with a statistically significant difference, which means that group A3 with relined crowns performed best in terms of marginal adaptation followed by crowns polymerized in 20°C water (group A1) and crowns polymerized at 30°C water (group A2). Control group crowns polymerized in air (group A) showed largest marginal gap.

REFERENCES


