Effect of water temperature and duration of immersion on the marginal accuracy of provisional crowns

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ABSTRACT

BACKGROUND

Fabrication of fixed restorations is time consuming. It is vital that the prepared teeth be protected by means of an interim restoration till the time definitive prostheses can be delivered. Marginal adaptation is one of the most important requirements for an interim restoration.

METHOD

This study was done to investigate the effect of water temperature and duration of immersion on the marginal accuracy of provisional restoration fabricated in autopolymerizing resin. The experimental model simulating a clinical situation was made. The test material was autopolymerizing methyl methacrylate.

Specimens were subjected to different water temperatures for 5 and 10 minutes, duration for continuing the polymerization. Marginal accuracy was determined by a travelling microscope under 100× magnification.

RESULTS

The measurements were tabulated and statistically analyzed using two way ANOVA technique. Results showed significant difference at all water temperatures. Marginal gaps were least when crowns were polymerized at 20°C for 5 minutes.

CONCLUSION

Study concluded that polymerizing the polymethyl methacrylate resin provisional crowns by direct technique in the water maintained at 20–30°C temperature for 10 minutes resulted in better marginal fit and this method can be utilized in clinical conditions for better results.

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Key Words: polymethyl methacrylate; provisional crowns

INTRODUCTION

The scope of fixed prosthodontic treatment can range from the restoration of a single tooth to the rehabilitation of entire

occlusion. Fabrication of fixed restorations requires numerous laboratory steps which are time consuming. It is vital that the prepared teeth be protected by means of an interim restoration till the time definitive prostheses can be delivered. One of the most important requirements for an interim restoration is good marginal adaptation. Poor marginal fit allows ingress of fluids and bacteria into the gap and can result in caries or pulpitis.¹

Autopolymerizing acrylic resin is the most commonly used material for fabrication of provisional restoration and direct technique is preferred as compared to indirect technique. This is mainly because direct technique requires less chair-side time and reduced cost as it does not require laboratory support.² The marginal fit of provisional crowns varies with different techniques, materials and conditions used for fabrication.³

Another important consideration during direct provisional resinous crown fabrication is the heat generated by the exothermic reaction of resin material during polymerization. This temperature rise can damage the pulp irreversibly. Therefore provisional crowns should be removed from the prepared tooth after initial polymerization and allowed to complete polymerization outside the mouth.^{4–6}

Few authors have reported that placing the provisional crown during polymerization in water enhances the polymerization efficiency and reduces the monomer content, which results in better provisional restorations.^{5,7} Literature has also shown that marginal fit and strength of provisional restoration varies when polymerization takes place at different water temperatures.^{8,9}

The aim of this study was to investigate the effect of water temperature and duration of immersion on the marginal accuracy of provisional restoration fabricated in autopolymerizing acrylic resin.

MATERIALS AND METHOD

The materials, Tempron (GC Corporation, Japan) autopolymerizing methyl methacrylate resin (Lot No. 0604064), virtual (Ivoclar Vivadent, Liechtenstein) hydrophilic polyvinylsiloxane impression material (Lot No. JL 4048), and petrolatum jelly were used in the study.

The experimental model simulating a clinical situation was made. Two stainless steel precision dies were made. The first stainless steel die simulating an unprepared tooth, was made with a base 12 mm in diameter, axial walls 7 mm in length (Figure 1). The second die simulating the prepared tooth was made 1 mm shoulder margin (Figure 2). A stainless steel base

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Figure 1 Stainless steel die simulating unprepared tooth.

Figure 3 Custom seating device without stainless steel die.

Figure 2 Stainless steel die simulating prepared tooth.

Figure 4 Provisional crown in rubber base matrix.

was constructed into which the dies could be accurately inserted and made interchangeable (Figure 3). A metal top simulating an impression tray, fitting over the master die was machined with an internal dimension 3 mm larger than the external dimension of the first die (simulating the unprepared tooth) for providing space for the impression material. Polyvinylsiloxane impression material was loaded in the custom tray and seated on the die simulating unprepared tooth. This was used as matrix for carrying provisional material.

The test material, autopolymerizing methyl methacrylate was mixed in a jar (1 g powder to 0.5 mL liquid) according to the manufacturer's instructions and was poured in the rubber base impression matrix. Matrix was seated over the prepared tooth die as soon as it reached dough stage and a constant load of 0.5 Kg was applied with custom weight device. Indexing of the custom tray helped in consistent positioning of the tray. Matrix was left on the die for three minutes so that initial polymerization of the material is over as specified by manufacturer's instructions. The polymerization of the crowns was then continued in a water bath at different water temperatures and duration of immersion. Water bath with thermostat (Equibath refrigerating circulating bath, UK) was used. Two hundred and seventy-five provisional crowns were prepared in this manner

and divided into eleven groups of twenty five samples each (Figure 4).

Specimens of group I were subjected to a temperature of 23°C air for 5 minutes and specimens of group II to XI were subjected to 20°C, 30°C, 45°C, 60°C, 80°C water temperature for 5 and 10 minutes duration for continuing the polymerization. After complete polymerization, provisional crowns were seated on the master die simulating prepared tooth and accuracy of the crown margins was determined by measuring the discrepancy between the margin of the crown and the finish line of the metal die by a travelling microscope under 100× magnification. Least count of the microscope was 0.01 mm.

Measurements of the marginal opening of each crown were made precisely at four predetermined reference points marked on the prepared tooth die by laser marking. The measurements of marginal gaps recorded for each group was then subjected to statistical analysis.

RESULTS

The measurements were tabulated and statistically analyzed using two way ANOVA techniques. Tables 1 and 2 depict the

Table 1 Descriptive statistics for marginal gap of provisional crowns polymerized at different water temperatures for 5 minutes.

Treatment	No. of observations	Mean of marginal gaps in μm	95% Confidence interval	SD
20°C water	100	56.80	55.06–58.54	8.86
30°C water	100	66.20	64.60–67.80	8.14
45°C water	100	100.40	98.43–102.37	10.04
60°C water	100	168.00	166.26–169.74	8.88
80°C water	100	296.60	294.07–299.13	12.89

Table 2 Descriptive statistics for marginal gap of provisional crowns polymerized at different water temperatures for 10 minutes.

Treatment	No. of observations	Mean of marginal gaps in μm	95% Confidence interval	SD
20°C water	100	58.50	57.15–59.85	6.87
30°C water	100	67.20	65.80–68.60	7.12
45°C water	100	113.30	111.56–115.04	8.88
60°C water	100	194.80	194.20–203.40	23.46
80°C water	100	321.40	320.15–322.65	6.36

Table 3 ANOVA table for two way classified data.

Source of variation	Sum of squares	Degree of freedom	Mean square	Variance ratio (<i>F</i>)	Sig
Time	45158.400	1	45158.400	358.912	0.000
Temperature	8686996.600	4	2171749.15	17260.735	0.000
Time $\times$ temperature	30020.600	4	0	59.650	0.000
Error	124562.000	990	7505.150		
Total	29715000.0	1000	125.820		

descriptive statistics, i.e. mean and standard deviation of all the groups polymerized in water at different temperatures. Table 3 depicts the two way ANOVA test.

As per the technique, variance ratio (i.e. *F* value) was computed. The value was tested to be significant, i.e. $P < 0.05$. Since the ratio turned out to be significant for time, temperature and interaction between time and temperature, all paired comparisons for time and temperature were analyzed to find out which time period as well as which temperature was significant using unpaired 't' test.

As per the analysis all paired comparison were statistically significant, i.e. $P < 0.05$. Results showed significant difference at all water temperatures. Marginal gaps were least when provisional crowns were polymerized at 20°C for 5 minutes.

DISCUSSION

Interim restorations are an essential part of fixed prosthodontic treatment. Several laboratory and clinical techniques for fabrication of provisional restorations have been described in the literature.¹⁰ Direct technique is routinely followed as compared to indirect technique as it saves chair side time and has reduced

cost to the patient by eliminating the laboratory support. Grajower et al recommended using silicone matrix for curing direct temporary crowns because it has a high heat absorption capacity and sufficient thermal conductivity for external heat dissipation.¹¹ Hence for the present study, silicone matrix was used for fabricating direct temporary crowns.

It had been seen that the provisional crowns polymerized in 20°C and 30°C water temperature had shown minimum marginal gap. Time periods of 5 and 10 minutes did not show much difference clinically on the marginal fit when crowns were polymerized at 20°C and 30°C water temperature. As the temperature of water bath used is increased, marginal discrepancy increases drastically between 5 and 10 minutes of immersion.

In clinical situation, it is common to readjust and reline a provisional crown few times until obtaining an acceptable marginal fit. The results of this study showed that crowns polymerized in 20°C and 30°C water had mean vertical marginal gap approximately two times smaller than those polymerized in 23°C air. So, this technique of polymerizing the provisional crown in 20–30°C water temperature may help a dentist to obtain better fit of direct provisional crown in a shorter chair side time, without the need for relining procedure. Because little difference in marginal gap was found between 20°C and 30°C

Table 4 Graph showing relative performance of study groups polymerized in water and air for different time periods.

and warmer water supposedly hastened polymerization; 30°C may be recommended as an optimum polymerizing condition from the marginal fit point of view. As marginal fit does not change much for 5 and 10 minutes immersion at this temperature, crowns can be placed in water for 10 minutes to decrease monomer content and reduce the chances of irritation by free monomer content. Limitation of the study is that the study was conducted using autopolymerizing resin Tempron (GC Corporation, Japan) only.

Polymerization shrinkage around margin is probably major reason for marginal discrepancies during polymerization. The increased vertical marginal gap produced in water at high temperatures may be explained by the following two reasons:

1. The heating of some monomers can cause them to vaporize, which reduce the ratio of monomer and this allows further dimensional contraction.
2. Heat activates the chemical reaction between monomer and polymer, and produces more complete polymerization.

Within the limitation of the study conducted only autopolymerizing resin Tempron (GC Corporation, Japan) was used. It is suggested that further study should be conducted using autopolymerizing resins of other brands also. From the above results and discussion, it can be concluded that polymerizing the polymethyl methacrylate resin provisional crowns by direct technique in the water maintained at 20–30°C temperature for 10 minutes resulted in better marginal fit and this method can be utilized in clinical conditions for better results.

Intellectual Contributions of Authors

Study concept: Maj Navneet Dhillon

Drafting and manuscript revision: Maj Navneet Dhillon, Lt Col Manjit Kumar (Retd)

Statistical analysis: Col DSJ D' Souza

Study supervision: Lt Col Manjit Kumar (Retd)

CONFLICTS OF INTEREST

None identified.

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