Clin Oral Invest (2008) 12:283–286
DOI 10.1007/s00784-007-0163-7

SHORT COMMUNICATION

Temperature rise during polymerization of three different provisional materials

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Received: 10 May 2007 / Accepted: 5 November 2007 / Published online: 15 December 2007

Abstract The purpose of this study was to evaluate the temperature rise during polymerization of three different provisional materials by direct method on two different dentin disc thicknesses. Two autopolymerizing; bis-acrylic composite (Fill-in; Kerr), polymethyl methacrylate (Temdent; Weil Dental), and one light polymerizing composite (Revotek LC; GC) provisional restoration materials were used in this study. Sixty dentin discs were prepared from extracted molars (diameter, 5 mm; height, 1 or 2 mm). These dentin discs (1 or 2 mm) were placed on apparatus developed to measure temperature rise. The temperature rise during polymerization was measured under the dentin disc with a J-type thermocouple wire that was connected to a data logger. Statistical analysis was performed with two-way analysis of variance followed by Tukey HSD test (α=0.05). Temperature rise values statistically varied according to the provisional restoration material used (light polymerized, auto polymerized; $P<0.001$) and the dentin thickness (1 and 2 mm; $P<0.001$). The polymethyl methacrylate based provisional material induced significantly higher temperature rise than other provisional restoration materials at 2-mm dentin thickness ($P<0.01$). At 1-mm dentin thickness, polymethyl methacrylate and composite induced significantly higher temperature increase than bis-acrylic composite provisional material ($P<0.05$). The risk for heat-induced pulpal damage should be taken into consideration during polymerization of provisional materials in deep cavities in which dentin thickness is less than 1 mm.

Keywords Pulp temperature · Provisional materials · Dentin thickness

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Introduction

Fabrication of provisional restorations is an important step towards achieving a successful prosthetic treatment. Materials available for fabricating provisional fixed partial dentures include autopolymerizing polymethyl methacrylate (PMMA), polyethylene methacrylate, polyvinyl methacrylate, urethane dimethacrylate (UDMA), bis-acryl, and microfilled resin [4, 8]. These materials can be polymerized by chemical, light, or both chemical and light activation. As the polymerization proceeds, C=C (π-bonds) are converted to new C–C (α-bonds). The C–C bond has energy of about 350 kJ/mol, and the carbon–carbon π-bond has 270 kJ/mol. The difference in energy between the two bonds, 80 kJ/mol, emits as heat [2]. In dentistry, it may cause thermal damage to the vital pulp. Susceptibility constraints to thermal damage may be due to temperature increases transmitted through the freshly cut dentin. Thermal damage includes various histopathologic changes of the pulp, resulting inacute inflammation of pulp, irreversible pulpitis, or pulp necrosis in severe cases [3, 4]. If the temperature increase exceeds the physiologic heat dissipating mechanisms of the dental–

Table 1 Compositions and manufacturers' of provisional materials studied

Provisional material	Composition	Material type	Manufacturer
Fill-in	Bis acrylic composite (Filler load 53 wt%)	Autopolymerizing	Kerr, CA, USA
Temdent	Powder: polymethylmetacrylate and copolymers Liquid: methacrylic ester	Autopolymerizing	Weil Dental, Rosbach, Germany
Revotek LC	Urethane dimethacrylate	Light polymerizing	GC Corp, Tokyo, Japan

periodontal system, damage could occur. According to the histological studies of Zach and Cohen [9], the temperature rise of 5.6°C can lead to a 15% loss of vitality in the pulp.

The purpose of this study was to evaluate the temperature rise during polymerization of three different provisional materials [bis-acrylic, PMMA, and one visible light polymerizing (VLP) composite] by direct method on two different dentin disc thicknesses (1 or 2 mm). The first research hypothesis was that the temperature rise during polymerization of light polymerized provisional material was higher than auto polymerized provisional materials; the second was that the temperature rise measured beneath 1 mm dentin disc was higher than 2 mm dentin disc.

Materials and methods

The provisional materials used in the study are listed in Table 1. Photo-polymerization was performed with the light polymerizing unit (Hilux 550; Express Dental Products, Toronto, Canada) at 550 mW/cm^2 (with the light tip to specimen distance of 0 mm, 90° apart) for 40 s.

Sixty extracted human molars were stored in physiologic saline. The occlusal enamel portion of the molars were removed using a low-speed saw (Isomet, Buehler, Lake Bluff, IL, USA) to expose the dentin by sectioning the teeth perpendicular to their long axis. Then, dentin discs 1 or 2 mm thick were sectioned perpendicular to the long axis of the teeth. Thus, 60 dentin discs were prepared from extracted molars (diameter, 10 mm; height, 1 or 2 mm).

A silicone mold was prepared as supporting structure of the dentin/provisional restoration material complex (Fig. 1). The dentin discs were placed on the bottom of this silicone mold. A Teflon mold was constructed from polytetrafluoroethylene and had a central aperture (10-mm in diameter, 2-mm height) placed over the dentin disc. The provisional materials were applied and polymerized in this area. The temperature rise was measured under the dentin discs to simulate the temperature rise in the pulp. No strip band was used during placement or light application to the provisional material. During polymerization of light polymerized materials, light output of the polymerizing unit was measured before each testing procedure using a digital radiometer (built-in radiometer on Optilux 501 unit).

A silicone heat-transfer compound (ILC P/N 213414, Wakefield Engineering, MA, USA) was applied under the dentin disc. A J-type thermocouple wire with 0.36 in. diameter (Omega Engineering, Stamford, CT, USA) was connected to data logger (XR440-M Pocket Logger, Pace Scientific, NC, USA) during polymerization of provisional material. The collected data were monitored real-time and were transferred to computer. The data were available in

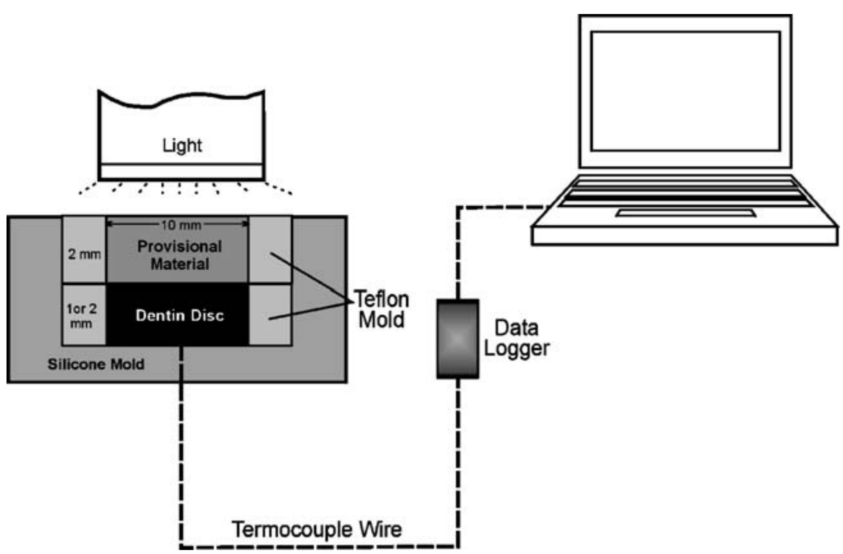

Fig. 1 Schematic drawing of experimental setup showing the temperature measurement during polymerization of provisional materials. Light source is applied only during polymerization of light polymerizing composite provisional material

Table 2 Two-way analyses of variance

	DF	MS	F	*P* value
Provisional material	2	19.244	22.204	0.000
Dentin thickness	1	56.028	64.64	0.000
Provisional material × Dentin thickness	2	7.034	8.115	0.001

both tabular and graphic form. Temperature changes were recorded every 2 s, until the pulp chamber temperature returned to original. Ten experiments were conducted for each system of provisional restoration material and two different dentin thicknesses. Difference between start and highest temperature reading was taken, and ten readings were averaged to determine the mean value in temperature rise.

The results of testing were analyzed with statistical software (SPSS PC, Vers.10.0; SPSS, Chicago, IL, USA). Two-way analysis of variance (ANOVA) was used to analyze the data (dentin thickness and provisional restoration material) for significant differences. Tukey HSD test was used to perform multiple comparisons at a significance level set at $p<0.05$.

Results

Temperature rise varied significantly depending on the provisional material (autopolymerizing, light polymerizing) and dentin thicknesses (1 and 2 mm; ANOVA, $P<0.001$; Table 2). Significant interactions were present between provisional material and dentin thicknesses (ANOVA, $P=0.001$).

Temperature rise during polymerization of the bis-acrylic composite material at 1-mm dentin thickness (2.9±0.8°C) was significantly lower than VLP composite (4.6±1.5°C) and PMMA (5±0.6°C; Tukey, $P<0.05$). The difference between VLP composite and PMMA was statistically significant (Tukey, $P<0.05$).

At 2-mm dentin thickness bis-acrylic composite material (1.4±0.8°C) and VLP composite (1.7±0.4°C) induced significantly lower temperature increase than PMMA (3.6±1.2°C; Tukey, $P<0.05$). The difference between composite materials (autopolymerizing and light polymerizing) was not statistically significant (Tukey, $P=0.982$).

Discussion

In this study, temperature rise during polymerization of three different provisional materials on 1- or 2-mm dentin discs were measured. The results obtained did not support the first research hypothesis that the temperature rise during polymerization of light polymerized provisional material was higher than autopolymerized provisional materials but support the second hypothesis that the temperature rise measured beneath 1-mm dentin disc was higher than 2-mm dentin disc.

Temperature changes from the exothermic reaction of the polymer-based provisional materials have been studied previously. Moulding and Teplisky [6] investigated the heat transferred to the pulp by polymethyl methacrylate resin and dimethacrylate-based materials, using different volumes of the materials and different types of matrices commonly used in the direct fabrication of extracoronal provisional restorations. It is stated that that the intrapulpal temperature rise ranged from 5.4 to 7.2°C and that intrapulpal temperature was dependent upon the volume of the materials used. Driscoll et al. [1] evaluated the exothermic release of the polymer-based provisional materials by a mercury thermometer method and concluded that the temperature increase produced by the materials ranged from 14.8 to 27.3°C. In the results of current study, the highest temperature rise value (5±0.6°C) was lower than the results of previous studies [1, 6] The differences in temperature rise values may be due to the experimental setup and differences in material volumes.

In the present study, three different materials were compared, and temperature rise value was the greatest with PMMA and the lowest with bis-acryl. This result is in accordance with the previous study, which concluded that intrapulpal temperature rise was dependent on the type of acrylic resin [6]. The tested materials have different compositions; PMMA- and UDMA-containing materials have homogenous compositions, but the bis-acrylic-containing material has fillers in it. The compositional differences of the materials may affect the temperature rise.

Considering the hazardous values for the pulp (5.6°C) [9], the maximal temperature increase detected during polymerization of the autopolymerizing polymethyl methacrylate provisional material was so close to this value (5±0.6°C) on 1-mm dentin thickness. However, the temperature rise values measured in this study cannot be directly applied to temperature changes in vivo. The reason is that the experimental setup of this study did not consider heat conduction within the tooth during provisional material polymerization due to the effect of blood circulation in the pulp chamber [7].

In a deeply prepared tooth with a smaller amount of the residual dentin, the potential for pulp damaged is greater because the flow of the heat through dentin is proportional to the thermal conductivity of dentin and inversely proportional to the thickness of the residual dentin. Thus, the thickness of the residual dentin is one of the critical factors in the protection of the pulp from thermal damage. Some suitable techniques should be applied to prevent vital pulp tissue from the damage. Cooling techniques using an air–water spray to dissipate the polymerization heat and to minimize the trauma to the pulp, or removal of the provisional restorations after initial polymerization allowing final polymerization to complete outside the mouth can be used [4, 5].

Conclusion

Within the limitations of this study,

1. Temperature rise values varied significantly depending on provisional material used and dentin thickness.
2. For all provisional materials, the highest temperature rise was recorded at 1-mm dentin thickness.

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