

In Vitro Comparison of Peak Polymerization Temperatures of 5 Provisional Restoration Resins

(Comparaison in vitro des températures dégagées lors de la polymérisation de 5 résines pour restaurations temporaires)

• Caroline Lieu, B.Sc.N. •
• Tang-Minh Nguyen •
• Lise Payant, B.Sc., DMD, MHE •

S o m m a i r e

Historique : La chaleur produite par les matériaux de fabrication des restaurations temporaires peut endommager la pulpe dentaire. Cette étude consiste à mesurer et à comparer les températures dégagées lors de la polymérisation de 5 de ces matériaux.

Méthodologie : Les matériaux examinés consistaient en 2 résines autopolymérisables (Integrity et Protemp) et en 3 résines à double polymérisation — auto et photopolymérisables — (Iso-Temp, TCB Dual Cure et Provipont DC). Un moule de la taille d'une molaire supérieure a été fabriqué de sorte à contenir 0,5 cm³ de résine. La hausse de température des différents matériaux a été enregistrée toutes les 10 secondes pendant 10 minutes.

Résultats : La hausse de température des résines Integrity (33,8 °C) et Protemp Garant (35,6 °C) était nettement plus élevée que celle des résines Iso-Temp (29,5 °C), TCB Dual Cure (28,4 °C) et Provipont DC (29,5 °C).

Conclusion : En utilisant des résines à double polymérisation dans les restaurations temporaires, on peut éviter d'endommager la pulpe.

Mots clés MeSH : crowns; dental pulp/injuries; resins, synthetic

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In fixed prosthodontics, a provisional restoration is required prior to the insertion of a definitive restoration. The provisional restoration protects the prepared tooth, prevents tooth migration, preserves occlusal and arch relationships, restores function, maintains periodontal health, and often provides acceptable esthetic results while the final restoration is being fabricated.¹⁻²

Provisional restorations are often fabricated from methyl methacrylate, ethyl methacrylate, vinyl methacrylate, bis-acryl resin, or visible light-cured (VLC) urethane dimethacrylate. All of these resins share the common problem of producing heat during polymerization when exothermic energy is released.² Peak temperature is defined as the highest temperature recorded during polymerization.³ Grajower and others¹ have reported the possibil-

ity of thermal damage to dental pulp during the setting of provisional resins.

When fabricating provisional crowns and bridges using a direct technique, heat generated by the exothermic reaction of self-curing resins may injure the dental pulp.¹ Mechanisms of injury include protoplasm coagulation, expansion of the liquid in the dentinal tubules and pulp with increased outward flow from the tubules, vascular injuries and tissue necrosis.^{4,5} Stanley⁵ reported that when external heat was applied to intact teeth, a 10°F (5.6°C) rise in the temperature of the pulp caused 15% of the pulps tested to lose vitality, a 20°F (11.2°C) rise in the temperature caused 60% of the pulps to lose vitality, and a 30°F (16.8°C) rise in the temperature caused irreversible pulpal necrosis in 100 % of the pulps.

Table 1 Provisional restoration resins tested

Product	Material type	Manufacturer	Ratio of mixing (gm of base to catalyst)	Batch No.
Iso-Temp	Dual cure	3M (St. Paul, MN)	10:1	19980206
TCB Dual Cure	Dual cure	Sci-Can (Pittsburgh, PA)	4:1	PC704949
Integrity	Self-cure	Dentsply Caulk (Milford, DE)	10:1	980515
Protemp Garant	Self-cure	ESPE (Norristown, PA)	4:1	B008 C068
Provipont DC	Dual cure	Ivoclar Vivadent (Schaan, Liechtenstein)	4:1	926024

Several studies have described the heat-producing capability of commonly used materials for the fabrication of provisional restorations.^{1,6-9} Driscoll and others⁶ investigated the exothermic release of 4 classes of resin materials (i.e., poly(methyl methacrylate), vinyl ethyl methacrylate, VLC urethane dimethacrylate and bis-acryl composite resin) and confirmed that all of the tested materials produced increased temperature readings during polymerization. Furthermore, Vallittu⁷ demonstrated that peak temperature increases were related to the amount of acrylic resin used and that the temperature could go as high as 82°C. Other studies compared temperature rise in pulp chamber during fabrication of provisional resinous restorations.^{1,8,9} Tjan and others⁹ tested the in vitro temperature rise in the pulp chamber induced by self-curing resins during the fabrication of provisional resin crowns using a direct technique. The results suggested the possibility of thermal damage to dental pulp and odontoblasts during the setting of provisional resins.

The purpose of this study was to measure and compare peak temperatures reached during polymerization of 5 different materials used in the fabrication of provisional restorations. The null hypothesis considered the 5 materials to be equivalent in terms of peak temperature reached.

Materials and Methods

Five bis-acryl resins were tested (Table 1). Two were self-curing resins (Integrity and Protemp Garant) and 3 were dual-cure resins (Iso-Temp, TCB Dual Cure and Provipont DC). Dual-cure resins contain bis-GMA composite and photo-initiators such as



Figure 1: Mould and electronic thermometer used to measure temperature rise of resins.

camphorquinone or benzoin methyl ether which give these resins their photopolymerization characteristics.

A mould approximately the size of a maxillary molar tooth was fabricated to contain about 0.5 cc of resin and to hold the tip of a thermometer (Fig. 1). The exterior of the mould was made from velmix and the inner part was lined with 2 mm of polyvinyl material (President microsystem, Coltene/Whaledent, Mahwah, New Jersey). The rise in temperature of the different materials was recorded every 10 seconds over a 10-minute period using a digital thermometer (Radio Shack, Inter-Tan Ltd, Canada) which read in 0.1°C increments. The measuring probe was calibrated to ensure its accuracy. A good thermal contact was always obtained between the probe and the tested material. Each material was tested 10 times. The mixed material, the mould and the probe were at room temperature when the test began. A cover lined with velmix-polyvinyl was always placed above the mould to minimize the heat loss of the tested materials.

A Bartlett statistics test was applied to determine homogeneity of variance of the results. The data for the peak temperatures were then subjected to a two-tailed analysis of variance test (ANOVA) to disclose statistically significant differences between groups ($p < 0.05$). Finally, a Tukey test for a posteriori comparison was used to determine the specific differences among the resins. The statistical software SAS was used to analyze the data.

Results

The mean temperature for each of the 5 resins recorded during a 10-minute period is presented in Figs. 2a to 2e. Table 2 lists the mean values of the maximum temperature elevations of the resins during polymerization. Protemp Garant had the highest mean temperature (35.6°C) while TCB Dual Cure had the lowest mean maximum temperature (28.4°C).

Table 2 Mean maximum temperature reached during polymerization

Resins	Mean (°C)	SD	Error Std.
Provipont DC	29.53	0.678	0.215
Integrity	33.75	1.113	0.352
Iso-Temp	29.47	0.389	0.123
Protemp Garant	35.63	1.269	0.401
TCB dual cure	28.42	1.037	0.328

SD = standard deviation

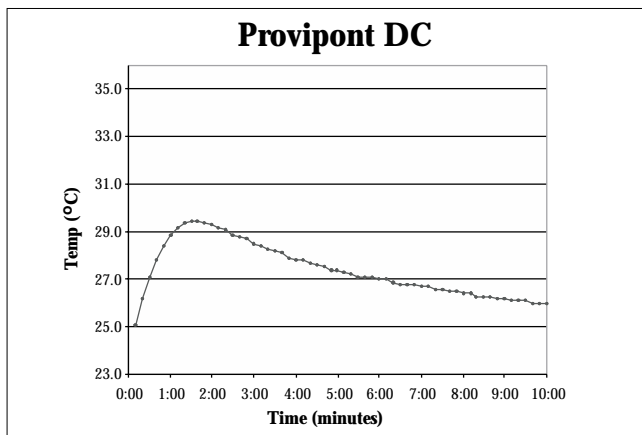


Figure 2a: Mean temperature of Provipont DC during polymerization.

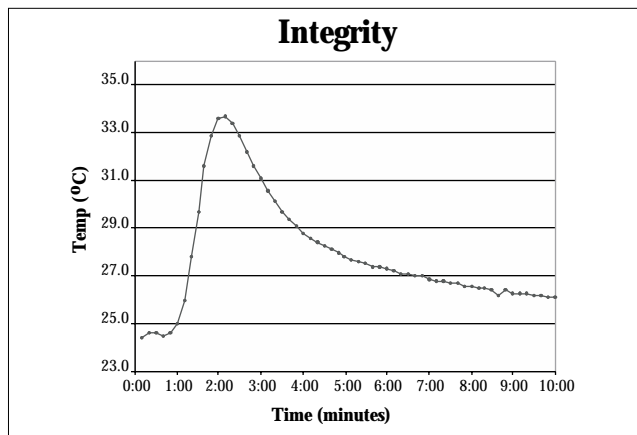


Figure 2b: Mean temperature of Integrity during polymerization.

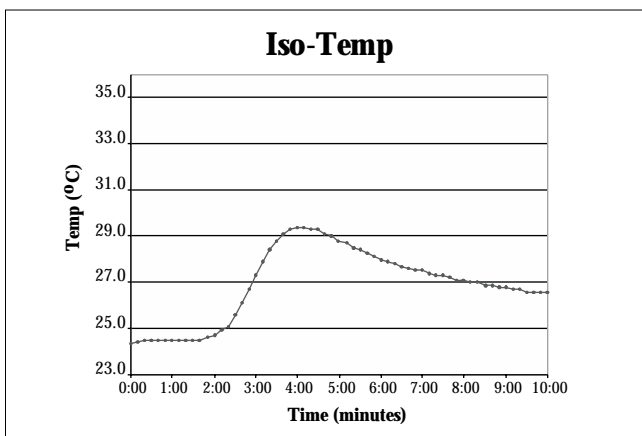


Figure 2c: Mean temperature of Iso-Temp during polymerization.

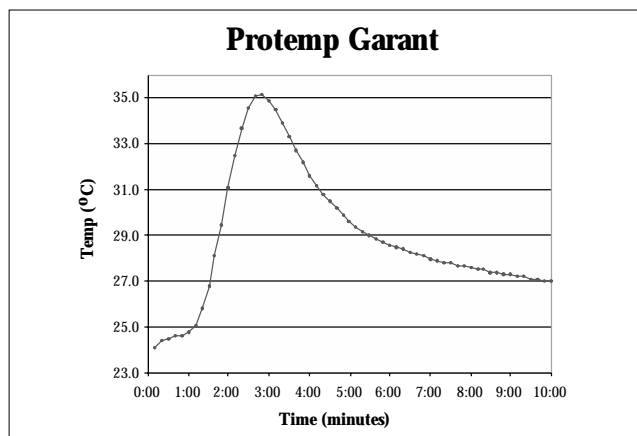


Figure 2d: Mean temperature of Protemp Garant during polymerization.

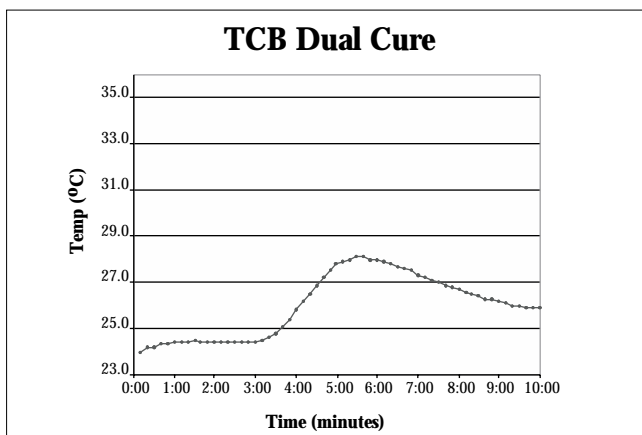


Figure 2e: Mean temperature of TCB Dual Cure during polymerization.

Homogeneity of variance was shown with the Bartlett test. Statistical analysis indicated significant differences among the resins tested in this study (Table 3); therefore, the null hypothesis, which stated that the peak temperatures of the 5 resins used in this experiment would be equal, was rejected. However, to determine the specific differences among the resins, Tukey's test for a posteriori comparison was used.

Peak temperatures of self-curing resins were found to be significantly different from peak temperatures of dual-cure resins ($\alpha = 0.05$). Tukey's test showed that Integrity (33.8°C) and Protemp Garant (35.6°C) were statistically higher in terms of peak temperatures than Provipont DC (29.5°C), Iso-Temp (29.5°C) and TCB Dual Cure (28.4°C) ($p = 0.0001$). No significant differences were found among the peak temperatures of products within the same category.

Discussion

Castelnuevo and Tjan⁸ reported that the bis-GMA resin had a lower rise in temperature than the bis-acryl composite. Since dual-cure resins contain a bis-GMA component, this may explain why we found that dual-cure resins released significantly less heat than self-curing resins. In this study, all 5 products tested produced a rise in temperature during polymerization. Specifically, the mean temperatures of self-curing resins at room temperature were significantly higher than that of the dual-cure resins. The self-curing resins produced a temperature increase of at least 5°C higher than the dual-cure resins. Considering that a rise of 10°F (5.6°C) in the temperature of the pulp can have a significant impact on the pulp,⁵ a difference of 5°C between the 2 classes of resins can be a major factor in the extent of injury to the pulp.

A temporary restoration should protect the teeth while a permanent restoration is being made. Most dentists use a direct

Table 3 Results of ANOVA comparing peak polymerization of resins

Source of variation	Sum of square	DF	Mean square	f-test	p-value
Provisional materials	395.096	4	98.774	108.88	0
Error (or residual)	40.824	45	0.9072		
Corrected total	435.92	49			

technique to fabricate provisional restorations because it costs less and is more efficient. However, the effect of the exothermic release of resins should always be a consideration when making a temporary restoration, as the heat released might harm the surrounding oral tissues and the dental pulp. The advantage of dual-cure resins lies in their lesser temperature rise during polymerization compared to self-curing resins. However, all types of temporary resins exhibit exothermic reaction. It is therefore the responsibility of the dentist to be aware of all heat-producing materials and to minimize their potential injury to oral tissues. Using an indirect technique may be more time-consuming, but it permits better control of the heat released during polymerization. External cooling with air or water during intraoral polymerization can be used to avoid undue heating to the pulp. Removing the temporary crown from the prepared tooth prior to the complete curing stage is strongly recommended, although this may cause some deformations in the crown.

Conclusion

All 5 resins tested caused a rise in temperature during polymerization. The self-curing resins (Protemp Garant and Integrity) caused a significantly higher temperature rise during polymerization than the dual-cure resins (TCB Dual Cure, Iso-Temp and Provipont DC). There was no significant difference among peak temperatures of products within the same category. Using the dual-cure resins for the fabrication of provisional restorations may reduce the risk of pulp injury because of its lesser temperature rise compared to self-curing resins. Further investigations should focus on in vivo trials of these products and on their effect on the physiology of the pulp. ♦

M^{lle} Lieu est étudiante à la Faculté de médecine dentaire, Université Laval.

M. Nguyen est étudiant à la Faculté de médecine dentaire, Université Laval.

Le Dr Payant est professeure à la Faculté de médecine dentaire, Université Laval.

Écrire au : Dr Lise Payant, Faculté de médecine dentaire, Université Laval, Québec, QC G1K 7P4. Courriel : lise.payant@fdm.ulaval.ca.

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