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Pre-warming of dental composites

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ABSTRACT

Objectives. Cavity lining with flowable composites have been proposed to improve initial marginal adaptation and minimize shrinkage stresses. The purpose of this study was to evaluate if prewarming of composites would influence the flow and enhance marginal adaptation thus the effect of pre-warming different types of composites on their properties are reported.

Methods. Six different composites were used in this study including a flowable and a polyacid modified composite. Uncured composites were pressed between two glass plates with a known load and the film thickness was measured to determine flow. Polymerization shrinkage was measured by means of a one-dimension contacting transducer. Flexural strength was determined using a three-point bend test. Microleakage was determined in human lower third molars on both enamel and dentin restoration interfaces. Cytocompatibility was analyzed with an Alamar Blue redox cell proliferation assay. The flow properties, linear shrinkage, flexural strength, microleakage and cytocompatibility were evaluated at 22 °C and 60 °C.

Results. The results indicated that the film thickness for each of the materials was significantly lower at 60 °C and the linear shrinkage was greater as a result of the higher degree of polymerization. The flexural strength of Spectrum TPH and Wave were found to be statistically significantly higher with pre-warming, however the other composites did not exhibit any differences. Microleakage studies showed that pre-warming had no significant bearing on the results and alamarBlue® results showed that the pre-heating did not have an effect on the cytotoxicity however the levels of cytotoxicity varied between the composites that can be attributed to the composition.

Significance. Pre-warming of the composites studied enhanced flow as observed by measuring film thickness and did not significantly affect other properties.

1. Introduction

Esthetics have been an important guiding concept in dental materials and as a consequence there is an increasing use of dental composite resins in dentistry. The success of dental composites in restorative dentistry stems from their good esthetic properties and adequate durability and consequently materials are constantly evolving to improve on existing properties. Composite restorations comprise of photopolymerizable dimethacrylate based resins with inert fillers that undergo an addition-cured polymerization to yield ahardened

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restorative material [1,2]. The extent of polymerization of dental composite resins ranges between 50 and 75% conversion, which has a direct bearing on the physical and mechanical properties and thus the durability of the restoration. Incomplete polymerization can lead to the presence of unreacted monomer within the restoration that may leach into saliva resulting into increased diffusion of oral fluids. Both oral fluids and unreacted monomer act as plasticizers, decreasing mechanical strength, dimensional stability and allow bacterial growth due to the ingress of oral fluids. Unreacted monomers can also cause allergic and sensitivity reactions.

Variants of composite resins have included materials with different flow characteristics such as packables and flowables although there is little clinical evidence to indicate their clear benefits. The low viscosity resin composites or the flowable composites have been shown to have a better marginal seal in Class V restorations in comparison to the traditional dental composites [3]. Large Class I restorations with minimal dentin support have been also reported to show reduced marginal enamel fractures when lined with a low viscosity resin composite [4]. One of the problems of placing resin composites has been achieving a good marginal contact of the restorative material and minimizing the gap between the tooth and the restoration, thus flowable composites with their greater ease of flow is expected to enhance marginal adaptation [5,6]. However, the low filler content of the flowable composite may also cause greater net shrinkage with lower elastic modulus than the traditional composites.

Recent literature suggests that there are benefits in increasing the flowability of composite resins by raising the temperature of the composite before placement and thus obtain a better adaptation in the cavity [7–11]. A commercial device was introduced (Fig. 1: *Calset*, AdDent Inc., Danbury, CT, USA) [12,13] that pre-heats dental materials to 37, 54 or 60 °C prior to placement in the cavity preparation with other similar devices now being marketed. A moderate increase in temperature of a resin composite is expected to exhibit enhanced flow due to the higher thermal energy that allows molecular motion. Enhanced flow can be advantageous in placement of composites, especially in the case of stiffer materials and better adaptation to the cavity and recent research also indicates that there is a higher degree of conversion [10] of the composite resins when cured at slightly raised temperatures.

The objective of this study was to evaluate the effect of pre-heating dental composite resins by measuring the uncured film thickness (flow), flexural strength, polymerization shrinkage, microleakage and cytocompatibility of six dental composite resins at both 22 °C (room temperature) and 60 °C.

2. Materials and methods

2.1. Materials

Six dental composite materials were evaluated in this study and their specifications are given in Table 1. They consisted of a *universal composite* (Spectrum), three posterior composites (Herculite, Heliomolar, Filtek P60), a flowable composite (Wave), and a compomer (F2000). One group of specimens for each trial were fabricated under ambient laboratory conditions (21 °C ± 1), while the other group was pre-heated to 60 °C in a Calset compule heating unit).

Fig. 1 – The Calset warming device.

2.2. Flow studies using film thickness

Each of the restorative materials were packed into 5 mm diameter × 3 mm brass rings placed on glass slides to obtain uniform film thicknesses of the uncured materials. The ring was removed with care and a glass slide (75 mm × 38 mm × 1 mm) placed gently over the uncured material. Subsequently, a 10 N weight was applied for 120 s and the flattened composite discs were the light cured as per manufacturers' specifications, and their diameters measured to an accuracy of 0.01 mm using a micrometer. Three repeats ($n = 3$) of each material at both temperatures were carried out. When testing the preheated composites, the brass ring, spatula, glass slides, and weight were heated to 60 °C and maintained before each measurement.

Table 1 – Six dental composite materials evaluated in this study.

Spectrum TPH Dentsply, Milford, DE (hybrid)	Bis-GMA, Bis-EMA, TEDGMA	Barium aluminumborosilicate glass/silicon dioxide	<1, 0.04/57%	20	509002350
Herculite Unidose XRV Kerr, Orange, CA (hybrid)	Bis-GMA, EBADMA, TEGDMA	Barium aluminoborosilicate	0.6/59%	40	706766
Heliomolar, Ivoclar (microfine)	Bis-GMA, UDMA	Dispersed silica – silanized copolymer, ytterbium trifluoride	0.04–0.2/64%	40	H17737
Filtek P60, 3M ESPE St. Paul, MN (posterior)	Bis-GMA, Bis-EMA, UDMA	Zirconia/silica	0.01–3.5/61%	20	5TP
F2000, 3M ESPE St. Paul, MN (compomer)	CDMA, GDMA	Fluroaluminosilicate (FAS) glass/silica	3–10/67%	40	19971008
Wave SDI, Southern Dental Industries (flowable)	UDMA	Strontium glass	/44%	20	

2.3. *Polymerization shrinkage*

Polymerization shrinkage of all six materials was determined by means of a one-dimension contacting transducer. The apparatus used has been previously described by Deb et al. [14] which in turn was based on an instrument used by Watts and Cash [15]. The set up of the apparatus is shown in Fig. 2. In brief, a 7.5 mm diameter × 1 mm thick brass-ring mold was placed onto a 1 mm thick rigid glass slide, filled with the test composite, and covered with a 0.1 mm flexible glass microscope cover slip. A LVDT displacement transducer was placed above this, connected to an S7M transducer amplifier (RDP Electronics, Wolverhampton, UK). Output was recorded in DC voltage on an Altai M3800 Multimeter (Altai Group Ltd., Merseyside. UK). Light curing was carried out from below the specimen through the glass slide. Readings were taken after 10 s, 20 s, 30 s, 40 s, 60 s, 120 s, 300 s, and 480 s of light exposure.

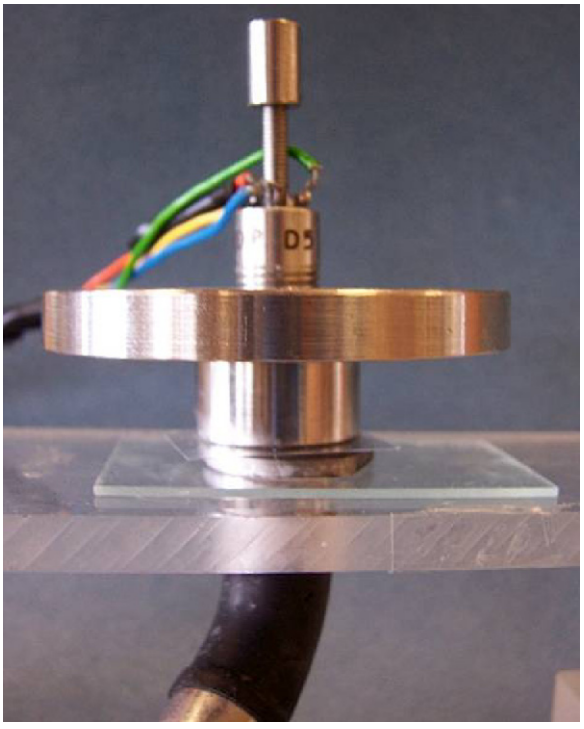

Fig. 2 – Apparatus to measure linear shrinkage.

Three repeats ($n = 3$) of each material at both temperatures were carried out.

2.4. *Flexural strength*

Rectangular bar specimens (25 mm × 3 mm × 1.5 mm) were fabricated using a customized mold. The materials were packed into the mold, covered by an acrylate strip and smoothed with a glass slide to achieve a uniform surface finish. Three overlapping sections of the composite were light cured with a conventional halogen curing-light (Optilux, Demetron Research Corp., Danbury, CT, USA) with irradiation times as per manufacturer's specification. After irradiation, the specimens were placed into deionized water at 37 °C. Eight specimens ($n = 8$) of each material at both ambient and preheated polymerization temperatures were fabricated and tested after 2 weeks. The maximum load (P) exerted on the specimen prior to fracture was recorded, and the flexural strength was calculated $3Pa/bd^2$ where P is the maximum load, 'a' is the distance between the supports (20 mm), 'b' is the specimen width and 'd' is the specimen thickness.

2.5. *Microleakage*

Sixteen freshly extracted caries-free lower third molar teeth were randomly divided into eight subgroups and stored in saline in a refrigerator prior to preparation. Two wedge-shaped cavities were prepared for each tooth (Fig. 3) one on the mesial surface and the other on the distal surface, using a tungsten carbide bur in a high-speed air turbine handpiece (Toplight 895) under a water spray. The inciso-apical width of the cavity was approximately 2 mm, and the depth was 3 mm, as measured by a rotary file with 1 mm markings. The cavities were placed 1 mm above the dentino-enamel junction (DEJ) and extended into the dentin below the DEJ. The prepared cavity was etched with 3 M Scotchbond (St. Paul, MN, USA) for 15 s, rinsed with distilled H_2O and blotted dry. Two consecutive coats of adhesive were then applied thinly on the cavity floor and dried for approximately 3 s, after which it was light cured for 10 s. The composite materials were packed into the prepared cavity in two increments, each time irradiated as per manufacturer's specifications. Adper Single Bond Adhesive (Lot 7AU, 3M ESPE, St. Paul, MN, USA) was used for Heliomolar, Wave, and F2000; and Prime & Bond NT (Lot 0306001369,

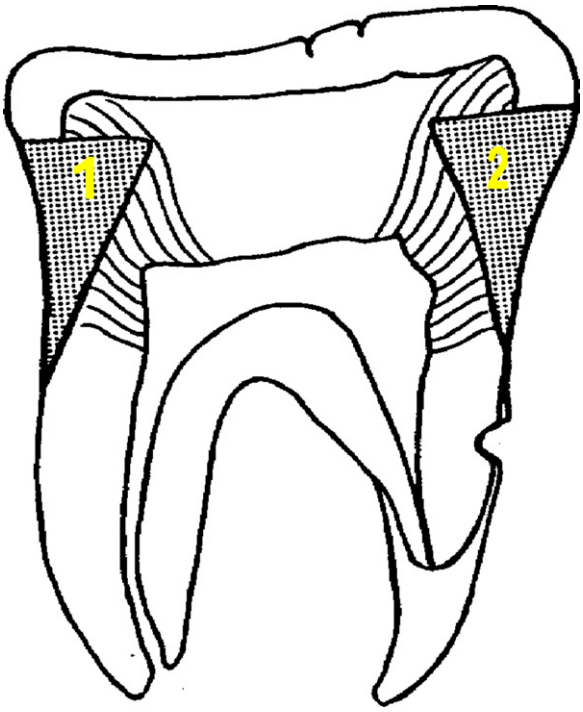

Fig. 3 – Wedge-shaped cavities on the mesial and distal surfaces (1 and 2) of a lower third molar.

Dentsply, York, PA, USA) was used for Spectrum.

The restored teeth were stored in airtight glass vials at 37 °C and 100% humidity. This was achieved by suspending the individual teeth in a holder with blue tack (Bostick®) and placing a moist bed of cotton. The tooth was not allowed to come in contact with the water bed but maintained in an 100% humid environment. The teeth were stored for 3 weeks and then subjected to dye penetration studies. The roots of the teeth were sealed and the entire tooth was then covered in nail varnish with the exception of the restoration and a 1 mm window surrounding it, and submersed in Rhodamine B dye.

After 24 h, the teeth were removed from the dye solution, sectioned longitudinally through the restorations using a slow speed (135 rpm) diamond saw (360 μm thick, Labcut 1010, Agar Scientific Ltd., UK). Tooth sections were then wet polished using three grades of silicon carbide paper (grit size: p1000, p2000 and p4000 Struers, Glasgow).

For microscopic examination, the tooth sections were mounted horizontally flat in Plasticine™ (Harbutts Plasticine®, UK) on a glass slide. Both halves were examined. Immersion oil was placed on the sample before and after placing a cover slip (170 μm thick). Oil immersion objectives of magnification 20×/0.8 NA/oil, 63×/1.4 NA/oil and 100×/1.4 NA/oil plus 10× eyepiece were used to examine the specimens. The interfaces were examined using a tandem scanning type of confocal microscope (TSM, Noran Instruments, USA). Images from the confocal microscope were recorded using a 35 mm camera (Kodak Elite Chrome 400). The extent of dye penetration at the incisal enamel and apical dentin margins was scored according to the following criteria, as used in a previous study by Kubo, et al. [16]:

Incisal enamel margins:

- 0 = No evidence of dye penetration.
- 1 = Dye penetration up to 1/2 of the enamel depth.
- 2 = Dye penetration greater than 1/2 of the enamel depth, but not beyond the dentino-enamel junction.
- 3 = Dye penetration beyond the dentino-enamel junction.

Apical dentin margins:

- 0 = No evidence of dye penetration.
- 1 = Dye penetration just at the cavity margin (less than 0.1 mm).
- 2 = Dye penetration up to 1/5 (approximately 0.5 mm) of the cavity depth.
- 3 = Dye penetration greater than 1/5 of the cavity depth.

2.6. *Biocompatibility*

Disc shaped specimens (2 mm diameter × 1 mm thick, $n = 4$) of each of the composites were light cured for alamarBlue® tests and one specimen ($n = 1$) for MTT (8 mm diameter × 1 mm thick) by curing at both temperatures. A human fibroblast cell-line was used for the tests. *alamarBlue® for cell proliferation*: Cells were cultured in Dulbecco's modified Eagle's medium (DMEM) (Sigma–Aldrich, Poole, UK), supplemented with 15% fetal calf serum (FCS), 0.02 m L-glutamine, penicillin and streptomycin. Tissue culture plastic was used as the negative (nontoxic) control and complete Eagle's medium containing 10% alcohol was used as the positive control. For the assessment of proliferation, fibroblast cells were seeded at a density of 1×10^4 cells/μL on both test materials and controls (4 replicates for test materials, 8 for controls) on a 96-well plate. The cells were cultured at 37 °C in a humidified atmosphere with 5% CO_2. After 48 h the medium was removed and substituted with 100 μL of 10% alamarBlue® diluted in phenol-red free medium, and the plate was incubated under the same conditions for a further 4 h. The absorbance was read at test wavelength 570, and reference 630 nm.

3. Results

3.1. *Flow studies*

The results of the flow studies are shown in Fig. 4 and Table 2 summarizes the flow diameter with the standard deviations. All the test materials exhibited a greater flow at the elevated temperature. As expected, Wave, the flowable composite showed a greater flow followed by the compomers F2000 and composites Heliomolar and Filtek. A significantly higher flow was observed for each of the materials when pre-heated to 60 °C indicating that pre-heating assisted flow. A comparison between the different composites at ambient conditions showed an order of Wave > Heliomolar > Spectrum = Filtek P60 = F2000 > Herculite, and for preheated conditions Wave > Heliomolar > F2000 = Filtek P60 > Spectrum > Herculite. There was a weak positive correlation between filler load and flow at both testing temperatures. Fig. 5 indicates a negative correlation between the filler load and flow for the test composites. Although, exact concentration of filler and matrix ratios are difficult to obtain from commercial

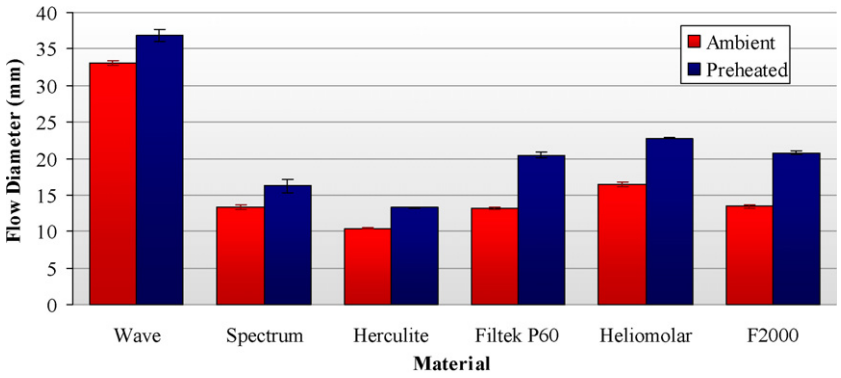

Fig. 4 – Flow diameter of the composites at 220 °C and 600 °C.

Table 2 – Composite flow means (standard deviation).

Material	Condition ($n=3$)	
	Ambient (mm)	Preheated (mm)
Wave	33.1 (0.4)*	36.9 (0.8)*
Spectrum	13.3 (0.3)*	16.3 (0.9)*
Herculite	10.4 (0.2)*	13.3 (0.1)*
Filtek P60	13.2 (0.2)*	20.5 (0.4)*
Heliomolar	16.4 (0.3)*	22.8 (0.1)*
F2000	13.4 (0.2)*	20.8 (0.2)*

* Standard deviation.

formulations a correlation of filler content with flow is shown in Fig. 5 on the basis of available information as shown in Table 1.

3.2. *Polymerization shrinkage*

Fig. 6 shows the linear shrinkage measured for each of the materials under both conditions. The flowable composite, Wave exhibited the highest shrinkage as expected. The pre-heated composites exhibited statistically significant increase in polymerization shrinkage except for F2000 however the net shrinkage was within acceptable limits. There was a positive correlation between filler load and shrinkage. In spite of these increases, only Wave (the flowable composite) experienced shrinkage values greater than the typical 2–6% range of observed in currently used composites. The linear shrinkage with time is shown for Heliomolar in Fig. 7 and a plot of the square root of time versus percentage shrinkage (Fig. 7) illustrates that there are the two typical stages of composite polymerization, auto-acceleration and diffusion-controlled termination. The preheated composites underwent both stages at higher rates. All composites tested exhibited a similar behavior.

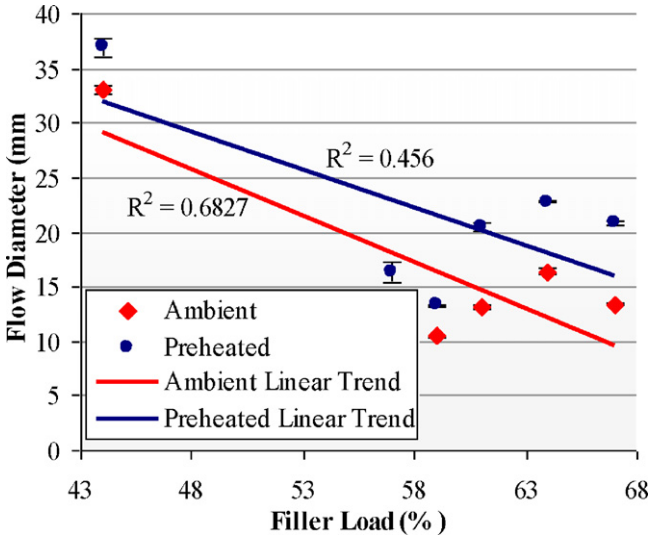

Fig. 5 – A negative correlation of the filler load with flow for the test restorative materials.

3.3. *Flexural strength*

The flexural strengths of the resin composites are shown in Fig. 8 for each material under both conditions. The composites, Spectrum TPH and Wave exhibited significantly higher flexural strengths when pre warming was conducted. The other

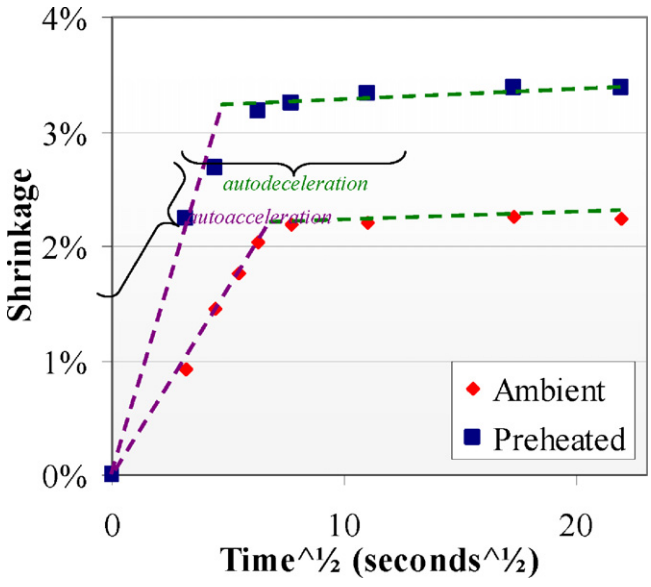

Fig. 6 – A typical shrinkage curve related to the square root of time (Heliomolar).

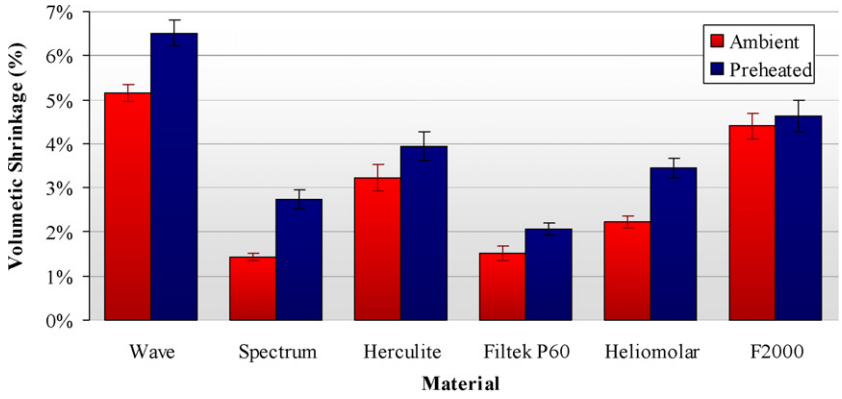

Fig. 7 – Linear shrinkage of the composites at 22 °C and 60 °C.

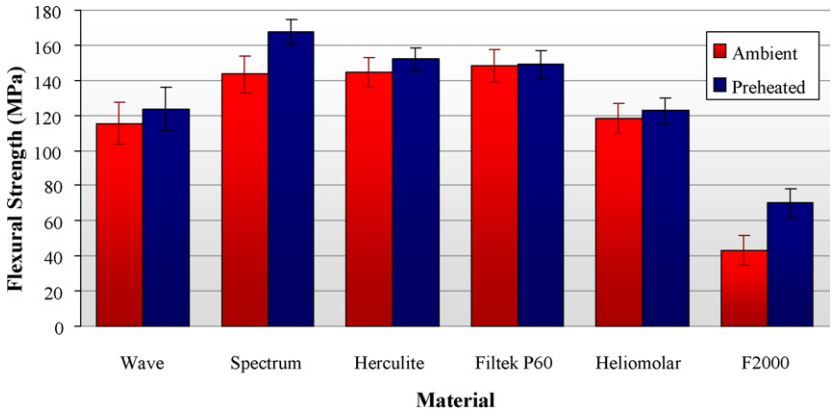

Fig. 8 – The flexural strength in MPa of the composites at 22 °C and 60 °C.

composites did not exhibit any significant differences as a result of pre-heating. A correlation between the filler content and flexural strength is shown in Fig. 9 that demonstrates a strong, negative correlation between filler load and flexural strength.

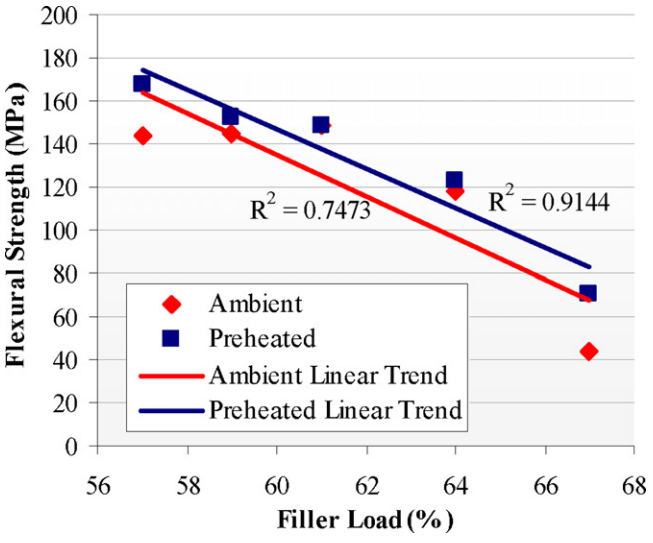

Fig. 9 – Correlation between filler load and flexural strength.

3.4. *Microleakage*

Only 4 composites were selected for this part of the study due to the fact that freshly extracted teeth are not available in abundance and the other two restoratives are standard composites. Thus, two standard composites (Spectrum and Heliomolar), a flowable composite (Wave) and a compomer (F 2000) were used for microleakage studies. The results are shown in Table 3 and microleakage occurred only at the adhesive interface between the adhesive and the cavity walls. In general, there was no microleakage at the incisal enamel margins and high levels at the apical dentin margins. No significant differences in the microleakage scores were found between the two test conditions. In addition, no significant differences were found between groups.

3.5. *Cytocompatibility*

The alamarBlue® results are shown in Fig. 10. No statistical differences were observed between the resin composites used at ambient or preheated conditions; however, the cytotoxicity varied between materials. The results showed there was no statistical difference between the ambient and preheated conditions for any composite; however, cytotoxicity varied between materials as indicated in Fig. 10.

Table 3 – Microleakage scores.

Material	Condition	Incisal enamel margins				Apical dentin margins				*n*
		0	1	2	3	0	1	2	3	
Heliomolar	Ambient	**6**	0	0	**2**	0	0	0	**8**	8
	Preheated	**8**	0	0	0	0	0	0	**8**	8
Spectrum	Ambient	**7**	0	0	0	0	0	**1**	**6**	7
	Preheated	**8**	0	0	0	0	0	0	**8**	8
Wave	Ambient	**4**	**3**	0	0	0	0	0	**7**	7
	Preheated	**6**	**2**	0	0	0	0	0	**8**	8
F2000	Ambient	**8**	0	0	0	0	0	0	**8**	8
	Preheated	**8**	0	0	0	0	0	0	**8**	8

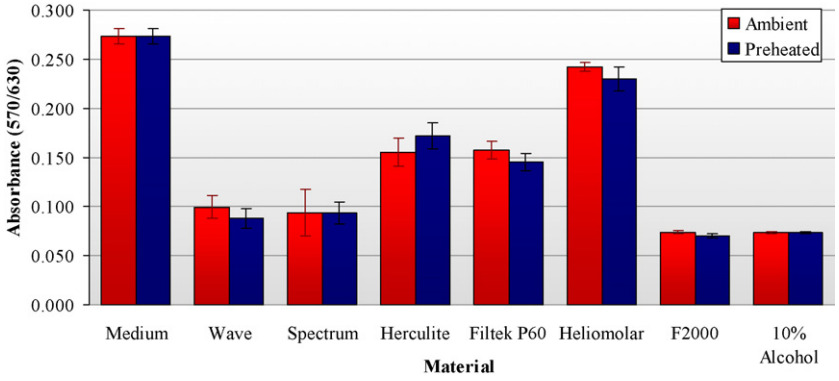

Fig. 10 – Alamar Blue cell proliferation results. Medium and 10% alcohol control data is displayed for both temperatures to aid comparison. Fibroblast cells were cultured directly on test materials over a period of 2 days.

4. Discussion

Restorative grade resin composites are dimethacrylate based resins with a significant amount of unreactive fillers. The resin composites set via photopolymerization, undergo free radical addition cured polymerization on exposure to light. The polymerization reaction is known to be dependent on temperature and the rate of conversion increases with rise in temperature. The higher degree of conversion may lead to enhanced physical properties of the composite with lower residual monomer however the shrinkage may be slightly elevated. Although some studies have tested the influence of elevated temperature and thus increased conversion on some composite physical properties [9,17] as well as uncured flow properties [18] the present study is the first of its kind to comprehensively examine the effect of elevated temperature on flow, flexural strength, polymerization shrinkage, microleakage, and biocompatibility of dental composite resins.

The preheating of the resin composites exhibited significant decrease in film thickness after preheating thus enhancing flow due to the thermal energy that increases the molecular motion of the monomer chains within the composite and also increases the collision frequency. The current study revealed that all the composites tested in this study had a greater flow at higher temperatures, which can be beneficial for the clinician as it is expected to ease the placement of the composite within the cavity and also enhance the adaptation of the material with the cavity walls. The flowable composite, Wave, has an inherently lower viscosity due to its low filler content, which on pre-warming yielded large diameters under pressure. Nevertheless the flowable composite has much lower film thicknesses at both temperatures thus cannot be equivocaly claimed that pre-heating of a composite circumvents flow but it does enhance flow. A negative correlation between flow and filler content was also found at both temperatures (Fig. 5), which was expected as the role of the filler particles is to add rigidity to the composite. The reduction in film thickness can be correlated to higher mobility and decreased viscosity caused by increasing the temperature of the composite, a similar finding has been reported by Daronch and Rueggeberg [10].

Dental composites undergo shrinkage as a result of the polymerization reaction that occurs during the setting of the dental resin composite. Recent studies have shown that photocuring at elevated temperatures in comparison to room temperature exhibit significantly higher conversion values [10,11], as well as require significantly less time to reach a given level of conversion [10,11]. The shrinkages of the composites were measured at both temperatures and a higher degree of shrinkage recorded on preheating dental composites to 60 °C in all cases except F2000. This outcome was expected, since shrinkage and shrinkage strain has been shown to increase proportionally with the degree of conversion [19,20]. Although the net shrinkages were higher on pre-warming, only Wave, the flowable composite, exhibited shrinkage values above the generally accepted 2–6% shrinkage range of currently used composites [21]. These results thus suggest that although the shrinkage increases were generally statistically significant, they may not significant in clinical scenarios.

Under both ambient and preheated conditions, there was also a significant correlation between shrinkage and filler load. As filler load increased, the affect of thermal agitation was less pronounced because the organic matrix played a progressively smaller role in the system. A plot of the linear shrinkage versus time clearly depicts the two characteristic stages, autoacceleration and autodeceleration [7,21]. As polymerization progresses a denser and viscous network forms due to the growing chains and as concentration increases the rate of polymerization exceeds the rate of termination due to the Trommsdorff-Norrish effect. As the reaction proceeds, however, the mobility of the radicals becomes even lower, and both propagation and termination occur at equal rates, dependant simply on the speed at which the free radicals can diffuse together and terminate. The molecular mobility eventually ceases and the reaction stops due to polymer vitrification. On preheating the dental composites, the monomers experience thermal agitation leading to a less viscous and restricted environment thus improving molecular mobility, which increases the radical collision frequency and propagation is allowed to continue for a longer time before the onset of deceleration, increasing conversion and shrinkage.

Strong correlations between flow and shrinkage at both ambient and preheated temperatures (Fig. 7) were observed in the same way that preheating reduced the viscosity of the system. The inherent flow properties of the composite would also allow for increased molecular motion and thus an increase in both conversion and shrinkage.

The flexural strength of the composites on preheating did not show significant increases with the exception of Spectrum TPH and F 2000. Although average strength values were improved in all cases, the standard deviations for Wave, Herculite, Heliomolar, and Filtek P60 were too large to distinguish between the two conditions. The margin of error may be attributed to the specimen geometry as rectangular bar specimens are cured with circular light guides thus compromising cure in the adjacent areas. A similar observation was reported by Palin et al. [22], who obtained similar standard deviations for the flexural strength of dental composites. Analogous to the increases in polymerization shrinkage, the moderate increases in flexural strength of the preheated Spectrum and F2000 composites can be attributed to the increased molecular mobility in the polymer system, delaying autodeceleration and facilitating cross-linkage among polymer chains. In fact, there was a strong, negative correlation between flexural strength and shrinkage values for both ambient ($R^2 = 0.9959$) and preheated conditions ($R^2 = 0.8222$) as shown in Fig. 9. A comparison between the materials, there was a strong, negative correlation between flexural strength and filler load. Previous studies have reported this relationship, as the function of the inorganic fillers is to strengthen the organic matrix [23,24]. The relatively low strength of F2000 compomer at ambient conditions in comparison to its high filler load can be attributed to the use of fluoroaluminosilicate glass fillers, which are inherently weak. F2000 at ambient conditions is consequently not indicated for stress-bearing restorations, but at preheated conditions the strength is significantly improved.

The enhanced flow and thus better marginal adaptation on preheating was expected to decrease microleakage, however no significant differences were observed between the preheated and ambient temperature use of the composites. However, the increase in shrinkage did not cause any adverse effects on the microleakage that may be attributed to the enhanced flow of the composites and were better able to conform to the prepared tooth surfaces. The microleakage study indicated that pre-warming had no adverse effect on the function, although it was expected that better adaptation would have decreased microleakage, however the study showed no statististically significant improvement. The cytocompatibility tests confirmed that pre-warming did not cause any monomer leaching from the composite matrix.

The cytocompatibility of both the prewarmed composites and composites at ambient temperature were assessed using human fibroblasts. A direct cell contact method was used and the effect of the composites was evaluated using alamarBlue® assay. alamarBlue® is a redox indicator and responds to reduction or oxidation of the surrounding medium. In this assay, it both fluoresces and changes color in response to the chemical reduction of culture medium due to cell growth and division. The advantage of the assay is that the medium can be removed for measurement and replaced with fresh medium hence it is a continuous and not an end-point assay. Our cavity-sized specimen submersed in 100 μL of medium in a 96-well plate provided exaggerated results. The composites tested would not cause this extreme effect on cells in only 2 days, however, the results illustrate the materials' cytotoxic potential caused by its inherent formulation. Although a broad representation of composite types and brands were tested in this investigation, it should be noted that all composites may not behave similarly. In addition, the results of this study were obtained *in vitro*, and composite properties may not behave similarly in clinical situations. Of importance is that composites pre-warmed did not cause any adverse reactions and the cytocompatibility of the leachants from the composites remained unaffected.

In a clinical situation the composite can be pre-warmed to gain the benefits, such as increased flow and easier adaptation to the cavity. The use of temperature to improve flow, avoids some of the possible problems associated with a high resin material flowable resins such as the ongoing release of unreacted monomer and less favorable physical characteristics. In clinical use a standard composite can be pre-warmed to achieve better flow and composite can be placed into a cavity and packed and contoured while at an elevated temperature but it is likely that it will have stabilized at the temperature of the tooth before light-curing is initiated. The study thus suggests that composites can be pre-warmed and used instead of flowable composites, which have definitely much higher shrinkage than standard composites.

5. Conclusion

Pre-warming dental composites enhances the flow and the degree of conversion of the composites but the extent of flow varies in different materials. Although the flowability of the composites increases on warming, they are not as flowable as flowable composites. The linear polymerization shrinkage increased with the higher degree of conversion however

the flexural strengths remained unaltered. The microleakage study revealed that the enhanced flowability did not decrease the incidence of microleakage but the increased shrinkage may have been offset by the better marginal adaptation of the composites due to the improved flow. Thus, pre-warming composites can be clinically advantageous in the placement and adaptation of the material in a cavity.

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