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ORIGINAL ARTICLE

Heat conduciton properties of flowable composite resins

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ABSTRACT

Objectives: To investigate and compare heat conduction of different flowable composites. **Materials and Methods:** In this study, four different flowable composites; GC Gradia Direct LoFlo (GC Corporation, Tokyo, Japan), Filtek Ultimate (3M ESPE, St. Paul, USA), Grandio Flow (VOCO GmbH, Cuxhaven, Germany) and SDI Wave (SDI, Victoria, Australia) were used. Flowable composites were placed into standard molds and used according to manufacturer instructions. The samples were prepared for every brand of flowable composites. The Heat Conduction Unit's (P. A. Hilton Ltd., England) linear heat conduction module was used in determining the flowable composites heat conductivity. The data were statistically analyzed by Mann–Whitney U-test (SPSS 13.0, SPSS, Chicago, IL, USA). **Results:** Heat conduction values of flowable composites were found different each other. Results for GC Gradia Direct and Grandio Flow were significantly different from 3M ESPE and SDI ($P < 0.05$). However, result for 3M ESPE was and nonsignificant different from SDI ($P > 0.005$). **Conclusions:** Within the limits of this study, flowable composites transmit the heat. However, results for GC Gradia Direct and Grandio Flow were significantly different from 3M ESPE and SDI.

Key words
Flowable composites, heat conduction, sensitivity

INTRODUCTION

Composite resin restorations are used commonly as the properties of composite materials improve, and the bond strength of resin adhesives to dental substrates increase.[1] However, to find a way out the problems of composite resins wear and polymerization shrinkage manufacturers increased filler content. As a result in higher paste viscosity and more difficult adaptation.[2,3] As a solution to these problems that has been the use of a lower filled, flowable composite resin prior to placement of the heavier filled material called flowable composites.[4,5]

Cavity preparation and restoration may cause thermal loading of teeth with subsequent irritation of the pulp tissue, resulting in hypersensitivity, pulpitis or even nonvitality.[6] During cavity preparation, frictional heat is created by the bur in contact with tooth structure. The materials used for restoring teeth conduct heat to or from the oral cavity.[7] Moreover, the possible damaging effect of temperature increases on the pulp tissue induced from exotherm of resin materials is still a problem. In a previous study, it was showed that temperature increased up to 20°C have been measured during light polymerization within resin composites.[8] It makes heat conduction important in dental materials, especially in composite resins. Based on this problem in this study, we aimed to test and evaluate heat conduction of flowable composite resins. Thus, we will have an opinion about the post filling process complication and complaints.

MATERIALS AND METHODS

The materials used in this research are listed in Table 1. Polyurethane, an insulating material, was used to

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prepare molds with diameters of 25 mm and thicknesses of 1.5 mm. Flowable composites resins placed into these molds according to the manufacturer's instructions. The samples were prepared for every brand of flowable composites. First, excess materials were removed with the help of grainy sandpaper, for both sides of the sample, resulting in a smooth polished surface was obtained. After this procedure, with an electronic compass, the sample's thickness was measured again to verify that it was 1.5 mm.

Heat conduction experiment

The Heat Conduction Unit's (P. A. Hilton Ltd., England) linear heat conduction module was used in determining the flowable composites heat conductivity. Thermal conducting paste was applied as a thin layer on each side surfaces of the sealer samples. The sample to be tested was placed in the sample slot of the conduction equipment's linear module between the heating and cooling compartment [Figure 1]. The linear module's pieces were then locked in a suitable form. For each sample that was tested, the module's hot end was heated with 10 W of energy and the module's cold end was cooled with cooling water. This way, while the heat was being produced on one side, cooling was being enacted on the other side of the testing sample. Every test sample was held as we waited for the experiment to reach the steady state. Even though the time required for the system to attain stability varied among the samples, the average time needed for a sample ranged between 40 and 60 min. When the experiment mechanism was reached to the steady state, the heat obtained from the thermostat temperature sensor that was situated on both sides of the tested samples, was read and recorded using the digital heat reader.

Table 1: Test materials, manufacturer and components

Products	Components	Manufacturer
Gradıa Direct LoFlo	Silica prepolymerized filler (0.85_m size) and UDMA methacrylate monomers	GC Corporation, Tokyo, Japan
Filtek Ultimate	Bis-GMA, TEGDMA, dimethacrylate polymer UDMA	3M ESPE, St. Paul, USA
Grandio Flow	Bis-GMA, TEGDMA, HDDMA, SiO_2 nanofillers, initiators, stabilizers	VOCO GmbH, Cuxhaven, Germany
SDI Wave	Multifunctional methacrylic ester Strontium, silica	SDI, Victoria, Australia

UDMA – Urethane dimethacrylate, Bis-GMA – Bisphenol A-glycidyl methacrylate, TEGDMA – Triethylene glycol dimethacrylate, HDDMA – 1,6-hexanediol dimethacrylates

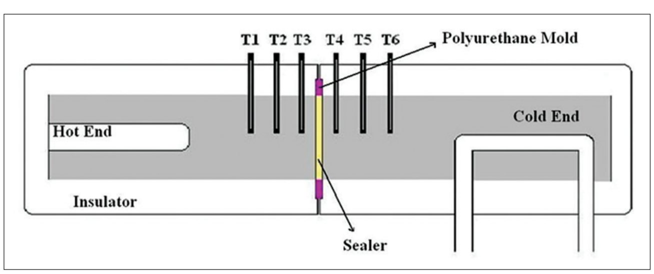

Figure 1: The Heat Conduction Unit's schematic drawing

Three temperature sensors were placed in both the heated and the cooled sections; the sensors closest to the sample were at a distance of 5 mm from the sample, and there was a distance of 10 mm between each sensor. In this manner, the heat values, which remained a designated distance away from the test sample, could be recorded. Measured heated point of composite resin called Ta and measured cooled point of composite resin called Tb. Regression curve analysis was conducted with these recorded heat values, and the heat of the test sample's heated surface (Ta) and its cooled surface (Tb) were defined using the Excel (Microsoft Office 2007, Microsoft Corp., Redmond, Washington, ABD). In this way, the heat was recorded at 8 points from each sample. Then, using the Fourier equation, the value of "k" in the equation was calculated for each sample with Excel (Microsoft Office 2007). Coefficients were compared by performing the Mann–Whitney U-test (SPSS 10.0, SPSS, Chicago, IL, USA) and statistically significant differences were found between some flowable composites ($P < 0.05$).

RESULTS

Heat conduction values of flowable composites were found different each other [Figure 2]. Results for GC Gradia Direct and Grandio Flow were significantly different from 3M ESPE and SDI ($P < 0.05$). However, the result for 3M ESPE was nonsignificant different from SDI ($P > 0.005$).

DISCUSSION

This study was carried out with flowable composite resins to experiment heat conduction of them. Flowable

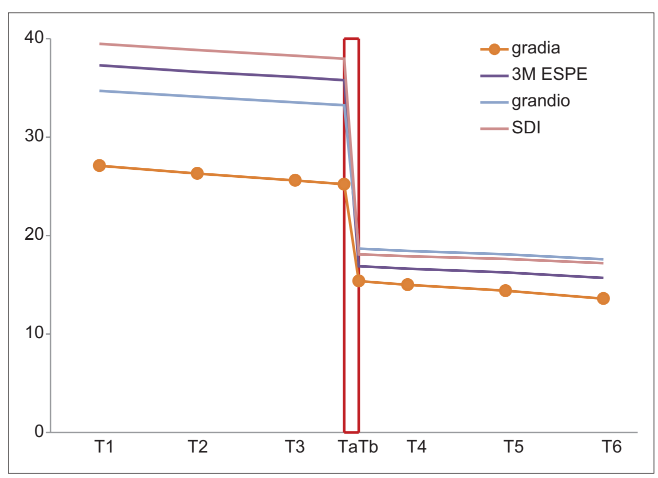

Figure 2: The average heat values and heat conduction schema from each heat measuring point of all flowable composite resins

composites have lower filler loading and a greater proportion of diluent monomers in the formulation than the nonflowable composites.[9] Recently, flowable composite resins of high filler loading have been introduced. In general, when the proportion of monomers in the formulation of the composite increases the higher fluidity is achieved.[10] As a result, their rigidity reduce, and traditional flowable composites may be successfully used in micro-conservative occlusal cavities since their polymerization shrinkage would be low because of the limited volume of the material used.[11]

Compared to traditional composite resins flowable composite resins have increased wettability lower viscosity, and when polymerized, have increased elasticity.[12] According to the manufacturers, the filler content and polymerization shrinkage of the new materials are comparable to those of the conventional hybrid composite resins but with the same low behavior. The application range for the newly introduced flowable composites is expected to include larger or deeper cavities and in higher thicknesses, similar to the conventional composites.[13] It is showed that using of flowable composite resins as a liner under hybrid and packable composite reduced leakage compared to hybrid and flowable composite alone[14] and lower thickness of a flowable composite resin provided less microleakage and better sealing tooth-restoration interface.[15]

If the dental material were conductive, heat would be conducted easily. During composite resin polymerization, heat conduction may occur because of the effect of blood circulation in the pulp chamber and fluid motion in the dentinal tubules.[16] Furthermore, flowable composites exhibited higher temperature rises than nonflowable composites, ıt could be related to their lower filler loading and higher resin content, which should increase the exothermic reaction.[17]

In this study, Grandio Flow was one of the most conductive flowable composites besides Gradia Direct. As the seen Table 1 composites we used and their components. Different components may be the reason of different conductivities.

Thermal conduction to the pulp is relevant with the distance between the floor of the cavity preparation and the remaining dentin thickness.[18] A previous study showed that the critical temperature for irreversible damage to the pulp begins at 42–42.5°C[19] and it is accepted the critical level of a 5.50°C increase thought to produce irreversible pulpal damage.[20] Therefore, when bonding procedures can be applied in deep cavities, where photoactivation of the adhesive is carried out without any layer of restorative resin that could act as a barrier for thermal conduction[21] it can be concluded that the pulp temperature rise should be kept as low as possible during the polymerization of dental resin restoratives to avoid any risk of harming the pulp.[22]

CONCLUSIONS

Within the limits of this study, flowable composites transmit the heat.

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Conflicts of interest
There are no conflicts of interest.

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