Polymerization Shrinkage in An Experimental Fibre-Reinforced Dental Resin Composite

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Abstract: Resin-based dental composite restorations are increasingly used to restore teeth in many clinical situations. However, they still have drawbacks such a polymerization shrinkage which limits their use. An experimental dental resin composite was made with fibre-reinforcement in an attempt to overcome some of the drawbacks. It has been stipulated that randomly oriented fibre reinforcement will significantly reduce shrinkage. **Aim:** This work aims to test the experimental fibre-reinforced composite (eFRC) with two commercially available materials, one fibre-reinforced and one particulate(Build It and Z250), in terms of their polymerization shrinkage using the bonded disc technique. **Results:** Z250 shrank significantly less than either fibre-reinforced material, thus disputing giving the theory that randomly oriented fibre-reinforcement reduces shrinkage. Further work needs to be done to study the theory.

[Fatin Hasanain. **Polymerization Shrinkage in An Experimental Fibre-Reinforced Dental Resin Composite.** *J Am Sci* 2015;11(8):25-27]. (ISSN: 1545-1003). http://www.jofamericanscience.org. 5

Key words: dental resin composite , polymerization shrinkage, experimental fibre-reinforced composite

1. Introduction

Dental resin-based composite restorations are increasingly used to restore teeth in many clinical situations (Stein *et al.*, 2005). Compared with dental amalgams, dental resin composites possess better esthetic properties, allow more conservative dental treatments to be carried out, and show reasonably satisfactory clinical results, (Gao *et al.*, 2008; Ferracane, 2011). Despite their widespread use and acceptance, dental resin composites have several drawbacks such as polymerisation shrinkage and an increased tendency to wear in high stress areas when compared with dental amalgam (Chan *et al.*, 2010; Ilie and Hickel, 2011). In general, dental resin composites shrink as they polymerise (Rueggeberg, 2002). This is due to a decrease in the distance between the atoms as the monomers react to establish a covalent bond as well as the reduction in the amount of free volume (Braga *et al.*, 2005; Schneider *et al.*, 2010).

An increase in filler particles has decreased polymerization shrinkage. Reinforcing resin composites with fibres has shown conflicting results. One study found that placing unidirectional fibres to reinforce the restoration resulted in higher shrinkage (0.41%) when compared with a commercially available particulate filled composite (0.32%), while biaxial fibre reinforced material shrank least of all (0.03%) (Anttila *et al.*, 2008). Another study found that the shrinkage stress of fibre reinforced dental resin composites (2.45±0.11) was significantly less than that of a particulate filled composite (2.04±0.09) (Garoushi *et al.*, 2008a). This could be explained by the orientation of fibres in the material. When the fibres are all oriented in the same direction, the shrinkage appears to increase. Materials with randomly oriented fibres in the material showed a much lower shrinkage volume. This is believed to be due to the formation of a 3-dimensional network in the presence of randomly oriented fibres (Anttila *et al.*, 2008; Garoushi *et al.*, 2008a).

Aim

This study aimed to examine the polymerization shrinkage of the experiment material (eFRC), and to compare this with two commercially available materials: the first (Build It) is fibre-reinforced composite (FRC), while the other (z250) is a particulate filled composite (PFC).

2. Material and Methods

The study used commercially available composites: "Build It" from JenericPentron and "Z250" from 3M ESPE as examples of the two resin types above-mentioned respectively. "Build It" is a core build-up material introduced over a decade ago and is generally well accepted clinically. Z250 is a hybrid dental resin composite which is widely used in dentistry.

To measure the polymerization shrinkage, the bonded disc technique was used. This is a technique developed by Watts and Cash to study light cured biomaterials (Watts and Cash, 1991; de Gee *et al.,* 1993; Venhoven *et al.,* 1993). It was based on the technique developed by Walls et al (1988) which monitored the distortion of a transparent cover slip on the surface of a range of light cured composites during setting to calculate their polymerisation shrinkage. The optimum specimen geometry for the bonded disc technique was a ratio between 7:1 and 9:1 for specimen diameter: height (Watts and Marouf, 2000). Since then, the bonded disk technique has been widely used by dental laboratories for its relative ease and precise results (Bryant and Mahler, 2007; Garoushi *et al.,* 2008a; Garoushi *et al.,* 2008b; Lee *et al.,* 2008).

To measure the polymerization shrinkage,cylindrical specimens of the uncured composites were made using a specially produced mould. Each specimen was made by placing the mould on a glass slide and placing uncured composite resin into the cut out area of the mould, leaving a free perimeter of 2- 3 mm within the mould. A flexible glass cover slip was placed on top of the slide then pressed with a thick plastic plate until the uncured material and cover slip were in even contact with the mould. The set-up is schematically represented in figure 1.

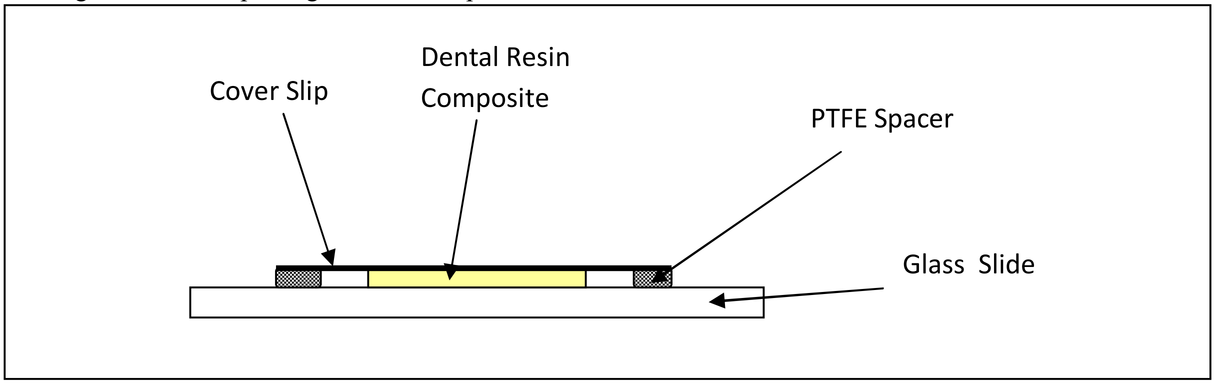

Figure 1. Set-up for polymerization shrinkage measurement

The entire set-up was then placed on a gauge measure to determine the amount of shrinkage immediately after the material had set. Each material was light cured according to the manufacturers' instructions and the shrinkage was calculated upon completion of curing. This was done by noting the extent the flexible glass slide had moved after the composite had set (fig 2) and then using that measurement to calculate the percent of overall shrinkage the material had undergone.

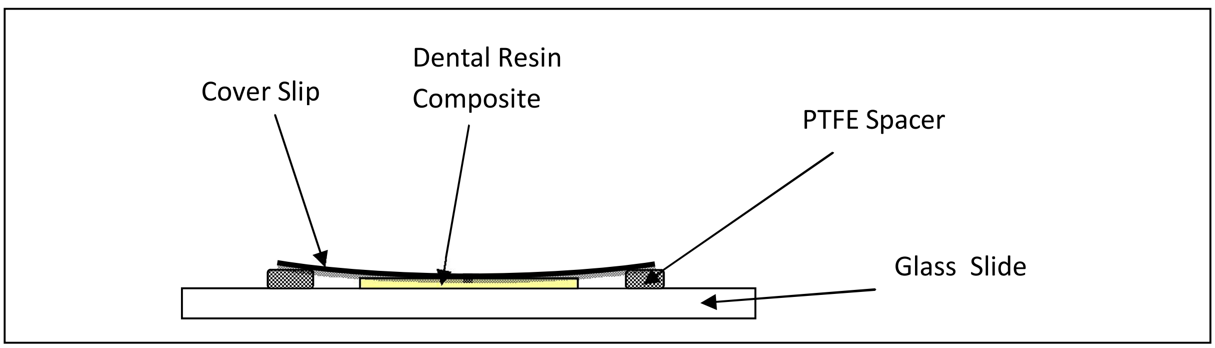

Figure 2. Experiment Setup after shrinkage

3. Results

The data was statistically analysed using SPSS Statistic 17. A one way ANOVA (at a significance level of 0.05) was applied to results of the material and Tukey's post hoc test was used to determine which materials caused a significant difference, if found.

All of the materials showed shrinkage values below 2%. Table 1 shows the percentage of polymerization shrinkage of each material.

Table 1. Percent Shrinkage Values (Standard Deviation)

Material	**Z250**	**eFRC**	**Build It**
Polymerization Shrinkage (SD)	0.68 (0.07)	1.40 (0.050)	1.69 (0.15)

4. Discussion

Previous researchers have found conflicting results when comparing the shrinkage of FRC and PFCs . For example, Filho *et al* (2007) found that a commercially available fibre-reinforced material shrank more than PFCin their laboratory. In contrast, Tezvergil *et al* (2006) found that a similar experimental FRC to the one tested in this study had no significant difference to PFC.

The results reported in this work were in agreement with those of Garoushi *et al.* (2008b). They noted significantly lower shrinkage of the PFC (2.04 ±0.09) compared with that of their experimental FRC (2.45 ±0.11).The results of the current study showed that the eFRC compares to "Build it" in the polymerization shrinkage. However, both have significantly higher shrinkage compared to that of the Z250. Garoushi *et al.* (2008b) believed that it was highly likely that their findings were due to a change in fibre orientation from randomly oriented, which resulted in an isotropic material, to a more aligned orientation resulting in an anisotropic material, with greater shrinkage being exhibited perpendicular to the direction of the fibres. This may lead to the speculation that, contrary to what some believe, the fibres do not form a rigid network which decreases shrinkage in either one of the fibre-reinforced composites in 1 mm thick discs . It may also be due to the fibre lengths not being optimized to decrease polymerization shrinkage. Further work needs to be done to determine the underlying mechanism.

Conclusion

The polymerization shrinkage of eFRC can be considered clinically acceptable as it is not statistically different to that of Build It. Further testing of other clinically relevant properties need to take place before the material is tested in patients.

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6/29/2015