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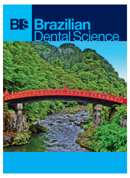

ORIGINAL ARTICLE

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Hygroscopic expansion of bulk fill composites: A three-month report

Expansão higroscópica de compósitos "bulk fill": um relato de três meses

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ABSTRACT

Polymer networks are considered to be largely affected by water and chemical absorption from environment. **Objective:** The aim of this study was to evaluate the hygroscopic expansion of bulk-fill composite. **Material and Methods:** Fifteen disks (5 in each group) with different thickness(4mm/2mm) of Tetric N-Ceram Bulk Fill composite(TB) and Tetric N-Ceram composite(TN) were made according to the manufacturer's instruction and stored in deionized water. The length of each specimen was recorded using a digital micrometer at baseline and at the end of 24 h, 1, 2, 4, 12 weeks intervals. Repeated measure ANOVA and Tukey HSD were used to determine the effect of variables. At 12 weeks, the mean hygroscopic expansion after water immersion ranged between 0. 33±0.09mm for TN to 0.41±0.07mm for TB with 2mm thickness. Repeated measure ANOVA revealed a significant increase in hygroscopic expansion over time ($P<0.05$). **Results:** The results indicated that at 24hours and 2weeks there was a significant difference among TN and TB with 4mm thickness ($p=0.007$ and $p=0.023$, respectively). The other differences were not significant. Hygroscopic expansion affected by the type of composite and the passing of time. **Conclusion:** The results showed that the time taken to reach stabilization in hygroscopic expansion was shorter for TN in comparison with TB. For 2mm thickness equilibrium was attained earlier.

RESUMO

Considera-se que as redes de ligações intrínsecas de polímeros são amplamente afetadas pela absorção de água e produtos químicos do meio ambiente. **Objetivo:** O objetivo deste estudo foi avaliar a expansão higroscópica do compósito bulk-fill. **Material e Métodos:** Quinze discos (5 em cada grupo) com diferentes espessuras (4mm / 2mm) de compósito Tetric N-Ceram Bulk Fill (TB) e Tetric N-Ceram (TN) foram confeccionados de acordo com as instruções do fabricante e armazenados em água deionizada. O comprimento de cada espécime foi registrado usando um micrômetro digital no início e no final de 24 h, 1, 2, 4, 12 semanas de intervalo. O teste de medidas repetidas ANOVA e Tukey foram usados para determinar o efeito das variáveis. Às 12 semanas, a expansão higroscópica média após imersão em água variou entre 0,33 ± 0,09mm para NT a 0,41 ± 0,07mm para TB com 2mm de espessura. ANOVA revelou um aumento significativo na expansão higroscópica ao longo do tempo ($P <0{,}05$). **Resultados:** Os resultados indicaram que às 24h e 2 semanas houve diferença significativa entre TN e TB com 4mm de espessura ($p=0{,}007$ e $p=0{,}023$, respectivamente). As outras diferenças não foram significativas. A expansão higroscópica foi afetada pelo tipo de compósito e pelo tempo. **Conclusão:** Os resultados mostraram que o tempo necessário para alcançar a estabilização na expansão higroscópica foi menor para TN em comparação com TB. Para 2 mm de espessura o equilíbrio foi atingido mais cedo.

KEYWORDS

Water; Expansion; Composites; Polymerization; Bulk-fill.

PALAVRAS-CHAVE

Água; Expansão; Composites; Polimerização.

INTRODUCTION

Polymer networks are considered to be largely affected by water and chemical absorption from environment. These effects may create biological, volumetric (plasticization, softening) and chemical changes (oxidation, hydrolysis) [1-4]. Therefore, it is important to understand the hygroscopic expansion pattern in oral environment over time. Expansion resulting from water sorption can be a clinically desirable phenomenon if it doesn't go over the shrinkage value, as further stresses could be resulted in debonding, crack and crazing in enamel surrounding the cavity preparation [5]. However, these changes may causes undesirable effects including softening of the resin matrix, resin degradation, reduction of stain-resistance and internal stress [6]. In additionally, water sorption may deteriorate mechanical properties of polymers, such as the modulus of elasticity, yield strength and produce changes in yield/ deformation mechanisms [7].

Recently, a new class of resin-based composite, the so-called "bulk-fill" composite has been introduced into the dental market. Owing to innovations inresin technology , such materials provide low curing shrinkage that may enable the omission of incremental layering, with the purpose of time and cost savings. The particularity of new composite material is stated to be the option to place in 4mm bulk instead of 2mm incremental technique without negative effects. Clinicians are uncertain about the depth of cure and mechanical properties which may not be suitable for clinical use, however, manufactures claim that polymerization is initiated even in very deep cavities and the material will be fully cured [8].

When these new materials are used in a large volume, undesirable polymerization in depth of cavity may cause unexpected water absorption. Therefore, effects of hygroscopic phenomena of bulk-fill composite material should be investigated and explained. Therefore the aim of this study was to evaluate the extent of hygroscopic expansion of new resin composites stored in distilled water at 37°C during 3 months. The null hypothesis was that there would be no significant differences in hygroscopic expansion among bulk fill and conventional layered composite.

METHODS

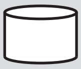
In the present study Tetric N-Ceram Bulk Fill composite and Tetric N-Ceram composite (Ivoclar Vivadent, Schaan, Liechtenstein) that utilized as control were used and manipulated according to the manufacturer's instruction. The specimens of conventional (6mm diameter and 2mm thickness) and bulk-fill composite resins at two different thicknesses (6mm diameter and 2mm and 4mm thickness) were prepared using two body-split type stainless steel mold. To prepare each specimen (Table 1), the mold was placed on a clean glass slide covered by a transparent Mylar strip and the test material was packed into the mold. composite layer was light cured 40s with Optilux 501 (800mW/ cm^2, Kerr, Danbury, CT, USA) according to the manufacturer's instruction; care was taken to avoid entrapped air while packing the materials. The mold was overfilled with the restorative material and another glass slide and strip was placed over it with firm pressure for the extraction of excess composite. Subsequent to curing, any flash of material was removed so that the surfaces of the specimen were leveled off perpendicular to the long axis of the specimen. This was further achieved by lapping the mold containing the specimen on 400 and 600 grit paper. Then the specimens were removed from the molds and stored in distilled water. Prior to the storage, the length of each specimen was measured using a digital micrometer with an accuracy of 1μ.

For each group 10 specimens were prepared. They were dried with a paper tissue prior to measurement. The length of each specimen was recorded at base time (L_1) and at the end of 24h immersing period in deionized water, then at intervals of 1, 2, 4, 12 weeks. In each time interval the specimens were measured three times and the mean of readings was used in the calculation of the linear dimensional change of each specimen using this formula:

$$\%\Delta L = (L_2 - L_1 / L_1) \times 100$$

The data were analyzed using Repeated measure ANOVA followed by a Tukey HSD post hoc comparison (a = 0.05).

Table 1 - Resin composite used in this study

Composite groups	Shape of sample (n=10)	Manufacturer	Resin matrix	Filler content	%WT of filler
Universal tetric N-Ceram Composite/ A2 shade(TN)		Ivocular vivadent, Schaan, Liechtenestein	Bis-GMA, UDMA	Ba glass, Ytterbium tri fluoride, mixed oxide	80 – 81%
Bulk fill tetric N-Ceram Composite/IVA shade(TB2)				Ba-Al-Si glass, pre polymerized filler (monomer, glass filler, and ytterbium fluoride), pherical mixed oxide	75 – 77%
Bulk fill tetric N-Ceram Composite/IVAshade(TB4)					

RESULTS

Table 2 shows the mean percentage of dimensional change (%ΔL) in 3 groups. The highest and lowest amount reported for TB4 at 1 day (0.44±0.03) and TN at 12 weeks(0.33±0.09) respectively. Repeated measures ANOVA revealed a significant increase in dimensional change over time ($P<0.05$). Tukey HSD exhibited no significant difference at any time points between TB2 and TB4 groups. However, %ΔL at 24 hours and 2 week was significantly different among group TN and TB4 ($p=0.007$ and $p=0.023$, respectively). In group TB4, there is no significant differences between 1 week and 2 week but other differences was found to be significant ($P<0.05$).

Table 2 - mean± SD %ΔL among different groups

Groups	Mean %ΔL ± SD				
	1day	1week	2weeks	4weeks	12 weeks
TN	0.12±0.11^{aA}	0.23±0.14	0.30±0.09^{aB}	0.30±0.10	0.33±0.09
TB_2	0.05±0.02	0.20±0.05	0.26±0.05	0.30±0.05	0.31±0.07
TB_4	0.44±0.03^{bA}	0.10±0.04	0.17±0.03^{bB}	0.26±0.04	0.37±0.05

Same capital letters in horizontal line and lowercase letters in vertical line indicate statistical different groups (Tukey's HSD test, $\alpha = 0.05$).

DISCUSSION

Excessive hygroscopic expansion may create stresses that possibly result in undesirable cuspal flexures and fracture of brittle, unsupported tooth structures. An understanding of the rate and extent of hygroscopic expansion due to water sorption of these materials is of considerable significance [9]. All of these affect the clinical durability of restoration in oral environment [10].

Dimensional changes of restorative materials caused by hygroscopic expansion can be verified by a variety of test methods such as: hydrostatic or Archimedes principle [11-13]; model cavities cut in brass in which the hygroscopic expansion of the material was expressed by the displacement force generated caused by water sorption[5]; the ability of materials in reducing the marginal gap [14]; measuring the relaxation of setting shrinkage shear stress [15]; measuring the length of specimens by means of an electrical or a computer-controlled laser micrometer or a microscope [16,17].In this study hygroscopic expansion of composites was evaluated by digital micrometer with measurement accuracy of one micron. In this experiment, all the specimens were allowed to absorb water freely through all their surfaces.

All materials have exhibited hygroscopic expansion values within the acceptable limits. The possible cause could be due to similarity in the resin matrix content. The water sorption of materials with similar resin matrix may depend on the filler content [18], the nature of filler particles, the coupling agents and the incompletely covered sites on filler surface[19]. Dimensional change increased during the period of the study in all groups, although the pattern was found to be different in bulk fill composite groups. The difference in this regard between 1 day and other time points in TB2 and TB4 was statistically significant, while TB4 had a lowest expansion and this could be related to more bulk mass in TB4 specimens during curing. It is known that the larger the volume of the material, the greater the shrinkage. This finding shows that lower filler content (75-77 wt%) or lower light penetration in TB4 composite could be related to their shrinkage at first 24 hours. After 2 weeks, TB4 showed the lowest expansion among all groups. This could be related to compensation of shrinkage which occurs in first day. It seems that TB2 after 2 weeks was reaching to a plateau and finally the curve became constant. However, TB4 specimens showed dimensional change during 3 months without stabilization, perhaps due to their insufficient polymerization. Also, the presence of pre-polymerized particles in this composite may further explain. These particles have been shown to result in inferior hardness value and weak filler/ matrix interface [20]. Water uptake can promote breakdown filler/ matrix interface and influence their dimensional change in this thickness. These findings are in line with our recent investigation about color stability of bulk fill resin composite [21]. The results demonstrated greater color changes with increasing increment thickness, which was significant at 14 and 28 d. It was concluded that the staining susceptibility of specimens after immersion in water could be due to their water absorption [21].

Hygroscopic change in TN group occurred constant with plateau pattern early after polymerization. This phenomenon could be related to equilibrium in total set of material. Such an approach is a normal physical phenomenon, where the expansion of the polymer network leads to an increasing restoring force opposing further sorption and expansion. During the process, water molecules occupies the previous space of any extracted leachable species [17,22].

Considering bulk-fill placement technique, it has been demonstrated that this characteristic did not produce better results for these materials. A technique that uses a large number of small, thin increments is recommended as the most appropriate placement technique.

It can be concluded that Hygroscopic expansion depended on the type of composite and the passing of time. The results showed that the time taken to reach stabilization in hygroscopic expansion was shorter for TN in comparison with TB. For the size 2mm thickness equilibrium was attained earlier.

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