EVALUATION OF THE FORMATION OF MARGINAL GAPS IN PREHEATED COMPOSITE RESIN RESTORATIONS

AVALIAÇÃO DA FORMAÇÃO DE FENDAS MARGINAIS EM RESTAURAÇÕES DE RESINA COMPOSTA PREAQUECIDA

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ABSTRACT

Composite resins are polymeric restorative materials that have acceptable mechanical properties, so they are used in anterior and posterior teeth. There is, however, polymerization shrinkage inherent in the polymeric materials. This contraction is responsible for the formation of cracks at the interface of the restoration. These gaps contribute to the staining of the composite resin and the appearance of cavities. In order to minimize the effects of polymerization shrinkage, variations in restorative technique has been introduced to fulfill this goal. The preheating resin composite is one of them.This study aimed to assess the formation of marginal gaps, using scan electron microscopy, in composite resin restorations created using one room-temperature composite resin and one preheated to 60°C. 20 recently-extracted human molars with circular cavities in the surface dentine of each proximal surface were used. The cavities were restored using Filtek Z350 (3M) composite resin affixed with Adper Scotchbond Multipurpose Adhesive (3M) and divided into two groups of 10 samples: group 1 – room-temperature composite resin restorations (n=10) and group 2 – composite resin restorations preheated to 600C (n=10). The samples were kept in a bacteriological incubator for a period of seven days. After this, the restorations were polished and epoxy resin replicas were created using a casting with addition silicone for subsequent SEM analysis. The gaps were measured with the aid of UTHSCSA Image tool software and the results were submitted to Student "t" test statistical analysis, achieving the following results: the highest marginal gap figures were obtained with Filtek Z350 resin preheated to 600C (t= -3.961 and p=0.000). Based on the methodology employed and the results achieved, it can be concluded that there was a greater formation of marginal gaps in the dentin-composite resin interface where Filtek Z350 resin preheated to 60°C was used for restorations, thus making it preferable to use room-temperature composite resin.

Keywords: Composite resin. Marginal gaps. Electronic microscopy.

INTRODUCTION

In recent decades, technological advances have given composite resins improved optical, physical and mechanical properties, making them the material of choice for direct restorations. However, it has been observed that composite resin does not polymerize completely at either room or intraoral temperature. Incomplete polymerization occurs, among other reasons, due to the chemical nature of monomers, which by promoting the formation of a densely crosslinked solid in a few seconds, also causes increased viscosity throughout the organic matrix. This high level of viscosity observed early on in the initial stages of chemical reaction prevents polymerization from occurring completely (ANDRZEJEWSKA E. 2001). In an attempt to improve the properties of current composite resins, a greater filler was incorporated, aiming at greater durability and resistance to wear, but conversely there was an increase in the viscosity of these resins when not polymerized. A direct consequence is a more difficult insertion and marginal cavity adaptation. In a bid to minimize the effect of increased viscosity when heating composite resin, the technique of thermal polymerization was created, which involves heating the composite resin in an apparatus with heated water and then photopolymerizing it with a conventional halogen lamp. The principal of this technique is based on moderately preheating tubes of composite resin to temperatures of 54 or 600C prior to photoactivation. As composite resin is a visco-elastic material, it is hoped that heating it will reduce its initial viscosity (FRIEDMAN J. 2001). One study has shown how preheating can significantly increase the fluidity of composite resins. This could improve the adaptability of the composite to the walls of the prepared cavity. Besides this factor, an increase in temperature, which generally accelerates chemical reactions, could also increase the degree of monomer conversion, with shorter photoactivation time (BLALOCK JS, HOLMES RG, *et al.,* 2006).

The application of heat after photopolymerization has already shown to be responsible for increasing the final conversion of composite resin, improving its physical properties. As well as an increased conversion, this improvement is attributed to the reduction of polymerization stresses. The application of post-photopolymerization heat acts as a homogenizing end treatment, relieving internal stresses resulting from polymerization (DEE GEE AJ, PALLAY WA *et al.,* 1990).

This study aimed to assess the formation of marginal gaps, using sweep electron microscopy, in composite resin restorations created using one room-temperature composite resin and one preheated to 60°C.

MATERIALS AND METHODS

Twenty extracted human molars were used in this study, which had been cleaned and stored at room temperature in a 1% solution of Chloramine T (Fluka, Switzerland) until being used (ASMUSSEN E & JORGENSEN KD, 1972) (Research and Ethics Committee 2063 CEP/HUPE).

To begin with, each tooth's proximal surface was sanded down in a motorized sander (model DP-92, Panambra Industrial e Técnica S.A., São Paulo), in order to expose the most superficial layer possible of dentin tissue. Silicon carbide sandpaper of granulation 320 through 600 (3M, Brazilian-made) was used at a speed of 300 rpm and cooled thoroughly with water. Thereafter they were stored in distilled water at room temperature. These dentin surfaces were subjected to a circular cavity preparation 3mm wide and 1.5 mm deep according to the norms of ISO/TC 106/SC 1 N326, Resolution 6 (6.3.3), starting with a spherical diamond tip, no 6 PM 1st series (K.G. Sorensen, Brazilian-made), followed by another spherical diamond tip from the no 82 PM 3rd series (K.G. Sorensen, Brazilian-made), both rotating slowly and with constant cooling by water and completed with a smooth cylindrical no 56 steel drill (S.S. White Art. Dent., Brazilian-made), both with a cursor measuring in millimeters and refrigerated in the same way (Picture 1).

During preparation, their dimensions were checked using a periodontal probe measuring in millimeters (S.S. White Duflex, Brazilian-made) and a digital caliper (727 series, Starrett, Brazilian-made).

The restoration technique, using Filtek Z350 (3M ESPE, Brazilian-made) composite resin, was carried out following the manufacturer's instructions: the procedure began with an etching process using 35% phosphoric acid (Ultra EtchR, Ultradent, Brazilian-made) for 15 seconds. The cavity was subsequently washed thoroughly with water for twice the time taken to perform the etching process and straight after that, was dried with absorbent paper.

Adper Scotchbond Multipurpose adhesive (3M ESPE, Brazilian-made) was applied as follows: after the cavity had been etched,

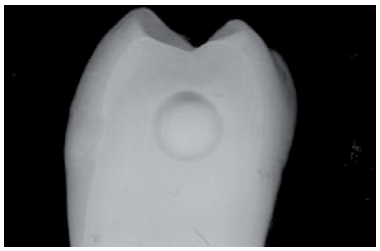


FIGURE 1
Preparation proximal cavity on the surface of a human molar.

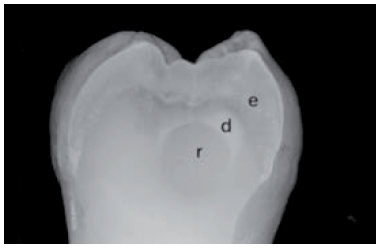


FIGURE 2
Cavity restored with composite resin.

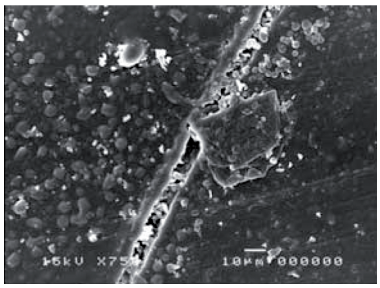
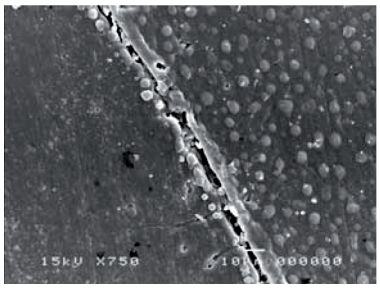


FIGURE 3 AND 4
Scanning Electron Microscopy of a marginal gap of a composite resin restoration with preheated.



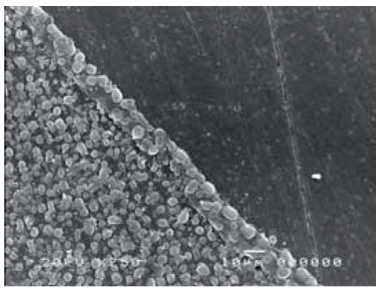
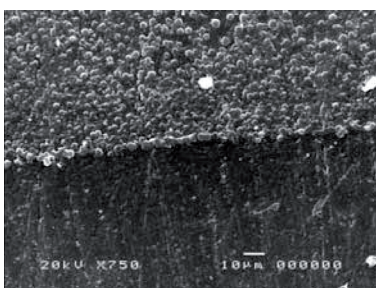


FIGURE 5 AND 6
Scanning Electron Microscopy of a restoration with composite resin at room temperature.



washed and dried, a layer of primer was applied and following a 20-second wait, the adhesive was applied and photoactivated for 20 seconds.

The composite resin was placed in the cavity using a Teflon spatula in two oblique increments and pressed with a polyester matrix strip and a glass slide in order to permit resin flow throughout the prepared cavity and subsequently photoactivated for 30 seconds, as recommended by the manufacturer.

The irradiation source used to activate the composite resins was a Vip Jr halogen or visible curing light (made by Bisco) with 500mW/cm2 light intensity. The light intensity was measured with a radiometer (Curing Radiometer Model 100 – Demetron).

The teeth were divided into two groups for analysis of the formation of marginal gaps.

- Group I - teeth restored with Filtek Z350 room-temperature composite resin + Adper Scotchbond Multi Purpose + Vip Jr. halogen light source (n = 10)

- Group II - teeth restored with Filtek Z350 composite resin preheated to 60°C + Adper Scotchbond Multi Purpose + Vip Jr. halogen light source (n = 10)

Polymerization of the composite resin restorations was performed in a room with controlled temperature and relative humidity, according to ADA guidelines (American Dental Association), which corresponds to values of 23 ± 2° Celsius and 50 + 10% relative humidity, respectively.

The restored teeth were immediately placed in a light-proof container for a period of 10 minutes counting from the start of polymerization. Thereafter, distilled water was added to the container, which was placed inside an incubator (Fanem Ltda., São Paulo) set at a temperature of 37 ± 2 ° C, for 7 days.

After this, the restorations were finished and polished by sanding a fine layer of composite resin, which during compression of the material, had spread beyond the cavities' limits (Picture 2). This procedure was carried out using a manual sander (Struers, Denmark) with, respectively, 1200, 1500 and 2000 grit silicon carbide sandpaper and thorough water-cooling.

Following this stage, a mould was cast of each sample using a polyvinyl siloxane (Adsil–Vigodent, light body, lot 002/2007, validity 12/2008), in order to produce epoxy resin replicas (Araltec-XGY 1109, HY 850 catalyst), to serve as material for verification in a scan electron microscope. It must be stressed that prior to creating the polyvinyl siloxane casting, a preliminary mould had been made using the same material, with a view to removing any impurities which may have resulted from finishing and polishing the restorations. The epoxy resin replicas were created, metalized and submitted to scan electron microscopy (JEOL – JSM – 5310, Biophysics - UFRJ), so that their images could be analyzed in order to measure any marginal gaps resulting from the contraction by polymerization of the tested resins (Pictures 3, 4, 5 and 6).

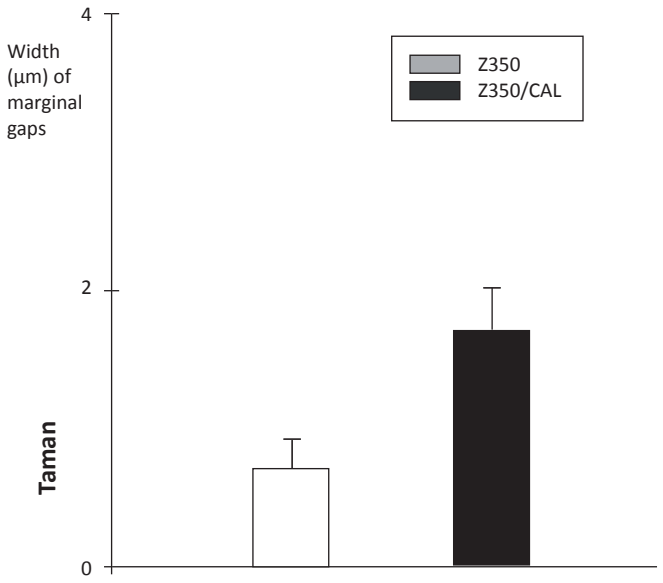
Figure 5 and 6 - Scanning Electron Microscopy of a restoration with composite resin at room temperature.

"UTHSCSA Image Tool" software was used to measure the marginal gaps; the pixels were converted to micrometers with the aid of a calibrator which was part of the software, using a rule equivalent to 10 □m provided by the electron microscope image.

After calibration, measurement began of reference points where the gaps were of the greatest amplitude, at four equidistant points; the gap was measured from beginning to end by a cursor, resulting in a distance in micrometer. Following this procedure, the data were submitted to statistical analysis using SPSS software in order to obtain the results. The Students' "t" test was chosen as the statistical test.

RESULTS

According to the methodology employed, it could be observed that the greatest marginal gap values were in the group in which composite resin preheated to 60°C was used. The statistical test showed that there was statistical difference between the groups cited above, where n= 40; t= -3.961 e p=0.000.



GRAPH 1
Measurements in micrometers of the width of marginal gaps in relation to the preheating of composite resin.

DISCUSSION

When comparing the composite resin-dentin interface, varying the temperature of the resin (preheated to 60°C and room temperature), larger marginal gaps were observed in the group in which preheated composite resin was used. The statistical test revealed a significant statistical difference between the groups (p=0.00). According to the average measurements of the four points of largest marginal gap-size, it can be noted that in the preheated composite resin group, the marginal gaps were much larger and there was not a single sample completely free of gaps.

Prasanna and Pallavi Reddy *et al.* (2007) agrees with the result obtained, concluding that the significant increase in the degree of conversion by preheating the composite resin resulted in increased polymerization shrinkage, generating marginal gaps in the composite resin-dentin interface.

Dee Gee and Pallay *et al.* (1990) and Wagner, Aksu *et al.* (2008) disagree with the results obtained in this study. The first authors cited showed that inserting preheated composite resin reduced leakage at the cervical margin in class II-type cavity restorations when compared with room-temperature composite resin. The second author concluded that the application of heat was responsible for increasing the final conversion of composite resin. Besides the increased conversion rate, this improvement is also attributed to the reduction in polymerization contraction.

One study has shown that restorations performed using preheated composite resins adapted better to the prepared cavity walls (CHOUDHARY N, KAMAT S *et al.* 2011), and another study has shown that heating composite resin before using it not only reduced its viscosity, but also improved its physical properties (WOOLUM JA, BERRY TG *et al.* 2008).

Lovell and Newman *et al.* (1999) concluded that the temperature at which resin monomers are polymerized also affects the degree of conversion and that raising the temperature improves the mobility of monomers and radicals, resulting in a higher rate of conversion.

Friedman (2003) suggested that the depth of polymerization also increased when the temperature was increased. Disagreeing with this claim, Erickson (2003) and Wagner, Neme *et al.* (2004) concluded that the depth of polymerization does not increase due to temperature.

We should consider not only the preheating of composite resin but also the intensity and type of polymerizing source. A recent study was carried out, whose authors

concluded that preheating composite resin did not improve marginal leakage when a high-intensity LED apparatus was used as a source of polymerization, however marginal leakage was significantly reduced when a low-intensity halogen lamp was used. This fact can be attributed to the increase in the conversion rate of composite resin when a high-intensity polymerizing source is used and when the temperature of the composite resin is increased, which can lead to restorations with larger marginal gaps and hence, marginal leakage (SANTOS RE & LIMA AF *et al.*, 2011). DARONCH M, RUEGGEEBERG FA *et al.* (2005) have noted that preheating composite resin before photoactivating it has led to greater monomer conversion when exposure time to photoactivating light was reduced, in this case a halogen lamp.

The results obtained here did not counter what some authors propose who advocate the use of preheated composite resins. These authors claim that preheating improves marginal adaptation as the resin's fluidity increases, making it adapt better. The likely cause of the larger marginal gaps found in the preheated composite resin group can be attributed to the fact that this resin significantly increased the speed and degree of conversion, which may have resulted in increased polymerization contraction, causing larger marginal gaps.

The preheated composite resin used in this study was a nanoparticle resin and it must be stressed that the incorporation of nanometric filler may have contributed to a decreased ability of this resin to fluidify with the action of temperature. Blalock, Holmes *et al.* (2006), when analyzing the thickness of films formed from preheated composite resins, compared with the thickness of room-temperature resin films, concluded that both preheated composite resin and room-temperature composite resin produced greater film thicknesses than those produced by flow resins and that nanoparticle resins did not produce films of a reduced thickness due to the action of temperature.

CONCLUSIONS

According to the results obtained and discussed in the previous chapter, this study allows us to reach the following conclusion:

•The room-temperature composite resin created restorations with smaller marginal gaps, making its use preferable when compared with preheated composite resin.

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