Effect of Light Curing in the Marginal Internal Adaptation of Bulk Fill in Class-I Preparations


Abstract

Modifications in the chemical compositions of dental composites have allowed creating new materials with different properties and filling techniques. However, the contraction by polymerization and stress that this generates is caused by factors such as configuration of the cavity, filling technique, and light-curing intensities. The objective of this study was to evaluate the micro leakage of Bulk Fill composites, SonicFill, and conventional composites using two intensities of photo polymerization. Standardized class I preparations were carried out on 60 extracted human molars and were restored using either Bulk Fill (Tetric N-Ceram Bulk Fill Ivoclar, Vivadent) group A, Sonic Fill (Kerr) group B, and a conventional composite (Tetric Evo Ceram, Ivoclar Vivadent) group C designed for 2 mm increments, with two light-curing intensities of 800 mW/cm² and 1,500 mW/cm². The specimens were subjected to a thermo cycling regime of 2,500 thermal cycles by immersion in water and were stained with a buffered methylene blue 2% for 24 h; after that, they were segmented sagittally and observed in the stereoscopic microscope. The three groups showed micro leakage, and the conventional composites exhibited less micro leakage compared with the Bulk Fill composite and Sonic Fill composite at 800 mW/cm². However, the SonicFill resin demonstrated less micro leakage, on being photo polymerized at light curing of 1,500 mW/cm². The conventional composite showed a better performance in class-I cavities at 800 mW/cm²; therefore, photo polymerization power is a determining factor to modify the internal adaptation of the composites in class-I cavities; conventional composites were more affected at 1,500 mW/cm².

Keywords: Light intensity; Bulk Fill; Micro leakage; Class-I cavities; Conventional composite

Introduction

Conservative dentistry has been searching to simplify minimally invasive clinical treatments; subsequently, the dentist can perform with previously established protocols. Dental composites are considered one of the dental materials in high demand and are used daily in dental practice. These dental composites require an adequate wavelength and light energy intensity to activate photo initiator and initiate polymerization [1]. The incremental technique utilized in conventional dental composites is employed to resolve the shrinkage stress resulting from the reaction to light curing, ensuring that the composite curing is complete at the exposure of light between each layer no greater than 2 mm in thickness, thus minimizing the volume of material contracted, resulting in the decrease of risk of failure [2]. The disadvantages presented by the incremental technique usually refer to its being considered a slow and tedious procedure with a risk of constant contamination between layers and the generating of voids by the entrapment of air [3].

The quality of the light curing is affected by critical factors such as wavelength, light intensity, distance of the light source, and exposure time. It has been demonstrated that a light-curing device that radiates an intensity of light greater than 223 mW/cm² provides sufficient energy intensity for curing layers of 1 mm, while for increments of 2 mm, twice th energy is required to achieve adequate photo polymerization. In contrast, it has been shown that light intensities of
1,200 mW/cm² comprise the maximal limit to avoid high-contraction indexes that can lead to stress and consequently, risk of marginal filtration [4]. As an important clinical aspect, the failure of any of these factors compromises adequate polymerization, causing a failure in the material and the consideration of postoperative sensitivity and secondary caries [5].

The volumetric reduction known as polymerization contraction is associated with stress; however, these are not always parallel to each other. Polymerization stress is a local physical state, not a basic property of the material. Therefore, its final value is dependent on a geometric system and the conditions of its environment [6]. The polymerization stress that is generated also depends on the configuration of the cavity: flat surfaces and small cavities favor the formation of a bond between the tooth and the composite, in that since the polymerization contraction occurs in only one direction. Feilzer et al. developed the concept of “Factor C”, which consists of the relationship between the free area and the adhered area of composite resin restorations: to simplify this relationship, the number of walls in the cavity vs. the number of free faces that will make up the restoration is used [7]. The C factor of a Class-I restoration of Black is 5, this meaning that the higher the number of the C factor, the higher the polymerization stress [8].

However, in the search for materials that offer a simplification procedure of the filling technique and that decrease the stress of contraction, the composite denominated in-block (Bulk Fill) is one option to this type of treatment. The general indication for the placement of a Bulk Fill composite is in cavities with horizontal increments 4 mm in thickness in order to fill the cavity with a single intent, which significantly optimizes the working times. In addition, employing lamps of >1,000 mW/cm² requires only 10 seconds of photo activation. If the cavity is of a greater depth, another increase should be made to ensure optimal depth of the curing material [9,10]. The polymerization of these materials is possible due to the change in their chemical composition, which reduces the stress caused by the polymerization, and greater translucency, which allows greater penetration of the light [11].

More over, multiple studies have been conducted to investigate which restorative technique have the greatest beneficial effects for placing a restoration with dental composite in the posterior sector with incremental layers or a single increment; however, it remains difficult to obtain a generalized conclusion [12]. Our null hypothesis was that light-curing intensities do not influence in the micro leakage of class-I cavities restored with Bulk Fill, SonicFill, composite (with a single increment), and conventional composite with the incremental technique. The objective of this study was to evaluate the micro leakage of Bulk Fill composite, SonicFill and conventional composite in class-I cavities depending on two light-curing intensities.

**Methodology**

Sixty premolars without caries and coronal fractures were donated by patients treated at the Orthodontics Clinic of the Universidad Autónoma de San Luis Potosí, Mexico. Informed consent was signed by all patients after approval of the study by the Ethics Committee. All of the specimens were stored in a hydrated medium, and scaling was performed to remove any plaque, calculus, or periodontal tissues. Subsequently, these were washed with saline solution and stored in distilled water. A single operator performed class-I MOD (Mesio-Occluso-Distal) cavities (4 mm in distal-mesial width, 3 mm in vestibule-palatine or buccolingually and 4 mm in depth), measurements were performed with a periodontal probe, and the cavities were carried out with a KaVo Extra Torque 605 turbine with two burs, 332 and 333L, maintaining constant irrigation. The teeth were randomly distributed in three groups of 20 samples each, according to the filling material.

The three groups were etched with 35% Ultra etch acid etchant for 15 seconds in enamel and dentin. After that, the acid etching was washed with water spray for 15 seconds and the cavity was dried with a. A solution of 2% chlorhexidine was applied with a micro brush, rubbing the cavity for 1 min and drying again without drying the cavity completely. The adhesive Adper Single Bond 2 (3M ESPE) was applied with a micro brush, rubbing the cavity for 10 seconds and applying a second layer with the same micro brush for another 10 seconds to proceed with the photo polymerization.

Group A was filled with Bulk Fill composite (Tetric N-Ceram Bulk Fill, Ivoclar Vivadent), group B with SonicFill composite (Kerr), and group C, with a conventional composite (Tetric Evo Ceram, Ivoclar Vivadent). Each system was filled according to the manufacturer’s specifications. Subsequently, each group was subdivided into two groups: the first was photo cured with a LED light at an energy of 800 mW/cm² (LUX E Wireless) at a distance of 10 mm, while the second group was photo cured using LED light with an energy of 1,500 mW/cm² (LED Cordless Curing Light) at a distance of 10 mm. The restorations were polished with flexible Sof-Lex finishing and polishing discs (3M ESPE). The teeth were covered with two layers of nail varnish on the entire surface, with the exception of the occlusal face. After
that, they were subjected to a thermo cycling regime of 2,500 thermal cycles by immersion alternating water at 5 ± 8°C and at 55 ± 8°C with a residence time of 2 min and a transfer time of 5 seconds in each bath. Following this, the samples were stained with 2% buffered methylene blue dye for 24 hours and washed with water to be sectioned in a vestibule-palatine or vestibule-lingual direction at the center of the crown with a fine grained diamond disc 3.0 mm in thickness, 220 mm in diameter, and with a rod length of 0.15 mm NTI mark in the sectioned halves. Samples were examined under a stereoscopic microscope (Leica EZ4HD 20x), micro leakage was observed, and microfiltration was measured by penetration of the staining agent into the cracks between the restoration and the dental tissue. Statistical analysis was performed with Minitab ver. 17 statistical software, applying the Mann-Whitney U test with 95% Confidence Intervals.

**Results**

The results obtained in this study showed that Bulk Fill and SonicFill composite did not show lower micro leakage than conventional composite at a curing light of 800 mW/cm². Figure 1 depicts the class-I cavities in molars and the protocols for restorations according to the filling material. We confirm that photo polymerization power comprises a predisposing factor to increase shrinkage by polymerization, especially in the conventional composite at 1,500 mW/cm². These results revealed that in terms of stain penetration from the occlusal surface to the cavity floor (Figure 2), the conventional composite obtained lower micro leakage with the incremental technique at 800 mW/cm² than at 1,500 mW/cm². The next group to demonstrate a decrease of micro leakage at 800 mW/cm² was the SonicFill composite, while the last group was that of the Bulk Fill composite. At a curing light of 1,500 mW/cm², lowest micro leakage was found in the group of SonicFill composite, followed by Bulk Fill, and worst performance was in group with the conventional composite. However, it was determined that there were no significant differences between the Bulk-Fill composite group at a curing light of 800 mW/cm² vs. 1,500 mW/cm² (p <0.344); at 800 mW/cm², the micro leakage score was 1,041 µm, and at 1,500 mW/cm² this showed 1,265 µm. In addition, the SonicFill group did not represent a statistically significant difference at both intensities (p <0.850): with an intensity of 800 mW/cm², this was 700 µm, while at 1,500 mW/cm², it was 667 µm. However, in the group of conventional composite, there was statistically significant difference: a curing light of 800 mW/cm² showed 407.8 µm, and at 1,500 mW/cm², this was 1,307 µm (p <0.0113) (Graphic 1).
Figure 2: Representative images of the scores of micro leakage after thermocycling, sectioned and stained images (stain penetration) in class-I cavities using conventional composite (A) (2 mm thick increments), SonicFill (B) and Bulk Fill (C) 4 mm single increments at a curing light of 800 mW/cm². Macroscopic view, Conventional composite (D), SonicFill (E) and Bulk Fill (F). Images were obtained with a stereoscopic microscope (Leica EZ4HD, 8X, 20X).

Graphic 1: A box plot of the micro leakage scores of MOD cavities (n = 10 for each group tested). The plot illustrates that micro leakage scores based on the extreme values comparing Bulk Fill and SonicFill at 800 mW/cm² vs. 1,500 mW/cm² did not identify statistically significant differences. However, in conventional composites, statistical significance was identified at 800 mW/cm² vs. 1,500 mW/cm² (p <0.0113). Highest micro leakage was in conventional composite at 1,500 mW/cm² and decreased in the same group at 800 mW/cm². Incremental gap in Bulk Fill and SonicFill composite demonstrated a lower proportion of micro leakage compared with the group of conventional composite at 800 mW/cm². Highest values were measured with SonicFill composite followed by Bulk Fill. Values with an (*) were significantly different.

Comparison among the composite groups at an intensity of 800 mW/cm² demonstrated that Bulk Fill vs conventional composite (p <0.0140) and SonicFill vs. conventional composite (p <0.0500) presents a statistically significant difference, whereas with Bulk Fill vs. SonicFill, a statistically significant difference was not present (p <0.3075). At an intensity of 1,500 mW/cm², Bulk Fill vs. conventional composite (p <0.6232) and SonicFill vs. conventional composite (p <0.1405), a statistically significant difference was not present; however, Bulk Fill vs. SonicFill, there was statistically significant difference (p <0.0173) (Graphic 2).
Discussion

Studies have shown that controversy remains on when to use certain dental filling techniques according to the restoration material selected and the cavity design, in that the majority of studies reveal that while there is always minimal marginal micro leakage, there does not exist a generalized conclusion that determines which of these two filling techniques, either the incremental technique or bulk polymerization (one increment), revealed a better marginal seal, therefore less micro leakage. In this study, we found that, despite the simplification in the filling technique with Bulk Fill and SonicFill composites in class-I cavities, cavities filled with conventional composites utilizing the incremental technique at 800 mW/cm² exhibited lower marginal micro leakage resulting from contraction due to polymerization.

In order to compare the controversial results of this study with others, Kapoor et al. concluded that class-I cavities filled with increments of 4 mm of Bulk Fill composite provided better results than conventional composites, demonstrating better adaptation and gap formation in the floor of the pulp chamber [13]. Van Ende., et al. confirmed that class-I cavities with a high C factor restored with Bulk Fill composite present lower micro leakage [14]. The results obtained in this study showed the opposite in class-I cavities, with conventional composites using the 2 mm layer incremental technique revealed less micro leakage at 800 mW/cm² than at 1,500 mW/cm², followed by SonicFill composites, with the last one Bulk Fill, also at 800 mW/cm². In conventional composite, micro leakage scores were significantly higher at 1,500 mW/cm² compared with those at 800 mW/cm²; consequently, the intensities of photo polymerization employed exerted a significant influence on micro leakage. However, there was no statistically significant difference between conventional composite vs. Bulk Fill and vs. SonicFill, in comparison with Bulk Fill at 1,500 mW/cm², at which here was a significant difference.

The results of our study support the research of Domínguez., et al. who compared the degree of marginal sealing of restorations made with incremental technique compared with those conducted with the mono incremental technique: the better marginal seal was obtained with the mono incremental technique. However, neither of the two composite systems employed completely eliminated marginal microfiltration in class-II cavities [15].

A study by Campos et al. found that Bulk Fill composites do not present better marginal adaptation than conventional composites in class-II cavities, this gave rise to greater micro leakage in the cervical margin [16]. Nascimento et al. evaluated the marginal sealing of Bulk Fill composites in class-II cavities, reporting that there is no statistically significant difference in marginal micro leakage between Bulk Fill composites and a conventional composite regardless of the adhesive technique utilized [17]. The majority of the studies involve the evaluation of class-II restorations. In this study, we decided to evaluate class-I cavities with high C-factor. The results of this study document that even the SonicFill is considered to be a bulk fill composite: it has lower micro leakage than Bulk Fill composite even at 800 mW/cm² and 1,500 mW/cm². In contrast, Hirata et al., who evaluated two systems of Bulk Fill composites and a conventional composite in class-I cavities, found a better fit in the internal adaptation of the cavity with a Bulk Fill composite, with the conventional composite revealing worst performance [18].
Although Gupta., et al. evaluated the micro leakage associated using a handpiece, this permitting a better adaptation of the composite to the walls of the cavity, facilitating the restoration procedure. However, this does not eliminate the gap formation that causes micro leakage. The majority of studies focus on comparing cavity types and restorative materials, concluding that the type of preparation of the cavity and of the bonding surface proved to be key factors in micro leakage. Others studies, such as that of Gamarra., et al. which prepared class II-cavities with SonicFill, showed micro leakage in the dentin at the cervical margin, regardless of the intensities of photo polymerization technique employed [20]. Kalmowicz., et al. also found significantly less micro leakage in class-I cavities restored with SonicFill and conventional composite, compared with class-II cavities restored with Bulk Fill [21].

The filling technique employed exerts an influence on the modification of stress caused by the polymerization and the magnitude of this stress mediated by the rigidity of the composite, its ability to release this stress, and its range of curing, among other factors. Stress generated during shrinkage by the polymerization of composites has the potential to cause adhesive failure or micro leakage of the restorative material. Therefore, the filling technique used influences the stress undergone: if polymerization occurs within a space with a minimal number of walls, the tensions decrease, while contrariwise, in a class-I cavity with five walls, the adhesion of the material to the dental walls results in transfer of forces and in deformation of the material toward the internal part of the cavity [22]. The incremental technique has been recommended largely because it is expected to decrease the C factor; it is considered a technique that utilized a large number of small, thin increments avoiding the generation of excessive stress [23-25]. Our result supports the study of Ruggeberg., et al. which found that the incremental technique with a conventional composite reduces formation gap [26].

Due to the filling technique, the main concern is whether the composite sufficiently cures the deepest parts, since the degree of conversion may be related to the composition of the material and translucency [27,28], in that not only marginal adaptation is important, ensuring good polymerization to obtain adequate clinical behavior. The degree of conversion can be influenced by the composition of the material (matrix and filling) and its translucency. Furthermore, the greatest concern regarding the bulk-filling technique is whether the composite sufficiently cures sufficiently in deeper portions: in several studies where both its degree of conversion and the kinetics of its polymerization have been evaluated, adequate polymerization of deep portions up to 4 mm in a single increment. Therefore, to date, the depth of polymerization promised by the manufacturers is reliable [29].

According to the study by Inoue, the authors mention that the intensity of photo polymerization units exert a relevant effect on the shrinkage of the composite: low intensities of light-curing result in less volumetric contraction than high-power intensities [30]. In our study, lowest micro leakage scores were at 800 mW/cm². Furthermore, it has been shown that volumetric shrinkage is proportional to the degree of conversion of the composite, which is a product of irradiation of light and time of exposure. Therefore, a lower degree of conversion is obtained with low-power intensities at a certain exposure time. In this manner, a slow curing process will delay the plastic phase of the composite, allowing relaxation of the stress in the composite and the interface, reducing the volumetric contraction. Previous studies reported that between 12 and 24 J/cm² of radiant exposure is needed to properly cure a 2 mm thick resin layer. In fact, depending on the brand and the shade, in up to 36 J/cm², it has been reported that this adequately cures some resin compounds [31,32].

As mentioned previously, the group most affected by the intensity of power in this study was the conventional resin group, and despite the fact that the samples from this group were sealed with a special technique (incremental technique) in which increases not exceeding 2 mm were respected, the expected results were not obtained in comparison with the Bulk Fill composite and the SonicFill composite, which were sealed with the technique of filling the bulk cavity. Rueggeberg., et al. mention that high levels of light intensity will cause a greater degree of stress due to polymerization contraction, a situation that affects the internal adaptation of the composite. Note that while polymerization occurs abruptly, it does not permit the relaxation of the polymer network prior to its being vitrified, recommending that to solve this problem, the power must be delivered in a way that the curing range can be controlled. In this manner, stress is released, allowing the resin to flow before its vitrification, thus expecting the adhesive failure potential between the restoration and the dental tissue to be much lower [26].
Conclusions

According to the results of this study, conventional composite showed a better performance when used to restore class-I cavities at an intensity of 800 mW/cm², followed by the SonicFill and the Bulk Fill composite. None of the photo polymerization techniques at 800 mW/cm² or at 1,500 mW/cm² employed in this study prevented micro leakage in the occlusal margin of class-I cavities. Although the performance of the bulk incremental technique remains controversial, the conventional technique with 2 mm layer increments continues to be widely utilized in daily dental practice. We consider that photo polymerization is a determinant factor to modify adaptation of the composite in class-I cavities.

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Conflict of Interest

The authors declare that they have no conflict of interest.

References