



Interfacial Stress and Bond Strength of Bulk-Fill or Conventional Composite Resins to Dentin in Class II Restorations

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The aim was to evaluate the microtensile bond strength (μ TBS) to dentin and interfacial stress in a class II cavity restored with bulk-fill or conventional composite resins and the margin interfaces. Vertical slot class II cavities in the mesial face, with the gingival end in dentin, were prepared in 72 third molars, being divided into groups (n=24): G1-Tetric N-Ceram; G2-Tetric N-Ceram Bulk-Fill; G3-SonicFill. Clearfil SE Bond adhesive system was used in all groups. Half of the teeth in each group (n=12) were submitted to thermo-mechanical cycling (TMC). Restored teeth (n=9) were cut perpendicular to obtain beams, which were submitted to a μ TBS test in an EMIC machine. The cervical margins in dentin of the restored teeth (n=3) were assessed using SEM through epoxy resin replicas as well as the section of the restoration. Interfacial stresses after load application were calculated by 2D finite element analysis. The μ TBS means-MPa followed by different letters represent statistical difference by ANOVA and Games-Howell's test (p<0.05): Without TMC: G1-15.68 \pm 6.10a; G2-10.08 \pm 5.21ab; G3-7.98 \pm 3.76b. With TMC: G1-9.70 \pm 5.52a; G2-5.79 \pm 1.42a; G3-4.37 \pm 1.87a. Interfacial stress (MPa) was 4.4 for SonicFill, 3.9 for Tetric N-Ceram, and 3.5 for Tetric N-Ceram Bulk-Fill. SEM images showed continuous margins for all composite resin restorations. It was possible to conclude that SonicFill obtained a slightly higher interfacial stress and lower bond strength to dentin in comparison with Tetric N-Ceram and Tetric N-Ceram Bulk-Fill. Continuous margin interfaces were obtained for Tetric N-Ceram, Tetric N-Ceram Bulk-Fill, and SonicFill. However, voids were observed in the SonicFill restorations.

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Introduction

Composite resin as direct restorative material has been extensively used to restore posterior teeth due to its low cost and more complete preservation of the sound tooth substance, as well as its favorable clinical performance (1).

The conventional composite resins require the incremental filling technique, with increments of less than 2 mm, aiming to decrease polymerization shrinkage stress and cuspal flexure as well as composite resin thickness (2). The referred technique is time-consuming and is likely to incorporate voids between composite resin layers (3).

Nowadays, there is a tendency to use materials that require fewer steps and more simple procedures. Towards this end, bulk-fill composite resins are designed for a single application. These materials are claimed to enable the restoration build-up in thick layers of 4 or even 5 mm without a prolonged polymerization time (4). This prevents void formation and contamination between the composite resin layers, providing more compact restorations. Therefore, bulk-fill composite resins are very attractive due to the possibility of quicker placement of restorations (4).

The possibility of bulk polymerization is due to a

greater translucency of these materials allowing deeper light penetration and polymerization. Besides, changes in these materials' composition modulate the polymerization reaction by the use of specific stress-relief monomers and more reactive photo-initiators (5).

Stresses generated during the composite shrinkage and when it is submitted to load application and are important issues for the clinical success of restoration because the sealing of the margins depends on many factors, such as the magnitude of shrinkage stresses that are generated during the placement and photopolymerization of the composite resin. Clinically, the stresses can be transferred to the restoration margins and therefore affect the marginal quality, contributing to the development of postoperative sensitivity, secondary caries, and pulp inflammation (6). Because of this, the adhesive system used is another important factor related to the quality of the margins (7) since the adhesive must resist the shrinkage stresses from the composite resin regardless of the configuration of the cavity (8).

Bulk-fill composite resins are used for posterior restorations. In a complex class II cavity with cervical wall

in dentin, the marginal adaptation is more challenging in relation to the cervical wall in enamel due to the bond to dentin being more complex (9). In addition, composite shrinkage stresses associated with the masticatory loads can decrease the bond strength between tooth and composite resin (10). In this way, the stresses generated at the interface and their relation to bond strength in dentin could provide reliable information for the clinical application of bulk-fill composite resins.

Therefore, the aim of this study was to evaluate the bond strength and interfacial stress in class II cavity preparations with cervical margin in dentin, using the same adhesive strategy with bulk-fill or conventional composite resins with or without thermal-mechanical cycling. Complementarily, the margin interface was also evaluated by scanning electron microscopy (SEM). The study was conducted under the null hypotheses that the type of composite resin does not influence (i) bond strength to dentin or (ii) interfacial stress.

Material and Methods

Teeth Selection

Seventy-two sound human third molars, extracted for therapeutic reasons, were obtained after approval from the Ethics Committee (56019916.8.0000.5145). The teeth were cleaned and disinfected in 0.5% chloramine T for 24 h and then stored in distilled water at 4 °C.

Root Embedment and Periodontal Ligament Simulation

The baseplate wax (Lysanda, São Paulo, SP, Brazil) was heated at 63°C, and the root surfaces were covered with approximately 0.3 mm thickness of the wax until 2 mm below the cement enamel junction (CEJ). The teeth were mounted individually in plastic tubes and the root embedded in polystyrene resin (Aerojet, São Paulo, SP, Brazil) chemically activated 2 mm below the CEJ. After the polymerization, the teeth were removed from the plastic tubes as well as the wax, obtaining an alveolus in the polystyrene cylinder. A polyether impression material (Impregum Soft, 3M ESPE, St. Paul, MN, USA) was mixed and used to create the artificial periodontal ligament, the excess being removed with a scalpel.

Cavity Preparation

Vertical slot class II cavities measuring 4 mm wide buccal-lingual and 2 mm deep distal-mesial were prepared in the mesial face of all selected teeth. The gingival floor was at dentin, measuring 6 mm occlusal-gingival from the highest cusp. The cavities were prepared by a single operator in a device specially developed that standardizes the preparation with diamond burs (#2096, KG Sorensen, Barueri, SP, Brazil) under refrigeration. Each diamond bur was replaced after five-cavity preparation.

Restorative Procedure

All the prepared teeth were cleaned, dried, and divided into three groups (n=24) in agreement with the composite resin used for the restoration (Table 1). A matrix band was placed in the proximal face to allow a correct insertion of the composite resins without excess. The adhesive system Clearfil SE Bond (Kuraray, Osaka, Japan) was applied in all groups following the manufacturer's instructions. The self-etching primer was applied to the dentin using a microbrush and scrubbed for 20 s, followed by gentle air drying for 5 s. The bond was applied using a microbrush and photo-activated for 10 s.

Group 1: Tetric N-Ceram: the incremental technique was applied in approximately 2 mm thickness increments and photo-activated with the photo-curing unit Radium Cal (SDI, Vic., Australia) having an output of 400 mW/cm² for 40 s to get 16.000 mJ of energy for each increment. The incremental technique was made with three increments. The light intensity was assessed by a radiometer (Model 100 Demetron, Saint Louis, MN, USA).

Group 2 : Tetric N-Ceram Bulk-Fill: the composite resin was applied in a bulk increment of 4 mm. It was inserted into the cavity with a hand piece that produced ultrasonic waves and photo-activated for 40 s. The remaining millimeter was filled, sculptured, and photo-activated for 40 s.

Group 3 : SonicFill: the composite resin was applied in a bulk increment of 5 mm and photo-activated for 40 s. Then, the remaining millimeter was completed and photo-activated for 40 s.

The restored teeth in each restorative system were divided into two sub-groups (n=12). The bond strength

Table 1. Composite resins used in the study

Material	Base resin	Filler (wt/vol%)	Manufacturer
Tetric N-Ceram	Bis-GMA, Bis-EMA, UDMA	81/57	Ivoclar Vivadent, Schaan, Liechtenstein
Tetric N-Ceram Bulk-fill	Bis-GMA, Bis-EMA, UDMA	77/55	Ivoclar Vivadent, Schaan, Liechtenstein
SonicFill	Bis-GMA, TEGDMA, EBPDMA	83/68	Kerr, West Collins, Orange, CA, USA

*Composition of base resin and filler content are from manufacturer's information. Abbreviations: BIS-GMA, bisphenol A dimethacrylate; BIS-EMA, bisphenol A polyethylene glycol diether dimethacrylate; UDMA, urethane dimethacrylate; TEGDMA, triethyleneglycol dimethacrylate; EBPADMA, ethoxylated bisphenol A dimethacrylate. *Mixed: adhesive and cohesive in composite resin.

test, interfacial stress analysis, and interface analysis were carried out before (sub-group 1) and after (sub-group 2) the thermo-mechanical cycling.

Thermomechanical Cycling

The restored teeth of sub-group 2 were submitted to 60,000 thermo cycles (5°/55°C) in a specific machine MSCT-3 (Marcelo Nucci ME, São Carlos, SP, Brazil) (≈5° to ≈55°, 15 s dwell time). A total of 100,000 mechanical cycles were carried out in a mechanical cycling machine (Odeme, Luzerna, SC, Brazil) with 50N load and 2Hz frequency, which was applied at the occlusal face of the restoration.

Obtaining Specimens for Microtensile Bond Strength (μTBS) Test

In each group, the restored teeth (n=9) were sectioned perpendicular to the bonded area to obtain beams with a transversal bonding area of approximately 0.8 mm² using a water-cooled diamond blade (Buehler Corporation, Enfield, CT, USA) in a low-speed saw machine (Isomet 1000, Buehler, Lake Bluff, IL, USA). Each tooth generated an average of three beams. The samples presenting defects, such as bubbles, lack of material, or irregular areas, were discarded. A total of 24 beams were tested per group.

Each beam was fixed to the grips of a microtensile

device using a cyanoacrylate adhesive (Odeme, Dental Ventures of America, Inc., Corona, CA, USA), and the test was conducted in a universal testing machine (EMIC 3000, São José dos Pinhais, PR, Brazil) with a load cell of 50 N at a crosshead speed of 0.5 mm/min until failure. μTBS values were calculated in MPa.

Following the μTBS test, specimens were examined with a stereomicroscope (Mitutoyo, Tokyo, Japan) at 30' magnification. The fractured surfaces were classified as adhesive failure, cohesive failure in composite resin, cohesive failure in dentin, or mixed failure.

Interface Analysis by Scanning Electron Microscopy (SEM)

The interface at the cervical margin of the tooth within each sub-group (n=3) was molded with vinyl polyxiloxane (Virtual, Ivoclar/Vivadent, Schaan, Liechtenstein), and the molds were pored with epoxy resin (Buehler, Lake Bluff, IL, USA). After the polymerization, the dies were removed from the molds. Next, the restorations were sectioned in the mesiodistal direction, parallel to the long axis, using a water-cooled diamond blade in a low-speed saw machine. The interfaces of the samples were polished with 600-, 1000-, and 1200-grit silicone carbide abrasive papers under moisture and then polished with 6-, 3-, 1-, and 0.25-μm grit

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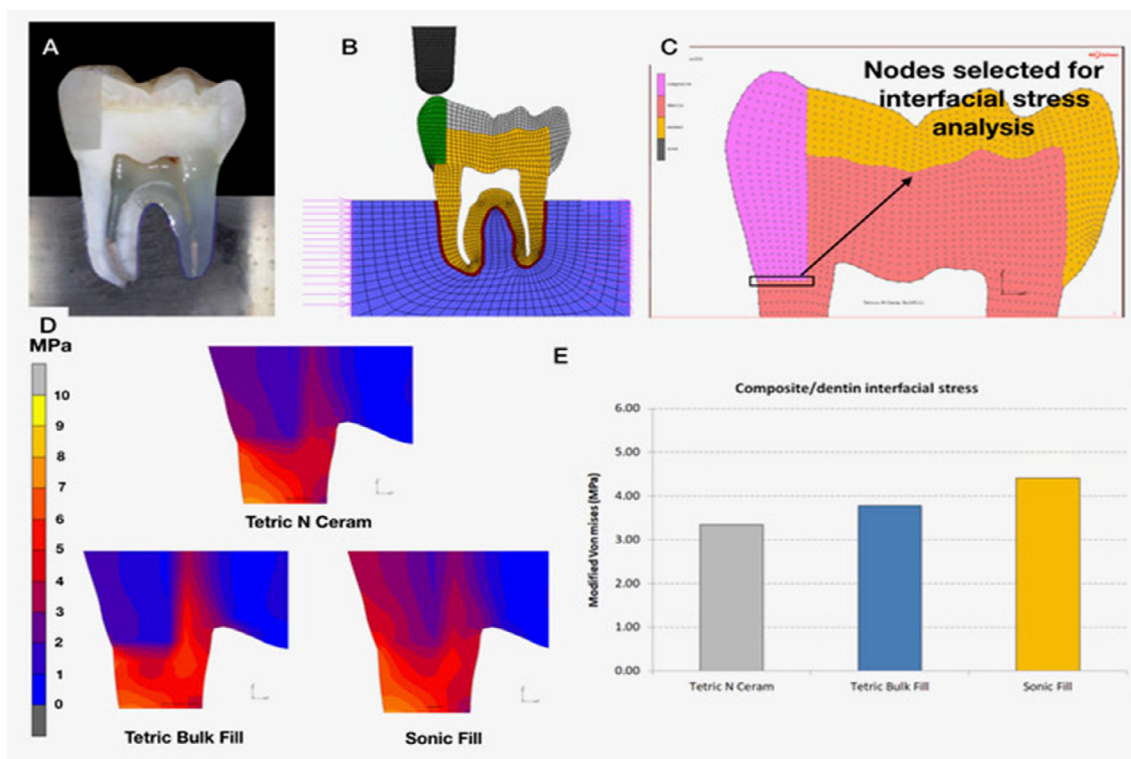


Figure 1. Selected tooth for finite element two-dimensional modeling (A); 100 N load application (B); Selected nodes for interfacial stress analysis (C); Stress distributions by modified von Mises (D); Interfacial stresses by modified Von Mises (MPa) after 100 N load application (E).

diamond pastes on a felt disk with manual pressure. Between each diamond paste, the samples were ultrasonically cleaned in distilled water for 10 min. The molds in epoxy resin and the sectioned teeth samples were fixed in brass stubs and sputter coated (Bal-Tec, Balzers, Liechtenstein) for 180 s at 40 mA. They were then examined by SEM (LEO 435 VP, Cambridge, England) at 500', 100', and 25' magnification, operated at 20 Kv by the same operator. Representative images from each group were obtained.

Two-dimensional Finite Element Analysis

One restored tooth from the experimental test with the vertical slot class II cavities was selected for the two-dimensional finite element analysis (Fig. 1A). The gingival floor was at dentin, measuring 6 mm occlusal-gingival from the highest cusp. The tooth image was imported to an image processing and analysis software ImageJ (National Institute of Mental Health, Bethesda, MD, USA) for tracing outlines of the dental structures and root embedment. The obtained coordinates were transferred to the software MSC Marc/Mentat (MSC Software Co, Los Angeles, CA, USA). Through these coordinates cubic-splines were created to get the right contour of the tooth structures. The element mesh was manually created using four-node isoparametric arbitrary

quadrilateral plane-strain elements with reduced integration which is the element number 115 from the Marc/Mentat element library (Fig. 1B). The nodes on the base of the root embedment were rigidly fixed in the X and Y directions (Fig. 1B). A metallic load tip was modeled with the same dimensions as used in the mechanical cycling and a 100 N load was applied (Fig. 1B). All materials were considered linear, isotropic and homogeneous and the mechanical properties applied are shown in Table 2 (11-15). Each model was solved in Marc. Stresses at the adhesive interface were analyzed using modified Von Mises criteria. At the end of the load application, the stresses at the adhesive interface (composite/tooth) were collected at the selected interfacial nodes and averaged (Fig. 1C). The average nodal stress at the composite dentin interface and standard deviation were calculated and correlated to the microtensile bond strength test.

Statistical Analysis

The values of μ TBS were submitted to the Shapiro-Wilk normality test. The data were analyzed using analysis of variance (ANOVA), followed by Games-Howell's multiple parametric comparison test. The significance level was 5%. Descriptive analysis was made of the values of interfacial

Table 2. Mechanical properties applied for dental materials and structures

Structure	Elastic Modulus (MPa)	Poisson's ratio	Compressive Strength (MPa)	Tensile Strength (MPa)	Reference
Enamel	84.100	0.30	384.0	10.3	¹¹ Zarone F, Sorrentino R, Apicella D, Valentino B, Ferrari M, Aversa R, Apicella A. Evaluation of the biomechanical behavior of maxillary central incisors restored by means of endocrowns compared to a natural tooth: a 3D static linear finite elements analysis. <i>Dent Mater</i> 2006;22:1035-44.
Dentin	18.600	0.30	297.0	98.7	¹² Sano H, Ciucchi B, Matthews WG, Pashley DH. Tensile properties of mineralized and demineralized human and bovine dentin. <i>J Dent Res</i> 1994;73:1205-11.
PDL (polyether)	50	0.45	-	-	¹³ Rees JS, Jacobsen PH. Elastic modulus of the periodontal ligament. <i>Biomaterials</i> 1997;18:995-99.
Polystyrene resin	13.500	0.31	-	-	¹⁴ Soares CJ, Soares PV, de Freitas Santos-Filho PC, Castro CG, Magalhães D, Versluis A. The influence of cavity design and glass fiber posts on biomechanical behavior premolars. <i>J Endod</i> 2008;34:1015-19.
Tetric-N-Ceram	10.800	0.24	308.6	63.3	¹⁵ Technical brochure
Tetric-N-Ceram Bulk Fill	10.000	0.24	267.24	39.5	¹⁵ Technical brochure
SonicFill	8.600	0.24	254.0	77.6	¹⁵ Technical brochure

stresses and for the interfacial analysis by SEM.

Results

μ TBS Test

The μ TBS means are shown in Table 3. According to ANOVA, before the thermo-mechanical cycling, Tetric N-Ceram obtained the highest μ TBS mean, which did not differ significantly from Tetric N-Ceram Bulk-Fill ($p>0.05$). The lowest μ TBS mean was obtained for SonicFill, which did not differ significantly from Tetric N-Ceram Bulk-Fill.

After thermo-mechanical cycling, there were no significant differences in μ TBS means among the composite resins ($p>0.05$). The thermo-mechanical cycling decreased the μ TBS means of all composite resins. However, there was significant difference for Tetric N-Ceram only.

There were mixed failures (adhesive and cohesive in composite resin) for the three composite resins when applied at dentin before thermo-mechanical cycling. After thermo-mechanical cycling, there was a predominance of adhesive failures (Table 4).

Interface Analysis by SEM

There were continuous margins for Tetric N-Ceram, Tetric N-Ceram Bulk-Fill, and SonicFill with or without thermo-mechanical cycling (white arrows). However, voids were observed for SonicFill (black arrows) (Fig. 2).

Interfacial Stress Analysis

The stress distributions by modified von Mises criteria are shown in Figure 1D (Light gray/yellow represent higher stresses values and dark gray/blue the lower stress values). A slightly higher stress was observed for the SonicFill after 100N load application. Tetric N Ceram generated lower stresses at the interface compared to the other tested composites (Fig. 1D). The highest interfacial nodal stress was obtained for SonicFill, the lowest for Tetric N-Ceram Bulk fill, and intermediate values were obtained for Tetric N-Ceram Bulk fill (Fig. 1E).

Table 3. μ TBS means (MPa) and standard-deviations (SD) of the composite resins evaluated at dentin without and with thermo-mechanical cycling

Composite resin	Without thermo-mechanical cycling	With thermo-mechanical cycling
Tetric N-Ceram	15.68 aA (\pm 6.10)	9.70 aB (\pm 5,52)
Tetric N-Ceram Bulk Fill	10.08 abA (\pm 5.21)	5.79 aA (\pm 1.42)
SonicFill	7.98 bA (\pm 3.67)	4.37 aA (\pm 1.87)

*Means followed by the same superscript lowercase letters within each column and uppercase letters within the row indicate no statistical difference at the 95% confidence level ($p<0.05$) based on Games-Howell's multiple parametric comparison test.

Discussion

It is clinically common to find structural loss in posterior teeth resulting in large cavities. However, flat surfaces are used for testing bond strength in most studies, which does not resemble the clinical situations found in the oral cavity. Flat preparations have higher μ TBS values than MOD preparations due to lower stresses at the dentin/composite resin interface relative to MOD-prepared cavities (10). Therefore, the present study applied the materials in occlusal-mesial cavities to obtain a more clinically relevant result of the bond strength and interfacial stress after load application. In addition, the μ TBS test was used with or without thermo-mechanical cycling, which is considered to be reliable because of its versatility and reliability in vitro (11).

According to the results, the hypotheses were rejected, since there were differences in the μ TBS among the composite resins evaluated with or without the thermo-mechanical cycling. In the present study, the same adhesive strategy was used with Clearfil SE Bond, which is considered the gold standard for self-etch adhesive systems (16). Therefore, the differences in μ TBS to dentin are directly related to the properties of the composite resins as well as to the stresses generated by each material during the mechanical cycling.

The results showed higher μ TBS values for the Tetric N-Ceram before thermo-mechanical cycling. We also observed that was generated less stresses at the interface for this composite. Thermo-mechanical cycling was applied to the samples, simulating the degradation of the bond interface that occurs in the oral cavity. There are controversies about the effectiveness of thermocycling as a clinical aging simulator (17). Besides this, there is no evidence of the possible number of cycles to be experienced in vivo, but a provisional estimate of approximately 10,000 cycles per year has been suggested (18). In this study, 60,000 cycles were applied to the specimens. The specimens were also submitted to 100,000 cycles of mechanical loading to simulate the masticatory loads applied on the restorations, resembling approximately five months of function (19). Although there was statistical difference

Table 4. Failure mode analysis

Composite resin	Without thermo-mechanical cycling	With thermo-mechanical cycling
Tetric N-Ceram	100% mixed*	90% adhesive 10% mixed*
Tetric N-Ceram Bulk-Fill	100% mixed*	80% adhesive 20% mixed*
SonicFill	100% mixed*	100% adhesive

*Mixed: adhesive and cohesive in composite resin.

only for Tetric N-Ceram, the μ TBS values decreased for all composite resins after the thermo-mechanical cycling. Before this aging procedure, the failures were 100% mixed, and after it the failures were predominantly adhesives, proving the effect of the thermo-mechanical cycling on the bond interface degradation. Regardless of the values of bond strength, the bond to the tooth has to resist the thermal stresses and the interfacial stresses generated by the polymerization shrinkage of the composite resin and after load application (20). Negative consequences are the presence of non-continuous margins and the occurrence of microleakage and secondary caries, two factors that compromise the longevity of restorations (21). In the present study, the composite resins presented continuous margin at dentin, regardless of the interfacial stress or the bond strength obtained.

In this study, finite element analysis was used to simulate the effect of the load application on the restored class II cavity to correlate with the mechanical cycling. The interfacial stresses (MPa) were calculated by the mean of the nodal stresses at the interface between composite resin and tooth after 100 N load application. Modified Von Mises (mvm) was used for stress assessment; this takes into consideration the tensile and compressive strength of the

materials and substrates by increasing the weight of tensile stresses. Small differences in the stress distributions were found between the composites tested. A slightly higher mvm stress value was observed for SonicFill composite resin compared to the other composites. This means that more tensile stresses were generated at the dentin/composite interface. SonicFill has a low elastic modulus (8.6 GPa) and higher tensile and compressive strength between the tested composites, this interaction of mechanical properties might explain the slightly higher interfacial stress. The results also showed that Tetric-N-Ceram Bulk Fill generated lower stresses that may be related to the high elastic modulus. The stresses developed by the composite resins can be related to the elastic modulus of the material, which is a function of many factors such as monomer chemistry, monomer structure, filler content, and filler/matrix interactions (22). Values of elastic modulus of the composite resin influence the stresses in the remaining tooth structures and at the tooth/restoration interfaces during the loading. There is less deformation in materials with high elastic modulus; being stressed, these materials produce more rigid restorations and generate less stresses at the interface. On the other hand, composites with lower elastic modulus values are less rigid and generated lower

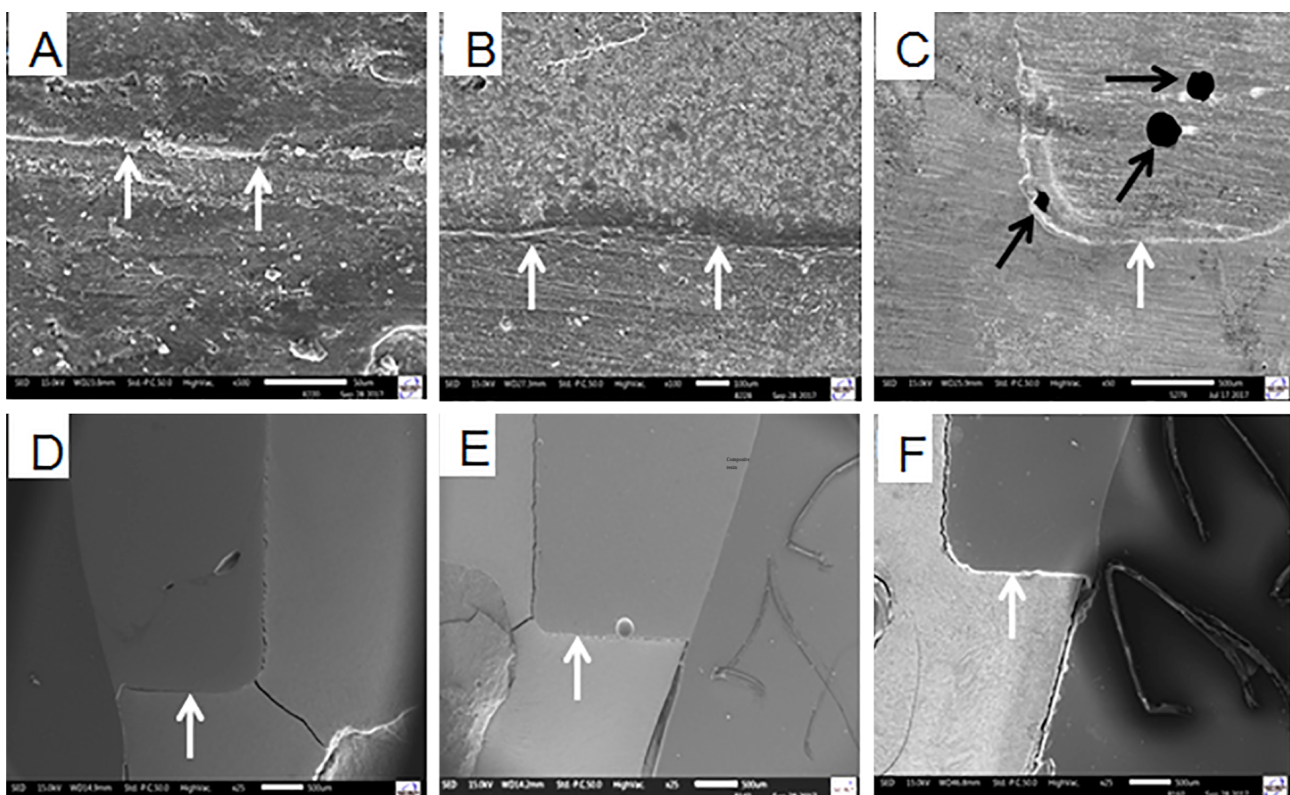


Figure 2. SEM images of the interface. Tetric N-Ceram (A,D); Tetric N-Ceram Bulk-Fill (B,E); SonicFill (C,F). SEM images from the epoxy resin replicas (A,B,C) and SEM images of the sectionated restorations (D,E,F) show continuous margins at the interface with dentin (white arrows). Voids are observed in the SonicFill restorations (black arrow).

stresses inside the composite but higher at the interface as we observed for Tetric N Ceram Bulk Fill (23).

The manufacturer claims that SonicFill composite resin has a depth of cure of 5 mm. It has a specific handpiece that provides sonic energy at different intensities which facilitates the placement of the composite resin. As the sonic energy is applied through the handpiece, the built-in modifier causes the viscosity to decrease (up to 87%) during the insertion of the composite resin. When the sonic energy is interrupted, the composite resin returns to a more viscous state, suitable for sculpturing. The manufacturer claims that this helps to fill a large cavity without voids. However, voids were observed at the dentin interface only for SonicFill in the analysis by SEM. These voids could compromise the sealing and influence bond strength. In addition, the restorative procedure using the SonicFill system seems more difficult, and even an operator with skills could have difficulties controlling the flow of the material using the ultrasonic device. Furthermore, for practitioners who are still beginners, very careful training should be completed before performing clinical restorations.

In the present study, the photo-activation was performed in the same way with all materials, and the light was applied with total intensity right from the beginning of the process. It has been shown that continuous and fast polymerization can cause an increase in discontinuity of the interface between composite resin and dental structure (24). For this reason, it has been suggested that the soft-start polymerization technique could bring better results, since this technique starts with a lower intensity light and then increases after 5 or 10 s. It prolongs the pre-gel stage to better accommodate the newly formed polymer molecules. As a consequence, the composite resin flow is improved, and the internal shrinkage stress of the material is relaxed, reducing the stresses inside the structure and enhancing marginal integrity (25). However, continuous polymerization is the most common technique of photo-activation applied by professionals. Using this technique of photo-activation, all composite resins in the present study showed discontinuity at the margin.

Considering the limitations of this study, it was possible to conclude that SonicFill obtained a slightly higher interfacial stress and lower bond strength to dentin in comparison with Tetric N-Ceram and Tetric N-Ceram Bulk-Fill. Continuous margin interfaces were obtained for Tetric N-Ceram, Tetric N-Ceram Bulk-Fill, and SonicFill. However, voids were observed in the SonicFill restorations.

Resumo

O objetivo foi avaliar a resistência de união à microtração (RU_μT) à dentina e o estresse interfacial em cavidades classe II restauradas com resina composta de incremento único ou convencional e as interfaces

marginais. Cavidades classe II na face mesial, com margem gengival em dentina, foram confeccionadas em 72 terceiros molares, sendo divididos em grupos (n=24): Grupo 1-Tetric N-Ceram; Grupo 2- Tetric N-Ceram Bulk-Fill; Grupo 3- SonicFill. O Sistema adesivo Clearfil SE Bond foi usado em todos os grupos. Metade dos dentes de cada grupo (n=12) foram submetidos à ciclagem termo-mecânica (CTM). Os dentes restaurados (n=9) foram cortados perpendicularmente para obter palitos que foram submetidos ao teste de RU_μT na máquina-EMIC. As margens cervicais em dentina dos dentes restaurados (n=3) foram observadas em microscopia eletrônica de varredura (MEV) por meio de réplicas em resina epoxy, assim como os cortes das restaurações. O estresse interfacial após a aplicação da carga foram calculadas por análise de elementos finitos 2D. As médias de RU_μT-MPa seguidas de letras distintas apresentam diferença estatística de acordo com ANOVA e teste de Games-Howell (p<0,05): Antes da CTM: G1-15.68±6.10a; G2-10.08±5.21ab; G3-7.98±3.76b. Após CTM: G1-9.70±5.52a; G2-5.79±1.42a; G3-4.37±1.87a. O estresse interfacial (MPa) foi 4,4 para SonicFill, 3,9 para Tetric N-Ceram e 3,5 para Tetric N-Ceram Bulk-Fill. Imagens em MEV mostraram margens contínuas para todas as restaurações em resina composta. Foi possível concluir que o SonicFill obteve um estresse interfacial ligeiramente mais alto e menor resistência de união à dentina em comparação com o Tetric N-Ceram e o Tetric N-Ceram Bulk-Fill. Interfaces de margem contínua foram obtidas para Tetric N-Ceram, Tetric N-Ceram Bulk-Fill e SonicFill. Entretanto, espaços vazios foram observados nas restaurações do SonicFill.

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