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External Marginal Gap Evaluation of Different Resin-filling Techniques for Class II Restorations—A Micro-CT and SEM Analysis

CS Sampaio • GA Garcés • N Kolakarnprasert • PJ Atria • M Giannini • R Hirata

Clinical Relevance

Secondary caries are the main reason for the failure of restorations, class II being the most affected. Techniques that promote less gap percentage are important. Flowable bulk fill composites used at such locations have been shown to decrease gap formation while being a faster procedure than an incremental technique.

SUMMARY

Purpose: To evaluate gap formation of class II restorations, resin-filling techniques using microcomputed tomography (µCT) and scanning electronic microscopy (SEM) are discussed.

Methods and Materials: Class II cavities were prepared in 30 third molars and analyzed in distal and mesial views. Prime&Bond Universal adhesive was applied in all teeth and divided into five groups (n=6): G1, SS+HIT (Spectra Smart+Horizontal Incremental Technique); G2, SS+OBL (Oblique Incremental Technique); G3, SDR+BFT (Surefil SDR+Bulk Fill Technique); G4, SDR+SS (SDR placed on cervical floors from mesial and distal boxes (not light cured), followed by incremental layering with SS and light curing incrementally with the horizontal technique); and G5, BEZ+BFT (Bulk EZ+BFT). All light-curing procedures were performed with high-mode/1200 mW/cm^2, Bluephase Style 20i. Teeth were scanned twice (first scan, empty tooth; second scan, filled tooth after light curing) by µCT.

*Camila S Sampaio, DDS, MS, PhD, assistant professor, Department of Biomaterials, College of Dentistry, Universidad de los Andes, Santiago, Chile

Gonzalo A Garcés, DDS, Department of Biomaterials, College of Dentistry, Universidad de los Andes, Santiago, Chile

Nantawan Kolakarnprasert, DDS, MS, Department of Biomaterials and Biomimetics, New York University College of Dentistry, New York, NY, USA

Pablo J Atria, DDS, MS, assistant professor, Department of Biomaterials, College of Dentistry, Universidad de los, Chile

Marcelo Giannini, DDS, MS, PhD, assistant professor, Department of Restorative Dentistry, Piracicaba Dental School, University of Campinas, Piracicaba, Brazil

Ronaldo Hirata, DDS, MS, PhD, assistant professor, Department of Biomaterials and Biomimetics, New York University College of Dentistry, New York, NY, USA

*Corresponding author: Av Monseñor Alvaro del Portillo 12455, Santiago, Chile; e-mail: csampaio@miuandes.cl

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Acquired μCT data were evaluated with software looking for gaps at the external mesial and distal margins and submitted to statistical analysis (one-way analysis of variance and least significant differences *post hoc* test). Validation of the μCT analysis was performed by SEM.

Results: G5 showed the lowest gap formation percentage, similar to G4 (p=0.20). G4 also showed statistical similarities to G1 and G3 (p>0.05). G2 showed the highest percentages, similar to G1 (p=0.10) but different from the rest of the groups (p<0.05). SEM validated the μCT technique by showing qualitative similar images regarding external marginal gap.

Conclusions: The dual-cure composite and the use of flowable nonpolymerized plus horizontal filling technique showed the best marginal adaptations. The μCT technique was validated for visualization of gap formation after being compared to the SEM technique.

INTRODUCTION

The current composition of dental resin composites allows their use in a variety of applications in the dental field, including but not limited to restorative procedures.[1] However, although the composition of composites has significantly evolved since their introduction, they still lack antibacterial properties and seem to favor the growth of cariogenic bacteria on their surfaces.[2] Thus, recurrent caries is one of the main reasons for resin composite restorations to fail or need replacement.[3,4]

Even though a perfect marginal seal is considered impossible to achieve, clinicians should aim to obtain adaptations that are as good as possible,[5] as it was observed that the bigger a gap is between the restoration and the tooth, the bigger it will become with time and the higher the microleakage at that specific surface will be.[6,7] The presence of gaps at the composite-tooth interface and subsequent microleakage of bacteria have long been considered to be the cause of recurrent caries wall lesions.[2,8]

Apart from marginal sealing and the characteristics of the material itself,[7] as recurrent caries is a multifactorial disease, other factors can also influence the survival rate of resin composite restorations, such as the skill of the clinician,[7] the caries risk of the patient,[9] the type of dental substrate on which the composite will be placed and bonded,[7,10] the cavity size,[11] the restorative technique used,[12] and the position of the tooth in the mouth,[2,11] among others. In this context, it is clearly stated in the literature that class II restorations are more prone to secondary caries and failures than class I restorations.[2] When performing class II restorations, however, it is obvious that the clinician cannot control all of the above-mentioned aspects. Still, what the clinician can control are the materials and techniques that will be used.

The incremental filling technique has been recommended for a various number of aspects, such as decreasing polymerization shrinkage stress[13] and promoting adequate light penetration[12] within the mass of the composite. However, disadvantages have also been mentioned and include the possibility of trapping voids within layers of composite during insertion and longer working times,[2,14] which can also increase the possibility of contamination when performing the restoration.[15] A newer class of material, the so-called bulk fill composites, surpasses those difficulties by modifying monomeric and loading composition.[12] Such composites present a higher translucency and incorporate a photoactive group in the methacrylate resin that allows for an adequate degree of cure within a 4-mm depth cavity and the lower shrinkage stress than conventional composites,[15] resulting in a quicker restorative procedure. Moreover, the composition of these materials allows for a modulated polymerization reaction by use of special stress-relieving monomers, the use of more reactive photoinitiators, and the incorporation of different types of fillers, such as prepolymer particles and fiberglass rod segments.[12]

Further improvements regarding such material relate to polymerization stress, which is considered one of the major drawbacks of direct composite restorations.[16] Shrinkage stress is influenced by cavity configuration and size as well as its compliance;[16] important properties influencing shrinkage stress are volumetric shrinkage and elastic modulus of the composites.[16] A recent literature review showed that depth of cure of such bulk fill composites is increased when compared to conventional composites, likely due to its increased translucency.[16] SDR, a flowable bulk fill resin composite, has been shown to present increased depth of cure[17] with decreased polymerization stress[16] and shrinkage[18] when compared to several other resin composites. Another class of resin composite material that also seems to present an advantage consists of the dual-curing resin composites; previous findings showed that chemical-cured core buildup composites lead to a significantly lower stress than light-cured ones.[19] Today, new dual-curing resin composites are available for the clinician, although they still lack scientific reports.

However, when it comes to marginal adaptation, results of studies seem to be controversial. On the one hand, most of the studies observe gaps in the internal margin of the restoration,[12,20–24] while it is markedly noted that the external proximal and cervical proximal margins in class II restorations are often considered to be their Achilles' heel,[25] as dentin bonding is often less predictable.[7,10,25] On the other hand, some authors state that the use of a flowable composite as a lining for the restoration promotes better composite adaptation,[20] while others show that thick flowable increments can promote higher degradation of the restoration due to the flowable resin's characteristics. It has also been shown that flowable bulk fill composites can demonstrate inferior internal adaptation in gingival walls compared to packable bulk fill composites in class II restorations, showing higher degradation.[21] Controversies also are related to the use of the incremental layering technique versus bulk filling, with some studies defending the use of different types of incremental layering (eg, oblique or horizontal),[26] while others defend the use of bulk filling.[12]

For evaluating marginal adaptation, different methodologies can be performed. Commonly, destructive methodologies are available, such as the use of dies and the sectioning of specimens to enable visualization of the margins through different types of microscopes or by replicas.[7,10,12,20,24,27] Currently, modern technologies allow for the evaluation of marginal adaptation without the need to destroy the specimens. Nondestructive technologies involve optical coherence tomography[22,23,28] and microcomputed tomography (μCT).[21,23,29] Although the first presents limited depth for visualization[22,23,28] because of a limitation of the technique, μCT allows for a 3D evaluation of the entire cavity, also enabling different types of parameters and tests to be analyzed for the restoration within the same scan.[21,29] Moreover, μCT has a series of different purposes, such as to quantify and evaluate polymerization shrinkage[18] and to evaluate voids within fiber-post cementations[30] and the film thickness of veneer cementations,[31] among others.

Thus, the aim of this study was to compare the external marginal adaptation at proximal boxes of different resin composites and filling techniques, using μCT scanning and validated by scanning electronic microscopy (SEM). The hypotheses tested were 1) that different resin filling techniques promote different percentages of gap formation on class II cavities and 2) that the μCT technique is effective for evaluating external gap formation when compared to the destructive technique of SEM that is evaluated qualitatively.

METHODS AND MATERIALS

The materials and their manufacturers, composition, and batch number are described in Table 1. Thirty human molars free of caries were obtained according to protocols approved by the ethical committee. Sample size was determined according to previous studies.[27–29] Teeth had their roots cut and their cusps flattened. After that, standardized class II cavities (2.5-mm occlusal depth×4 mm wide×4 mm mesial box depth and 1 mm beyond the cemento-enamel junction distal box depth) were prepared in each tooth ($n=6$ per group) and analyzed in distal and mesial views. In the mesial box, 4-mm-depth preparations were done in all teeth, while in the distal box, cemento-enamel junctions were visually detected and preparations done 1 mm beyond them to have a cementum margin. Cavities were prepared using two diamond burs (codes 845kr018 and 868A021, Brasseler, Savannah, GA, USA), which provided a standardized active head size to deliver consistent cavity preparation depth. Burs were changed after every five preparations. The final cavity dimensions were then checked with a digital caliper.

After that, teeth were divided into five groups: G1, SS+HIT (Spectra Smart, Dentsply Sirona+Horizontal Incremental Technique); G2, SS+OBL (Spectra Smart+Oblique Incremental Technique); G3, SDR+BFT (Surefil SDR Flow, Dentsply Sirona+Bulk Fill Technique); G4, SDR+SS (Surefil SDR Flow placed on the cervical floors from the mesial and distal boxes from the class II cavity and not light cured), followed by incremental layering of conventional composite Spectra Smart and light curing incrementally with the horizontal technique; and G5, BEZ+BFT (Bulk EZ, Danville Materials+Bulk Fill Technique). For all teeth, the adhesive protocol used was Prime&Bond Universal adhesive (Dentsply Sirona, York, PA, USA) applied according to the self-etch protocol of the manufacturers' instructions, as most of the adhesion was performed in dentin. All light-curing procedures were performed for 20 seconds at occlusal, mesial, and distal surfaces (high mode/1200 mW/cm^2, Bluephase Style 20i, Ivoclar Vivadent, Schaan, Liechtenstein); when the incremental technique was used, each increment was light cured separately for 20 seconds. The polymerization unit step-over distance was kept constant at approximately 2 mm.

Table 1: *Materials Used in This Study and Their Manufacturers, Composition, and Batch Number*

Material (Manufacturer)	Color	Batch	Composition
Spectra Smart (Dentsply Sirona, York, PA, USA)	A2	2758401	Glass, silica, colloidal hydrophobe, dimethacrylate, benzophenone III, EDAB, FluBlau concentrate, camphorquinone, BHT butylated hydroxytoluene, yellow iron oxide, red iron oxide, black iron oxide, titanium dioxide Filler percentage: 75-77 wt%
Surefil SDR Flow (Dentsply Sirona)	U	1609143	Barium-alumino-fluoro-borosilicate glass, strontium alumino-fluoro-silicate glass, modified urethane dimethacrylate resin, ethoxylated bisphenol A dimethacrylate, triethylene glycol dimethacrylate, camphorquinone, photo-accelerator, butylated hydroxyl toluene, UV stabilizer, titanium dioxide, iron oxide pigments, fluorescing agent Filler percentage: 68 wt%
Bulk EZ (Danville Materials, Anaheim, CA, USA)	A2	42728	Ethoxylated bisphenol A dimethacrylate esters, triethylene glycol dimethacrylate, bisphenol A glycidyl methacrylate, urethane dimethacrylate, fluoride compound, glass compound Filler percentage: proprietary
Universal adhesive Prime&Bond Universal (Dentsply Sirona)		1702004905	Phosphoric acid modified acrylate resin, multifunctional acrylate, bifunctional acrylate, acidic acrylate, isopropanol, water, initiator, stabilizer
Acid phosphoric gel 37% (Maquira, Maringá, Brazil)		015216	Phosphoric acid, chlorhexidine digluconate, thickener, purified water, dye
Bluephase Style 20i light-curing unit (Ivoclar Vivadent, Schaan, Liechtenstein)		1140000142	

Filling techniques are described as follows (Figure 1): G1, SS+HIT: Resin composite was placed in horizontal consecutive layers of 2 mm each, individually for mesial, distal, and occlusal walls. G2, SS+OBL: Resin composite was placed in oblique consecutive layers of 2 mm each, without adhering two opposite walls, individually for mesial, distal, and occlusal walls. G3, SDR+BFT: Flowable composite was placed at the gingival margin without light curing, and the first layer was applied horizontally in a 2-mm layer and light cured; after that, resin composite was placed using the horizontal technique previously described. G4, SDR+SS: Resin composite was placed in one single increment. G5, BEZ+BFT: Resin composite was placed in one single increment.

μCT Analysis

For all groups, teeth were individually scanned before and after resin composite application (first scan, empty tooth; second scan, filled tooth after light activation) by μCT (μCT40, Scanco Medical, AG, Basserdorf, Switzerland). The μCT apparatus was calibrated using a phantom standard at 70 kVp per beam hardening, 200 mgHA/ccm. The operating condition for the μCT device was an energy (70 kVp and 114 mA) with a medium resolution and a voxel size created of 16 μm per slice, using a specimen holder of 16.5 mm. The average of the total number of slices was approximately 250, with an average scan time of 30 minutes per tooth, as previously described.[18]

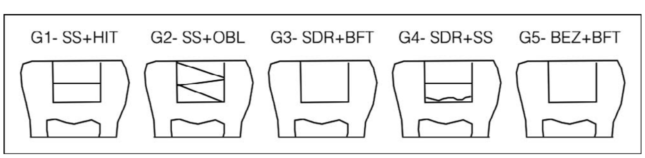
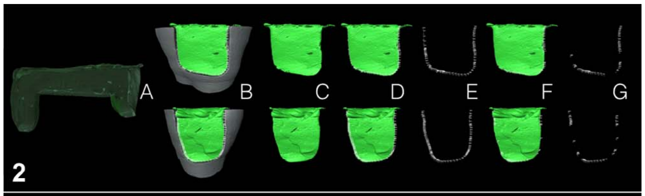
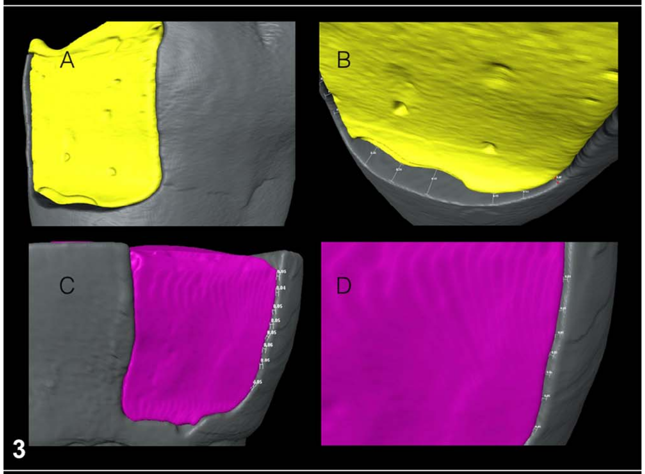


Figure 1. *Filling techniques used in this study. G1, horizontal technique; G2, oblique technique; G3, bulk fill technique; G4, flowable composite placed at the gingival margin without light curing, followed by horizontal technique; G5, bulk fill technique.*

Since enamel, dentin, and resin composite have similar densities, the first scan was performed after cavity preparation but before cavity filling (empty tooth) for all teeth. This procedure allows for posterior subtraction of both scans and acquiring a pure image of the restorations and also minimizes artifacts during the threshold segmentation.

For the second scan, a plastic laboratory sealing film (Parafilm M, SPI Supplies, West Chester, PA, USA) was used as a matrix and placed around each tooth to keep the composites in place for performing the restorations and during the scanning time. Since this matrix presents some level of elasticity, it allows for a good adaptation around the dental tissue, facilitating the placement of the restoration. Moreover, as the sealing film is transparent, light curing could be performed with the film in place. The instrument used for composite placement was a





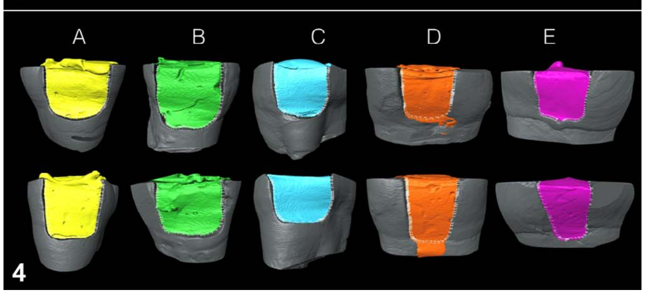


Figure 2. *Schematic depicting image analysis. (A): Restoration outside the tooth cavity. Observe the presence of voids within the composite mass. (B): Restoration observed from mesial and distal surfaces of the tooth. (C): Restoration outside the tooth at mesial and distal views. (D): Measurement of the length of the restoration to be used as total length for analysis of gap percentage. (E): Observation of the total length separated from the restoration and the cavity. (F): Measurement of the gap length within the restoration. (G): Observation of the gap length separated from the restoration and the cavity.*

Figure 3. *Gap measurements were performed from the outer surface of the cavity until its contact with the composite surface, as seen in the white lines. (A): Restoration showing a large gap and a bubble on the cervical wall. (B): Measurement of the maladjustment with the measurement tool. (C): Restoration showing adaptation in the proximal wall. (D): Maladjustment from this wall was checked to see if it was within the limit of 0.06 mm. Maladjustments below this limit were considered as gap-free margins.*

Figure 4. *Representative images of each group for μCT. (A): Group 1 (Spectra Smart, horizontal technique). (B): Group 2 (Spectra Smart, oblique technique). (C): Group 3 (SDR, bulk fill technique). (D): Group 4 (SDR placed on cervical floors, not yet light cured, followed by application of Spectra Smart with the horizontal technique). (E): Group 5 (Bulk EZ dual-curing composite, bulk fill technique).*

resin composite spatula with a burnisher at one end (1 Goldstein Flexi-Thin composite instrument, Ref CIGFT16, Hu-Friedy, Chicago, IL, USA). A single operator performed all restorative steps.

Acquired μCT data were imported into a workstation and evaluated with Amira software (version 5.5.2, VSG, Burlington, MA, USA). Both scans (empty and filled) were superimposed with the software ("superimposition" tool), and a subtraction was performed with the Boolean operation (filled tooth minus empty tooth), obtaining an image of the restoration only. Thresholds of the restorations were visually determined per specimen since the same threshold could not be used for all groups due to the different radiopacities and attenuation levels from the resin composites.

For analysis of gaps and maladjusted mesial and distal margins, the "3D measurement" operation tool was used. Quantification of gaps was performed throughout the entire length of the mesial and distal margins and quantified as percentages. A schematic depicting image analysis is shown in Figure 2. First, the entire length of the contour of the cavity was measured; after that, locations where gaps were identified and measured, and a percentage of the total was considered. Gaps were considered when maladjustments were bigger than 0.06 mm from the outer surface of the external wall toward the axial wall where resin composite was present, according to previous findings.[2,9] If the maladjustment was $>$0.06 mm from the external margin to the resin composite, it was considered a gap; if the maladjustment was $<$0.06 mm, it was not considered a gap. Measurements were performed from the outer surface of the cavity until its contact with the composite surface (Figure 3). Images from μCT scans for each group can be seen in Figure 4.

Data were checked for normality and analyzed by a one-way analysis of variance (ANOVA), and a least significant differences *post hoc* test was carried out using 95% confidence intervals. The software used was SPSS Statistics (IBM, Armonk, NY, USA).

SEM

SEM was performed for validation of the gaps and misfits observed in the μCT analysis. Each tooth was sectioned in the middle of its restoration (from mesial to distal) in its long axis in order to allow visualization of the mesial and distal margins of the restoration (Figure 5), which was also where μCT analyses were performed. SEM images were qualitatively compared with the μCT images in order to check if gaps were present or absent (Figure 6). Variable-pressure secondary electron (SEM) images were acquired with a Zeiss EVO 50 (Carl Zeiss Microscopy GmbH, Jena, Germany) in a vacuum of 20 Pa, an accelerating voltage of 15 kV, and a working distance of 13.5 mm at 5.716-mm field width.

Table 2: *Mean (%±SE) of Gap Formation (n=6, Two Sides) Determined for Each Class II Restoration Technique Observed Through μCT*[a]

Group	Gap Formation (%)
G1: SS+HIT	76.1 (5.8) AB
G2: SS+OBL	89.1 (2.9) A
G3: SDR+BFT	70.5 (1.9) B
G4: SS+SDRNP	64.0 (5.7) BC
G5: BEZ+BFT	53.7 (8.9) C

[a] *Means followed by different letters differ from each other in the same column* (p<*0.05).*

RESULTS

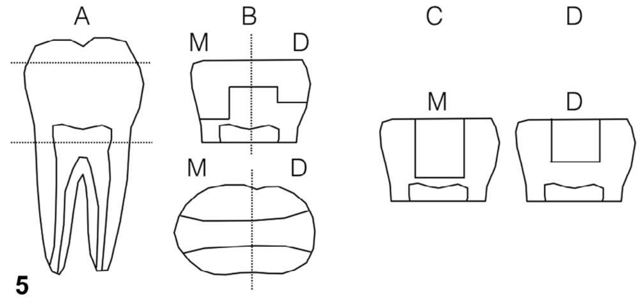
Table 2 shows the gap formation mean percentages determined for each class II restoration technique. One-way ANOVA revealed that there were significant differences between groups ($p<0.05$). Figure 4 shows a representative image obtained from a μCT scan for each group. Figure 6 shows representative images of each group for both μCT and SEM analysis.

Group 5, representing the bulk fill technique with the dual-curing composite, showed the lowest percentages of gap formation in the resin/dentin external marginal interface and did not differ from group 4, which represented the SDR resin composite unpolymerized with the addition of a conventional composite ($p>0.05$). Group 4 was also not statistically different than group 3, representing the SDR bulk fill technique ($p>0.05$). Group 2, the oblique incremental technique, was shown to be the technique with the highest amount of gap formation percentages, not statistically different than the horizontal incremental technique (group 1) ($p>0.05$), both incremental techniques being performed with a conventional composite.

Qualitatively, it was observed that most of the gaps were observed on the cervical floor rather than in the proximal walls. Such results were validated by the images acquired by SEM, as seen in Figure 6. Gap observation in the SEM images corresponded to the same location where gaps were observed in the μCT images.

DISCUSSION

Gap formation around composite restorations has been previously described in the literature; however, controversies still exist regarding the ideal technique for decreasing its formation. The present study focused on characterizing different filling techniques for class II restorations in order to observe how gap



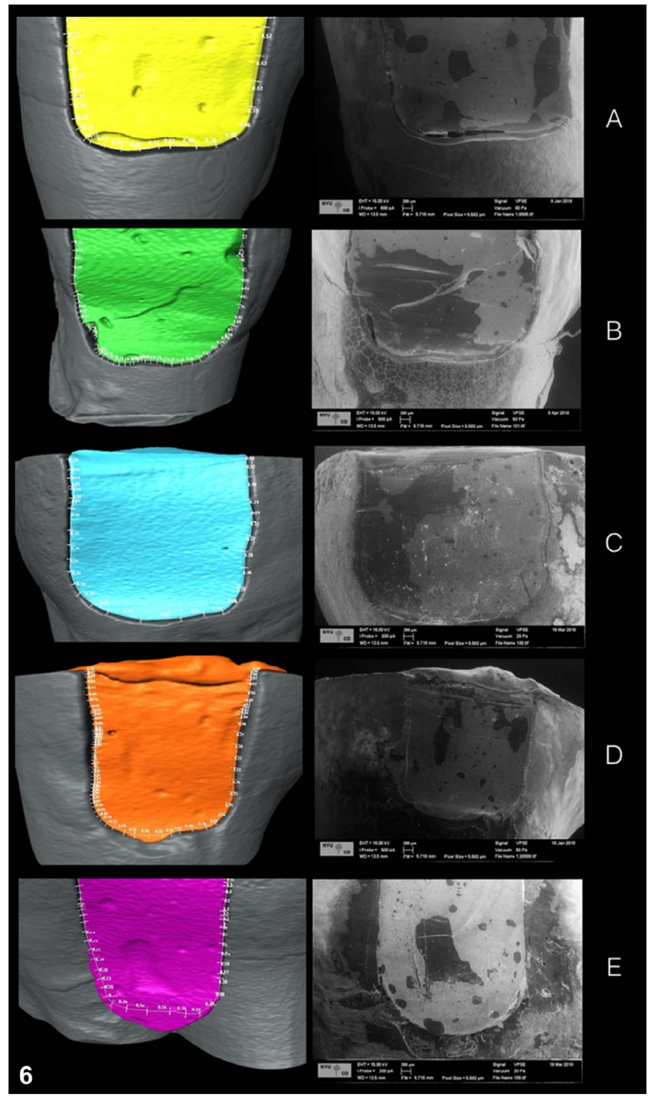


Figure 5. *Schematic depicting image analysis scanning electron microscopic specimen preparation. (A): Teeth had their roots cut and their cusps flattened. (B): After microcomputed tomographic scans, each tooth was sectioned in the middle of its restoration (from mesial to distal) in its long axis. (C): Visualization of the mesial margin of the restoration. (D): Visualization of the distal margin of the restoration.*

Figure 6. *Representative images correlation within μCT and SEM. Qualitatively, it was observed that most of the gaps were observed at the cervical wall rather than in the buccal/lingual walls. One can observe specimens that showed spreading of the material beyond the margin. A correlation was observed within the images from μCT and SEM. μCT, microcomputed tomography; SEM, scanning electron microscopy.*

formation can be decreased in the external interproximal margins of these procedures. Such margins (external interproximal mesial and distal) of class II restorations were chosen since it was observed that they are the type of restorations with the highest incidence of secondary caries formation,[2] usually located gingivally (or at cervical margins).[32] Moreover, it was observed that after aging, marginal adaptation in dentin is decreased.[7]

Since there is no accepted specific threshold for determining the correlation between gap size and wall lesion, the one used in the present study was 0.06 mm, any maladjustment bigger than this being considered a gap. This threshold was chosen because a recent study observed that a gap of about 60 μm may lead to the development of a wall lesion and predispose interfacial demineralization,[2,9] which is much less than what was previously thought, explaining the much higher values of gap percentages in this study, reaching from 53.7% to 89.1% of external proximal marginal gap when compared to other studies that showed much less a percentage of internal and external gap formation.[6,27,29] Results from a recent study showed that no matter which insertion technique was used, all resin composites present polymerization shrinkage, voids, and gaps[6] in accordance with our study. Findings from the current research indicate that different filling techniques do affect gap formation on the external interproximal margins of class II restorations, thus accepting the first hypothesis.

In this study, it was observed that the use of a flowable composite, being either the dual-curing bulk fill composite (Bulk EZ), the flowable bulk fill composite (SDR), or a combination of the nonpolymerized bulk fill flowable with incremental filling, resulted in lower percentages of gap formation than when the incremental filling technique was used purely with a conventional composite. The placement of low-viscosity materials provided better adaptation to the cavity walls. For groups 4 and 5, an excess of resin composite in the cervical floor for all of the specimens and for half of the specimens, respectively, caused by the spreading of the material in this region was observed, decreasing thus the gap formation. For group 3, this also occurred but was limited to one specimen only, while for the other specimens, the material flowed until the margin or a bit before the margin, thus causing a gap formation. For groups 1 and 2, spreading of the material was not observed beyond the cervical margins of the teeth for any specimen. The presence and absence of spreading of material beyond the margins of the teeth explain the statistical differences within groups. The gingival margin of class II restorations is the most susceptible for recurrent caries and also the place where more misfits, maladjustments, and gaps occur.[25] When such regions were covered with an excess of resin composite, such gaps were prevented from forming, thus decreasing the gap percentage of the restorations. Groups 1 and 2 showed, for all specimens, gaps in the cervical floor, explained by the lack of spreading at this region. It is believed that, for group 4, excess of material occurred for all specimens since this technique requires slight pressure in the conventional resin layer after the flowable material is applied and before it is light cured.

Obviously, flash of material is also of concern since it can lead to overhangs in the restoration, which were documented as promoting the trapping of food, periodontal problems, and subsequent recurrent caries.[33,34] Thus, mostly when flowable materials are used, it is important to observe using dental floss if this excess of material is leading to an overhang at the interproximal margins of the restoration. According to the authors' visualization in such restorations, the excess of material was not sufficient to promote overhangs that could lead to such problems for any group, although it could be a subject for future studies.

Another topic that can be related to the findings from this study is that, in a previous study, it was observed that in the postgel period, shrinkage is counteracted by adherence and by plastic flow of the resin composite;[27] the authors mentioned that the higher the plastic flow, the longer the resin composite can withstand gap formation and the smaller the resulting gap.[27] This observation can explain our results, which showed better marginal adaptation and lower gap formations when flowable composites were used. The flowability of resin composites is a determinant of gap formation, mostly in dentin cavities,[27] since they are less viscous materials that can flow easily and adapt well to the tooth surface.[20] They also serve as a flexible intermediate layer that absorbs stress during polymerization shrinkage stress of composite resin.[20]

However, the use of thick layers of flowable resin composite can also cause higher polymerization shrinkage because of the lower filler content in relation to conventional resin composites, although it depends on the type of flowable material.[35] Nevertheless, this is not the case in our study since the flowable composite used was a bulk fill flowable composite type, which has been proven to present less polymerization shrinkage than some conventional packable and flowable composites[12,18] and similar depth of cure in the entire 4-mm extension of cavities.[12] Polymerization shrinkage and depth of cure of the studied dual-curing composite has not been studied to date to the authors' knowledge.

It was observed that the μCT technique was an effective tool for the evaluation of external interproximal gap formation visualization, validated against SEM, a destructive technique, thus accepting the second hypothesis. The microcomputed analysis has shown to be efficient at a series of different uses,[6,18,21,31] and its nondestructive aspect undoubtedly presents an advantage for *in vitro* studies.

Limitations of this study include the fact that the authors used a self-etch approach with a universal adhesive; possibly, by using a selective enamel etching technique, gap percentages could have been different where enamel is present. Moreover, gaps on class II cavities also depend on the anatomy of the teeth. To reduce the variation of tooth anatomy, teeth were chosen according to the most adequate anatomy to adapt in the matrix used (ie, Parafilm, which presents good adaptation in the cavity walls), and after that, teeth were assigned randomly within the groups. It was observed that marginal deterioration is a sensitive predictor of failure of a posterior composite;[36] thus, future studies should evaluate the size of gap related to wall lesion after demineralization through μCT since it was observed in this study that the size of gap and its extension are easily measurable through this method.

CONCLUSIONS

The results from this study suggested the following:

1) The use of flowable bulk fill composites at the gingival wall of class II restorations, being used either in a dual-curing technique, a conventional bulk filling technique, or a flowable bulk fill resin composite in combination with conventional incremental resin composite, was shown to be a good alternative for decreasing the percentage of gap formation besides being a faster procedure when compared to incremental technique.
2) The bulk fill techniques, along with the reported technique of filling the cervical floor with the flowable composite without polymerization and posterior filling with the incremental technique with a conventional composite, performed better than incremental resin composite filling techniques when gap percentages in the external class II proximal areas were analyzed. An excess of material was observed in all flowable composite groups, although it was shown not to be a problem involving overhang after being observed with dental floss.
3) The nondestructive μCT technique was shown to be an effective alternative tool for external gap formation evaluation when compared to SEM, a destructive technique, which was evaluated qualitatively.

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Regulatory Statement

This study was conducted in accordance with all the provisions of the local human subjects oversight committee guidelines and policies of the University of University of the Andes, Chile.

Conflict of Interest

The authors of this article certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

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