©Operative Dentistry, 2021, **46-2**, 226-233

Effects of Preheating and Sonic Delivery Techniques on the Internal Adaptation of Bulk-fill Resin Composites

G Demirel • AI Orhan • O Irmak • F Aydın • A Büyüksungur • B Bilecenoğlu • K Orhan

Clinical Relevance

The internal adaptation of resin composites that are recommended to be placed with the conventional insertion technique could be improved when the resin composites are preheated prior to their placement. SonicFill 2 and VisCalor bulk show the best internal adaptation when they are inserted as per the manufacturer's recommended techniques.

SUMMARY

Objective: To compare the effects of conventional (hand-placed), sonic, or preheated insertion techniques on the internal adaptation of bulk-fill resin composites.

Methods and Materials: A total of 150 freshly extracted human third molars were used to prepare standardized cylindrical occlusal cavities. Teeth were divided into five main groups according to the resin composites: 1 incremental (Clearfil Majesty Posterior [CMP]) and four paste-like bulk-fill (SonicFill 2 [SF2], VisCalor bulk [VCB], Filtek One bulk-fill restorative [FBR], and Tetric EvoCeram bulk-fill [TEB]). Each main group was divided into three subgroups according to the placement technique: conventional, preheating, and sonic delivery (n=10). In the conventional placement

Gülbike Demirel, DDS, PhD, Ankara University, Faculty of Dentistry, Department of Restorative Dentistry, Ankara, Turkey

Ayşe Işıl Orhan, DDS, PhD, Ankara Yildirim Beyazit University, Faculty of Dentistry, Department of Pediatrics Dentistry, Ankara Turkey

Özgür Irmak, DDS, PhD, Near East University, Faculty of Dentistry, Department of Restorative Dentistry, Nicosia, Turkey

Fulya Aydın, DDS, PhD, Ankara University, Faculty of Dentistry, Department of Restorative Dentistry, Ankara, Turkey

Arda Büyüksungur, PhD, BIOMATEN, Center of Excellence Biomaterials and Tissue Engineering, Middle East Technical University (METU), Ankara, Turkey

Burak Bilecenoğlu, DDS, PhD, Ankara University, Faculty of Dentistry, Department of Basic Medical Sciences, Ankara, Turkey

*Kaan Orhan, DDS, PhD, Department of Dentomaxillofacial Radiology, Faculty of Dentistry, Ankara University, and Ankara University Medical Design Application and Research Center (MEDITAM), Ankara, Turkey

*Corresponding author: Department of Dentomaxillofacial Radiology, Faculty of Dentistry, Ankara University, 06500, Ankara, Turkey; e-mail: kaan.orhan@kuleuven.be

http://doi.org/10.2341/19-241-L

technique, cavities were filled manually. In the sonic insertion technique, a specific handpiece (SonicFill Handpiece; Kerr Corporation) was used. In the preheating technique, a heating device (Caps Warmer, Voco, Cuxhaven, Germany) was used to warm the resin composites before placement. Internal voids (%) of the completed restorations were calculated with microcomputed tomography. Data was analyzed with two-way analysis of variacne followed by Tukey's multiple comparisons test (α=0.05).

Results: All resin composites showed fewer internal gaps with preheating compared with the conventional placement (*p*<0.05). For all resin composites other than SF2, preheating provided fewer internal gaps than that of the sonic placement (*p*<0.05). Sonic placement led to fewer internal gaps compared with the conventional placement, but only for SF2 and FBR (*p*<0.05). For the conventional placement, the lowest gap percentage was observed with the incremental resin composite (CMP, *p*<0.05). Among all groups, the lowest gap percentages were observed for preheated VCB followed by sonically inserted SF2 (*p*<0.05).

Conclusion: The best internal adaptation was observed in sonically inserted SF2 and preheated VCB, which were the manufacturers' recommended insertion techniques. Preheating considerably improved the internal adaptation of all resin composites, except for that of SF2.

INTRODUCTION

Bulk-fill resin composites are considered efficient alternatives to traditional resin composites for posterior restorations. As they allow for filling deeper cavities with fewer increments, or even a single increment, they have become very popular in recent years. However, gap formation between the bulk-fill resin composite and the tooth structure remains a significant issue.[1,2] These internal gaps could permit dentin fluid transduction in the region,[3] and this could elicit the degradation of the hybrid layer,[4] which adversely affects the longevity of the restoration.

Other than the clinician's operative skill, polymerization shrinkage stress could influence the internal adaptation of resin composites.[5] Shrinkage stress is a highly complex issue, and it is affected by many factors such as cavity size,[6] the ratio of bonded to unbonded surfaces (the configuration factor [C-factor]),[7] compliance of the cavity wall,[8] filler content of the resin composite,[9] the structure of the organic matrix,[10] the polymerization shrinkage rate,[9] and the viscoelastic properties[11] of resin composite materials.

It is well known that in a high cavity C-factor, the internal adaptation is inferior to that of a low cavity C-factor for both conventional and bulk-filled resin composites.[6] In addition to the C-factor and material-dependent properties, the placement technique of resin composite restorations may also affect their internal adaptation.[5] Flowable resin composites may enhance the internal adaptation of the restoration due to their lower viscosities and self-leveling properties.[12,13] A more viscous resin composite material may adversely affect its adaptation.[14] Different techniques have been proposed to facilitate the placement of resin composites and to improve adaptation to the cavity walls without changing the mechanical properties of the material. The preheating of resin composites reduces film thickness and viscosity, thus increasing flowabilty[15] and improving their adaptation.[16] Another technique is to reduce the viscosity by vibration to improve adaptation. For this purpose, a specially designed handpiece-type device, SonicFill (Kerr Corporation, Orange, CA, USA), has been introduced, which creates sonic energy that lowers the viscosity of the resin composite during placement.

The two abovementioned placement techniques may lead to different outcomes depending on the brand of the bulk-fill material used. Despite several studies that have examined the internal and marginal adaptation of bulk-fill resin composites, to the best of the authors' knowledge, there are no studies that have compared the effects of different insertion techniques on the internal adaptation of bulk-fill resin composites. The purpose of this investigation was to evaluate the effects of different insertion techniques (conventional [hand-placed], sonic, or preheating) on the internal adaptation of different bulk-fill resin composites in cylindrical Class I cavities, as assessed by microcomputed tomography (micro-CT). The null hypotheses tested were that 1) the insertion techniques would not affect the internal adaptation of bulk-fill resin composites, and 2) there would be no difference between different bulk-fill resin composites by means of internal adaptation.

METHODS AND MATERIALS

This study was conducted in accordance with all the provisions of the World Medical Association Declaration of Helsinki and the University Faculty of Dentistry's local human subjects oversight committee guidelines and policies of the ethics committee for the study of humans and animals.

Tooth Selection and Cavity Preparation

A total of 150 extracted human third molar teeth, free of caries, hypoplastic defects, or cracks were included in the study. Teeth were stored in 0.5% chloramine-T solution at 4°C after extraction and were used within 14 days. Occlusal surfaces were trimmed with a cutting machine (Micracut 201; Metkon, Ankara, Turkey) under water-cooling to obtain enamel-free, flat dentin surfaces. Cylindrical cavities measuring 5 mm in diameter and 2 mm in depth were prepared in each tooth's occlusal surface using a flat disk-shaped diamond bur (5 mm in diameter, 2 mm in length; 822-806-314-042-524-050; Meisinger GmbH, Neuss, Germany) attached to a high-speed air turbine. A new bur was used for each cavity preparation.

Restorative Procedures

One paste-like resin composite (Clearfil Majesty Posterior [CMP]; Kuraray, Okayama, Japan) suited for the incremental technique (incremental resin composite) and four paste-like bulk-fill resin composites (SonicFill 2 [SF2], Kerr Corporation; VisCalor Bulk [VCB], Voco, Cuxhaven, Germany; Filtek One bulk-fill restorative [FBF], 3M ESPE, St Paul, MN, USA; and Tetric EvoCeram bulk-fill [TEB]. Ivoclar Vivadent, Schaan, Liechtenstein) were evaluated (Table 1). Teeth

Table 1: *Material Type and Compositions of Resin Composites Used in This Study (Information as Disclosed by the Manufacturers)*

Material	Material Type	Recommended Insertion Technique	Shade	Matrix Composition	Filler % by Weight	Recommended Maximum Thickness	Recommended Curing Time and Irradiance for Each Layer	Manufacturer
SF2	Bulk-fill paste-like	Sonic	A2	Poly(oxy-1,2-ethanediyl), α,α′ -[(1-methylethylidene) di-4, 1-phenylene] bis[ω-[(2- methyl-1-oxo-2-propen-1-yl)oxy], 2,2′ -ethylenedioxydiethyl dimethacrylate	81.3	5 mm	10 s, ≥1000 mW/cm^2	Kerr Corporation, Orange, CA, USA
VCB	Bulk-fill paste-like	Preheat	A2	Bis-GMA, aliphatic dimethacrylate, inorganic fillers	83	4 mm	20 s, ≥1000 mW/cm^2	VOCO GmbH, Cuxhaven, Germany
FBR	Bulk-fill paste-like	Conventional	A2	AUDMA, AFM, DDMA, UDMA, ytterbium trifluoride, zirconia/slica	76.5	5 mm	10 s, 1000–2000 mW/cm^2	3M Dental Products, St Paul, MN,USA
TEB	Bulk-fill paste-like	Conventional	IVA (A2)	Bis-GMA, UDMA, Barium glass, YbF3, prepolymer, additives, catalysts, stabilizers, and pigments	76-77	4 mm	10 s, ≥1,000 mW/cm^2	Ivoclar Vivadent; Schaan, Liechtenstein
CMP	Conventional paste-like	Conventional	A2	Bis-GMA, TEGDMA, hydrophobic aromatic dimethacrylate, glass ceramics, surface-treated aluminamicro filler; 1.5 mm, 20 nm	92	1.5 mm	20 s, >300 mW/cm^2	Kuraray, Okayama, Japan

Abbreviations: AFM, addition fragmentation monomer; AUDMA, aromatic urethane dimethacrylate; Bis-GMA, bisphenol A glycidylmethacrylate; CMP, Clearfil Majesty Posterior; DDMA, 1, 12-dodecanediol dimethacrylate; FBR, Filtek One bulk-fill restorative; s, seconds; SF2, SonicFill 2; UDMA, diurethane dimethacrylate; TEB, Tetric EvoCeram bulk fill; TEGDMA, triethylene glycol dimethacrylate; VCB, VisCalor bulk.

were randomly and equally divided into five main groups according to the tested resin composites, then each main group was divided into three subgroups according to the placement technique: conventional (hand-placed), preheating, and sonic delivery (n=10). Prior to the application of the restorative materials, a universal adhesive (Single Bond Universal; 3M ESPE) was applied on the dry cavity surfaces in self-etch mode and light cured for 10 seconds.

For the conventional (hand-placed) resin composite insertion technique, unidose compules were attached to the dispenser (Prisma compules gun dispenser; Dentsply Sirona, Bensheim, Germany). The incremental resin composites were applied into the cavity from the pulpal floor to the occlusal surface, and vertical pressure was applied using a resin composite filling instrument (Polyfill, 1051/95; Carl Martin GmbH, Solingen, Germany).

For the preheating resin composite insertion technique, the resin composites were first heated with a preheating device for compules (caps warmer; Voco GmbH) at 68°C for three minutes. Then, the preheated resin composites were applied into the cavity immediately after removal from the preheating device and from the pulpal floor to the occlusal surface. The mean time between removing the compules from the device and light polymerization was approximately 30 seconds.

For the sonic insertion technique, the resin composites were transferred from each original compule into a SonicFill compule (Kerr Corporation) to be compatible with the SonicFill handpiece (Kerr Corporation) as described in the study of Hirata and others.[17] Sonication was generated by the handpiece attached at speed level 3. The sonically activated resin composites were inserted into the cavity from the pulpal floor to the occlusal surface.

All bulk-fill resin composites were placed into the cavity as a single increment, then the top surfaces were covered with a polyester strip and a 1-mm thick glass slide. Each bulk-fill resin composite was light cured according to the manufacturer's instructions, and the curing tip was constantly contacting the glass slide. The incremental resin composite was placed in two increments as required by the manufacturer's guidelines. A 1-mm increment was placed and light cured, then the second 1-mm increment was placed. Similar to the bulk-fill resin composites, the topmost surface of the incremental resin composite was covered with a polyester strip and a 1-mm thick glass slide, and was light-cured in a similar manner.

A light-emitting diode light curing unit (SDI Radii Plus; SDI, Bayswater, Victoria, Australia) was used for polymerization of the adhesive and resin composites. A radiometer (Hilux Ledmax Curing Lightmeter; Benlioşlu Dental, Ankara, Turkey) was used tto monitor the light output of the unit to ensure that radiant emittance was over 1000 mW/cm^2 before each curing step. After the polymerization of the resin composites, the occlusal surfaces of the restorations were wet-finished with a series of graded aluminum oxide disks: coarse, medium, and fine (Sof-Lex; 3M ESPE). All restorative procedures were performed by a single operator with 16 years of experience (GD). Specimen preparation and testing were performed at a controlled room temperature (25°C). Teeth were kept in distilled water at 37°C during the experiment, except throughout the restorative procedures and micro-CT scanning, where they were handled dry.

Micro-CT Scanning and Evaluation

A high-resolution desktop micro-CT system (Bruker SkyScan 1275; Bruker, Kontich, Belgium) was used to scan the specimens. The scanning conditions were as follows: 80 kVp, 125-mA; 1.0-mm Al filter; and 20 μm pixel size and rotation at 0.6 step. To minimize ring artifacts, the air calibration of the detector was carried out before each scan. Each specimen was rotated 360° within an integration time of two minutes. The mean time of scanning was around 12 minutes. Other settings were based on prior scans and reconstructions of the teeth, which included beam hardening correction, as described, and input of optimal contrast limits according to the manufacturer's instructions.

Reconstructions were performed using NRecon software (v 1.6.7.2; SkyScan, Kontich, Belgium) through a modified algorithm described by Feldkamp and others.[18] This modified algorithm was obtained by using a 3-dimensional (3D) density function based on a series of 2-dimensional (2D) projections. The NRecon software, which has this algorithm, was used to create 2D axial images. Other settings included beam-hardening correction, as already described above, and input of optimal contrast limits (0-0.1), which were set prior to the reconstruction of the teeth. Contrast limits were applied following SkyScan instructions. The lowest limit was zero so that the density scale had zero origins. The maximum limit was at the top of the brightness spectrum, representing the highest density value. The image data set was approximately 601 axial tomographic slices, each measuring 1024 x 1024 pixels, with a 16-bit gray level. The CTAn (SkyScan, Aartselaar, Belgium) software was used for the 3D volumetric analysis, and the volume of the specimen was used for the micro-CT. The reconstructed images were further processed in Skyscan CTVox (Skyscan, Aartselaar, Belgium) for visualization. The Dataviewer

(Skyscan, Aartselaar, Belgium) was also used for visualization of the reconstructed images.

To calculate the gaps in 3D volumes, the original grayscale images were processed with a Gaussian low-pass filter for noise reduction, and an automatic segmentation threshold was used to subtract enamel and dentin from the resin composite restorations and gaps using CTAn. A global thresholding (binarization) process was used, which entailed processing the range of gray levels to obtain an imposed image of only black and white pixels. The region of interest (ROI) of each specimen per micro-CT slice was drawn, which included the entire borders of the cavity within the teeth using CTAn software, with all specifications of the program used to analyze the 3D microarchitecture. By making the enamel and dentin translucent, restorations and internal gaps at the cavity borders were elucidated (Figure 1). In each slice, gaps along the cavity borders were drawn to calculate the total gap volume (mm^3) at the cavity borders for each specimen. Additionally, total cavity volume (mm^3) per specimen was calculated. CTAn software was used for the volume calculations. Finally, internal gap (%) expressed as gap volume per total cavity volume was calculated for each specimen. Micro-CT scan was performed by a single operator (AB). Evaluation of the scanned images was performed by another operator (KO).

Statistical Analysis

The internal void data was analyzed using the Shapiro-Wilk test for normality and equality of variances, followed by a parametric statistical test. Two-way analysis of variance was used to compare the effects of resin composites and insertion techniques. Tukey's test was used for multiple comparisons. A commercially available software (Prism 6.0; GraphPad Software, La Jolla, CA, USA) was used for all statistical analyses (α=0.05).

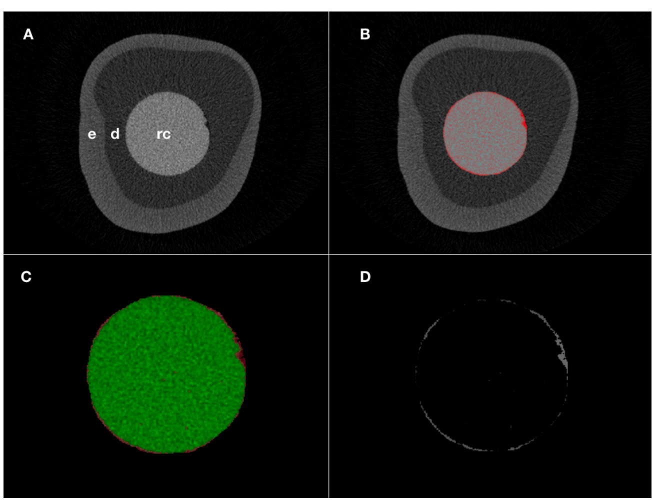

Figure 1. *Reconstructed micro-CT image in transverse plane. (A): Enamel, dentin, and resin composite. (B): Region of interest (red) selection including cavity borders. (C): ROI showing gaps (red) and resin composite (green). Enamel and dentin subtracted from the image. (D): Internal gaps (grey) along the cavity border. Abbreviations: d, dentin; e, enamel; rc, resin composite, ROI, region of interest.*

RESULTS

Mean internal gaps (%) of the tested resin composites placed with different techniques (conventional, sonic, and preheating) are given in Table 2. All resin composites showed fewer internal gaps with preheating compared with the conventional placement (p<0.05). For all resin composites other than SF2, preheating provided fewer internal gaps than that of the sonic placement (p<0.05). Sonic placement led to fewer internal gaps compared with the conventional placement—only for SF2 and FBR (p<0.05). For the conventional placement, the lowest internal gap percentage was observed with the incremental resin composite (CMP; p<0.05).

VCB showed the lowest internal gap percentage for the preheating technique and SF2 showed the lowest internal gap percentage for the sonic placement technique, which were the manufacturers' recommended insertion techniques (p<0.05). Mean internal gaps (%) of the tested resin composites placed according to the manufacturers' recommended insertion techniques are given in Table 3. According to the multiple comparisons, conventionally placed bulk-fill resin composites (FBR and TEB) showed the highest internal gap percentages (p<0.05). Lowest internal gap percentages were observed for preheated VCB followed by sonically inserted SF2 (p<0.05). Figure 2 presents representative micro-CT images of cavities restored with different insertion techniques.

DISCUSSION

This study evaluated the effects of different insertion techniques on the internal adaptation of paste-like bulk-fill and paste-like conventional resin composites using micro-CT. The insertion techniques and type of resin composite affected the internal adaptation of the resin composites; therefore, both null hypotheses were rejected.

Various devices and methods, such as micro-CT,[17,19,20] optical coherence tomography,[21,22] or the classical sectioning method[3,23] can be used to evaluate the internal and marginal adaptation of restorative materials. Specimen sectioning in the classical method is a destructive and time-consuming process and does not provide 3D quantification of the entire material mass.

Table 2: *Multiple Comparison Results of Mean Internal Adaptation Percentages (%) of the Tested Composites Placed with Different Techniques (Conventional, Sonic, and Preheating) (n=10)[a]*

	SF2	VCB	FBR	TEB	CMP
Conventional	3.84 ± 0.20 ABa	4.41 ± 0.27 Aa	4.04 ± 0.38 Aa	3.40 ± 0.49 Ba	2.73 ± 0.19 Ca
Sonic	1.34 ± 0.15 Bb	6.38 ± 0.91 Cb	2.98 ± 0.10 Ab	3.48 ± 0.20 Aa	4.56 ± 0.70 Db
Preheated	2.26 ± 0.12 Ac	0.78 ± 0.09 Bc	2.16 ± 0.11 Ac	2.26 ± 0.18 Ab	2.02 ± 0.32 Ac

Abbreviations: CMP, Clearfil Majesty Posterior; FBR, Filtek One bulk-fill restorative; SF2, SonicFill 2; TEB, Tetric EvoCeram bulk fill; VCB, VisCalor bulk.

[a]Means sharing a letter are not significantly different (p>0.05). Uppercase letters compare means in each row; lowercase letters compare means in each column.

Contrarily, micro-CT evaluation is nondestructive and allows for a thorough 3D assessment of the materials. The specimens remain intact and can be used several times without any alterations in their structures. This technique is proven to be a suitable tool for the porosity assessment inside resin composite restorations or for internal adaptation evaluation;[17,24] therefore, in this study a micro-CT device was used to evaluate the internal adaptation of the resin composite restorations.

Conventional placement, preheating, and sonic insertion techniques were evaluated in this study. According to the results, for all tested resin composites except SF2, the preheating insertion technique provided better internal adaptation to the cavity walls than those of the conventional and sonic insertion techniques. Thermal energy increases the molecular motion of the monomer chains within the resin composite[15] and reduces their viscosity,[25] thereby possibly leading to reduced gap percentages. Contrary to the other preheated resin composites, preheated SF2 was superior to conventionally placed SF2, but inferior to sonically placed SF2, regarding the adaptation to cavity walls. Thermal energy might have not been sufficient to improve the adaptation of SF2 to the extent of sonic placement. Preheated VCB provided a far better internal adaptation than the other preheated resin composites did. This was an expected outcome, since VCB was designed specifically for the preheating insertion technique.

Similar to the results of the current study, previous studies[26,27] demonstrated that preheated resin composites showed better adaptation to the cavity walls compared with the resin composites applied at 23°C-25°C. The heating device (Caps warmer; Voco) used for the preheating technique has three temperature settings: 37°C, 54°C, and 68°C; however, its manufacturer recommends 54°C or 68°C, and the authors opted to evaluate the highest temperature setting. Research indicated that the mean temperature of the resin composite inside the warmed Viscalor

Table 3: *Multiple Comparison Results of Mean internal Gap Percentages (%) of the Tested Composites Placed with the Recommended Insertion Technique[a]*

Material	Recommended Insertion Technique	
SF2	Sonic	1.34 ± 0.15 a
VCB	Preheat	0.78 ± 0.09 a
FBR	Conventional	4.04 ± 0.38 b
TEB	Conventional	3.40 ± 0.49 c
CMP	Conventional	2.73 ± 0.19 d

Abbreviations: CMP, Clearfil Majesty Posterior; FBR, Filtek Onebulk-fill restorative; SF2, SonicFill 2; TEB, Tetric EvoCeram bulkfill; VCB, VisCalor bulk.

[a]Means sharing a letter are not significantly different (p>0.05).

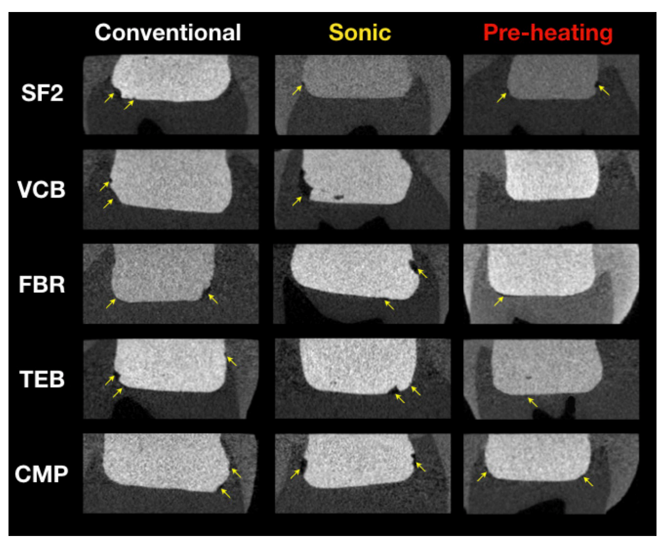

Figure 2. *Representative micro-CT images of cavities restored with different insertion techniques. Yellow arrows indicate the internal gaps at the resin composite-cavity interface. Abbreviations: CMP, Clearfil Majesty Posterior; FBR, Filtek One bulk-fill restorative; SF2, SonicFill 2; VCB, VisCalor bulk.*

compules after a warming period of three minutes at 68°C was 39.1°C.[28] Since absorption of thermal energy is largely related to the inorganic particle amount of resin composites,[29] it is quite possible that the viscoelastic behavior of different resin composites would be different and thereby could influence their internal adaptations. Additionally, different preheating temperatures could yield different outcomes regarding the gap formation.

The sonic insertion technique caused varying internal gap percentages for all the resin composites tested in this study. SF2 showed the best internal adaptation among all other sonically placed resin composites. As SF2 was developed exclusively for sonic application, this result was not surprising. While the internal adaptations of SF2 and FBR were improved, VCB and CMP were negatively affected and TEB performed similarly compared with the conventional insertion technique. We speculate that one possible reason for this inconsistent outcome could be related to the inability of sonic energy to adequately decrease the viscosity of the tested resin composites due to viscoelastic behavior differences between them, as each material has unique organic matrix and inorganic fillers. None of the resin composites, other than SF2, were formulated to be inserted using sonic energy, hence the experimental sonic application was deemed not suitable for all resin composites tested. During the manufacturing process, many resin composites are loaded into the syringes under vacuum, which would minimize the existence of voids in the material.[30] However, in this study, TEB, CMP, VCB, and FBR were removed from their original compules and manually loaded into empty SonicFill compules because the SonicFill handpiece was designed for use only with these compules. This process might have introduced inherent voids and might have influenced the outcome of the sonic insertion technique. A study suggested that sonic energy did not enhance the internal adaptation of FBR,[31] which contradicts this study's results. The major difference between the abovementioned study and the current one was the source and application of the sonic energy. They used a vibratory packing device (COMO; B&L Biotech, Ansan, Korea) for adaptation of the resin composite into the cavity. In that system, the resin composite is first manually placed in the cavity, then sonic vibration is activated while the tip of the device is in contact with the resin composite. The Sonic-Fill device changes the rheological properties of the resin composite right before it is placed in the cavity, while COMO interacts with the resin composite after it has been inserted into the cavity. This may explain the different results obtained between the studies.

There are some limitations in this study. Standardized cylindrical Class I cavities were prepared for restorations, and cavity preparation depths were limited to 2 mm. As occlusal enamel was removed, the remaining dentin thickness would not allow preparing cavities deeper than 2 mm in most of the teeth, which would eventually lead to a pulpal exposure beyond this depth; therefore, the cavity preparation depth had to be limited to 2 mm. In routine clinical practice, dentists could face some cavities with hard-to-access configurations, such as extensive Class II cavities with deep gingival margins. In such cases, the adaptation behavior of resin composites might be different. Further research would be needed to verify the influence of different cavity configurations on internal adaptation with various resin composite insertion techniques. Besides, we do not exactly know how sonic energy and preheating affect the rheological properties of resin composites, which could have helped to elaborate our results. Further studies may focus on this issue.

CONCLUSIONS

Based on the results of this study, the following conclusions may be drawn:

1. The lowest internal gap was observed in sonically inserted SF2 and preheated VCB, which were the manufacturers' recommended insertion techniques.
2. Compared with the conventional placement and the sonic insertion techniques, the preheating technique considerably improved the internal adaptation of all resin composites, except for that of SF2.
3. Experimental sonic application for resin composites other than SF2 was deemed to have unpredictable performance.

Regulatory Statement

This study was conducted in accordance with all the provisions of the human subjects oversight committee guidelines and policies of Ankara University Faculty of Dentistry Ethics Committee The approval code issued for this study is 20191101.

Conflicts of Interest

The authors of this manuscript 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.

(Accepted 23 June 2020)

REFERENCES

1. Agarwal RS, Hiremath H, Agarwal J, & Garg A (2015) Evaluation of cervical marginal and internal adaptation using newer bulk fill composites:An *in vitro* study *Journal of Conservative Dentistry* **18(1)** 56-61.
2. Benetti AR, Havndrup-Pedersen C, Honore D, Pedersen MK, & Pallesen U (2015) Bulk-fill resin composites: Polymerization contraction, depth of cure, and gap formation *Operative Dentistry* **40(2)** 190-200.
3. Alqudaihi FS, Cook NB, Diefenderfer KE, Bottino MC, & Platt JA (2019) Comparison of internal adaptation of bulk-fill and increment- fill resin composite materials *Operative Dentistry* **44(1)** E32-E44.
4. Hashimoto M, Nagano F, Endo K, & Ohno H (2011) A review: Biodegradation of resin–dentin bonds *Japanese Dental Science Review* **47(1)** 5-12.
5. Soares CJ, Faria ESAL, Rodrigues MP, Vilela ABF, Pfeifer CS, Tantbirojn D, & Versluis A (2017) Polymerization shrinkage stress of composite resins and resin cements: What do we need to know? *Brazilian Oral Research* **31(Suppl 1)** e62.
6. Han S-H, Sadr A, Tagami J, & Park S-H (2016) Internal adaptation of resin composites at two configurations: Influence of polymerization shrinkage and stress *Dental Materials* **32(9)** 1085-1094.
7. Feilzer AJ, De Gee AJ, & Davidson CL (1987) Setting stress in composite resin in relation to configuration of the restoration *Journal of Dental Research* **66(11)** 1636-1639.
8. Demirel G, Baltacioglu IH, Kolsuz ME, Ocak M, Bilecenoglu B, & Orhan K (2019) Volumetric cuspal deflection of premolars restored with different paste-like bulk-fill resin composites evaluated by microcomputed tomography *Operative Dentistry* **45(2)**, 143-150.
9. Braga RR, Ballester RY, & Ferracane JL (2005) Factors involved in the development of polymerization shrinkage stress in resin-composites: A systematic review *Dental Materials* **21(10)** 962-970.
10. Kaisarly D & Gezawi ME (2016) Polymerization shrinkage assessment of dental resin composites: A literature review *Odontology* **104(3)** 257-270.
11. Labella R, Lambrechts P, Van Meerbeek B, & Vanherle G (1999) Polymerization shrinkage and elasticity of flowable composites and filled adhesives *Dental Materials* **15(2)** 128-137.
12. Li Q, Jepsen S, Albers HK, & Eberhard J (2006) Flowable materials as an intermediate layer could improve the marginal and internal adaptation of composite restorations in Class-V-cavities *Dental Materials* **22(3)** 250-257.
13. Peutzfeldt A, Muhlebach S, Lussi A, & Flury S (2018) Marginal gap formation in approximal "bulk fill" resin composite restorations after artificial ageing *Operative Dentistry* **43(2)** 180-189.
14. Moreira da Silva E, dos Santos GO, Guimaraes JG, Barcellos Ade A, & Sampaio EM (2007) The influence of C-factor, flexural modulus and viscous flow on gap formation in resin composite restorations *Operative Dentistry* **32(4)** 356-362.
15. Deb S, Di Silvio L, Mackler HE, & Millar BJ (2011) Pre-warming of dental composites *Dental Materials* **27(4)** e51-e59.
16. Trujillo M, Newman SM, & Stansbury JW (2004) Use of near-IR to monitor the influence of external heating on dental composite photopolymerization *Dental Materials* **20(8)** 766-777.
17. Hirata R, Pacheco RR, Caceres E, Janal MN, Romero MF, Giannini M, Coelho PG, & Rueggeberg FA (2018) Effect of sonic resin composite delivery on void formation assessed by micro-computed tomography *Operative Dentistry* **43(2)** 144-150.
18. Feldkamp LA, Goldstein SA, Parfitt AM, Jesion G, & Kleerekoper M (1989) The direct examination of three-dimensional bone architecture *in vitro* by computed tomography *Journal of Bone and Mineral Research* **4(1)** 3-11.
19. Demirel G, Baltacioglu IH, Kolsuz ME, Ocak M, & Orhan K (2019) Micro-computed tomography evaluation of internal void formation of bulk-fill resin composites in Class II restorations *Polymer Composites* **40(8)** 2984-2992.
20. Han SH & Park SH (2017) Comparison of internal adaptation in class II bulk-fill composite restorations using micro-CT *Operative Dentistry* **42(2)** 203-214.
21. Nazari A, Sadr A, Saghiri MA, Campillo-Funollet M, Hamba H, Shimada Y, Tagami J, & Sumi Y (2013) Non-destructive characterization of voids in six flowable composites using swept-source optical coherence tomography *Dental Materials* **29(3)** 278- 286.
22. Nazari A, Sadr A, Shimada Y, Tagami J, & Sumi Y (2013) 3D assessment of void and gap formation in flowable resin composites using optical coherence tomography *Journal of Adhesive Dentistry* **15(3)** 237-243.
23. Samet N, Kwon KR, Good P, & Weber HP (2006) Voids and interlayer gaps in Class 1 posterior composite restorations: A comparison between a microlayer and a 2-layer technique *Quintessence Int* **37(10)** 803-809.
24. Balthazard R, Jager S, Dahoun A, Gerdolle D, Engels-Deutsch M, & Mortier E (2014) High-resolution tomography study of the porosity of three restorative resin composites *Clinical Oral Investigations* **18(6)** 1613-1618.
25. Lucey S, Lynch CD, Ray NJ, Burke FM, & Hannigan A (2010) Effect of pre-heating on the viscosity and microhardness of a resin composite *Journal of Oral Rehabilitation* **37(4)** 278-282.
26. dos Santos RE, Lima AF, Soares GP, Ambrosano GM, Marchi GM, Lovadino JR, & Aguiar FH (2011) Effect of preheating resin composite and light-curing units on the microleakage of Class II restorations submitted to thermocycling *Operative Dentistry* **36(1)** 60-65.
27. Froes-Salgado NR, Silva LM, Kawano Y, Francci C, Reis A, & Loguercio AD (2010) Composite pre-heating: Effects on marginal adaptation, degree of conversion and mechanical properties *Dental Materials* **26(9)** 908-914.
28. Yang J, Silikas N, & Watts DC (2019) Pre-heating effects on extrusion force, stickiness and packability of resin-based composite *Dental Materials* **35(11)** 1594-1602.
29. Al-Qudah AA, Mitchell CA, Biagioni PA, & Hussey DL (2005) Thermographic investigation of contemporary resin-containing dental materials *Journal of Dentistry* **33(7)** 593-602.
30. Ironside JG & Makinson OF (1993) Resin restorations: Causes of porosities *Quintessence International* **24(12)** 867-873.
31. Han SH & Lee IB (2018) Effect of vibration on adaptation of dental composites in simulated tooth cavities *Korea-Australia Rheology Journal* **30(4)** 241-248.