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Clinical Research

Influence of Adhesive Type and Placement Technique on Postoperative Sensitivity in Posterior Composite Restorations

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Clinical Relevance

The use of a single increment of new bulk-fill material, even in deep cavities, did not generate more postoperative sensitivity when compared to its use in an incremental filling technique. Similarly, the adhesive strategy did not have any impact on postoperative sensitivity.

SUMMARY

Purpose: This double blind, randomized clinical trial compared the postoperative sensitivity of the placement technique (incremental and bulk fill) in posterior composite resin restorations bonded with two different adhesive strategies (self-etch and etch-and-rinse).

Methods: Posterior dental cavities of 72 participants (n=236), with a cavity depth of at least 3 mm, were randomly divided into four groups. The restorations were bonded using either the etch-and-rinse Tetric N-Bond (Ivoclar Vivadent) or the self-etch Tetric N-Bond SE (Ivoclar Vivadent). The composite resin Tetric N-Ceram Bulk Fill (Ivoclar Vivadent) was placed either incrementally or using the bulk-fill technique. Two experienced and calibrated examiners evaluated the restorations using World Dental Federation criteria after one week of clinical service. Spontaneous postoperative sensitivity was assessed using a 0-4 numerical rating scale and a 0-10 and 0-100

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visual analog scale up to 48 h after the restorative procedure and after one week.

Results: The risk ($p>0.49$) and intensity of spontaneous postoperative sensitivity ($p>0.38$) was not affected by the adhesive strategy or the filling technique. The overall risk of postoperative sensitivity was 20.3% (95% confidence interval 15.7-25.9) and typically occurred within 48 hours after the restorative procedure.

Conclusions: The overall risk of immediate postoperative sensitivity was 20.3% and was not affected by either the adhesive strategy (etch-and-rinse/self-etch) or the filling technique (incremental/ bulk).

INTRODUCTION

Incremental layering has long been accepted as a standard technique for placing composite resins in cavity preparations.[1] Typically, this technique consists of placing composite resin in increments with a maximum thickness of 2 mm to ensure adequate curing. This procedure produces a composite resin restoration with enhanced physical properties (when compared with chemically cured composite resins), improved marginal adaptation, and reduced cytotoxicity.[2,3] Incremental filling also reduces polymerization shrinkage by reducing the volume of composite resin placed as well as the C-factor, which is the ratio of bonded to unbonded areas of the cavity preparation.[4,5]

On the other hand, the incremental filling technique has some drawbacks.[6] Contamination or incorporation of voids between layers can occur. When compared to bulk filling, this technique is more time demanding, which is contrary to the clinician's desire for simplified and fast procedures.[7,8] These drawbacks have led some manufacturers to introduce composite resins for "bulk-filling techniques," allowing composite resin placement in increments of up to 5 mm thickness.

Contrary to the old version of bulk-fill composite resins,[9,10] these newest bulk-fill composite resins have adequate degree of conversion,[11] microhardness,[12,13] low volumetric shrinkage, and high depth of cure,[14-16] even when used at a thickness of 4 mm.

Despite these promising laboratory findings, some studies have reported that the placement of composite resins in 4- or 5-mm-thick increments may increase cuspal deflection[17,18] and the development of stress at the adhesive interface,[19] which may be clinically apparent by increased postoperative sensitivity. Other studies, however, have reported that the filling technique has no influence on polymerization shrinkage at the adhesive interface[20-22] and that the adhesive strategy may be more important than the composite resin placement technique[23] in preventing the deleterious effects of polymerization stress.

There are currently two available adhesive strategies for use with composite resins: etch-and-rinse and self-etch.[24] Etch-and-rinse adhesives use phosphoric acid for substrate conditioning before adhesive application. After phosphoric acid rinsing, dentin hydration should be adequately managed; otherwise, resin monomers cannot infiltrate into the demineralized dentin[25] and cannot seal dentin tubules,[26] increasing the chances of postoperative sensitivity. Self-etch adhesives do not require multiple steps for bonding. The simultaneous application of a primer and an acidic monomer in a single step results in a lower discrepancy between dentin demineralization and resin infiltration into the dentin,[27] which may reduce postoperative sensitivity when compared to the etch-and-rinse technique.[28,29] However, the role of adhesive strategy on postoperative sensitivity in posterior teeth is still controversial.[30,31]

Therefore, the objective of this double blind, randomized clinical trial was to compare the postoperative sensitivity of the placement technique (incremental or bulk fill) in posterior composite resin restorations bonded with two different adhesive strategies (self-etch or etch-and-rinse). The null hypotheses tested were that 1) the layering technique and 2) the adhesive strategy do not influence the postoperative sensitivity of posterior composite resin restorations.

METHODS AND MATERIALS

This study was written according to the CONSORT statement.[32] The study was conducted at the clinic of the School of Dentistry from the State University of Ponta Grossa, Brazil. All participants were informed about the nature and objectives of the study; however, they were not aware of which treatments their lesions would receive. The Ethics Committee of the State University of Ponta Grossa (Paraná, Brazil) reviewed and approved this study under protocol number 109.846. A written informed consent was obtained from all participants before starting the treatment.

Study Design

This was a double blind (evaluator and patient) and split-mouth randomized clinical trial with four study groups and an equal allocation ratio.

Participant Recruitment

Two calibrated dental residents performed the selection of the participants, using a mouth mirror, an explorer (SS White, Rio de Janeiro, Brazil), and a periodontal probe (#6 Satin Steel Handle; mm, Hu-Friedy, Chicago, IL, USA). We recruited eligible patients in the order they appeared for the screening session in the Dental Clinic at the Local University, thus forming a convenience sample of patients.

Sample Size Calculation

The risk of postoperative sensitivity was the dependent outcome used for sample size calculation (primary outcome). Earlier clinical trials reported that the risk of postoperative sensitivity in deep and wide cavities in posterior teeth was approximately 30%.[29,33,34] In order to identify a difference of 20% in the risk of postoperative sensitivity between any of the experimental conditions, a minimum sample size of 59 restorations per group were required, with an alpha of 5% and a statistical power of 80%. The sample size calculation was performed using a software program that is freely available online at http://www.sealedenvelope.com.

Inclusion and Exclusion Criteria

Selected participants had to be at least 18 years old. They had to have at least 12 posterior teeth in occlusion and not receiving orthodontic treatment. Each patient had to have at least two or four posterior teeth in need of restorative treatment (due to carious lesions, defective restorations with secondary caries, fractures, or a patient request for replacement due to esthetic reasons). The dental cavities had to be at least 3 mm deep, which was diagnosed using a bitewing radiograph and a ruler. Each tooth to be restored had to be in "normal occlusion" with natural antagonist and adjacent teeth.

According to the rules of the School of Dentistry from our university, patients are able to receive restorative treatment only when they are no longer caries active and they have reached a good level of oral hygiene. For this purpose, the patients selected for this study were instructed about oral hygiene and diet. Staining with dyes was performed weekly; patients received restorations only when low biofilm formation was observed.

We checked the pulp vitality with a cold test (Roeko-Endo-Frost, Coltène/Whaledent, Langenau, Germany). After 10 seconds of cold application, participants were expected to answer positively to this test providing a short and transient pain response. We excluded participants needing endodontic treatment or those with non-vital teeth and periodontal problems. Pregnant or breast-feeding women, participants with known allergies to resin-based materials or any other material used in this study, and those taking anti-inflammatory, analgesic, or psychotropic drugs were not included in this study.

Characteristics of the Cavities and Calibration of Operators

For each restoration, the tooth type (molar/premolar) and cavity type (number of restored surfaces) were recorded. A bitewing radiograph of each tooth was taken with an exposure time of 0.4 seconds using an X-ray device (Timex 70 E, Gnatus, Ribeirão Preto, Brazil) set at 70 kVp and 7 mA.

Four operators conducted all restorative procedures. At the time the study was conducted, all the operators had five or more years of clinical experience and all were PhD students specializing in restorative dentistry. The operators measured the height and depth of the proximal and occlusal cavity boxes with a periodontal probe (#6 Satin Steel Handle; mm, Hu-Friedy).

For the calibration of the operators, one professor, a specialist in restorative dentistry with more than 15 years of clinical and research experience, placed one restoration of each group in order to identify all restorative steps involved in the application technique. Then each operator placed four restorations of each group under the supervision of the experienced clinician. The restoration deficiencies were shown to the operators prior to starting the study and discussed. After that, the operators were considered to be calibrated and able to perform the restorative procedures. The same calibrated dental residents who participated in the patient screening selection restored all teeth under the supervision of an experienced clinician.

Randomization and Allocation Concealment Mechanism

We performed two different randomization schemes: one for the subjects with four teeth and another scheme for the subjects with two available teeth for restoration. For the subjects with four teeth, the randomization was done on an intra-individual basis so that each subject ended up with four restorations, each one resulting from one of all possible combinations of filling technique (incremental filling [IF] or

bulk filling [BF]) and adhesive strategy (etch-and-rinse or self-etch).

In the patients with two teeth, two different randomization lists were performed with block sizes of two and four (to guarantee an equal number of restorations in the groups and prevent disclosure of the allocation concealment). The first randomization list defined the type of adhesive strategy used in that patient. The second randomization list defined the order of the composite resin placement.

These randomization schemes were performed using software available at http://www.sealedenvelope.com. A researcher not involved in the any of the experimental phases performed this procedure. The randomization lists were numbered consecutively and individually placed in opaque and sealed envelopes. These envelopes were opened at the day of the restorative intervention to prevent disclosure of the randomization scheme.

In all cases, the tooth with the highest tooth number received the treatment described first, while the tooth with the next number in sequence received the treatment mentioned second, with placement continuing in a similar manner until the fourth tooth (for the patients with four teeth). All restorations in the same subject (two or four) were always placed in different sextants.

Study Blinding Protocols

The operator who implemented the interventions was not blinded to the procedure. However, participants and the evaluators were kept blind to the group allocation during examinations.

Interventions: Restorative Treatment

All patients received oral hygiene instructions and a professional tooth cleaning before initiating the restorative intervention. The operators anesthetized the teeth (Mepisv 3%, NovaDFL, Rio de Janeiro, Brazil) and performed rubber dam isolation. The cavity design was restricted to the elimination of carious tissue or defective restorations using a spherical diamond bur (#1015-1017; KG Sorensen, Barueri, Brazil) mounted in a high-speed handpiece with air-water spray. No liner or base was used. For restoration of class II cavities, a sectional matrix system (Palodent, Dentsply Caulk, Millford, DE, USA) was preferentially used. However, circumferential matrix systems were used when a good adaptation could not be obtained with the sectional matrix system.

Two adhesive systems were used: Tetric N-Bond (two-step etch-and rinse, Ivoclar Vivadent, Schaan, Liechtenstein) and Tetric N-Bond SE (one-step self-etch, Ivoclar Vivadent). The adhesives were applied following the manufacturer's instructions (Table 1). The composite resin Tetric N-Ceram Bulk Fill (also known as Tetric EvoCeram Bulk-Fill in other countries, Ivoclar Vivadent) was placed according to either the incremental or the bulk-filling techniques (Table 1).

In the groups assigned for increment filling, we restored the dental cavity with 2-mm-thick horizontal layers. In the incremental filling technique, a small increment of resin composite was removed from the compule, shaped into a ball using the right thumb and index finger, and finally placed in the cavity with a resin spatula. During this step, the operators wore clean gloves to avoid contamination between composite resin layers. In the bulk-filling groups, one 4-mm-thick horizontal layer was placed at the bottom of the cavity, as previously described in the incremental filling technique. If the cavity had a depth greater than 4 mm, additional material was added to fill the whole cavity. We also recorded the number of layers required for the restoration of each dental cavity.

The operators adapted the composite resin using a flat-faced or elliptical condenser and light cured each increment for 20 seconds using a Bluephase light-curing unit (Ivoclar Vivadent) at 1200 mW/cm^2. The curing tip was placed as close as possible to the occlusal surface of the teeth, as some light attenuation was anticipated due to the cavity depth. The light-curing output was checked daily. We performed occlusal adjustments using fine-grit diamond burs (KG Sorensen) and checked the quality of the interproximal contact and the cervical adaptation by means of dental flossing and bitewing radiographs (using the same parameters as described earlier).

We performed finishing and polishing immediately after the final light-curing step using fine-grit diamond burs (KG Sorensen), OptraPol NG (one-step silicon polishing set with diamond particles, Ivoclar Vivadent) and Astrobrush (Ivoclar Vivadent) under constant water-cooling. We used abrasive strips (3M ESPE, St Paul, MN, USA) on the proximal surfaces when necessary.

Clinical Evaluation

Two experienced and calibrated examiners who were not involved in the placement of the restorations

Table 1: *Application Mode of Each Material Used in the Study*

Material (Manufacturer) Batch Number	Composition	Application Mode
Total N-Etch (Ivoclar Vivadent) N05612	Phosphoric acid (37%), thickness agent and color pigments	Apply phosphoric acid on the prepared enamel and then flow the etchant onto the prepared dentin. The etchant was left to react on the enamel for 15 to 30 s and on the dentin for 10 to 15 s. After that, the phosphoric acid was removed with a vigorous water spray for at least 5 s. Excess moisture was removed with air gun, leaving the dentin surface with a slightly glossy wet appearance (wet-bonding).
Tetric N-Bond (Ivoclar Vivadent) N40889	Bis-GMA, urethane dimethacrylate, dimethacrylate, hydroxyethyl methacrylate, phosphonic acid acrylate, nanofillers (SiO_2), ethanol, initiators and stabilizers	After acid etching, apply a thick layer of adhesive on the enamel and dentin surfaces, using a microbrush. Brush the material gently into the dentin for 10 s. Remove excess material and the solvent by a gentle stream of air so that the adhesive completely covers the enamel and dentin without pooling. Light cure adhesive for 10 s (light intensity 1200 mW/cm^2). A shiny tooth surface prior to the application of the composite shows that all surfaces are completely covered.
Tetric N-Bond Self-Etch (Ivoclar Vivadent) R59913	Bis-acrylamide derivatives, bis-methacrylamide dihydrogenphosphate, amino acid acrylamide, hydroxyalkyl methacrylamide, water, nanofillers (SiO_2), initiators and stabilizers	No applied acid etching. Apply a thick layer of adhesive on the enamel and dentin surfaces, using a microbrush. Brush the material gently into the dentin for 30 s. Remove excess material and the solvent by a gentle stream of air so that the adhesive completely covers the enamel and dentin without pooling. Light cure adhesive for 10 s (light intensity 1200 mW/cm^2). A shiny tooth surface prior to the application of the composite shows that all surfaces are completely covered.
Tetric N-Ceram Bulk Fill (Ivoclar Vivadent) R52450	Dimethacrylates, prepolymer, barium glass filler, ytterbium trifluoride, mixed oxide, additive, initiators and stabilizers, pigments	Apply resin composite in layers of maximum 2 mm (incremental technique) or 4 mm (bulk technique) and contour/adapt the material to the cavity walls using a suitable instrument. Light cure each increment for 20 s (light intensity 1200 mW/cm^2).

performed the evaluation using the World Dental Federation criteria[35,36] after one week of clinical service.

For the evaluation of the primary outcome, participants were asked to record whether they experienced sensitivity using a 0-4 numerical rating scale (0 = none, 1 = mild, 2 = moderate, 3 = considerable, and 4 = severe) and a 0-10 and 0-100 visual analog scale (VAS). In the 0-10 VAS scale, the participants had to place a line perpendicular to a 10 mm line, with zero at one end, indicating "no sensitivity," and at 10 mm in the other end, indicating "unbearable sensitivity." In the 0-100 VAS scale, participants had to attribute one number varying from zero (no pain) to 100 (unbearable pain) that most represented the postoperative sensitivity. The patients were asked to fill in the pain scale forms 24 hours after the restorative procedure and daily up to seven days. Additionally, we also instructed them to record in a diary if the sensitivity was spontaneous or induced by mastication, air, heat, or cold stimuli.

The secondary clinical end points were restoration fracture/loss of retention, marginal caries, marginal staining, marginal adaptation, surface texture, and color match. We ranked these variables using the

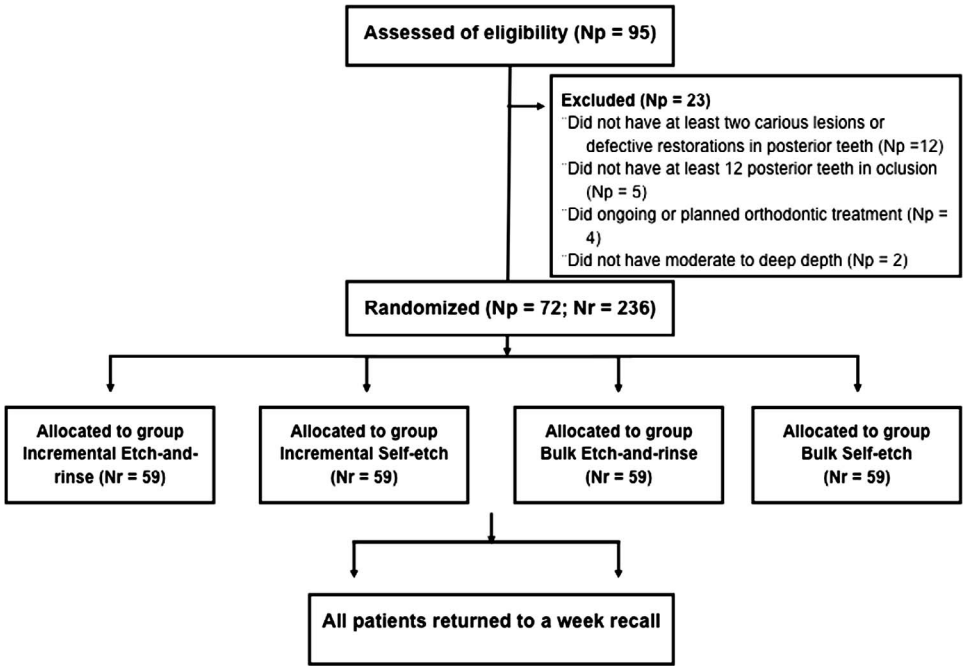

Figure 1. *Participant flow diagram in the different phases of the study design. Np, number of participants; Nr, number of restorations.*

following scores: clinically very good, clinically good, clinically sufficient/satisfactory, clinically unsatisfactory but can be repaired, and clinically poor and needing replacement. For marginal adaptation and marginal staining, we employed the semiquantitative SQUACE criterion, proposed by Hickel and others[35,36] The results of these evaluation criteria will be published at a later time.

Statistical Analysis

The statistician was blinded to the type of study groups, and the analyses followed the intention-to-treat protocol.[32] Participants who experienced at least one event of postoperative sensitivity (regardless of the intensity) during the one-week evaluation were considered as having postoperative sensitivity.

The risk of postoperative sensitivity among the groups was compared using the chi-square test and Fisher exact test. The intensity of the postoperative sensitivity was evaluated using the Kruskall-Wallis and Mann-Whitney tests. We also compared the immediate postoperative sensitivity (up to 48 hours after the restorative procedure) and one-week postoperative sensitivity (one week after the end of the procedure) with the Fisher exact test. Additionally, the risk of postoperative sensitivity according to tooth type, cavity depth, and number of faces was compared using the chi-square test. In all statistical tests, the alpha was set at 5% (Statistica for Windows 7.0, StatSoft Inc, Tulsa, OK, USA).

RESULTS

Characteristics of the Participants and Cavities

The experimental protocols were implemented exactly as planned, and no modifications were performed. Figure 1 depicts the participant flow diagram at the different phases of the study design. A total of 52 women and 20 men participated in this study. The mean age of the participants was 34 $\pm$ 10 years. Two hundred thirty-six restorations were placed, 59 for each group.

The distribution of the restorations was similar between class I (126) and class II (110) cavities (Table 2). The homogeneity of cavity characteristics between the study groups can be seen in Table 2. All of the participants attended the one-week recall.

Postoperative Sensitivity

None of the subjects needed an analgesic drug to reduce postoperative sensitivity. Only two subjects reported with postoperative sensitivity who also had preoperative sensitivity. Regardless of the group, most of the postoperative sensitivity complaints occurred within the first 48 hours after treatment.

Neither the restorative technique (incremental vs bulk) nor the adhesive strategy (etch-and-rinse vs self-etch) affected the risk (Table 3; $p>0.49$). The overall risk of postoperative sensitivity was 20.3% (95% CI 15.7-25.9). Seventy five percent (36/48) of

Table 2: *Characteristics of the Dental Arches and Cavities*

Characteristic	Number of Restorations			
	ER-IF	ER-BF	SE-IF	SE-BF
Tooth distribution				
Premolar	19	18	23	18
Molar	40	41	36	41
Spontaneous preoperative sensitivity				
Yes	9	5	9	9
No	50	54	50	50
Cavity depth				
3 mm	43	42	43	36
4 mm	8	9	9	11
>4 mm	8	8	7	12
Black classification				
I	33	32	32	29
II	26	27	37	30
Number of restored surfaces				
1	26	22	21	23
2	27	30	30	30
3	5	4	6	5
4	1	3	2	1
Reasons for replacement				
Marginal fracture	6	5	7	5
Esthetic reasons	33	32	25	32
Marginal discoloration	4	5	3	5
Bulk fracture	7	4	5	5
Primary or secondary caries lesion	9	13	19	12

Abbreviations: ER, etch-and-rinse; SE, self-etch; IF, incremental filling; BF, bulk filling.

the teeth with postoperative sensitivity occurred in only 11 patients (15% of total number of patients).

One week after treatment, the risk of postoperative sensitivity was statistically lower than the risk recorded in the periods immediately after restorative treatment (Table 4; $p<0.002$). Only 2.5% of the participants (95% confidence interval [CI] 1.2-5.4) reported spontaneous postoperative sensitivity after one week (Table 4).

Also, neither the restorative technique (incremental vs bulk) nor the adhesive strategy (etch-and-rinse vs self-etch) affected the intensity of spontaneous postoperative sensitivity (Table 5; $p>0.38$; for all pain scales).

In 18 out of 48 sensitive restorations, participants reported that the teeth were sensitive only to air. In another 10 restorations, participants reported that their teeth were sensitive only to cold. In six restorations, patients reported that their teeth were sensitive only to mastication. Some patients reported

Table 3: *Comparison of the Number of Patients Who Experienced Spontaneous Postoperative Sensitivity During the One-Week Follow-Up As Well As the Absolute Risk (n=59/Group)*[a]

Adhesive Strategy	Placement Technique	Tooth Sensitivity (Number of Patients)		Absolute Risk (95% Confidence Interval)
		Yes	No	
Etch-and-rinse	Incremental	13	46	22.0 (13-34)
	Bulk	10	49	17.0 (9-28)
Self-etch	Incremental	14	45	23.7 (15-36)
	Bulk	11	48	18.6 (12-44)
Overall		48	188	20.3 (15.7-25.9)

[a] *Chi-square test ($p>0.49$).*

that their teeth were sensitive to both air and cold (six participants), air and mastication (four participants), and cold and mastication (four participants).

When the characteristics of tooth type and cavities were evaluated, only the number of surfaces was statistically significant (Table 6; $p=0.01$). Cavities with three or four surfaces showed more postoperative sensitivity when compared with cavities that had one or two surfaces. The tooth type and cavity depth were not statistically different (Table 6; $p>0.06$).

DISCUSSION

In the present randomized clinical trial, restorations placed using the bulk-fill technique showed a risk and intensity of postoperative sensitivity similar to composite resin restorations placed with the traditional 2 mm incremental technique, and therefore we could not reject the first null hypothesis. Taking into account that one characteristic of an ideal dental composite resin restorative would be that it can be effectively cured in a single increment, facilitating placement, this is a very interesting result and may be attributed to some singular properties of the bulk-fill material used in this current study,[37] which makes it very similar to conventional composite resins cured incrementally, except for the fact that they can achieve a higher depth of cure.[12,38-40]

The material used in this study (Tetric N-Ceram Bulk Fill) was also found to have an increased translucency,[14,41] which can play a role on its good depth of cure[12,38-40] by reducing light scattering and improving deeper blue-light penetration.[42,43] However, this material also possesses a newly patented initiator system. In addition to the traditional camphorquinone/amine initiator system, Tetric N-Ceram Bulk Fill has an "initiator booster" (Ivocerin),

Table 4: *Number of Patients (%) Who Experienced Spontaneous Postoperative Sensitivity in Two Different Time Assessments (n=59/Group)*[a]

Time Assessment	Etch-and-Rinse		Self-Etch		Overall Risk (95% Confidence Interval)
	Incremental	Bulk	Bulk	Incremental	
Up to 48 h	13 (22.0%) A	10 (17.0%) A	11 (18.6%) A	14 (23.7%) A	20.3 (15.7-25.9)
One week later	2 (3.4%) B	1 (1.7%) B	1 (1.7%) B	2 (3.4%) B	2.5 (1.2-5.4)

[a] *The same letter indicates no statistically significant difference between groups (Fisher exact test,* $p<0.002$).

which is able to polymerize the material to a greater depth. Ivocerin is described as a germanium-based initiator system with a higher photocuring activity than camphorquinone/amine system because of its higher absorption in the wavelength region between 400 and 450 nm and the ability to form at least two free radicals to initiate the radical polymerization.[41]

Additionally, Tetric N-Ceram Bulk-Fill polymerized in a single increment has polymerization shrinkage values[38-40,44,45] and shrinkage stress[40,44,45] closer to the conventional composite resins cured in increments. The increased filler content can, to a certain extent, reduce the polymerization shrinkage by increasing the filler-to-monomer ratio,[5,46] but the presence of pre-polymerized particles can also contribute to the lower polymerization shrinkage of this material.[47] This also explains why the marginal gap formation and marginal integrity of bulk-fill composite resins was not statistically different than what was observed for incremental composite resins.[38,48] This result was also recently confirmed by Heintze and others.[49] In an *in vitro* study, those authors evaluated the marginal quality of composite resin restorations placed with Tetric N-Ceram Bulk-Fill (four mm) or with Tetric EvoCeram in three increments in class II cavities in molars. Microscopic evaluation showed no significant differences in marginal defects of the proximal margins when the bulk or incremental techniques were compared.[49]

In summary, *in vitro* studies have demonstrated that the Tetric N-Ceram Bulk-Fill has a good depth of cure without generating significant polymerization shrinkage and the associated residual stresses generated from shrinkage when compared to the same resin composite used with an incremental technique, explaining why we observed similar risks of postoperative sensitivity in the present study for both placement techniques.

So far, only a few clinical trials evaluated the postoperative sensitivity of bulk-fill materials in posterior restorations.[50-54] One limitation of these earlier studies is that they do not report the depth of the included cavities, which is of paramount importance when evaluating the performance of bulk-fill composite resins. Van Dijken and Pallesen[50,51] compared the bulk-filling technique (using flowable composite resin plus a capping layer made of composite resin applied in an incremental technique) with a conventional composite resin placed incrementally. Similar to the present study, these earlier studies[50,51] reported no significant differences in postoperative sensitivity between the two techniques evaluated. In another clinical study,[52-54] a single bulk-fill increment was compared to an incrementally filled composite resin in posterior restorations. However, postoperative sensitivity was evaluated only after 14 days, preventing us from comparing it with this study's findings.[52-54]

The overall absolute risk of postoperative sensitivity of the present study was higher than that observed in a recent systematic review of class II composite restorations.[30] However, in this review, the data from restorations of different studies were pooled together, and the effect of cavity depth was not taken into consideration. There are only few

Table 5: *Means (Standard Deviations) of Spontaneous Postoperative Sensitivity Experienced by Patients for All Groups Using Three Pain Scales*[a]

Pain Scales	Etch-and-Rinse		Self-Etch	
	Incremental	Bulk	Incremental	Bulk
NRS scale	0.4 (0.8) A	0.2 (0.4) A	0.4 (0.9) A	0.3 (0.6) A
VAS scale (0-100)	5.9 (14.9) a	4.5 (11.6) a	8.0 (18.2) a	5.2 (13.1) a
VAS scale (0-10)	0.5 (1.5) [a]	0.4 (1.0) [a]	0.7 (1.7) [a]	0.5 (1.4) [a]

[a] *For each scale, the treatment groups were compared with Kruskall-Wallis and Mann-Whitney tests. Statistically similar groups are represented by the same uppercase letter (NRS scale), lowercase letter (VAS scale [0-100]), or superscript letter (VAS scale [0-100])* ($p=0.38$; $p=0.63$, and $p=0.67$, *respectively*).

Table 6: *Comparison of the Number of Patients (%) Who Experienced Spontaneous Postoperative Sensitivity During the One-Week Follow-Up According to the Characteristics of Dental Arches and Cavities*

Characteristic	Number of Sensitive Teeth (%)		*p*-Value ([a])
	No	Yes	
Tooth distribution			
Premolar	68 (87.2)	10 (12.8)	0.06
Molar	120 (75.9)	38 (24.1)	
Cavity depth			
3 mm	133 (81.1)	31 (18.9)	0.51
4 mm	55 (76.4)	17 (23.6)	
Number of restored surfaces			
1 + 2 faces	172 (82.3)	37 (17.7)	0.01
3 + 4 faces	16 (59.3)	11 (40.7)	

[a] *Chi-square test.*

studies that have compared the postoperative sensitivity in posterior cavities according to the size (depth and width), and they reported risks of postoperative sensitivity ranging from 25% to 40%, which is similar to the current results.[29,33,34,55]

According to the results of the present study, cavity depth did not show any impact on postoperative sensitivity. As the primary objective of this study was to evaluate the postoperative sensitivity of different placement techniques in posterior composite resin, only patients with a minimum cavity depth of 3 mm were included in the present study. Therefore, most of the cavities restored in the current study had a cavity depth varying from 3 to 5 mm, and this was probably responsible for the similarity of results.

However, a closer view of the studies that evaluated the relationship between cavity size and postoperative sensitivity provides controversial results.[29,34,56-58] This is likely related to the arbitrary classification of the cavity depth, which is usually based on the operator experience,[29] as there is lack of strict guidelines for defining the cutoff points for deep and shallow cavities.[59]

On the other hand, the number of surfaces restored had a significant impact on postoperative sensitivity, and this finding is in agreement with previous studies.[55-58,60,61] The increase in the removal of dental structure[33] and the difficulties faced by clinicians when restoring large preparations[60] may be the reason for an increased rate of postoperative sensitivity when the cavity involves more than two surfaces.

After one week, the risk of postoperative sensitivity was very low, as previously demonstrated by a meta-analysis of clinical studies,[30] indicating that postoperative sensitivity generated immediately after placement of a restoration appears to be transient, as previously demonstrated by histological studies in deep cavities.[62,63] The immediate postoperative sensitivity might be the result of trauma produced by bur cutting of the dentin substrates as well as those related to material polymerization.

In the present study, only spontaneous postoperative sensitivity was measured. This is in accordance with a recent systematic review and meta-analysis that compared the type of adhesive strategy on the risk and intensity of postoperative sensitivity in posterior composite resin restorations.[31] In that review, approximately 50% of the studies included in the meta-analysis assessed postoperative sensitivity by asking patients whether they experienced spontaneous postoperative sensitivity during a specific time frame.[31] Although the use of a stimulus to assess the risk and intensity of postoperative sensitivity has been used in some studies,[64-67] these approaches are especially important when evaluating pulp vitality rather than postoperative sensitivity.

There is a widespread belief among clinicians that self-etch systems lower the risk of postoperative sensitivity, as they do not remove but rather incorporate the smear layer in the hybridized complex with the advantage of being less technique sensitive.[68] Although there is a biological plausibility behind this belief with some clinical studies reaching this conclusion,[28,29] the perception that self-etch adhesives cause less postoperative sensitivity than etch-and-rinse systems seems to be more anecdotal than an evidence-based finding,[69] as other clinical trials do not support this trend.[64,67]

Indeed, the results of the present investigation are in line with a recent systematic review of the literature,[31] and therefore we could not reject the second null hypothesis. That systematic review concluded that the type of adhesive strategy used in bonding procedures in posterior composite resin restorations does not influence the risk and intensity of postoperative sensitivity immediately after the restorative procedure.[31]

Finally, one should report the limitations of the present study design. The present study was conducted in a university setting in which restorations are placed under ideal conditions to produce restorations as near perfect as possible. Calibrated

and experienced operators with a deep knowledge of the techniques and materials placed the restorations without time constraints. Additionally, moisture control was usually done with rubber dam isolation, preventing contamination of the operative field. Private clinicians must provide care with an eye toward minimizing the length of the appointment. A shorter appointment is more comfortable for the patients, it constrains costs, and it maintains a reasonable profit level. Additionally, just one type of bulk-fill material was evaluated, which prevents us from generalizing the findings of the present study to other bulk-fill materials available on the dental market.

The university setting is more appropriate for determining a material's optimal performance, while a practice-based setting investigates a material's typical performance. Therefore, further clinical studies using a practice-based design should be conducted to highlight whether the current results are applicable to less-than-ideal conditions.

CONCLUSION

The overall risk of immediate postoperative sensitivity was 20.3% (95% CI 15.7-25.9), and it was not affected by the adhesive strategy (etch-and-rinse/self-etch) or the filling technique (incremental/bulk).

Regulatory Statement

This study was conducted in accordance with all the provisions of the local human subjects oversight committee guidelines and policies of the State University of Ponta Grossa. The approval code for this study is 109.846.

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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