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ORIGINAL RESEARCH

THE EFFECT OF BONDING AND SURFACE SEALANT APPLICATION ON POSTOPERATIVE SENSITIVITY FROM POSTERIOR COMPOSITES

Yüzey Örtücü Uygulaması ve Bonding'in Arka Bölge Restorasyonlarda Oluşan Postoperatif Hassasiyet Üzerine Etkisi

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ABSTRACT

Purpose: *The purpose of the study was to evaluate the postoperative sensitivity of posterior Class I composite restoration at short-term, restorated with two different all-in-one self-etch adhesives with or without surface sealant application.* ***Materials and Methods:*** *44 restorations were inserted in 11 patients who required Class I restorations in their molars. Each patient received 4 restorations, thus four groups were formed; (1) G-Aenial Bond (GC, Japan); (2) Clearfil S3 Bond (Kuraray, Japan); (3) G-Aenial Bond+Fortify Plus (Bisco, USA), (4) Clearfil S3 Bond+Fortify Plus. Sensitivity was evaluated at 24h, 7, 15, and 30 days using cold air, ice, and pressure stimuli using a visual analog scale. Comparisons of continuous variables between the sensitivity evaluations were performed using the Friedman's One-Way Analysis of Variance with repeated measures test ($p<0.05$).* ***Results:*** *The type of adhesive used and the application of a surface sealant had no significant effects in postoperative sensitivity ($p>0.05$). The use of Clearfil S3 Bond resulted in almost the same level of postoperative sensitivity as did the use of G-Aenial Bond. The highest sensitivity scores were observed for the surface sealant applied teeth without any statistical significance ($p>0.05$).* ***Conclusions:*** *Self etch adhesives displayed postoperative sensitivity. The sensitivity scores slightly decreased at the end of 30 days ($p>0.05$). Surface sealant application did not result in a decrease in sensitivity scores for either dentin adhesives.*

Keywords: *All-in-one adhesives; surface sealant; postoperative sensitivity*

ÖZ

Amaç: *Bu çalışmanın amacı iki farklı all-in-one self etch adezif ile yüzey örtücü uygulamasının arka bölge sınıf I restorasyonlarda oluşan postoperatif hassasiyet üzerine etkisini değerlendirmektir.*
Gereç ve Yöntem: *Arka bölge azı dişlerinde sınıf I restorasyon endikasyonu bulunan 11 hastada 44 restorasyon bu çalışmaya dahil edilmiştir. Her bir hastaya 4 restorasyon yapılmıştır. Restorasyonların tamamlanmasında bonding olarak G-Aenial Bond (GC, Japan) ve Clearfil S3 Bond (Kuraray, Japan), kompozit materyali olarak Clearfil Majesty Posterior (Kuraray, Japan) kullanılmıştır. Restorasyonların tamamlanmasının arkasından her bir bağlayıcının uygulandığı iki dişten rastgele seçilen bir tanesine yüzey örtücü (Fortify Plus, Bisco, USA) uygulanmıştır. Hassasiyet değerlendirmesi soğuk hava uygulaması, buz ve basınç uygulaması ile 24 saat, 7, 15 ve 30 gün sonunda VAS skalası kullanılarak yapılmıştır. Hassasiyet değerlerinin karşılaştırmasında Friedmen Tek yönlü varyans analizi kullanılmıştır ($p<0.05$).*
Bulgular: *30 gün sonunda 44 restorasyon incelenmiştir. Çalışmada incelenen adezif veya yüzey örtücü, restorasyonların hassasiyet skorlarında anlamlı bir değişikliğe sebep olmamıştır. Clearfil S3 Bond ve G-Aenial bond hemen hemen aynı hassasiyet skorları sergilemişlerdir. En yüksek hassasiyet, yüzey örtücü uygulanmış dişlerden elde edilmiştir.*
Sonuç: *Self etch adezif sistemler restorasyonlarda hassasiyete sebep olmuşlardır. Restorasyonlardaki hassasiyet 30 gün sonunda hafif düzeyde azalmıştır. Yüzey örtücü uygulaması hassasiyet skorlarında azalmaya sebep olmamıştır.*

Anahtar kelimeler: *All-in-one adezifler; yüzey örtücü; postoperatif hassasiyet*

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Introduction

In recent years, resin composite has become widely used as a restorative material in posterior teeth (1-3). Despite improvements in materials and techniques for composites, postoperative sensitivity has remained a problem (4). Postoperative sensitivity from posterior resin composite restorations may result from marginal microleakage (1, 2, 4). Several other factors may also be responsible for postoperative sensitivity in posterior composite restorations, including composite polymerization shrinkage, acid etching, and incomplete coating of the dentin surface/tubules with dentin adhesive. Excellent marginal adaptation extends the longevity of restorations. However, all current dimethacrylate-based dental materials produce volumetric shrinkage during polymerization (5). Polymerization shrinkage of composite restorations adversely affects quality requirements of restorations (6). Following shrinkage, adhesive bonds were put under tension, tensile, and/or shear stresses at the tooth restoration interface. When polymerization shrinkage stress exceeds the bond strength to the cavity walls, it causes contraction gaps to form at the tooth restoration interface (5, 7). Debonding, resulting in gaps, which can potentially occur after polymerization shrinkage could cause postoperative pain (8-10). Postoperative sensitivity may be reduced by different methods. One method to reduce sensitivity is the use of self etching adhesives that do not remove the smear plugs, thus reducing hydraulic conductance through the dentinal tubules (11).

Self etch adhesives were recently developed to simplify bonding procedures and combine in one solution the etching, priming, and bonding steps of the traditional etch and rinse adhesives. They remove minerals from the dentine surface while simultaneously replacing them with resin monomers (12). The incorporation of the smear layer, collagen, minerals, and resin into a hybrid layer and superficial portion of the resin tags may prevent postoperative sensitivity. This method uses the smear layer as a bonding substrate, leaving residual smear plugs that cause less dentinal fluid flow (13-15). Another method to reduce postoperative sensitivity is the use of HEMA containing agents. Since HEMA (hydroxyethyl methacrylate) is miscible with water, it promotes resin penetration into demineralized moist dentin (16). HEMA can also polymerize in the presence of water to form flexible water insoluble solids known as hydrogels (13). This indicates that good dentin sealing, despite the presence of water, is a factor in the prevention of postoperative sensitivity (17).Surface sealants are light, polymerizable materials and present great fluidity and penetration capacity. These materials have been used to diminish micro leakage because of their capacity to penetrate into micro gaps at the interface and consequently promote a better marginal seal (18). Several laboratory studies (19-23) have evaluated the influence of these sealing agents on the tooth/restoration interface. However, there is not enough data about the clinical effectiveness of surface sealant agent on postoperative sensitivity of Class I restorations. Therefore, the aim of this study is to evaluate the efficacy of two different all in one, self etch adhesives on postoperative sensitivity of Class I restorations, either with or without surface sealant application.

Materials and Methods

Selection of Subjects

The study was approved by the ethics committee at the Human Ethics Committee of University of Kocaeli (KOÜ KAEK 2014/156). The subjects were recruited from patients seeking routine dental care at the Department of Restorative Dentistry, University of Kocaeli. Before participating in the study, all patients signed a written consent form after a full explanation of the treatment procedure. Specific inclusion and exclusion criteria for patients are given in Table 1.

Table 1. *Inclusion and exclusion criteria.*

Inclusion criteria:	Exclusion criteria:
Good general health	History of existing tooth sensitivity
Having at least 4 class I carious lesion or existing defective restorations	Absence of adjacent and antagonist teeth
Clinically diagnosed as moderate to deep occlusal caries; no caries detected on other surfaces	Severe periodontal disease and poor oral hygiene
Did not have any signs or symptoms of pulpal and periapical disease	Symptoms of pulpitis, spontaneous pain
Had at least one antagonist tooth with occlusal contact more than 50% of the occlusal surface	Bruxism and visible wear facets in the posterior dentition
Had healthy or mildly inflamed gingival tissues, without gingival recession/ alveolar bone loss	Known allergy to resin materials
	Known inability to return for recall appointments
	Fractured or visibly cracked tooth
	Chronic use of anti-inflammatory, analgesic, or psychotropic drugs
	Pregnancy or breastfeeding
	Orthodontic appliance treatment within the previous three months
	Abutment teeth for fixed or removable prostheses
	Teeth or supporting structures with any symptomatic pathology
	Periodontal surgery within the previous three months

During the period of April-September 2014, a total of 44 Class I restorations using two self etching adhesives (G-Aenial Bond and Clearfil S3 Bond) with or without surface sealant application were placed in 11 patients free of pain. Patients had occlusal caries in posterior teeth and were aged from 16-41 years old with a mean age of 21.40 years. More than 90% of the patients were under the age of 30 years.

Selection and Isolation of Teeth

The molar teeth, selected for the study, were neither tender to percussion nor did they show any sign of periapical radiolucency. A pre operative radiographic examination using bitewing radiographs was taken to rule out proximal caries. All teeth had sound proximal contact with adjacent teeth and had at least one antagonist tooth. If maxillary premolars or molars were selected, both right and left teeth were restored at the same visit. If mandibular teeth were selected, one tooth was restored at each visit to avoid giving two inferior dental blocks simultaneously. Isolation was achieved with cotton rolls and saliva ejectors.

Cavity Preparation

Bitewing radiographs of the teeth to be restored were taken pre operatively. On the basis of the radiographs, the lesions needed to be categorized according to their depth as being in the outer (shallow), middle or inner (deep) one third of the dentin (24). If there was a possibility pulp capping according to radiography and clinical symptoms, the tooth was excluded from study. To prevent patient discomfort during the restorative procedures, local anesthesia was given when necessary. The teeth to be restored were cleaned with a pumice water slurry in a rubber cup to remove salivary pellicle and any dental plaque. Cavity preparations were limited to the removal of caries. Diamond burs (SWS, Diamond bur; lot:K46570) were used with a high speed handpiece and constant water cooling to access the carious lesion. Carious dentin was removed using carbid burs (Medin, tungsten carbid; lot:11355011) and a low speed handpiece. Carious tooth structure was removed until hard tissue was detected by tactile examination of the cavity using dental probe. The enamel walls were smoothed with a cylindirical finishing bur at slow speed. The cavosurface angle of the prepared cavity was approximately 90º. The depth of the prepared cavity was measured against the mesial and distal marginal ridges using a graduated periodontal probe. The bucco lingual dimension of each carious cavity was less than half the intercuspal width. If there was a pulp exposure or pink dentin was visible, the tooth was excluded from the sample. Any protective layer was not applied under the restorations.

Application of Bonding System

For each subject, the all in one adhesive systems G-Aenial Bond (GC, Tokyo, Japan) and Clearfil S3 Bond (Kuraray, Okuyama, Japan) were applied strictly according to the instructions provided by the manufacturers (Table 2). For each patient, half of the lesions were treated with G-Aenial Bond and the other half were treated with Clearfil S3 Bond. Both types of adhesive were applied in random order by which the first randomly selected adhesive was used to restore the tooth with the lowest tooth number (according to the FDI system) (25) and the alternative adhesive was used for the tooth with second lowest tooth number (26).

Table 2. *Dentin bonding agents used, manufacturer, adhesive composition and application technique.*

Material	Manufacturer	Composition	Manufacturers' Instruction
G-Aenial Bond	GC Corparation, Tokyo, Japan	Acetone, water, dimethacrylate, 4-methacryloxyethyltrimellitate anhydride, phosphoric ester monomer, silicon dioxide, photo initiator	Shake adhesive bottle. Apply adhesive. Leave for 10 seconds. Dry thoroughly for 5 seconds with oil free air under maximum air pressure. Light cure for 10 seconds.
Clearfil S3 Bond	Kuraray Medical, Okayama, Japan	Bisphenol A diglycidylmethacrylate, 2-hydroxyethyl methacrylate, 10-methacryloyloxydecyldihydrogen phosphate, ethanol, colloidal silica, dl camphorquinone, water, initiators, accelerators	Apply adhesive. Leave for 20 seconds. Dry by high pressure blowing for more than 5 seconds. Light cure for 10 seconds
Fortify Plus	Bisco, Schaumburg, IL, USA	Urethane Dimethacrylate (UDMA), Bisphenol A, Ethoxylated dimethacrylate (BisEMA), filler	Etch the surface of the restoration and approximately 1-2mm beyond the tooth/restoration margin for 15 s. Apply a thin layer to previously etched surfaces using a scrubbing motion. Air thin by blowing a gentle stream of air over this layer to assure an even distribution. Light cure sealant for 10 seconds.

Restoration with Composite

After bonding procedures, Clearfil Majesty Posterior (Kuraray, Okuyama Japan) composite material was applied incrementally in two or three small horizontal layers to cavities. Each layer was cured for 20 s with a LED light curing unit (Elipar S10, 3M, ESPE, St Paul MN, USA) having a minimal output of 1200 mW/cm^2. The light intensity output was monitored using a dental radiometer (Hilux Ledmax Light Curing Meter, Benlioğlu Dental Inc, Ankara, Turkey). Final countering and finishing of the restorations were performed using polishing points (PoGo, Dentsply) and flexible discs and finishing strips (Sof Lex, 3M ESPE, St Paul MN, USA).

Following completion of the restorations, to one of the teeth which was applied same bonding agent, was covered of surface sealant material (Fortify Plus Surface Sealant, Bisco, USA), other was not. Fortify Plus was applied according to the manufacturer's instructions to a random selection of restorations. After the completion of the restorative procedures, patients were contacted and reexamined after 24 h and again after 7, 15, and 30 day to assess postoperative sensitivity. All cavities were prepared and the restorations placed by the same operator (S.A.G).

Postoperative sensitivity evaluation procedure

Objective Assessment

The sensitivity of each tooth to applications of compressed cold air, an ice stimulus, and pressure was recorded using the patient's response to a visual analogue scale from 0 to 10. According to this scale, 0 meant no pain, 1-2 mild pain, 3 to 7 moderate pain, 8-9 severe pain, and 10 worst pains (Figure 1) (27).

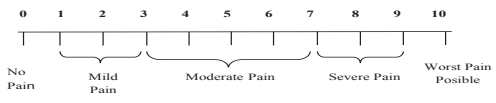

Figure 1. *The visual analog scale for pain assessment (27).*

Ice was applied in the form of an ice stick applied to the buccal surface of tooth (28), and compressed cold air was applied from the dental unit syringe at a distance of approximately 2 cm to the restoration. Pressure was applied by moving the probe over the restored tooth surface. The application of both stimuli was timed from the onset until the subject responded, with a maximum application lasting 15 seconds (29).

For the pressure examination, a 2 mm silicone disc was placed on the restored tooth and the patient was instructed to bite until all occlusal contacts were achieved. This pressure was sustained for up to 5 seconds. Two clinicians were present at each evaluation period. The clinicians did not participate in the restorative procedures and were unable to detect which system was used. When disagreement occurred during the evaluations, the restorations were re evaluated by both dentists and a consensus was obtained. New blank sheets were used at each recall to avoid bias.

Subjective Assessment

At recall visits, each of the patients' subjective assessment of postoperative sensitivity was recorded according to the VAS scale at daily activities. The patients were asked to report pain from any of the teeth selected for restoration during normal daily activities such as mastication and drinking hot or cold drinks.

Statistical Analysis

The absence or presence of postoperative sensitivity was determined by three criteria: cold air application, ice application, and pressure application. The incidence of postoperative sensitivity was independently calculated for three variables: dentin bonding agents (Clearfil S3 Bond, G-Aenial Bond), the use or omission of a surface sealant around the restorations, and depth of cavity (shallow, medium, deep). All statistical analyses were performed using IBM SPSS for Windows version 20.0 (SPSS, Chicago, IL, USA). Kolmogorov Smirnov tests were used to test the normality of data distribution. Continuous variables were expressed using mean and standard deviation and categorical variables were expressed using counts (percentages). Comparisons of continuous variables between the times were performed using the Friedman's One Way Analysis of Variance with Repeated Measures Test. Comparisons of categorical variables between the groups were performed using the Pearson chi square test. A two sided p value <0.05 was considered statistically significant. The incidences of postoperative sensitivity for the three categories of cavity depth (shallow, middle, and deep cavities) were independently calculated. Comparisons of continuous variables between groups were performed using the Kruskal Wallis Analysis of Variance and Dunn's Post Hoc Test. A two sided p value <0.05 was considered statistically significant.

Results

Between the baseline and 30 day evaluations, all the patients returned for the evaluation. The Friedman test showed that there was no statistically significant difference in the sensitivity level when the baseline was compared with the post treatment times (7.days, 15.days, and 30 days) (Table 3, 4). Clearfil S3 Bond and G-Aenial Bond exhibited the same sensitivity scores from compressed cold air, ice application, and pressure stimulus for each of the evaluation periods. The application of the surface sealant did not cause the decrease the sensitivity scores not only at 24 hours, but also after 30 days for both dentin adhesives (Table 3, 4) ($p>0.05$). The highest sensitivity scores obtained from S3 Bond/Fortify Plus with cold air application and G-Aenial Bond with ice application at 24 h (0.64±1.76 mean) at 24h. At 30 days, the highest sensitivity was obtained from S3 Bond Fortify Plus (0.64±1.56 mean) with ice application ($p>0.05$). According to the effect of the stimulus type on postoperative sensitivity; Chi Square showed that the ice application caused the highest rates of sensitivity on teeth when compared to compressed cold air and pressure, but there was no significant difference. After pressure application, almost all patients gave a score 0 according to their sensitivity response. For the compressed cold air stimulus, the highest sensitivity was observed for S3 Bond/Fortify Plus application (0.64±2.11) at 24 hours, same was valid after 30 days (0.36±1.20). For the ice stimulus, the highest level of sensitivity was observed for G-Aenial Bond (0.64±1.12) at 24h, but after 30 days S3 Bond/Fortify Plus (0.64±1.56) displayed the highest sensitivity scores. For the pressure stimulus, S3 Bond exhibited the highest sensitivity scores at 24 h (0.36±1.20) and S3 Bond/Fortify Plus at 30 days (0.36±1.20) ($p>0.05$). None of the patients experienced postoperative sensitivity with application of pressure stimuli after 30 days for G-Aenial Bond and G-Aenial Bond/Fortify Plus. After 30 days, only 2 patients reported mild pain at a score level of 1. Only 1 patient reported severe pain (score 8) at the cold air application at 7 days for S3Bond/Fortify Plus. Apart from this, all patients reported mild or moderate pain for all bonding procedures and stimuli (Table 4). Postoperative sensitivity remained mild level at 2 teeth and moderate levels at 3 teeth, a total of 5 in 44 teeth after 30 days. According to 24 hour, there was a decrease generally in the occurrence of sensitivity for all groups. The results of this study showed that there were no statistically significant differences in sensitivity scores between shallow, middle, and deep cavities (Table 5). However, in general, the highest sensitivity scores were obtained from deep cavities. The patients did not complain of pain from any of the teeth selected for restoration during normal daily activities such as mastication and drinking hot or cold drinks at all the post treatment times.

Table 3. *Comparison of the Postoperative Sensitivity (VAS) by time (mean±standard deviation, median, minimum and maximum values), for cold air stream, ice application and pressure application.*

		24 h		1 week		2 weeks		1 month			
Stimulus type	**Material**	**Mean S T**	**Median (min-max)**	**Mean S T**	**Median (min-max)**	**Mean S T**	**Median (min-max)**	**Mean S T**	**Median (min-max)**	**Chi-Square**	**P**
Cold air application	**Clearfil S3Bond**	0	0. (0-0)	0.18±0.60	0. (0-2)	0	0. (0-0)	0	0. (0-0)	3.00	0.39
	G-Aenial Bond	0.45±1.50	0.(0-5)	0.18±0.60	0. (0-2)	0	0. (0-0)	0	0. (0-0)	3.00	0.39
	S3 Bond-Fortfy Plus	0.64±2.11	0. (0-7)	0.73±2.41	0. (0-8)	0.64±2.11	0. (0-7)	0.36±1.20	0. (0-4)	3.00	0.39
	G-Aenial-Fortify Plus	0.18±0.60	0. (0-2)	0	0. (0-0)	0.18±0.60	0. (0-2)	0.27±0.90	0. (0-3)	3.00	0.39
Ice application	**Clearfil S3Bond**	0.09±0.30	0. (0-1)	0.36±1.20	0. (0-4)	0.09±0.30	0. (0-1)	0.09±0.30	0. (0-1)	3.00	0.39
	G-Aenial Bond	0.64±1.12	0. (0-3)	0.55±1.29	0. (0-4)	0.36±1.20	0. (0-4)	0.27±0.90	0. (0-3)	1.66	0.64
	S3 Bond-Fortfy Plus	0.45±1.50	0. (0-5)	0.45±1.50	0. (0-5)	0.45±1.50	0. (0-5)	0.64±1.56	0. (0-5)	3.00	0.39
	G-Aenial-Fortify Plus	0.18±0.60	0. (0-2)	0	0. (0-0)	0.27±0.90	0. (0-3)	0.27±0.90	0. (0-3)	3.00	0.39
Pressure application	**Clearfil S3Bond**	0	0. (0-0)	0.36**±1.20**	0. (0-4)	0.18**±0.60**	0. (0-2)	0.18**±0.60**	0. (0-2)	1.28	0.73
	G-Aenial Bond	0	0. (0-0)	0	0. (0-0)	0	0. (0-0)	0	0. (0-0)	-	-
	S3 Bond-Fortfy Plus	0	0. (0-0)	0.27**±0.64**	0. (0-2)	0.36**±1.20**	0. (0-4)	0.36**±1.20**	0. (0-4)	2.20	0.53
	G-Aenial-Fortify Plus	0	0. (0-0)	0	0. (0-0)	0	0. (0-0)	0	0. (0-0)	-	-

Table 4. *Appearance of sensitivity prevalence (%) of teeth according to VAS. (0=No pain 1, 2=mild pain, 3,4,5,6,7=moderate pain, 8, 9=severe pain, 10=worst pain.)*

S3 Bond/ Fortify Plus			S3 Bond			G-AenialBond/ Fortify Plus			G-Aenial Bond			Treatment procedure	
Pressure	Ice	Cold air	Pressure	Ice	Cold air	Pressure	Ice	Cold air	Pressure	Ice	Cold air	Sensitivity evaluating test method	
11 (%100)	10 (%90.9)	10 (%90.9)	11 (%100)	10 (%90.9)	11 (%100)	11 (%100)	10 (%90.9)	10 (%90.9)	11 (%100)	8 (%72.7)	10 (%90.9)	0	24 hours
-	1 (%9.1)	-	-	1 (%9.1)	-	-	1 (%9.1)	1 (%9.1)	-	2 (%18.2)	-	1,2	
-	-	1 (%9.1)	-	-	-	-	-	-	-	1 (%9.1)	1 (%9.1)	3,4,5,6,7	
-	-	-	-	-	-	-	-	-	-	-	-	8,9	
-	-	-	-	-	-	-	-	-	-	-	-	10	
9 (%81.8)	10 (%90.9)	10 (%90.9)	10 (%90.9)	10 (%90.9)	10 (%90.9)	11 (%100)	11 (%100)	11 (%100)	11 (%100)	9 (%81.8)	10 (%)	0	1 week
2 (%18.2)	-	-	1 (%9.1)	-	1 (%9.1)	-	-	-	-	1 (%9.1)	1 (%)	1,2	
-	1 (%9.1)	-	-	1 (%9.1)	-	-	-	-	-	1 (%9.1)	-	3,4,5,6,7	
-	-	1 (%9.1)	-	-	-	-	-	-	-	-	-	8,9	
-	-	-	-	-	-	-	-	-	-	-	-	10	
10 (%90.9)	10 (%90.9)	10 (%90.9)	10 (%90.9)	10 (%90.9)	11 (%100)	11 (%100)	10 (%90.9)	10 (%90.9)	11 (%100)	10 (%90.9)	11 (%100)	0	2 weeks
-	-	-	1 (%9.1)	1 (%9.1)	-	-	-	1 (%9.1)	-	1 (%9.1)	-	1,2	
1 (%9.1)	1 (%9.1)	1 (%9.1)	-	-	-	-	1 (%9.1)	-	-	1 (%9.1)	-	3,4,5,6,7	
-	-	-	-	-	-	-	-	-	-	-	-	8,9	
-	-	-	-	-	-	-	-	-	-	-	-	10	
10 (%90.9)	9 (%81.8)	10 (%90.9)	10 (%90.9)	10 (%90.9)	11 (%100)	11 (%100)	10 (%90.9)	10 (%90.9)	11 (%100)	10 (%90.9)	11 (%100)	0	1 month
-	1 (%9.1)	-	1 (%9.1)	1 (%9.1)	-	-	-	-	-	-	-	1,2	
1 (%9.1)	1 (%9.1)	1 (%9.1)	-	-	-	-	1 (%9.1)	1 (%9.1)	-	1 (%9.1)	-	3,4,5,6,7	
-	-	-	-	-	-	-	-	-	-	-	-	8,9	
-	-	-	-	-	-	-	-	-	-	-	-	10	

Table 5. *Distributions of restorations according to cavity depth, mean sensitivity scores and standard deviations (SD) according to cavity depth.*

	S3 Bond	G-Aenial Bond	S3 Bond/Fortify Plus	G-Aenial Bond/ Fortify Plus	Mean ±S D
Shallow	4	2	3	3	0.108±0.265 A
Medium	7	6	7	7	0.152±0.358 A
Deep	-	3	1	1	0.798±1.696 A
Total of restorations	11	11	11	11	p=0.599

Means followed by distinct capital letters represent statistical significant differences in each column ($p < 0.05$).

Discussion

In the current study, the effect of surface sealant and the adhesive system on postoperative sensitivity was examined in occlusal cavities. Clearfil S3 Bond and G-Aenial Bond displayed similar sensitivity scores ($p>0.05$). The sensitivity scores slightly decreased at the end of 30 days, although not significantly ($p>0.05$). Also, notwithstanding the type of adhesive system used, surface sealant application did not diminish postoperative sensitivity of restorations. On the contrary, the highest sensitivity scores were observed for teeth which had the surface sealant applied teeth. In this study, we also compared the sensitivity scores according to cavity depth. In their review, Weiner *et al.* (30) noted that there are no strict guidelines for defining deep or shallow cavity preparations. But in general, previous studies have classified cavities as 1/3 shallow, 1/3 medium, and 1/3 deep cavities (15). The result of the outcomes of this study showed that there was no significant difference between postoperative sensitivity in shallow, medium and deep cavities using the different stimulus and bonding procedures. However, though not statistically significant, the highest sensitivity scores were obtained from deep cavities. This may be attributed to the fact that in deep cavities (small remaining dentin thicknesses) the short tubules offer even less intratubular resistance to fluid flow. This could increase the potential for dentin sensitivity (31). In other words, thick dentin (or shallow cavities) offers more resistance to hydrodynamically induced fluid flow than does thin dentin. In agreement with our study, Unemori *et al.* (4) reported that the incidence of postoperative sensitivity was significantly higher in deep cavities than in the medium or shallow cavities, when all restorations were grouped by cavity depth.

The findings of this study showed that using self etching adhesives did not eliminate postoperative sensitivity after 24 hours or even after 30 days. In agreement with our study, Caselli *et al.* (17), Burrow *et al.* (28) and Perdigao *et al.* (29) reported of total etching adhesives. In contrary, Tay *et al.* (11), Unemori *et al.* (15) reported that postoperative sensitivity diminishes when self etching adhesives (Fluoro Bond, Liner Bond II) are used. Both adhesive used in the study are seventh generation all in one adhesives. The only difference between the two is HEMA content. Clearfil S3 Bond contains HEMA in composition whereas, G-Aenial Bond does not. HEMA draws water through osmosis from the dentin, and the number of water droplets increases during light curing (16). According to hydrodynamic theory, sensitivity results from dentin tubules fluid movement. However, the presence of a smear layer over intertubuler dentin could be preventing the fluid movement for the self etching systems. When HEMA is omitted from the adhesive blend, a high amount of solvent is added to the bonding system. The ratio contains an average of 40% acetone for G-Aenial Bond. If such a high level of solvent cannot be completely eliminated from the adhesive before light curing, it may have an adverse effect on the polymerization of the monomers. Poor polymerization of resin can lead to crack formation and premature bonding failure (32) and consequently, premature bonding failure could be influential on developing percolation and postoperative sensitivity (17). Current commercial dental composites have a volumetric shrinkage ranging from 1-4% volume (7). When polymerization shrinkage stress exceeds the bond strength to the cavity walls, it causes contraction gaps to form at the tooth restoration interface (33) and, consequently, postoperative sensitivity (34). Kleverlaan *et al.* (35) reported that the contraction stress was measured to range from 3.3 to 23.5 MPa. Such high forces could affect the failures at bonded interfaces, and in this way, could cause the development of postoperative sensitivity. In addition to polymerization shrinkage forces, the high C factor of Class I cavities could be influential to increase stresses at interfaces.

To reduce the stress generated by polymerization shrinkage, various procedures have been tried for a long time. According to Kemp Scholte *et al.* (36) applying a relatively thick adhesive layer may compensate for the polymerization stress due to its

elastic properties; therefore, it has been suggested as a means to reduce gap formation. However, most of the current all-in-one adhesives, commonly used under high pressure, air dry and this potentially causes a thin adhesive layer on the dentin. Both G-Aenial Bond and Clearfil S3 Bond are used under high air pressure for least 5 sec according to manufacturer instructions; the purpose of the high air pressure is to remove water/moisture completely from interface. Van Landuyt *et al.* (37) reported that Clearfil S3 Bond has a 10µm and G Bond has a 10-15µm adhesive layer thickness, whereas the bonding that applied with mild air drying adhesives has an adhesive layer thickness of 50µm. A relatively thin adhesive layer could be liable for the development of postoperative sensitivity after polymerization for both types of adhesive. Also, a thin adhesive resin layer was reported to be less polymerized and more permeable (38). Also, its bonding interface was reported to be sensitive to thermal stress (39). All of these reasons could contribute to the development of postoperative sensitivity associated with the self etch adhesives used in the study. This study's outcomes showed that application of Fortify Plus around the restoration did not diminish the sensitivity, not only at 24 h but also after 30 days. On the contrary, the highest sensitivity scores were obtained from teeth which were restored using Clearfil S3 Bond and applied with Fortify plus. Lima *et al.* (21) reported that the surface sealant materials promote excellent sealing and decrease microleakage, thus providing greater protection to the restored tooth.

In agreement with Lima *et al.* (21), Munro *et al.* (22) and Owens *et al.* (23) reported that surface sealant application significantly reduced microleakage under laboratory conditions and thus enhancing marginal integrity of restorations. However, Erhardt *et al.* (20) and Delfino *et al.* (19) reported that the application of sealant round the restorations did not reduce the microleakage of restorative systems. If considering that Fortify Plus is influential to closing the leakage pathway and in this way could be influential to reduce the postoperative sensitivity, the results of this clinical study contradict this finding. According to Letzel *et al.* (40) nearly 30% of patients present with postoperative sensitivity after placement of resin composites in posterior teeth. Unemori *et al.* (4) reported 11% postoperative sensitivity was detected at composite restorations after 3 years. Al Omari *et al.* (24) reported that 43% of teeth were sensitive on the second day postoperatively, and this figure decreased to zero at three months. Different from these studies, this study was conducted in short time. The cause of the choosing the short term was the diminish the postoperative sensitivity generally during the first few weeks after restoration placement (40, 41). Akpata *et al.* (1) reported that using ice sticks to detect the postoperative sensitivity give reasonably accurate outcomes. So, it could be stated that 11.36% of postoperative sensitivity was detected in this study after 30 days. The hydrodynamic theory of dentin sensitivity states that movement of tubule content or tubule fluid causes dentin sensitivity (42). Such a high rate of sensitivity from ice application when compared to other methods could be attributed to hydrodynamic theory. Also, in this study, restorations were mostly applied to young patients. Young patients have larger pulp chambers and larger dentinal tubules, making it more likely that their teeth would be more sensitive to hydrodynamic stimuli (4, 10).

Optam *et al.* (10) reported that 56% of the restorations resulted in sensitivity upon loading, while 14% of the teeth experienced spontaneous postoperative sensitivity. Sarrett *et al.* (43) reported that the percent of restorations considered failures due to pain or sensitivity ranged from 2 to 8%. In this study no patients stated spontaneous postoperative sensitivity. So, none of the restorations needed to be replaced as a result of postoperative sensitivity.

Conclusion

Based on the findings of this *in vivo* study, it may be concluded that there was no statistically significant difference in the sensitivity level when the baseline was compared with the post treatment times, but postoperative sensitivity tends to decrease over time. Self etching adhesives demonstrate postoperative sensitivity at the short term. Application of surface sealant material around the restorations does not diminish postoperative sensitivity. Deep cavities display a higher rate of postoperative sensitivity compared to shallow and medium cavities. Stimulus type could be effective on sensitivity prevalence.

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None declared

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