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Effect of Dentin Sealers on Postoperative Sensitivity of Complete Cast Crowns Cemented with Glass Ionomer Cement

Abdulhamaid A. Maghrabi, BDS, MS, PhD

Department of Oral and Maxillofacial Rehabilitation, King Abdulaziz University, Jeddah, Saudi Arabia

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Correspondence
Abdulhamaid A. Maghrabi, Oral and Maxillofacial Rehabilitation, King Abdulaziz University, P.O. Box 80157, Jeddah 21589, Saudi Arabia. E-mail: abdulmag_99@yahoo.com

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Abstract

Purpose: The purpose of this study was to clinically evaluate the effects of pretreatments with copal/ether varnish and dentin bonding system on postoperative sensitivity of complete cast crowns cemented with glass ionomer cement.
Materials and Methods: Three posterior teeth with no pain symptoms were selected from each of 17 patients, totaling 51 teeth, for which a crown was indicated. Rexillium III complete cast crowns were prepared using conventional laboratory techniques. For each patient, the first tooth, which served as the control, received only glass ionomer cement (Ketac-Cem). Copal/ether varnish (Bosworth Copaliner) was applied to the second tooth preparation prior to cementation. Dentin bonding agent (OptiBond Solo Plus) was used on the third tooth before cementation. Sensitivity to different stimuli (cold, heat) was assessed at 7 days, 1 month, and 6 months following restorative procedures by questionnaire.
Results: There were no statistically significant differences between the three groups regarding applied stimulus and day of the study ($p > 0.05$). No statistically significant differences were found between the postoperative sensitivity responses from 7 days to 1 month, and from 1 month to 6 months ($p > 0.05$).
Conclusions: Postoperative sensitivity resulting from glass ionomer cement with complete cast crowns cannot be completely eliminated with the prior use of a cavity varnish or bonding agent.

It is a widely recognized phenomenon that after restoring a tooth, the patient can experience postoperative sensitivity, particularly to thermal stimuli, which in many cases disappears after a short time.[1-3] There is much less consensus, however, about the number of complaints.[4-6] These complaints have been found to occur in 20 to 30% of crowns.[7,8] Moreover, this percentage remains at 6% after 2 years, and 3% after 3 years.[9] Although these complaints are normally of a transient nature, sensitivity can be a great concern to the patient and dentist. In addition, there is no unanimity of opinion about the cause of postoperative sensitivity or the solutions proposed to reduce these complaints.[10]

There are several explanations for postoperative sensitivity. When the dentinal tubules are open in greater number and expanded, the adverse effects caused by cavity preparation, such as excessive heat and dentin dehydration, reach the pulp more easily.[11] This condition is further aggravated when the dentin is acid etched. Acid etching not only widens the tubules, but also removes the smear layer covering them and physically seals them off from all outside stimuli.[11,12] Infection caused by bacterial invasion, whether originating in the smear layer or because of microleakage of provisional cement, seems to be the main sensitivity-triggering event, which is why some investigators[12,13] advocate the use of chemical substances prior to restoration to inhibit bacterial growth and reproduction.

The pH of glass ionomer cement increases as the cement sets.[14] It has been suggested that the initial low pH may be responsible for early anecdotal reports of sensitivity following crown cementation.[14] However, laboratory studies indicate that the dentine buffers the hydrogen ions released from glass ionomer cement, and reports have shown that glass ionomer cement was not associated with postoperative sensitivity.[15,16] A further complication in interpreting human and animal studies is the generally accepted theory that bacterial microleakage is responsible for the majority of pulp damage. The contribution of material damage and bacterial damage to overall damage is difficult to separate.[17]

Various attempts have been made to reduce postoperative sensitivity, particularly in the choice of operative technique and the copious use of water cooling during tooth reduction.[11,18]

Nevertheless, replacing a thermally insulating substance with a conducting metal can make prevention of thermal irritation a challenge, particularly after the pulpal tissues have suffered the insult of tooth preparation.[19] Traditionally two or three thin coats of a copal/ether varnish have been used under amalgam and crowns to provide a barrier against sensitivity. The varnish is intended to occlude the dentin tubules thought to provide the pathway for pain transmission through dentin; however, under scanning electron microscopic examination, the varnish layer appears incomplete and probably only provides partial protection.[20]

Use of dentin desensitizing agents for reducing sensitivity after crown preparation or before cementation has been shown to be an effective clinical treatment.[19,20] Desensitizers obturate exposed dentin tubules with a resinous material, blocking tubule fluid flow, and reducing the sensation of pain.[21] After crown preparation, as many as 1 to 2 million dentinal tubules may be exposed,[22] increasing the potential for postoperative sensitivity. After tooth preparation, dentin can still become sensitive as a result of interim restoration microleakage and the resultant formation of bacterial byproducts.[23,24] However, with the use of a thin layer of resin-based dentin desensitizing agent, tubules can remain blocked, and the effect of external agents on dentin sensitivity can be greatly reduced.[19,20]

The development of dental adhesives has contributed greatly to reducing the occurrence of postoperative sensitivity following composite resin restoration procedures.[19] Dental adhesives are able to bond the restorative material to the tooth structure and obliterate open dentinal tubules.[25,26] Well-sealed dentinal tubules prevent invasion from outside bacteria and susceptibility to outside stimuli.[27] Moreover, most contemporary systems rely on impregnating the collagen network of the surface dentin with a hydrophilic resin like 2-hydroxyethyl methacrylate (HEMA). The step may be preceded by etching to remove the smear layer. The resulting resin-penetrated layer is called the hybrid layer and is used to attach the restorative material.[25] Studies on the efficacy of contemporary dentin bonding systems have demonstrated gap-free bonding and restoration retention.[28–30] With recent advances in adhesive technology, manufacturers and practitioners have proposed using bonding resins in place of conventional cavity varnish under amalgam and crowns.[31] Discussions with general dental practitioners in the United States have suggested this as a popular application of the material.[32] In vitro studies using the resin and nonresin sealer as a desensitizing treatment for prepared teeth showed no effect on crown retention for glass ionomer cement.[11,33,34]

Indirect evidence supports the replacement of cavity varnish with the bonded resin technique. Microleakage, which may be a source of postoperative sensitivity, has been reduced when bonded resin is used,[35,36] and it has reduced the sensitivity of exposed radicular dentin.[37,38] It has also been shown to reduce sensitivity of prepared teeth for complete crowns[39] and be effective in reducing sensitivity associated with composite resin restorations.[40] However, no definitive information is available as to whether the routine use of bonding resin can be recommended as a method for reducing postoperative sensitivity of fixed restorations. The purpose of this investigation was to assess the effectiveness of copal/ether varnish and dentin bonding system in preventing postoperative sensitivity in complete cast crowns. The null hypothesis was that pretreatments with copal/ether varnish and dentin bonding agent would have no influence on the postoperative sensitivity of complete cast crowns. This should be monitored over 6 months.

Materials and methods

The trial was performed in the specialty clinics of King Abdulaziz University, Faculty of Dentistry, with 86 volunteers recruited from Jeddah, Saudi Arabia. Following enrollment, subjects followed a regimen of brushing twice daily with standard commercial fluoride toothpaste for 4 weeks, the wash-in phase, followed by a 6-week period of home use of toothpaste. Out of 86 patients, a total of 51 molar teeth from 17 adult patients (three teeth per patient) 18 to 50 years age (mean: 38.7 ± 14.1 years) seeking extracoronal fixed restorations on vital tooth/teeth and taking no medications that would affect pain perception, inflammation, or infection were selected. All patients signed a written informed consent and agreed to be available for periodic recall. After the patients were given a brief explanation on the type of investigation to be conducted, they all consented to take part in the study and signed the consent form approved by the Bioethical and Research Committee of King Abdulaziz University, Jeddah, Saudi Arabia.

The patients taking part in this investigation showed no signs of spontaneous dental or orofacial pain. Whenever possible, contralateral teeth of the same jaw were treated. Only teeth with a maximum of a two-surface build-up and normal sensitivity (no hypersensitivity or pain) were included in the study. Pulp tests were carried out with hot (gutta-percha stick) and cold (ice stick) stimuli to establish whether there was any alteration in the pulp, which could jeopardize final investigation results. The stimulus was placed against the buccal surface of the experimental tooth, whose reaction was compared with that of nearby teeth. Periapical and interproximal radiographs were taken of all the teeth to evaluate pulp proximity. Teeth with anatomy compromised by severe destruction to the dental crown, as well as those with cavities too close to the pulp, as revealed by radiographic examination, and even those with signs of periapical radiolucency, were rejected.

Depending on the extent of sound tooth structure after caries removal, a micro-hybrid composite resin (Z100, 3M ESPE, St Paul, MN) was used in combination with an OptiBond FL dentin adhesive (Kerr, Orange, CA) for any necessary build-up of selected teeth according to the manufacturer's instruction. Only one tooth received composite resin restoration. The subjects returned within 1 week to the study center, where baseline measures of tooth sensitivity were tested. Following anesthesia, tooth preparations were performed with diamond burs (6856–016; Brasseler USA, Savannah, GA) under abundant irrigation. Tooth preparations were initiated by an occlusal reduction of 1 to 1.5 mm, followed by axial reduction. A chamfer margin 0.3 to 0.5 mm wide was formed by the round-ended tapered rotary instrument. The finished tooth preparation resulted in an abutment height ranging from 5 to 6 mm. All preparations were finished by rounding sharp angles. A new rotary instrument was used for each tooth, and a continuous water jet was directed at the rotary instrument.

All patients included in the investigation were given the same treatment. The first tooth of each patient was prepared according to the protocol adopted for the control group. When the first preparation was concluded, the patient was given a questionnaire and instructions to record any postoperative pain for that tooth. The patient was asked to fill out the questionnaire at home. The patient was also asked to make an appointment following day 7 (the day after restoration) to have another molar tooth prepared. The procedure repeated until three teeth were prepared in each patient. To minimize the effect of variations in the preparation procedure, the same clinician completed all preparations. Provisional crowns (TBA 2000, Kerr, Salerno, Italy) were fabricated and temporarily cemented with a eugenol-free provisional cement (Freegenol, GC, Tokyo, Japan).

At the following appointment, the session for impression taking (Examix; GC America Inc., Chicago, IL), the provisional crowns were removed, and the abutment teeth were subsequently cleaned with prophylaxis paste for 30 seconds to remove remaining provisional cements.[19] Afterwards, the provisional crowns were cemented again. Impressions were cast with type IV die-stone (Jade stone; Whip Mix Corp, Louisville, KY). Die spacer (Tru-Fit; George Taub Products and Fusion Co Inc, Jersey City, NJ) was applied in four even thickness layers to within 0.5 mm of the preparation margin. The four layers of die spacer used in this study were used to standardize the definitive thickness of die spacers and ensure almost 25 μm of internal relief.[41] A wax pattern (Gator Wax; Whip Mix Corp.) was made for each stone die. The patterns were invested with phosphate-bonded investment (Cera-Fina; Whip Mix Corp.) and cast with an Ni-Cr-Be base metal alloy (Rexillium III; Jeneric/Pentron, Wallingford, CT). Investing and casting protocol was established by pilot testing to produce crowns that seated well on the stone dies and tooth preparations with minimal force and could not be rocked or rotated.

Castings were recovered from the investment and airborne-particle abraded with 50 μm aluminum oxide for 10 seconds with a contra-angle microetcher (model erc-er; Danville Engineering, Danville, CA) at 60 psi. To minimize the effect of variations in the casting procedure, the same clinician completed all castings. The intaglio surface of each casting was inspected with a 20× stereomicroscope (SMZ-1; Nikon Inc., Melville, NY), and nodules were removed with a half-round bur in a slow-speed straight handpiece. After necessary adjustment, castings fit their tooth preparations passively but were not noticeably loose or unstable. The restorations were accepted for cementation when there was no sign of interference, and the fit of the margins was judged to be acceptable with an explorer. Subsequently, the tooth preparations were polished with prophylaxis paste for 30 seconds.[19] The intaglio surfaces of the artificial crowns were ultrasonically cleaned. Cast crowns and corresponding teeth were assigned to three groups following one of the three protocols listed:

(1) *Control group*: Tooth preparation + glass ionomer cement + restoration.
(2) *Cavity varnish group*: Tooth preparation + copal/ether varnish prior to cementation + glass ionomer cement + restoration.
(3) *Dentin bonding system group*: Tooth preparation + OptiBond Solo Plus prior to cementation + glass ionomer cement + restoration.

Cavity varnish (Bosworth Copaliner, Bosworth Company, Sickle, IL) was applied to the prepared dentin using a very small cotton pledget with the cotton plier dipped into the copalite bottle, then immediately coating the tooth preparation followed by drying the tooth with air. Two coats were necessary to make the film continuous.[11] Dentin bonding agent (OptiBond Solo Plus, Kerr, Romulus, IL) was applied with a disposable brush to the entire tooth preparation structure and left to permeate for 10 seconds. The excess was then removed with a stream of air at a 5- to 6-cm distance, for 10 seconds, following the manufacturer's recommendations and then light cured (UltraLume LED 5; Ultradent Products Inc, South Jordan, UT) for 10 seconds. Light intensity output was monitored with a curing radiometer (Demetron/Kerr, Danbury, CT) to be at least 750 mW/cm.^{2}

Glass ionomer (Ketac-Cem; 3M ESPE) cement was activated for 2 seconds and mixed for 10 seconds in an amalgamator (Silamat; Ivoclar Vivadent, Amherst, NY). A stiff brush was used to coat the intaglio surface of each crown with an even thickness of cement. Each crown was seated with finger pressure and use of a slight back and forth axial rotation through an 80-mm long × 6-mm diameter orange wood stick placed horizontally on the occlusal surface of the crown. The opposite end of the loaded stick was subjected to horizontal and vertical movement for 20 seconds, and the force was maintained for 10 minutes. Excess cement was then removed with an explorer and dental floss. A 1-week interval was assigned between one treatment and the other, thus eliminating detrimental effects caused by treatment order. The follow-up examinations were conducted in a blind manner. The patient did not know which dentin sealer was used, so the patients were blinded to the treatment.

All patients included in the investigation were given the questionnaire and instructions following restorative procedures used by Scherer et al[42] to record any postoperative pain for that tooth. Each patient was asked to fill out the questionnaire about the subjective sensitivity of his or her teeth at home. Each patient was also asked to make an appointment following 7 days, 1 month, and 6 months, counting as of the day after restoration. The patients themselves were asked to record the sensitivity level noticed during specific periods and triggered by different stimuli: (i) intake of cold drinks, (ii) intake of hot drinks. Information as to the patient's age, sex, tooth/teeth number, and the date of the cementation were collected on the consent form/data collection card. The patients rated the level of sensitivity according to the pain scale (see Appendix). The McNemar chi-square test was applied to analyze the progression of the sensitivity responses from day 1 to day 4 and from day 4 to day 7, considering each material used and stimulus given separately.[43,44] A level of significance of 5% was adopted for each case considered.

Results

There were no statistically significant differences between the three groups regarding applied stimulus and day of the study

Table 1 Number of teeth according to level of sensitivity due to cold stimulus (n = 17)

	Sensitivity according to period of evaluation											
	1 day				1 month				6 months			
Group	No	Mild	Moderate	Severe	No	Mild	Moderate	Severe	No	Mild	Moderate	Severe
Control	15	1	1	0	16	0	1	0	16	0	1	0
Varnish	16	0	1	0	17	0	0	0	17	0	0	0
Bonding	13	2	2	0	15	1	1	0	15	0	1	1

($p > 0.05$). No statistically significant differences were found between the postoperative sensitivity responses from 7 days to 1 month, and from 1 month to 6 months ($p > 0.05$). Tables 1 and 2 show the number of teeth for each pain sensitivity level (no sensitivity, mild, medium, severe) recorded by patients for each group treated (control, cavity varnish, dentin bonding system) during the postoperative evaluation periods (7 days, 1 month, 6 months) in response to different stimuli (cold, heat). At baseline, the patients did not complain of pain from any of the teeth selected for restoration during usual cold or hot food intake or from oral hygiene procedures; however, some patients developed sensitivity 24 hours postoperatively.

Discussion

The data support the null hypothesis of the study, that dentin desensitizer and dentin bonding agent would have no influence on complete cast crown postoperative sensitivity. Many treatment modalities and agents have been used in the treatment of dentin hypersensitivity, but the efficacy of most of them has been varied and not well established.[18] Specific studies on attempts to avoid the incidence of postoperative sensitivity in vivo following permanent cementation are very few and limited to providing an evaluation of these processes.[18]

Because the number of teeth presenting sensitivity (mild, medium, severe) was very small, it was decided to combine the three groups into one. The number of teeth with sensitivity was very low, whereas the number of teeth with no sensitivity was very high. The pain felt by patients following restoration with complete cast crowns did not occur routinely. Nonetheless, before we started the investigation, we assumed that postoperative sensitivity in conventionally treated teeth (control group) would be more frequent than that actually found in our investigation. Therefore, the high percentage of teeth reported to have no sensitivity regarding postoperative sensitivity to the three types of stimuli in the three groups came as a complete surprise. In addition, this condition of no sensitivity remained practically constant throughout the 7 days of evaluation, as confirmed by statistical analysis. Comparisons with other research papers became very complex, as the conditions of the present study were different. Unemori et al[1] studied the symptoms of postoperative sensitivity after resin composite restorations for all types of cavities, and found that only 11% of all teeth showed postoperative sensitivity. Similar results were found by Opdam et al[2] where postoperative sensitivity was reported in 14% of all teeth, when Class I cavities were restored with resin composite.[3]

Postoperative sensitivity is a common problem that exists because of the restoration technique, which is very sensitive.[1,2,7,10,21] In the current study, postoperative sensitivity would originate from the marginal microleakage resulting either from restorative material bonding failure or from the technique employed. When the pulp tests were performed (cold/hot), the teeth showing pulp inflammatory processes were automatically eliminated, thus making it possible to standardize the teeth researched in relation to the initial condition of the pulp.

The method used in the current study to assess pain proceeded from routinely used categories of pain rated by patients.[10,45,46] Another method to assess sensitivity involves visual analogue scales, which seem to provide more effective statistical tests than tests based on fixed categories.[47] However, in the current study most patients had some difficulties in responding to visual analogue scales in the pilot study, leading the author to prefer using fixed categories of pain.

In the present study, human teeth were used to simulate the clinical condition. The dimensions of tooth preparations were

Table 2 Number of teeth according to level of sensitivity due to heat stimulus (n = 17)

	Sensitivity according to period of evaluation											
	1 day				1 month				6 months			
Group	No	Mild	Moderate	Severe	No	Mild	Moderate	Severe	No	Mild	Moderate	Severe
Control	16	0	1	0	16	0	1	0	16	0	1	0
Varnish	17	0	0	0	16	0	1	0	16	0	1	0
Bonding	16	0	1	0	16	0	1	0	15	0	1	1

also chosen to most closely fit the tooth size of the collection. The teeth were prepared in a manner that provided a close tolerance of ±0.1 mm for all specimens in all dimensions. Cementation procedure was conducted as per manufacturer's directions with the use of newer formulations of luting cements to simulate clinical conditions. The optimum situation for best precision in results is to have one operator do the entire study. Though the test method used in the present study attempted to simulate the clinical situation, there were some limitations. The results obtained in this study represent preliminary observations and should be analyzed carefully. The low number of teeth studied and the strictly followed protocol could have limited the findings, as no differences were found between the materials studied. To obtain more reliable results, it is necessary to conduct further clinical studies. It would be advisable to evaluate a greater number of teeth for longer periods; however, it is important to eliminate variables such as using the teeth of the same subject, using the same group of teeth, and using similar cavities.

This study emphasizes that when the restorative procedure is properly performed, only a small percentage of restored teeth become sensitive postoperatively. During the investigation, all steps of the restoration procedure were carefully followed, from radiographic examination and pulp testing to the cementation of the restoration. Perhaps this is the best explanation for the results reported in this study: there were no statistically significant differences between the pretreatments with copal/ether varnish and dentin bonding system. Opdam et al[2] advised that postoperative sensitivity, as one of the major factors determining the clinical success of a restoration, is significantly influenced by the restorative technique used by the clinician.

Conclusions

Within the limitations of this study, the incidence of postoperative sensitivity following cementation of crowns with this particular glass ionomer cement was low, but not zero, and did not change with the prior use of a cavity varnish or bonding agent.

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Appendix: Questionnaire completed by the patient

Questions
Please comment on the specific tooth. How is the sensitivity of this tooth? (Simultaneously the specific tooth was shown to the patient with a hand mirror and was touched with an explorer.)
Please think about your daily life. Hot drinks, cold drinks, sweets. Please rate the sensitivity of the tooth on the visual scale provided.
0 – No pain, tooth feels no different from others when having hot or cold drinks or sweet food.
1 – Mild pain, tooth feels sensitive to hot, cold, or sweet but able to eat normally.
2 – Moderate pain, tooth is sensitive to hot, cold, or sweet but eating on the other side of the mouth.
3 – Severe pain, tooth is very sensitive to any hot, cold, or sweet and need a pain reliever to control the problem.