Composite resin restoration and postoperative sensitivity: clinical follow-up in an undergraduate program

M. Unemori*, Y. Matsuya, A. Akashi, Y. Goto, A. Akamine

Department of Operative Dentistry and Endodontology, Faculty of Dentistry, Kyushu University, Fukuoka City, Japan

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Abstract

Objectives: To analyze the relationship between the cavity depth and liners with postoperative sensitivity of resin composite restorations.

Methods: A clinical follow-up was conducted on 319 resin composite restorations made in the final year of an undergraduate program over a 3-year period. Along with the analyses of cavity type, cavity depth, type of pulpal protection and the materials used, the postoperative sensitivity was also examined on each restoration.

Results: Thirty-nine percent of the restorations had no protective layer (Group 1). As the depth of the prepared cavities increased, the restorations received one of the three pulpal protection methods; a calcium hydroxide base (Group 2), glass ionomer cement (Group 3), or protection with a calcium hydroxide base in combination with glass ionomer cement (Group 4). The incidence of postoperative sensitivity showed no significant difference among Groups 1, 2 and 3, but was significantly lower in Group 1 than in Group 4. The restorations made in shallow and medium depth cavities demonstrated significantly less postoperative sensitivity than those made in deep cavities. The newer generation dentine-bonding agents showed a significantly lower incidence of postoperative sensitivity than the early generation group.

Conclusions: Postoperative sensitivity in resin composite restorations was not related to the absence of protective layers but increased with the depth of cavities restored with the resin composite. The type of dentine-bonding agents could also be responsible for postoperative sensitivity. © 2001 Elsevier Science Ltd. All rights reserved.

Keywords: Resin composite restoration; Postoperative sensitivity; Pulpal protection; Dentine-bonding system; Cavity depth; Cavity class; Clinical survey; Undergraduate program

1. Introduction

For many years, acid etching of vital dentine has been related to postoperative problems such as tooth sensitivity and pulp inflammation [1–3]. Restorative resin materials have also been the subject of concern since they are considered to be toxic to pulp [4,5]. Therefore, it has been generally recommended to provide a protective barrier for dentine and pulp in the form of a base or liner [1–6]. But recent studies have demonstrated that acid etchants or restorative materials have no adverse effects on pulp if a good cavity sealing is established [7–9]. Therefore, such studies suggest that no conventional liners or bases are required for composite restorations [7–9].

There remains a view that the protection of liners and bases is necessary for adhesive resin restorations, especially in deep cavities [10–13]. This view has been supported also

by the fact that various components of dentine-bonding agents and restorative resin materials are directly toxic to cells [12,14,15]. Dentine conditioning agents can also be harmful when the pH value is lower than 5.5 and when they approach or come in contact with pulp [16].

Evidence-based treatments of the newest bonding agents are not yet available. This results in a wide range of various treatments by clinicians. Some clinicians feel compelled to create pulpal protection for a new material even if the cavity is shallow. The aim of this study was to survey the postoperative sensitivity of patients following placement of resin composite restorations by undergraduate dental students under the supervision. Such clinical follow-ups will help improve the teaching program and also provide valuable insight into the performance of the materials used.

2. Materials and methods

2.1. Subjects

A clinical follow-up was conducted on 151 patients, who

* Corresponding author. Address: 3-1-1 Maidashi, Higashi-ku, Fukuoka 812-8582, Japan. Tel.: +81-92-642-6432; fax: +81-92-642-6366.

E-mail address: unemori@dent.kyushu-u.ac.jp (M. Unemori).

Table 1
Details of patients and restorations

<i>Patients</i>	Total	Male	Female
Number	151	89	62
Average age (year)	33.6	29.9	38.9
Median of age (year)	24.0	24.0	40.5
<i>Number of restorations</i>	Anterior	Premolar	Molar
Upper	161	31	29
Lower	29	34	35

were assigned to receive resin composite restorations by final-year undergraduate dental students during the period from 1996 to 1998. The age of the patients varied from 18 to 83 and 319 restorations that were placed in vital teeth were surveyed. Further details on the patients and the teeth are given in Table 1.

2.2. Clinical procedures

All cavities were prepared by students under the supervision of 10 clinical instructors. High-speed rotary cutting instruments were operated under air–water spray. Excavation of caries was made with slow-speed round burs and/or hand-operating excavators. Either the student or instructor arbitrarily categorized the depth of a cavity either as shallow, medium or deep, when it was ready for restoration.

The electrical impedance of the floor of the cavity was measured, whenever the clinical situation allowed, using a Caries Meter (Onuki Medical Industrial Corp. Ltd, Tokyo, Japan) [17] in two ranges, 0–100 and 0–2 MΩ. The tooth was dried with a three-in-one syringe and isolated with either a rubber dam or cotton rolls to prevent surface conduction by saliva. Next, a small amount of physiological saline solution was placed on the cavity floor for measurement. The probe tip was 0.8 mm in diameter and the clip was attached to the oral mucous membrane.

The instructors made their diagnosis regarding the need for pulpal protection. This resulted in four different protection procedures: no protection layer (Group 1); protection with calcium hydroxide base (Group 2); the placement of glass ionomer cement (Group 3); or protection with a

Table 2
Liners and bases used

Name	Manufacturer
Calcium hydroxide Dycal ^a	Caulk
Glass ionomer cement <i>Chemical-cured type</i>	
Lining cement	GC
Dentin cement	GC
<i>Light-cured type</i>	
Fuji lining LC	GC

^a A two-paste chemical cure material.

Table 3
Dentine-bonding systems used (a, apply conditioner to enamel and dentine; b, rinse conditioner; c, apply primer to enamel and dentine; d, air dry; e, apply light-cured adhesive resin; f, apply chemical-cured adhesive resin)

Code	Dentine-bonding system (Company)	Recommended use
Chemical-cured		
CNB	Clearfil New Bond (Kuraray)	a b d f
SB	Super Bond C&B (Sun Medical)	a b d f
Light-cured (A)		
BW	Bond Well LC (GC)	a b d e
Light-cured (B)		
LB	Clearfil Liner Bond II (Kuraray)	c d e
FB	Fluoro Bond (Shofu)	c d e
MB	Mac-Bond II (Tokuyama)	c d e

calcium hydroxide base in combination with glass ionomer cement (Group 4). The calcium hydroxide base and glass ionomer cements used in this study are listed in Table 2.

Six dentine-bonding agents and seven resin composites were available for use during the present follow-up study. These materials are listed in Tables 3 and 4, respectively. The bonding agents were either a chemical-cured type (CNB and SB) or a light-cured type (BW, LB, FB and MB). A two-step procedure, conditioning of dentine with acid solution and then rinsing with water, was recommended for the former type and for one of the light-cured agents (BW), while the placement of the primer was recommended for the rest of the light-cured bonding agents. The resin composites were also either chemical-cured (CF) or light-cured types (EST, APX, LF and PAL). The selection of the bonding agent and restorative resin was left up to the instructor. They did not necessarily choose the two materials from the same manufacturer. Polishing of the restorations was performed at least one day after the placement of restorations and before or on the day when postoperative sensitivity was examined. The following examination was generally one week after the placement of restorations.

2.3. Data collection and analysis

A standardized form was used to record variables

Table 4
Resin composites used

Code	Name	Manufacturer
Chemical-cured		
CF	Clearfil F II	Kuraray
CF	Clearfil F III	Kuraray
CF	Clearfil posterior	Kuraray
Light-cured		
EST	Estio LC	GC
APX	Clearfil AP-X	Kuraray
LF	Lite Fil II	Shofu
PAL	Palfique Estelite	Tokuyama

Fig. 1. Distributions of restorations in each category.

involved in the restorative treatments. These included, apart from those given in Table 1, the type and depth of the cavity, the type of protection (Groups 1–4), and the brand names of the dentine-bonding agent and of the restorative resin composites.

The absence or presence of postoperative sensitivity was determined by three criteria: spontaneous pain, thermal sensitivity and sensitivity to percussion. The incidence of postoperative sensitivity (IPS) was independently calculated for four variables, type of protection, type of cavity, depth of cavity and dentine-bonding agents, in percentages, against the total number of restorations for a particular variable. The IPS values obtained were then analyzed using Shaffer's sequentially rejective multiple test [18], with statistical significance at $p < 0.05$.

3. Results

3.1. Distribution of restorations

Fig. 1 shows details of restorative treatments for five clinical variables. Restoration of Class III cavities was the

highest (39%), followed by Class I (23%), Class V (22%) and Class II (8%). Almost half of all restorations (44%) were made in shallow depth cavities. The restoration of medium cavities was also high (38%), resulting in only 18% of the restoration being classified as deep. The percentage of restorations that had no pulpal protection (Group 1) was 39%, which was the highest. Among the groups that had pulpal protection, calcium hydroxide base (Group 2) was used most often (28%), followed by the use of calcium hydroxide in combination with glass ionomer cement (GIC) in Group 4 (20%), and the least often, by GIC in Group 3 (13%). The most commonly used dentine-bonding agent was light-cured LB (29%). However, the use of both light-cured FB and chemical-cured CNB also approached this value (about 25%). The use of a light-cured resin composite (APX) was the highest (64%), followed by another light-cured material EST (16%) and chemical-cured CF (13%).

The details of pulpal protection are shown regarding the cavity depth in Fig. 2. More than half (62%) of all shallow cavities had no protective layer, but the remaining 38% were protected by one of the three treatments. The types of pulpal protection for the medium depth cavities were almost equally divided by the four protection treatments, which were classified as Groups 1, 2, 3 and 4. Some deep cavities did not receive any pulpal protection (7%). The use of calcium hydroxide in combination with glass ionomer cement was the most common protective measure (63%) for deep cavities. The use of calcium hydroxide alone remained fairly constant for the three cavity depths, at about 30%.

3.2. Effect of clinical variables on postoperative sensitivity

Of the total 391 restorations surveyed in the present study, no spontaneous pain was detected. However, at least one of the remaining postoperative symptoms was detected in 35 restorations (11%). The most commonly reported painful stimulus was cold water/drinks, followed by hot water/drinks and then sensitivity to percussion.

Fig. 2. Distributions of restorations applied with protective layers in shallow, medium and deep cavities.

Fig. 3. Incidence of postoperative sensitivity (IPS) with or without protective layers for composite restorations (*: $p < 0.05$).

Figs. 3–6 show the relationship between clinical variables and postoperative sensitivity. There were no significant differences in the IPS values among the three types of pulpal protection (Groups 1–3), while the IPS value for the combination treatment (Group 4) was significantly higher ($p < 0.05$) than those of Groups 1 and 2 (Fig. 3). The IPS values increased as the cavity depth increased with the IPS value for deep cavities being significantly higher ($p < 0.05$) than those of shallow and medium cavities (Fig. 4). The light-cured dentine-bonding agents were classified into two groups according to the way the dentine was conditioned (Table 3). When this grouping was considered, the light-cured (B) group showed significantly ($p < 0.05$) less IPS values than that of the chemical-cured group (Fig. 5). While Class III and IV restorations gave higher IPS values, the traditional cavity classification did not show any statistically significant relation with IPS (Fig. 6).

3.3. Electrical impedance measurement

Electrical impedance measurements were made in 62 cavities. As the values obtained did not show a normal distribution against cavity depth, we assessed the significance of differences in median values using Wilcoxon's

Fig. 4. Incidence of postoperative sensitivity (IPS) in composite restorations placed in shallow, medium and deep cavities (*: $p < 0.05$).

Fig. 5. Incidence of postoperative sensitivity (IPS) in composite restorations with different types of dentine-bonding agents (*: $p < 0.05$).

rank sum test. As shown in Fig. 7, the impedance values significantly decreased as the cavities deepened ($p < 0.05$).

4. Discussion

In this study, 39% of the composite restorations had no protective layer underneath the restorative material (Fig. 1). While this figure is almost the same as that of shallow cavities, some of the cavities classified as having medium and deep depths were also restored without any protective layer. Thus, while most of shallow cavities were restored without pulpal protection (62%), some deep cavities were also restored without any of forms of protection, (26%, medium and 7%, deep), as shown in Fig. 2.

The percentages of protection measures given to the shallow (38%) and medium cavities (74%) seem high, because it is generally considered that placing protective liners under resin composite restorations is unnecessary for shallow or normal depth preparations using most modern materials [10]. In order to prevent postoperative problems such as sensitivity and pulp inflammation, dentinal tubules, which are opened by dentine conditioning or etching, need to be completely sealed. However, this is a technically sensitive operation for students who are new to clinical dentistry. It is quite likely therefore that clinical supervisors take extra

Fig. 6. Incidence of postoperative sensitivity (IPS) in composite restorations placed in different types of cavities.

Fig. 7. The median of impedance values in shallow, medium and deep cavities (*: $p < 0.05$, Wilcoxon's rank sum test).

caution by directing them to use conventional bases and liners to protect dentine from acid etching.

The classification of cavity depth, when it was ready for restoration, was arbitrary in this study. This may also be one of the reasons for the high percentages of pulpal protection given to the shallow and medium depth cavities. Weiner [19] referred to the fact that there were no strict guidelines for defining deep or shallow cavity preparations based on a review of the dental literature. In an attempt to verify the judgments provided by clinical supervisors, we included measurements of electrical impedance in the present study and thus found the impedance value to significantly increase with the decrease in cavity depth as it was categorized clinically (Fig. 7). This finding substantiates the validity of cavity depth defined by the experienced clinical instructors who took part in this survey.

The percentage of the restorations that showed postoperative sensitivity was 11% despite the extra care given to pulpal protection. This figure is higher than that found in other clinical studies [10]. This is probably due to the fact that the proportion of young patients was high in this survey (Table 1). Young patients have larger pulp chambers and larger dentinal tubules, making it more likely that their teeth would be more sensitive to hydrodynamic stimuli.

Many studies [10–13,20] have shown that restorations placed in deep cavities are associated with more pulpal problems including postoperative sensitivity. The present study confirms this; in spite of the wide range of treatments involving multiple factors that were used in this survey, the restorations in the shallow and medium cavities showed significantly lower IPS values than those in deep cavities (Fig. 4). Under the generally accepted pulpal hydrodynamic theory [21,22], a gap between dentine and restoration allows the slow outward movement of dentinal fluid and inward leakage of microbial products. Thermal or mechanical stimuli cause a sudden movement of this fluid, which is perceived by the patient as pain. As the dentine is prepared closer to the pulp, the tubule density and diameter increase, thus increasing both the volume and flow of pulpal fluid susceptible to such hydrodynamic effects. Resistance to

such fluid movement is proportional to the dentine thickness or tubule length [23]. Both the toxicity/irritation of dentine-bonding agents and the adverse effect of acid etching to the pulp increase as the thickness of the cavity floor decreases [24,25].

For many years, dentists have applied conventional liners and bases under composite restorations to protect the pulp [1–6]. This survey, however, showed no statistical difference in the IPS values between no protection and the Group 2 or Group 3 protection. On the other hand, the Group 4 protection (combination of calcium hydroxide base + GIC) showed a significantly higher IPS value than no protection. These findings indicate that the absence of protective layers (no protection) was not responsible for the postoperative sensitivity, and therefore protective layers do not necessarily prevent postoperative sensitivity. As the Group 4 protection was frequently chosen for deep cavities, which exhibited significantly higher IPS values than shallow and medium cavities (Fig. 4), further studies are required to investigate whether other types of pulpal protection could be more effective in lowering the IPS index of deep cavities.

The high IPS value with the Group 4 protection is also likely to be associated with microleakage. When Fusayama [26] tested leakage at the dentinal margins of cervical cavity preparations, full coverage of the cavity floor with a lining material considerably loosened the marginal seal. He concluded that lining or capping must be limited to a minimal area and as much dentine as possible must be left uncovered to facilitate adhesion. The Group 4 protection may thus result in less dentine surface being available for adhesion compared with the other three types of protection, thus resulting in more marginal leakage. The increased marginal leakage most likely explains the high IPS value of Group 4.

Another finding of this study was that the type of dentine bonding had a significant effect on the postoperative sensitivity. We grouped the dentine-bonding agents used into three groups according to their polymerization mechanism and the method used to condition dentine. The chemical-cured group had a significantly higher IPS value than the light-cured (B) group (Fig. 5). Almost all of the material chosen from the former group (76/77) was Clearfil New Bond, which is one of the early generation dentine-bonding systems. As a result, the system requires acid-etching of dentine with the phosphoric acid solution but does not utilize a moist technique. Water-rinsing and air-drying must be performed before applying an adhesive resin over the dentine. Recently this procedure has been considered detrimental to adhesion, because acid-etching followed by water-rinsing and air-drying presumably makes demineralized dentine shrink, thus limiting the size of the spaces around the collagen fibrils through which the resin must diffuse [27]. This might lead to poor sealing of dentine surfaces and thus a high IPS value. On the other hand, the light-cured (B) group is the so-called self-etching/self-priming systems and one of the latest dentine-bonding systems.

These systems are speculated to generate rather thin but more uniform resin infiltration into dentine, which is one of the most important factors for achieving a high bond strength [27] and thus prevent micro leakage. This may explain why the light-cured (B) group showed lower IPS values. The new generation material could be technically less sensitive compared with the old generation group.

The traditional cavity classification did not show any statistical difference in the obtained IPS values, although Class IV could be the most difficult in preventing postoperative sensitivity (Fig. 6). The number of Class IV restorations was small (15 restorations) and the ratio of deep cavities in the Class IV restorations was high (33%), compared to those in other cavity types (from 30% in the Class III group to 4% in the Class I group). This might explain the high IPS value in the Class IV group. There have been reports [28,29] that tooth sensitivity is commonly found with Class I and II resin restorations. These classes showed relatively low IPS values in the present study (Fig. 6), where the majority of the cavities were shallow and medium deep cavities, 96% (Class I) and 83% (Class II), respectively. The relationship between cavity type and postoperative sensitivity thus requires further study.

5. Conclusions

A clinical follow-up was conducted on 319 resin composite restorations made in a final year undergraduate program over a 3-year period. Along with the analyses of cavity type, cavity depth, the type of pulpal protection and the materials used, postoperative sensitivity was examined on each restoration. The results can be summarized as follows:

1. The age of the 151 patients varied between 18 and 83 years of age and 39% of the restorations had no protective layer placed prior to restoration.
2. The restorations requiring one of the three pulpal protection methods increased as the depth of the prepared cavities increased.
3. The judgment of the depth of cavities made by clinical supervisors generally correlated with electrical impedance measurements.
4. The absence of protective layers was not responsible for postoperative sensitivity after resin composite restorations.
5. The restorations made in shallow and medium deep cavities showed significantly lower postoperative sensitivity than those made in deep cavities.
6. The classification of the dentine-bonding systems indicated the postoperative sensitivity to be significantly less with the self-etching/self-priming system than with the early generation system. A technically less-sensitive material would thus be suitable as the material for undergraduate teaching programs where less-experienced students are involved in the restoration work.

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