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Effects of NaOCl on Bond Strengths of Resin Cements to Root Canal Dentin

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Microleakage occurs due to the lack of sealing ability of root sealing materials or adhesive cements used to lute post-core materials. This may cause premature failure of endodontic treatment. The purpose of this study was to evaluate regional bond strengths of four adhesive systems to root canal dentin. Sixteen extracted human single rooted teeth were used. After removing the crowns and the pulp tissues, the root canals were then instrumented and irrigated with or without 5% NaOCl. The root canal dentin walls were then bonded with C&B Metabond, Panavia F, Variolink II, or Rely-X. Microtensile bond strengths to root canal dentin were then measured using an Instron machine. The bond strength data were recorded and expressed in MPa. Statistically significant differences were found among the NaOCl treated and nontreated groups ($p < 0.05$). C&B Metabond gave the highest bond strength compared with others in the control group ($p < 0.05$). C&B Metabond also had significantly higher bond strength compared with Variolink II and Panavia F groups when the canals were irrigated with NaOCl ($p < 0.05$).

Endodontic treatment generally causes loss of internal tooth structure and this sometimes causes teeth to fracture. Therefore, in the restoration of endodontically treated teeth a post is utilized as a means to retain a core or foundation for final restorations (1–3). Custom-cast tapered post and core procedures have been traditionally used to restore endodontically treated teeth. However, the use of prefabricated posts has become increasingly popular. The post itself, whether custom cast or prefabricated, often requires removal of sound tooth structure to gain a path of insertion and avoid undercuts, further weakening the tooth (4–6). Many methods have been introduced to simplify post and core techniques. All of these methods seek to provide an accurately fitting post and core, to simplify clinical procedures, reduce chair-side time, and cut costs, while striving to improve retention and resistance to rotation.

With the advent of the latest generation of dentin bonding agents, resin luting cements, and restorative materials, endodontically treated teeth can be rebuilt and reinforced conservatively (5, 7, 8). If resin cements are to be used to cement endodontic posts in prepared post spaces, it is important to optimize maximum bond strengths between the resin and dentin and between the resin and the post material (9). If the sealing ability of adhesive systems used to lute post-core materials is inadequate, subsequent microleakage may cause failure of endodontic treatments (10).

Adhesion to dentin may be affected by many factors. The use of some disinfectant solutions or medications during root canal preparation may have an adverse effect on the bond strength of posts to root canal dentin. Because there is limited information concerning resin bonding to root canal dentin, the aim of this in vitro study was to evaluate the effect of NaOCl treatment on bonding of four different resin-based cements to root canal dentin using a microtensile bond strength test (11).

MATERIALS AND METHODS

Sixteen extracted human single-rooted teeth were used. The crowns were removed at the CEJ using a diamond fissure bur in a high-speed handpiece with copious air water spray. The canal spaces were mechanically enlarged using K-files (up to #70) and Gates Glidden burs (#3, 4, 5) in a slow-speed contra-angle handpiece. The 16 teeth were then randomly distributed into 8 groups of 2 teeth each (Table 1).

Group 1: Teeth were irrigated with 5% NaOCl during the preparation of the root canal as one would do clinically. The time of exposure to NaOCl was 5 min per tooth. After washing with water for 2 min, the canals were dried with paper points. The root canal dentin walls were then treated with C&B Metabond (Parkell, Farmingdale, NY) according to the manufacturer's instructions using the brush tip technique.

Group 2: Teeth were irrigated with 5% NaOCl as in group 1. The root canals were then filled with Panavia F (Kuraray, New York, NY) according to the manufacturer's instructions.

Group 3: Teeth were irrigated as described in group 1. The root canals were then filled with Variolink II (Vivadent, Amherst, NY) according to the manufacturer's instructions.

Group 4: The root canals were filled with Rely-X (3M, St. Paul, MN) according to the manufacturer's instructions after 5% NaOCl treatment.

Group 5, 6, 7, and 8 were treated with same resin cements as groups 1, 2, 3, and 4 (C&B Metabond, Panavia F, Variolink II, and Rely-X), but water was used to irrigate instead of 5% NaOCl. Rather than use a post, post space was filled with the resin cements

TABLE 1. Manufacturer's instructions for the restorative materials evaluated

Restorative materials	Components	Directions
C&B Metabond	10% citric acid + 3% ferric chloride, conditioner	5 s apply, rinse, gently dry
	4 drop META +MMA, 1 drop catalyst and powder	mix, brush-on technique
Panavia F	Liquid A, liquid B, CD primer past A, past B	60 s apply, gently dry
		20 s mix, apply, 20 s light-cured
Variolink II	Liquid A, liquid B, Cleafil	30 s apply, dry
	Liner Bond 2V primer	
	Cleafil Liner Bond 2V bond	20 s light-cured
	Base and catalyst	10 s mix, 40 s light-cured
Rely-X	3M Scotchbond, etchant	15 s apply, 10 s rinse and dry with a cotton pelet
	3M Single Bond adhesive past A, past B	apply, 5 s dry, 10 s light-cured
		10 s mix, apply, 40 s light-cured

TABLE 2. Mean bond strengths (SD) to root canal dentin with or without 5% Na OCl pretreatment

Restorative Materials	*n*	NaOCl (−) Mean ± SD (MPa)	NaOCl (+) Mean ± SD (MPa)
C&B Metabond	10	27.7 ± 5.9[a]	22.6 ± 3.9[a]
Panavia F	10	20.1 ± 7.4[b]	10.6 ± 6.6[bc]
Variolink II	10	19.3 ± 4.8[b]	8.5 ± 2.5[c]
Rely-X	10	16.8 ± 4.9[b]	16.6 ± 6.4[ab]

C&B Metabond showed highest bond strength values compared with others without NaOCl treatment ($p < 0.05$). When the roots were irrigated with 5% NaOCl, C&B Metabond bond strengths were significantly higher than those of the Variolink II and Panavia F groups ($p < 0.05$). Different letters indicate significant differences ($p < 0.05$).

to permit evaluation of cement-dentin bond strengths without the complications of bonds to posts versus bonds to dentin.

All the self-curing resin cement filled specimens were allowed to cure undisturbed for 10 to 15 min. The filled specimens were then soaked in 37°C water for 24 h.

Twenty-four hours later, the specimens were dried and then fixed to a Plexiglas block for testing procedures with sticky wax to permit creation of serial cross-sections 1-mm thick from the CEJ to apex using a Isomet saw (Buehler Ltd., Lake Bluff, IL). The nontrimming method (12) was used to obtain sample sticks with cross-sectional areas of 1 mm^2. The specimens were glued to a Instron machine with cyanoacrylate cement (Zapit Dental Venures of America, Corona, CA) and then microtensile bond strengths to root canal dentin were measured with this device. The bond strength data were expressed in MPa and statistical analyses were performed using a one-way analysis of variance, followed by multiple comparisons performed using a Duncan test.

All failed specimens were then examined in a stereomicroscope at ×15 magnification to classify the modes of failure, and then one sample was prepared from each groups for SEM examination.

RESULTS

The mean bond strengths of each material group with or without 5% NaOCl pretreatment are shown in Table 2.

Statistically significant differences were observed among the NaOCl treated and nontreated groups ($p < 0.05$). C&B Metabond showed the highest bond strength values compared with the other materials in the control group (i.e. without NaOCl treatment) ($p < 0.05$). In the roots that were irrigated with 5% NaOCl, C&B Metabond bond strengths were significantly higher than those of the Variolink II and Panavia F groups ($p < 0.05$).

The failure modes of the samples are shown in Table 3. With 5% NaOCl treatment, C&B Metabond showed 60% adhesive failures, whereas Panavia F showed 90% adhesive failure and Variolink II showed 80% adhesive failure.

SEM photographs of material-dentin bonds were examined. Resin tag formation was more apparent in the specimens irrigated with water (Fig. 1A) than in the 5% NaOCl-irrigated groups (Fig. 1B), although the reverse was true using Panavia-F. Although there were more resin tags in the Variolink II bonded specimens irrigated with NaOCl, there were no differences between the two treatments when dentin was bonded with Rely-X.

DISCUSSION

In this study, regional bond strengths to root canal dentin walls and the effect of NaOCl were evaluated. To simplify the laboratory procedures, the root canals were filled with resin cements. Endodontic posts are also elected to simplify the experimental design and to permit evaluation of resin-dentin bonds without the complication of resin post bonds.

When the results were evaluated statistically, C&B Metabond showed highest bond strength values ($p < 0.05$) regardless of whether NaOCl was used. Panavia F, Variolink II, and Rely-X are all dual-cure resin cements and showed low bond strengths compared with self-cured C&B Metabond. In this study, an initial light-curing procedure to initiate the polymerization was used with the dual-cure cements. However, the setting reaction of dual-cure resin cements inside the canal or in a dark environment is still unclear. High C-factor (13) associated with resin bonding in a long narrow tube (i.e. root canal) may have an effect in causing low bond strength values with dual cure materials. C&B Metabond is a chemically cured resin that takes about 5–10 min to completely polymerize. During this slow polymerization, as stresses build up they are immediately relieved by flow of the developing oligomers. The resin system is based on methylmethacrylate/polymethacrylate, a system that creates linear polymers, rather than cross-linked polymers. These self-curing resins generally create less residual stress than cross-linked resin systems (14). Because it is unlikely that light could be transmitted from the access opening down the canal more than 5 to 10 mm with sufficient intensity to induce adequate polymerization, the use of chemically cured resin should be preferred for bondable post placements.

Chemical irrigants, such as sodium hypochlorite, hydrogen peroxide, and their combination, are commonly used in the endodontic treatment to provide gross debridement, lubrication, disinfection, and dissolution of tissues. In an in vitro study by Nikaido et al. (10) it was demonstrated that Single Bond and Superbond C&B had lower bond strengths when the root canals were chemically irri-

TABLE 3. Adhesive and cohesive failures

Restorative Materials	*n*	Treatment	Adhesive	Dentin Cohesive	Composite Cohesive	Mixed
C&B Metabond	10	water	3	3	4	—
		NaOCl	6	—	4	—
Panavia F	10	water	8	—	1	1
		NaOCl	9	—	1	—
Variolink II	10	water	3	1	6	—
		NaOCl	8	1	—	1
Rely-X	10	water	10	—	—	—
		NaOCl	10	—	—	—

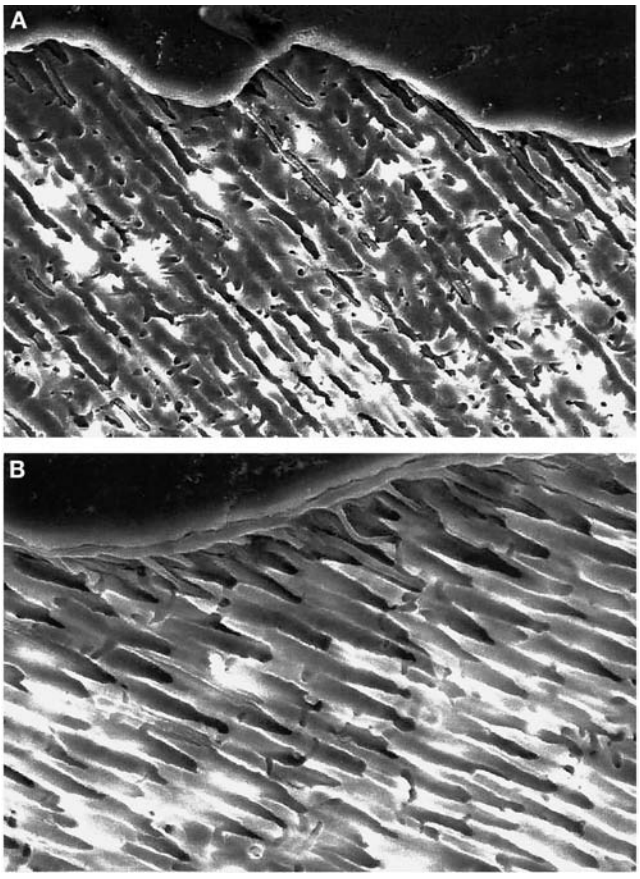

FIG 1. (*above*) SEM photographs of the interface between resin and dentin in a specimen treated with 5% NaOCl before bonding with C&B Metabond. (*below*) SEM photographs of the interface between resin and dentin in a specimen treated with water before bonding.

gated with 5% NaOCl and 3% H_2O_2. Ngoh et al. (15) reported that eugenol lowered the bond strength of C&B Metabond to root canal dentin. In an another study by Gaston et al. (16), the results indicated that bond strengths to the apical third were significantly higher than to the cervical or middle third with C&B Metabond versus Panavia 21. In this study, 5% NaOCl reduced the bond strengths to dentin of all resin cements by 18% except for Rely-X.

The effect of the chemical irrigants on dentin bonding is still unclear. However, sodium hypochlorite can remove the organic components of dentin, mainly collagen. This should increase the penetration of monomers into the demineralized dentin structure. In addition, sodium hypochlorite breaks down to sodium chloride and oxygen. Oxygen from such chemicals causes strong inhibition of the interfacial polymerization of resin bonding materials (10, 17). The generation of oxygen bubbles at the resin-dentin interface may also interfere with resin infiltration into the tubules and intertubular dentin.

Morris et al. (14) reported that 15- to 20-min NaOCl treatment reduced bond strength of C&B Metabond to root canal dentin by 67%. This result is in contrast with our results. The only difference among these two studies was the exposure period. There is a correlation between exposure period and bond strength. The bond strength increased by the decreasing exposure time.

Conversely, it is very difficult to create a reliably wet surface during bonding procedures with in vitro conditions. Rely-X requires the use of the wet bonding technique. In this study, after etching the dentin the surface was not air-dried, but a cotton pellet was used to remove excess water. Because the bond strengths obtained with Rely-X in this study were similar to these obtained in previous studies (10, 18), it seems that the root dentin was sufficiently moist.

In conclusion, the results of this study indicated that a self-cured adhesive cement (C&B Metabond) showed higher bond strength values compared with dual-cure resin cements (Panavia F, Variolink II, Rely-X). Self-cured adhesive cements may be preferable for the cementation of adhesive post-cores. Conversely, further in vivo studies are still needed to predict the long-term success of these materials

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