

Effect of Three Endodontic Materials on the Bond Strength of Two Composite Core Materials to Dentin

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Purpose: This study investigated the effect of dentin treatment with iodine potassium iodide, calcium hydroxide or a biphenol-A- diglycidylether epoxy resin sealer on the dentin bond strength of titanium-reinforced Bis-GMA and urethane dimethacrylate composite materials.

Materials and Methods: Dentin was exposed in four groups of extracted teeth (20 specimens each). Three groups were treated with one of the contaminants and the fourth group was left uncovered and served as the control group. All specimens were stored for 1 week at 37°C and 100% humidity. The dentin surfaces were cleaned with pumice slurry using a prophylaxis rubber cup, rinsed and dried. Then the dentin surfaces were treated using the conditioner and the primer of the GLUMA adhesive system followed by placement of composite core materials. After 20 minutes, debonding of the core materials was accomplished using a shear-peel test. A two-way analysis of variance and Tukey's multiple range test was performed based upon core type and contaminant type ($\alpha = 0.05$).

Results: Titanium-reinforced Bis-GMA composite showed significantly greater bond strength values than the urethane dimethacrylate composite material ($p < 0.0001$). The mean bond strength values in megapascals for the Bis-GMA resin ranged from 8.47 ± 1.52 for the calcium hydroxide group to 9.81 ± 0.94 for the control group. Mean bond strengths for the urethane dimethacrylate resin ranged from 3.35 ± 0.90 for calcium hydroxide to 3.99 ± 0.88 for iodine potassium iodide groups. Within each core group, no difference in bond strengths were noted compared to the uncontaminated control.

Conclusion: Pretreatment of the dentin with iodine potassium iodide, calcium hydroxide, or epoxy resin followed by pumicing and using the GLUMA system conditioner and primer had no effect on the bond strength of the two resin composite core materials. However, the titanium reinforced Bis-GMA composite exhibited significantly greater bond strength to dentin than the urethane dimethacrylate based composite.

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INDEX WORDS: bonding agents, intracanal medicaments, iodine potassium iodide, calcium hydroxide, epoxy resin, sealer cements

A COMMON clinical problem facing prosthodontists is the restoration of severely damaged teeth due to caries, fracture, trauma, previous restorative procedures, or endodontic access. A traditional approach has been to restore the missing coronal structure with core materials such as amal-

gam, resin composite, or glass polyalkenoate (ionomer). A full coverage restoration is subsequently placed to prevent tooth fracture.¹

For the core build-up to provide retention and resistance for the final restoration, it must be well retained. Preparation options available to retain cores include posts, retentive pins, and the use of modified radicular tooth spaces. However, root perforation can occur during post space preparation, particularly in curved canals of posterior teeth. The use of retentive pins is also associated with problems, such as risk of perforation, dentin crazing and cracking,² weakening of the core restoration and prohibiting proper core condensation.³ Removal of radicular dentin might lead to weakening of root structure and consequently increase the risk of root fracture.⁴

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The intradental retentive features, such as channels, slots, and axial boxes and grooves have been suggested as an alternative for retaining core build-up materials to overcome the aforementioned difficulties.⁵⁻⁶ Direct bonding to tooth structure may improve the retention of the restorative material. Although glass polyalkenoate (ionomer) chemically bonds directly to tooth structure,⁷ a resin composite must be bonded by using proper bonding agents.⁸

Resin composite core materials are easy to use, can be bonded to dentin with the use of adhesives, have high fracture resistance,^{6,9} have a desirable shade under a ceramic crown, and can allow for the core build-up, crown preparation, and final impression to be completed at the same visit. However, they have some disadvantages, including polymerization shrinkage and subsequent microleakage,¹⁰ and water absorption. The latter might affect the fit of the future crown.¹¹

The bond potential of dental adhesive materials to enamel and dentin is influenced by the prior management of the tooth surface. The effects of several materials on the bond strength of resin composite to dentin has been investigated.¹²⁻¹⁸ The resin bond strength to tooth structure is affected by common forms of contamination such as saliva, plasma, headpieces lubricant, and eugenol,¹³⁻¹⁶ but can be improved by proper cleaning procedures that involve demineralization of tooth surface.^{12,14,15,17,18}

Several endodontic materials are used prior restoring endodontically treated teeth with resin composite core build-up, and the influence of these materials on the bond strength of resin composite core materials to dentin must be investigated. The use of a eugenol containing materials during endodontic procedures could significantly reduce the bonding of resin to dentin.^{13,14,16} On the other hand endodontic materials such as calcium hydroxide (Dycal advanced formula; Dentsply, Milford, DE) and zinc oxide (Cavit; ESPE, Seefeld, Germany) may have no adverse effect on bond strength.¹³ Moreover, no evidence is available suggesting that other intracanal medicaments, such as iodine potassium iodide or epoxy resin sealer cement, affect bond strength. The purpose of this study was to investigate the effect of dentin treatment using iodine potassium iodide, calcium hydroxide, or epoxy resin on the bond strength to dentin of a titanium-reinforced Bis-GMA-based or a urethane dimethacrylate-based composite material.

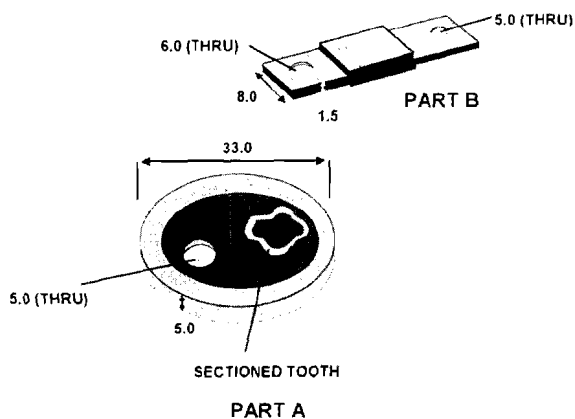


Figure 1. Specimen dimensions (in millimeters).

Materials and Methods

The 2 commercial autopolymerizing resin composite core materials tested in this investigation were Ti-Core (Essential Dental Systems, Hackensack, NJ) and FluoroCore (Caulk Co., Milford, DE). Three materials were used as potential contaminants that may interfere with the core materials adhesion to dentin. Two of them were intracanal medicaments¹⁹: a laboratory-prepared 2% iodine potassium iodide (IKI) solution and a calcium hydroxide [$\text{Ca}(\text{OH})_2$] paste packed in anesthesia cartridges (Cela-sept; Scania Dental AB, Knivsta, Sweden). The third material was a biphenol-A-diglycidylether (epoxy resin)-based root canal sealing and filling material (AH-26; Dentsply Detrey, Konstanz, Germany).

An apparatus to prepare testing specimens was used previously.¹⁶ The test assembly consisted of 2 parts, A and B, as shown in Figure 1.

Extracted, noncarious, permanent molars were embedded in cylindrical acrylic blocks. The crowns of these teeth were sectioned with a fine diamond disc (Brassler GmbH, Lemgo, Germany) in a horizontal plane, perpendicular to their long axis exposing dentinal surfaces. The resulting acrylic disc, 33 mm in diameter and 5 mm thick, with the sectioned tooth embedded in the center, formed part A of the test assembly. Part B, cast in a base metal alloy (Wirron 99, Bego, Germany), comprised a rectangular plate that served both as a matrix to hold resin specimens directly on the dentin surfaces of part A and as a fixture facilitating the application of load on the specimen during testing.

The dentin specimens were divided into 4 groups of 20 each to receive different treatments. The teeth in group 1 received no contaminant and served as a control. In group 2, the dentin was coated with IKI; in group 3, with $\text{Ca}(\text{OH})_2$; and group 4, with AH-26. The dentin surfaces were completely covered by contaminant. IKI was brushed in 3 layers, $\text{Ca}(\text{OH})_2$ was syringed, and AH-26 was applied by a plastic instrument. Manufacturer's instructions were followed carefully. After contaminant application and setting, the specimens were stored in

100% humidity at 37°C for 1 week. At the end of the storage period, only the $\text{Ca}(\text{OH})_2$ and AH-26 were removed from the dentin, using a Hollenbeck carver. The dentin surfaces of all 4 groups were then cleaned with a fine-grit pumice slurry using a prophylaxis rubber cup in a slow speed handpiece for 10 seconds, rinsed in distilled water for 10 seconds, and dried with air syringe for 10 seconds. The conditioner and the primer of the GLUMA adhesive system (Miles, South Bend, IN) were applied on all specimens according to the manufacturer's instructions. The conditioner was applied using impregnated cotton pellets for 30 seconds, rinsed for 15 seconds, and dried for 10 seconds. The primer was then applied and kept for 30 seconds before drying for 10 seconds.

The samples in each group were further divided into 2 subgroups of 10 each for the specimens of Ti-Core and FluoroCore materials. The samples were left on the bench at room temperature for 20 minutes. The 6-mm diameter hole in part B of the test assembly served as a mold for fabricating the disc-shaped core material specimen (6 mm diameter \times 1.5 mm thick) directly on the flat surface of the dentin sample.

Two steel hooks passing through the 5-mm-diameter hole in part A and a similar hole in part B of the assembly were used to connect the assembly to the upper and lower grips of the Accuforce Elite test system (Model E500; Amelek, Largo, FL) (Fig 2). The testing machine did not necessarily apply tensile forces in the same plane as the dentin surface–resin cement specimen interface. The actual force developed on the interface was a combination of shear and peel. The load was applied to the specimen at a crosshead speed of 1.25 mm/min (0.05 in/min) until it separated from the dentin surface. The bond strength was calculated from the data on separation load and the nominal area of the interface between the core material specimen and the dentin surface.

Visual observations were made to determine whether cohesive or adhesive failure of the resin-to-dentin bond occurred. The data obtained were analysed statistically using two-way analysis of variance (ANOVA) and Tukey's multiple-range test ($\alpha = 0.05$).

Results

The mean bond strength values obtained with the 2 different resin composite core materials are shown in Table 1. The table also shows the values for the range and the standard deviation. The two-way ANOVA (Table 2) showed that the type of core material significantly influenced bond strength ($p < 0.0001$). Tukey's test confirmed that Ti-Core specimens in all of the 4 groups exhibited significantly greater bond strengths than the FluoroCore specimens ($p > 0.05$). Furthermore, for both resin materials, there was no significant difference between the control and contaminated specimens ($p > 0.05$).



Figure 2. Specimen mounted in the testing apparatus.

Visual evaluation of the debonding sites displayed no visible resin on the dentin surface of any specimen.

Discussion

For each core material group, the contaminants had no effect on the strength of the bond between core material and dentin after the cleaning regimen, which included cleaning with a pumice–water slurry, rinsing with water, and treatment with conditioner and the primer of the GLUMA adhesive system before core materials were placed. One may hypothesize that contaminants remain on the dentin surface after cleansing, that they were soluble in the core material, and that they did not interfere with polymerization. A second possible explanation is that most or all of the contaminants on the

Table 1. Core Material–Dentin Mean Bond Strength (MPa)

	<i>Ti-Core</i>				<i>FluoroCore</i>			
	<i>C</i>	<i>IKI</i>	<i>Ca(OH)₂</i>	<i>AH-26</i>	<i>C</i>	<i>IKI</i>	<i>Ca(OH)₂</i>	<i>AH-26</i>
n	10	10	10	10	10	10	10	10
	*	*	*	*	**	**	**	**
Mean	9.81	8.94	8.47	9.59	3.77	3.99	3.35	3.79
Standard deviation	0.94	1.19	1.52	1.47	0.58	0.88	0.90	1.02
Maximum	11.15	10.48	11.82	11.59	4.68	5.13	4.68	5.35
Minimum	8.25	7.13	7.36	7.13	3.12	2.23	2.23	2.23

Abbreviation: C, control.

*, ** no significant difference.

surface were removed with the pumice–water slurry. A third plausible explanation could be that the conditioner used by the GLUMA adhesive system dissolved remaining contaminants, thus eliminating their potential effect in reducing bond strength. Several investigators^{13,15,16} have reported that endodontic materials and other contaminants decrease the bond strength of resin composite to dentin despite pumice–water slurry application. Accordingly, one must conclude that traces of the contaminants tested in this study were not removed with the pumice–water slurry alone, and that subsequent adhesive system application removed them further. GLUMA can reduce dentinal surface contaminants through a 30-second application of 1.6% oxalic acid to condition the dentin, which demineralizes surface dentin to a depth of 5 to 6 μm .²⁰ Alternatively, Tjan and Nemetz¹⁴ found that etching with 37% phosphoric acid for 60 seconds was effective in restoring the retention that had been affected by eugenol. Similar findings were reported by Powers et al¹⁵ for other contaminants after 10 seconds of re-etching.

The testing assembly has been used successfully by Al Wazzan et al.¹⁶ The fixture used for building the core material specimens directly on the dentin samples was first designed and used by Hammad et al.^{21,22} The mold cavity in the fixture is used to fabricate core material specimens directly on the dentin samples and also serves as a specimen holder during the application of debonding load. The alignment of the test fixture was designed so that the forces generated on the resin cement specimen–dentin interface would be of a shear nature. However, because the bonding interface was not aligned at the middle of the thickness of each specimen, forces were not directed primarily at the dentin–core interface, and thus forces were directed diagonally. The actual force developed on the interface is a combination of peeling and shear-

ing actions. This combination of shear and tensile stresses could simulate clinical stress situations.

Ti-Core™ showed significantly greater bond strength values than FluoroCore, which supports previous studies.¹⁶ The difference between the bond strengths obtained with 2 core materials may be attributed in part to the differences between their strength properties. The strength of the resin plays a role in the retentive strength of the hybrid layer.^{23,24} Autopolymerized titanium-reinforced resin composite has significantly greater diametral and compressive strength than polyurethane.²⁵ The difference could be also related to inadequate resin penetration into the dentin surface and the degree of polymerization of the resin at the dentin–resin interface.

The mean value of the debonding force of the Ti-Core control group (9.81 MPa) was similar to that reported in a previous study by Al Wazzan et al¹⁶ (10.03 MPa) but is greater than the value reported by Cohen et al^{26,27} (1.59 to 8.02 MPa). Values for FluoroCore (3.77 MPa) corroborate those reported in a previous study¹⁶ (3.42 MPa) but are lower than the findings of Levartovsky et al²⁸ (7.66 MPa). The variations may be explained by differences in bonding methodology, storage environment, and testing techniques.

Visual analysis of the surface fracture sites displayed no visible resin on the dentin surface, suggesting an adhesive bond failure. Similar findings were reported by Cohen et al²⁶ concerning Ti-Core, and by Levartovsky et al²⁸ regarding FluoroCore.

Results from the current study indicate that the use of IKI, Ca(OH)₂, and AH-26 may not adversely affect the bond strength between resin core material and dentin. The clinician is able to obtain bond strengths similar to the control after brief pumice prophylaxis and acid conditioning of the dentin. Clinically, endodontically treated teeth are not flat, and debris removal may be more difficult. Also,

Table 2. Two-Way ANOVA

Source	Degree of Freedom	Sum of Squares	Mean Square	F	P
Core materials	1	600.01	600.01	492.88	<0.0001
Treatments	3	9.29	3.10	2.54	0.06
Materials vs. treatments	3	4.10	1.37	1.12	0.35
Standard Error	72	87.65	1.22		
Total	79	701.05			

dentin areas cannot often be cleaned with a prophylaxis cup, and in those situations contamination could occur, as could a reduction in bond strength.

Conclusions

Within the limitations of this study's design, the following conclusions are made:

1. The bond strength of Ti-Core or FluoroCore to dentin surfaces contaminated with 2% IKI solution, a Ca(OH)₂ paste, or a biphenol-A-diglycidylether epoxy resin root canal sealing and filling material was the same as bond strengths to control dentin surfaces when a dentin-cleaning regimen including pumice-water slurry prophylaxis, water rinses, and a GLUMA adhesive system conditioner and primer were used before placement of core materials.
2. For each core material, no significant difference in bonding was noted among the surface contaminants evaluated.
3. Ti-Core exhibited significantly greater bond strength to dentin than FluoroCore regardless of the dentin contaminant used.

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