Effect of chemical irrigants and medicaments for endodontic treatment on dentin bonding

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Purpose: To evaluate the bond strengths of two different types of resin luting cements to dentin treated with chemical irrigants and medicaments for root canal treatment.

Materials and Methods: The bovine incisors were ground with silicon carbide paper to expose a dentin. Dentin surface was treated with either 3% hydrogen peroxide (H_2O_2), 5% sodium hypochlorite (NaOCl), the combination of H_2O_2 and NaOCl (H_2O_2/NaOCl), formocresol (FC), or calcium hydroxide ($Ca(OH)_2$) for 60 s, then rinsed and air dried. Dentin without any treatment was used as the control group. The area for bonding was then demarcated with a vinyl tape (4 mm-in-diameter hole), and bonded using one of two resin cement, Super-Bond C&B or Panavia F according to the manufactures' instructions. After storage in water for 1 day, tensile bond strengths were measured using a universal testing machine.

Results: For Super-Bond C&B, statistically lower early bond strengths were obtained in the experimental group compared with the control. In the case of Panavia F, the early bond strengths decreased significantly in H_2O_2, H_2O_2/NaOCl, and $Ca(OH)_2$, while no influence of NaOCl and FC on early bond strengths was observed. However, the visual inspection showed a large increase of adhesive failures between the resin and dentin occurred with the experimental groups, which was marked for both resin cements.

Conclusion: The early bond strengths of resin cements to dentin were adversely influenced by the chemical irrigants and medicaments for root canal treatment. **(Int Chin J Dent 2003; 3: 7-12.)**

Clinical Significance: The medicaments for endodontic treatment are the clinical factors influencing dentin bonding of the resin cements.

Key Words: chemical irrigant, dentin bonding, medicament for endodontic treatment, resin cement.

Introduction

The conventional belief that all endodontically treated teeth are weaker or more brittle than vital teeth,[1] has lead to the philosophy encouraging aggressive reinforcement of remaining tooth structure. Until recently, nonvital teeth were usually treated with a crown, core, and/or dowel.[2] This often leads to good remaining tooth structure being sacrificed for the preparation of a traditional cast restoration.

The function of a conventional coronoradicular post is to provide retention for a core. Post retention

using conventional luting cements (zinc phosphate, polycarboxylate, and glass ionomer cements) is believed to be a major factor in restoration survival. However, overpreparation of the post space and large diameter posts decrease the resistance against root fracture and increase the risk of apical pathoses.[3] A significant increase in dowel retention using adhesive resin cements was demonstrated compared with conventional cements.[4] Therefore, the use of adhesive resin cement can compensate for the reduction of overpreparation for the post and dowel.[5] Endodontic therapy has become a routine procedure for treating and retaining nonvital teeth. Endodontic treatment consists of removing all contents of the root canal system before and during shaping. Successful cleaning entails the use of instruments to mechanically remove dentin, irrigants to flush loosened debris away, and chemicals to dissolve contaminants from inaccessible regions.[6] H_2O_2 and NaOCl have been commonly used as chemically active irrigants.[7] For root canals that require more than one visit to complete, there are sufficient remaining bacteria within the root canal system to grow and reinfect the root canal space between appointments. Placement of intracanal medicaments, such as FC and $Ca(OH)_2$, has become a popular method of preventing bacterial regrowth.[8]

However, there are limited information about the effect of chemical irrigants and medicaments for root canal treatment on dentin bonding.[9,10] The purpose of this study was to evaluate the early bond strengths of two different types of resin luting cements to dentin treated with chemical irrigants and medicaments for root canal treatment.

Materials and Methods

Freshly extracted bovine incisors, stored frozen, were used in this study. The labial surfaces of the incisors were ground with 600-grit silicon carbide paper under a stream of running water to expose a flat surface in superficial dentin. Then these incisors were divided into two groups. A dentin surface without any treatments was used as the control group. For the experimental group, the dentin surface was treated with either 3% H_2O_2, 5% NaOCl, the combination of H_2O_2 and NaOCl (H_2O_2/NaOCl), FC, or $Ca(OH)_2$ for 60 s, then rinsed with water for 10 s and air dried. The bonding area was demarcated with a vinyl tape (4 mm diameter hole), and then one of two resin cements, Super-Bond C&B (Sun Medical, Moriyama, Japan) or Panavia F (Kuraray Medical, Tokyo, Japan), was applied to the dentin surface according to the manufactures' instructions (Table 1). In the Super-Bond C&B group, dentin was treated with 10% citric acid-3% ferric chloride for 5 s, rinsed with water for 10 s then air-dried. The mixture of monomers, catalyst, and PMMA powder were applied to the dentin surface using brush-on technique. A resin composite rod, used for the tensile bond test, was cemented immediately to the dentin surface (Fig. 1). In the Panavia F group, the dentin surface was conditioned with a mixture of ED primer A and B for 60 s. The mixture of Paste A and Paste Universal was applied to the dentin surface. A resin composite rod was placed on the conditioned dentin surface, and light-cured for 20 s each from three directions (Optilux, Kerr, Orange, CA, USA). Thirty minutes after specimen preparation, they were stored in water at 37°C in for one day. Following this, tensile bond test was performed at a crosshead speed of 2 mm/minute using a universal testing machine (Autograph AG-500B, Shimadzu, Kyoto, Japan). The failure mode of specimens

was examined visually after completion of the tensile test. Ten specimens were measured for each test group. The data were statistically analyzed using analysis of variance (ANOVA) and Fisher's PLSD test at the 5% level.

Table 1. Manufacturers' instructions for the rein cements evaluated.

Cement/Components	Chemical composition	Directions
Super-Bond C&B		
Etchant	10% Citric acid, 3% Ferric chloride	5 s apply, rinse, gentle dry
Adhesive	4-META, MMA, TBB, PMMA	Mix, brush-on technique
Panavia F		
ED Primer A	MDP, HEMA, Chemical initiator, Water, 5-NMSA	
ED Primer B	5-NMSA, Chemical initiator, Water	Mix, 60 s apply, dry
Paste A	Silanated silica, Microfiller, MDP, Dimethacrylates, Photo/chemical initiator	
Paste Universal	Silanated barium glass, Surface treated NaF, Dimethacrylates, Chemical initiator	Mix, 20 s light-cured

4-META; 4-methacryloxyethyl trimellitate anhydride, MMA; methyl methacrylate, TBB; tri-n-butyl borane, PMMA; poly(methyl methacrylate), MDP; 10-methacryloyloxydecyl dihydrogen phosphate, HEMA; 2-hydroxyethyl methacrylate, 5-NMSA; N-methacryloyl 5-aminosalicylic acid.
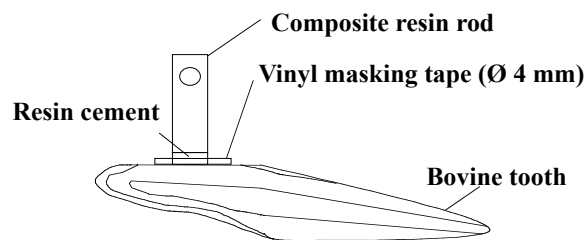

Fig. 1. Specimen assembly for the tensile test.

Results

The tensile bond strengths of the two bonding systems to dentin are summarized in Table 2. Statistically lower bond strengths were obtained in the experimental groups compared with the control groups for Super-Bond C&B ($p < 0.05$). However, this was not the case for Panavia F. The bond strengths decreased significantly in H_2O_2, H_2O_2/NaOCl and $Ca(OH)_2$ ($p < 0.05$), while no influence of NaOCl and FC on bond strengths was observed.

Visual inspection showed mixed failure of adhesive failures between the resin and dentin, and cohesive

failure within the bonding resin occurred predominantly for all materials in the control groups. However, a large increase of adhesive failures between the resin and dentin occurred with the groups treated with chemical solutions. This was marked for both resin cements.

Table 2. Tensile bond strengths to endodontically treated teeth.

	Control	H_2O_2	NaOCl	H_2O_2/NaOCl	FC	$Ca(OH)_2$
Super-Bond	16.0 (5.8)	4.9 (1.3)*	5.8 (1.3)*	7.1 (1.7)*	13.8 (3.8)*	8.2 (2.3)*
Panavia	10.9 (3.5)	3.8 (2.4)*	10.3 (3.1)	5.9 (2.5)*	8.9 (1.8)	7.5 (1.7)*

N=10, Mean (S.D.). Data indicated with an asterisk are significantly different from the control (p<0.05).

Discussion

Adhesion of resin cement to dentin occurs as a result of hybrid layer formation which is as the same as resin composite.[11] Two different types of resin cements were used in this study. Super-Bond C&B is composed of 10-3 solution and 4-META/MMA-TBB resin with PMMA powder. The ferric chloride in the 10-3 solution is believed to act as a stabilizer of collagen during the demineralization process. The 4-META monomer promotes the penetration of monomers into demineralized tooth structure.[12] Panavia F is composed of ED primer and the dual-cured resin cement. ED primer functions as a self-etching primer and also as a co-activator for interfacial polymerization of the resin cement. An adhesion promoting methacrylate, MDP, is an important ingredient of the cement.

For Super-Bond C&B, the tensile bond strengths to dentin statistically decreased, when the dentin surfaces were treated with the chemical irrigants and also the medicaments. For Panavia F, the bond strengths also significantly decreased after the treatment with chemical irrigants and medicaments on dentin surface except for the case of NaOCl and FC. From the visual inspections of the fracture modes, mixed failure of adhesive failures between the resin cement and dentin, and cohesive failure within the resin cement occurred predominantly in the control groups, whereas adhesive failures between the resin and dentin increased with the chemically-treated groups. The tendencies of the fracture modes were similar in both Super-Bond C&B and Panavia F.

Nikaido et al. reported the chemical irrigation in the root canal of bovine incisors with hydrogen peroxide and sodium hypochlorite adversely affected on early bond strengths of several dentin bonding systems to coronal superficial dentin.[13] However, Clearfil Liner Bond II self-etching bonding system was hardly affected by the chemical irrigants used. The result of the current study is the same tendency of the previous one. However, the chemical irrigants and the medicaments were applied on the superficial coronal dentin directly before bonding in this study. Therefore, influence of such treatments on dentin bonding must be severer than the previous study. Generally, NaOCl is believed to damage the organic

components of dentin, mainly the collagen. This may influence the penetration of monomers into the demineralized dentin structure. In addition, NaOCl breaks down to sodium chloride and oxygen. H_2O_2 also breaks down to water and oxygen. The liberation of oxygen takes place by the chemical reaction of H_2O_2 with NaOCl. Oxygen from such chemicals causes strong inhibition of the interfacial polymerization of resin bonding materials.[14] On the other hand, NaOCl has been used to obtain adhesion between dentin mineral and dentin adhesives.[15,16] Acceptable adhesion to phosphoric acid-NaOCl treated dentin was obtained, when the NaOCl treated teeth were rinsed thoroughly to remove any residual NaOCl.[17]

Soeno et al. reported soaking of dentin surface in FC for 2 days decreased the bond strengths of several resin cements.[18] Since the soaking period of FC on dentin surface was only 1 minute for each specimen in this study, therefore, the influence of FC on the bond strength is relatively mild in this study. However, the bond strength of Super-Bond C&B significantly decreased with the FC treatment. One of the ingredients in FC is formaldehyde, which is generally known to fix collagen. FC applied on the dentin surface probably modifies the smear layer and the underlying dentin, which would change permeability of monomers into dentin and affect the bond strength.

$Ca(OH)_2$ also affected the bond strength of each resin cement to dentin. $Ca(OH)_2$ indicates high pH value around 10 to prevent the bacterial regrowth. When $Ca(OH)_2$ was applied, a powder of $Ca(OH)_2$ is mixed with saline to prepare a paste, and then placed on the dentin surface with an injection. The high pH value of $Ca(OH)_2$ may influence the denature of dentin collagen. Also, the $Ca(OH)_2$ would contaminate the dentin surface after the treatment since $Ca(OH)_2$ is a powder, which is not easy to be rinsed off completely.

When an adhesive system is applied to nonvital tooth, the influence of endodontic treatment and also the regions, such as coronal dentin, pulpal floor dentin and root dentin, should be considered. For a direct restoration, Yoshiyama et al. reported that the self-etching primer systems produced good adhesion to coronal, cervical and mid-root dentin, but bonding to apical root dentin was poor.[19] Akagawa et al. reported that the self-etching bonding system, Clearfil Liner Bond 2V, provided good bonding to pulpal floor dentin as well as to superficial and deep coronal dentin.[20] However, there have been limited information about the regional bond strengths of resin cement for nonvital tooth.[9,10] Further studies should be required to know dentin bonding performance of resin cement for nonvital tooth restorations.

Conclusion

The medicaments for endodontic treatment are the clinical factors influencing dentin bonding of the resin cements. We need to focus in these results in order to obtain a successful adhesive restoration.

References

1. Gutmann JL. The dentin-root complex: Anatomic and biologic considerations in restoring endodontically treated teeth. J Prosthet Dent 1992; 67: 458-67.
2. Wagnild GW, Muller KI. Restoration of the endodontically treated tooth. Pathways of the pulp. 7th ed. St. Louis: Mosby; 1994. p. 691-717.

3. Assif D, Gorfil C. Biomechanical considerations in restoring endodontically treated teeth. J Prosthet Dent 1994; 71: 565-7.

4. Diaz-Arnold AM, Vargas MA, Haselton DR. Current status of luting agents for fixed prosthodontics. J Prosthet Dent 1999; 81:135-41.

5. Nissan J, Dmitry Y, Assif D. The use of reinforced composite resin cement as compensation for reduced post length. J Prosthet Dent 2001; 86: 304-8.

6. West JD, Roane JB. Cleaning and shaping the root canal sysytem. Pathways of the pulp. 7th ed. St. Louis: Mosby; 1994. p. 203-57.

7. Chow TW. Mechanical effectiveness of root canal irrigation. J Endod 1983; 9: 475-9.

8. Gluskin AH, Cohen AS, Brown DC. Orofacial dental pain emergencies: Endodontic diagnosis and management. Pathways of the pulp. 7th ed. St Louis: Mosby; 1998. p. 20-49.

9. Akkayan B, Glumez T. Resistance to fracture of endodontically treated teeth restored with different post systems. J Prosthet Dent 2002; 87: 431-7.

10. Miller BH, Nakajima H, Powers JM, Nunn ME. Bond strength between cements and metals used for endodontic posts. Dent Mater 1998; 14: 312-20.

11. Nakabayashi N. Resin reinforced dentine due to infiltration of monomers into dentine at the adhesive interface. J Jpn Dent Mater 1982; 5: 54-64.

12. Nakabayashi N, Kojima K, Masuhara E. The promotion adhesion by infiltration of monomers into tooth substrates. J Biomed Mater Res 1982; 16: 265-73.

13. Nikaido T, Takano Y, Sasafuchi Y, Burrow MF, Tagami J. Bond strengths to endodontically-treated teeth. Am J Dent 1999; 12: 177-80.

14. Nikaido T, Nakabayashi N. Relationship between polymerization and adhesion to teeth. Adhes Dent 1998; 6: 229-34.

15. Hosoda H, Sugizaki J, Nakajima M, Shono T, Tagami J. A study on the mechanism of bonding between resin and dentin. Part 1. Bonding to dentin treated with sodium hypochlorite. Jpn J Conserv Dent 1993; 36: 1054-8.

16. Vargas MA, Cobb DS, Armstrong SR. Resin-dentin shear bond strength and interfacial ultrastructure with and without a hybrid layer. Oper Dent 1997; 22: 159-66.

17. Inai N, Kanemura N, Tagami J, Watanabe LG, Marshall SJ, Marshall GW. Adhesion between collagen depleted dentin and dentin adhesive. Am J Dent 1998; 11: 123-7.

18. Soeno K, Taira Y, Atsuta M. Influence of formaline cresol on bond strength of adhesive luting agents to dentin. J Oral Rehabil 2000; 27: 623-8.

19. Yoshiyama M, Carvalho RM, Sano H, Horner JA, Brewer PD, Pashley DH. Regional bond strengths of resins to human root dentin. J Dent 1996; 24: 435-42.

20. Akagawa H, Nikaido T, Tagami J. Bonding of resin composite to pulpal chamber floor. Am J Dent (in press).

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