Effect of resin-coating technique on coronal leakage inhibition in endodontically treated teeth

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Purpose: To evaluate the effect of the resin coating technique on coronal leakage inhibition in endodontically treated teeth.
Materials and Methods: Thirty-six extracted human incisors were cut at the level of the cemento-enamel junction and standard endodontic obturations were made. They were divided into two groups; resin-coating group, and non-coating group. For the resin-coating group, the dentin surfaces were coated with either a one-step coating material, Hybrid Bond or a combination of Hybrid Bond and a low viscosity microfilled resin, SB Coat. They were subjected to thermal cycling for 0 or 1,000 times. Following this, the specimens were coated with nail varnish leaving the coronal openings exposed. The apical parts were sealed with utility wax. They were then immersed in 1% methylene blue solution for 48 hours. After removal from the dye, the teeth were sectioned faciolingually using a diamond saw. Linear dye penetration (in mm) from the cementoenamel junction was measured with photomicroscope. The number of the specimens was 12 for each group. The data were analyzed by two-way ANOVA and Dunnett's T3 test ($p=0.05$).
Results: Coronal leakage was influenced by the coating material and thermal stress ($p<0.05$). The resin-coating groups of HB and HB/SB had significantly less dye penetration compared with the non-coating group ($p<0.05$). The combination of Hybrid Bond and SB coat effectively inhibited coronal leakage ($p<0.05$).
Conclusion: The resin coating technique effectively minimized coronal leakage of endodontically treated teeth. Thermal stress demonstrated acceleration of dye penetration into the obturated root canal space.
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Key Words: coronal leakage, endodontically treated tooth, resin coating technique, thermal cycling.

Introduction

Obtaining a hermetic seal is one of the keys to achieving a successful long-term root filling. However, a hermetic seal cannot be obtained if root canal filling materials do not bond to the dentin walls.[1,2] Several methods have been reported for preventing coronal leakage through obturated root canals in the event that the coronal restoration becomes defective or lost. These include placement of an additional material into the canal orifice after removal of part of the gutta-percha and sealer, sealing the entire chamber floor with a restorative material, or use of a root canal filling method that provides a seal without the addition of other sealing materials.[3] Ideally, it would be that the root canal obturation alone prevents coronal leakage, since no extra steps would then be required.

A resin coating technique has been developed for indirect restorations, in which both a hybrid layer and a tight sealing film are produced on the dentin surface.[4] In this technique, a resin coating of a dentin adhesive system and a low-viscosity microfilled resin are recommended to be applied to the prepared cavity immediately after tooth preparation and just before taking impression. This technique has the ability to minimize pulpal irritation caused by mechanical and thermal stimuli and bacterial infiltration in vital teeth.[4] In addition, the technique can also be applied in the restoration of non-vital teeth. Maruoka et al. evaluated the effect of resin coating on coronal leakage inhibition in endodontically treated teeth.[5] They concluded that application of a resin coating to the coronal openings significantly reduced coronal leakage scores. However, the sealing ability was material dependent. Perfect sealing was demonstrated by a combination of Clearfil SE Bond and Protect Liner F, while a single coating of Hybrid Bond (reported as an experimental material, RZII), did not eliminate the coronal leakage completely. The development of the single-step resin coating material, Hybrid Bond was aimed at resin-coating crown preparations.[6,7] Because of a coating created with a single application of Hybrid Bond is approximately 5-6 μm thick,[8] Hybrid Bond might have allowed dye solution to penetrate through the Hybrid Bond adhesive, thereby resulting in an increase in the coronal leakage score.[5] In the clinical situation, a greater degree of stress may be concentrated in the root, which may adversely affect the coronal leakage scores. Therefore, the purpose of this study was to evaluate coronal leakage inhibition using resin coating with a single application of a single-step coating material and a combined application with a low-viscosity microfilled resin.

Materials and Methods

Materials used in this study

The materials used in this study are listed in Table 1. For the resin coating, a single coat of Hybrid Bond (HB) or a combination of Hybrid Bond and a microfilled resin, SB Coat (HB/SB, Sun Medical, Moriyama, Japan) was applied to dentin. Hybrid Bond is a single-step bonding material, which is appropriate for the resin coating of crown preparations. Hybrid Bond was applied two times to all specimens in this study. SB Coat was also developed as a low-viscosity micro-filled resin for resin coating.

Table 1. Materials used in this study.

Trade name / Lot		Composition	Instruction
Hybrid Bond* Lot KL1	Liquid:	Water, Acetone, 4-META, Polyfunctional acrylate, Monomethacrylate, Photo-initiators, Stabilizers	Mix sponge and liquid, Apply 20 s, Dry, Light exposure 10 s, Double coat
	Sponge:	*p*-toluene sulfinate, Amine	
SB Coat* Lot GL1	Liquid:	Acetone, Dimethacrylate, Aromatic amine	Apply, Mildly air-blow, Light exposure 20 s

*Sun Medical Co., Ltd., Moriyama, Japan; 4-META, 4-methacryloyloxyethyl trimellitate anhydride.

Specimen preparation

Specimen preparation is illustrated in Fig. 1. Thirty-six extracted, single-canal, human incisors stored in distilled water within 3 months of extraction were used. All the teeth were cut at the level of the cementoenamel junction with a diamond bur (ISO #173016, GC Corp., Tokyo, Japan) under water spray. Standard endodontic access cavities were made and the root canal contents were removed with #15-#35 K-type files (Zipperer, VDW GmbH, Munich, Germany). Patency of the apical foramen was determined using a #35 K-type file. The working length was established 0.5 mm short of the length at which this file exited the foramen, ensuring that the apical preparation was complete to within 1 mm of the apical foramen. The canals were irrigated with 3% sodium hypochlorite and chemomechanically prepared to a #35 master apical file. The canals were dried with paper points followed by apical cleaning. Master gutta-percha cones (GC Corp.) were fitted to within 1 mm of the working length for each root canal. The cones were coated with Sealapex (Kerr, Orange, CA, USA), placed in the canal, and condensed by cold lateral condensation. Excess gutta-percha was removed with a heated hand instrument at the level of the cementoenamel junction. After endodontic obturation, all the specimens were placed in water at 37°C for 24 hours to allow the sealer to set.

The specimens were randomly divided into two groups; a non-coating group and a resin-coating group. For the resin-coating group, the dentin surface was coated with either two coats of Hybrid Bond (HB) according to the manufacturer's instructions or a combination of Hybrid Bond and SB coat (HB/SB). Resin coated surface was light cured by using New Light-VL-II (GC Corp.). Half of the specimens in all the groups were then subjected to thermal stress, which ranged from 5˚C to 55˚C for 1,000 times.

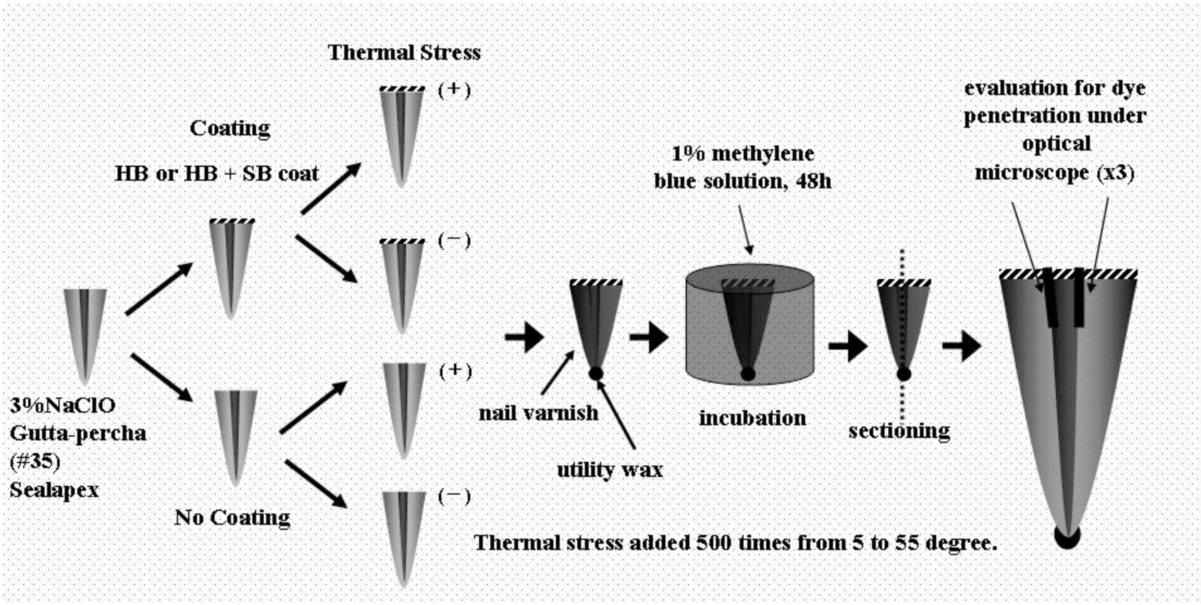

Fig. 1. Specimen preparation.

Following this, the entire tooth surfaces were coated with nail varnish leaving only that coronal openings exposed. The apical parts were sealed with utility wax. The teeth were then placed in 1% methylene blue solution for 48 hours and then sectioned faciolingually using a water-cooled diamond saw (Leitz 1600, Wetzlar, Germany). Measurement of the dye penetration was carried out to the nearest 0.01 mm using a stereomicroscope (Olympus Colposcope, Olympus Optical Japan, Tokyo, Japan) with x3 magnification. Each side of linear dye penetration from the cementoenamel junction was measured.

Statistics

Dye penetration at a total of 12 points was scored for each group. The mean dye penetration score was compared for each group utilizing two-way analysis of variance (ANOVA) at a 95% confidence interval. The two factors analyzed were coating material and storage condition. Following this, Dunnett's T3 test was performed ($p=0.05$).

Results

The results of the dye penetration test are summarized in Table 2, respectively. Two-way ANOVA revealed that coronal leakage was influenced by both coating material ($F=174.71$, $p<0.0001$) and thermal stress ($F=39.21$, $p<0.0001$). The resin-coating groups of HB and HB/SB had significantly less dye penetration compared with the non-coating group ($p<0.05$). In comparison among the resin-coating groups, resin-coating with HB/SB showed statistically lower coronal leakage than HB ($p<0.05$). All the groups that were thermal cycled exhibited statistically increased dye penetration scores than the groups without thermal stress ($p<0.05$).

Table 2. Effect of thermal stress on dye penetration score (mm).

Thermal cycling	No coating			Hybrid Bond			Hybrid Bond / SB Coat		
	Mean	SD	Category	Mean	SD	Category	Mean	SD	Category
0	1.48	0.50	a, d	0.41	0.26	b, d, e	0.13	0.17	c, d, e
1,000	2.27	0.32	a, f	0.87	0.35	b, f	0.29	0.23	c, f

Sample size=12, Identical letters indicate statistically significant differences ($p<0.05$).

Discussion

In order to evaluate dye penetration, methylene blue solution was chosen as a tracer in this study. Previously, several dye solutions, such as nitric acid,[9] pelican ink,[3,10] india ink[12] and methylene blue dye solution[2,5,12-14] have been used for the dye penetration test. Although there is no universally accepted solution, dye penetration experiments using a 0.2-2.0 % methylene blue solution have been commonly used in leakage studies.[15,16]

Higher coronal leakage occurred in the non-coated groups. Temporization was not carried out in this study. It was reported that a temporary filling material did not provide a sufficient marginal seal.[5] A water-setting temporary material, Cavit-G (3M-ESPE, Seefeld, Germany) was recommended after resin coating,[17] which reduces mixing inconsistencies commonly encountered during chairside manipulation. However, such a hygroscopic material tends to absorb fluids, which can be demonstrated by dye penetration into the filling material.[18] Therefore, temporary fillings can delay the progress of dye penetration but not inhibit coronal leakage.

A post space was not prepared at the coronal opening in this study. However, it was reported that post space preparation increased coronal leakage in non-coated specimens.[5] It is desirable that during post space preparation, the root canal sealer/gutta-percha and root canal sealer/root dentin interfaces should be stabilized without dislodgement or loss of seal. However, post space preparation stimulates a gap between the root and root canal filling material.[19] Moreover, a post space preparation shortens the distance from the root opening to the apex, thereby increasing the risk of coronal leakage.

Application of a resin coating to the coronal openings significantly reduced coronal leakage scores. In the previous study, good coronal sealing was demonstrated by a combination of Clearfil SE Bond and Protect Liner F.[5] With the resin-coating technique, a suitable combination of a dentin bonding system and a low-viscosity microfilled resin can improve adhesion to dentin.[20] Furthermore, an additional application of a low-viscosity microfilled resin can protect and promote polymerization of the underlying adhesive, resulting in increased bond strength.[21]

The resin coating material, Hybrid Bond, is categorized as an all-in-one adhesive, which is composed of an adhesive and a sponge. The sponge contains co-activators of *p*-toluene sulfinate and an aromatic amine that promote polymerization at the adhesive-tooth interface.[22] It has been reported that a single coat of Hybrid Bond applied to the flat dentin surface created a thin film, 5-6 μm thick, which is appropriate for resin coating a crown preparation.[7] The previous study reported that there were no significant differences in dentin bond strength between single and double coats of Hybrid Bond.[22] Therefore, a double coat of Hybrid Bond was applied in this study. The present results revealed that application of Hybrid Bond reduced coronal leakage, but did not eliminate it completely. SB Coat was developed as a low-viscosity micro-filled resin for resin coating. The combination of Hybrid Bond and SB Coat significantly reduced coronal leakage scores, however, perfect sealing could not be achieved.

Thermal cycling allows bonded specimens to be subjected to extreme temperatures, which simulate intraoral conditions. The ISO TR 11405[23] has indicated that the thermal cycling test comprising 500 cycles in water between 5 and 55°C is an appropriate accelerated aging test. However, the effects of thermal cycling depend on the adhesive bonding systems used, and the number of thermal cycles.[24] In the present study, the groups that were thermally stress demonstrated significantly higher dye penetration than the groups which were not.

Recent dentin adhesive systems can bond to root canal dentin and pulpal floor dentin as well as to coronal dentin. However, the chemical irrigants and medicaments that are used during root canal treatment are the clinical factors that influence dentin bonding.[25,26] Further studies are required to evaluate the influence of such factors on coronal leakage inhibition. From a clinical stand-point, the resin coating technique has strong possibilities for minimizing coronal leakage and removal of sound tooth structure, resulting in the achievement of minimally invasive restorations for non-vital teeth.

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