The Quasi–Three-Dimensional Marginal Leakage of Full-Coverage Crowns: Resin Coating Versus Sodium Hypochlorite Treatment

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This study compared the effects of various surface treatments and techniques on the marginal leakage of full-coverage crowns using a quasi–three-dimensional evaluation. Crowns were cast using a gold-silver-palladium alloy by means of the lost-wax technique. Twenty-eight recently extracted human molars were divided randomly into four groups according to surface treatment before crown cementation: *(1)* no pretreatment (negative control), *(2)* primer (positive control), *(3)* resin coating and primer, and *(4)* phosphoric acid, sodium hypochlorite, and primer. All specimens were cemented with composite cement. The lowest marginal leakage was observed in group 4. Variation in marginal leakage between specimens originating from the same tooth was observed. *Int J Prosthodont 2010;23:406–409.*

In contrast to enamel, dentin is a much more challenging substrate to establish a reliable and durable bond. Different adhesive approaches, along with the specific adhesive composition and application procedure, influence the outcome considerably.[1] Despite the fact that adhesion to dentin has improved significantly, secondary caries caused by marginal leakage still remains a major problem.[2] Marginal leakage can not be controlled well, even when a high-precision casting method is employed and the restoration is luted adhesively. While some authors recommend the direct formation of a hybrid layer to achieve durable and strong bonding to dentin,[1] others have reported higher bond strengths when the surface was treated with sodium hypochlorite prior to cementation.[3] In this study, crown restorations were sectioned every 1 mm to check the marginal leakage in detail. The null hypothesis tested was that marginal leakage of full-cast crowns would not vary between the different dentin pretreatments.

Materials and Methods

Twenty-eight recently extracted human molars were prepared for full-cast crown restorations using a high-speed hand piece (NSK) with diamond points (K2 and K2ff, GC). Cervical margins were located 1 mm below the cementoenamel junction with a chamfer-type margin. All specimens were divided into four groups randomly according to their respective surface pretreatments: *(1)* no pretreatment (negative control), *(2)* primer (Panavia Fluoro Cement, Kuraray; positive control), *(3)* resin coating and primer (Clearfil SE, Kuraray), and *(4)* phosphoric acid, sodium hypochlorite, and primer (NaOCl; K-Etchant, Kuraray; AD Gel, Kuraray; Panavia Fluoro Cement) (Table 1). In the resin coating group, resin coating was applied on the abutment tooth and the margin was reprepared over an area approximately 1-mm wide using the K2ff bur to

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Table 1 Materials Used per Experimental Group

Material	Composition	Application
Negative control group (no primer)	–	–
Positive control group with primer		
Panavia Fluoro Cement (Kuraray)	ED primer II A: HEMA, 10-MDP, 5-NMSA, water, accelerator; ED primer II B: 5-NMSA, water, sodium benzene; Paste A (universal): 10-MDP, 5-NMSA, silica, dimethacrylate monomer, photo-initiator, accelerator; Paste B (catalyst): barium glass, sodium fluoride, dimethacrylate monomer, BPO.	1. Mix ED primer II A and B. 2. Apply primer for 30 s and air dry. 3. Mix universal and catalyst paste for 20 s. 4. Light cure for 20 s. 5. Apply Oxyguard for 3 min.
Resin coating group with primer		
Clearfil SE (Kuraray)	Primer: 10-MDP, HEMA, hydrophilic dimethacrylate, photo-initiator, water; Bond: 10-MDP, HEMA, bis-GMA, hydrophilic dimethacrylate, photo-initiator, silanated colloidal silica.	1. Apply primer for 20 s and air dry. 2. Apply bond and gently air dry. 3. Light cure from occlusal side for 10 s. 4. Margin was reprepared over an area of almost 1 mm in width using a K2ff bur to get a fresh adhesive surface. 5. Impression of the abutment tooth.
Panavia Fluoro Cement	Same as for positive control group.	Same as for positive control group.
NaOCl treatment group with primer		
K-Etchant (Kuraray)	40% phosphoric acid, thickener	1. Apply for 30 s. 2. Rinse for 30 s.
AD Gel (Kuraray)	10% sodium hypochlorite, 14% aluminum oxide (alumina)	1. Apply for 60 s. 2. Rinse for 60 s.
Panavia Fluoro Cement	Same as for positive control group.	Same as for positive control group.

HEMA = hydroxyethyl methacrylate; 10-MDP = 10-methacryloyoxydecyl dihydrogen phosphate; 5-NMSA = N-methacryloyl-5-aminosalicylic acid; BPO = benzoyl peroxide; bis-GMA = bisphenol glycidyl methacrylate.

obtain a fresh adhesive surface before taking an impression. Impressions of the abutment teeth were then taken from specimens in all groups with an impression material (Exafine Injection Type, GC) and poured in die stone (Fujirock, GC) to produce a master cast. The dies were trimmed and covered with stone hardener (Aron Alpha, Toagosei), followed by two layers of die spacer (Ishifuku Material) above the preparation margin. The wax pattern (Inlay Wax medium, GC) was cast in a gold-silver-palladium alloy (Castwell M.C., GC). The fit of the castings was checked with silicone material (Fit Checker, GC) and the inner surfaces were air-abraded with 50-μm aluminum oxide.

After surface pretreatment, a dual-curing resin cement (Panavia Fluoro Cement) was mixed following the manufacturer's instructions and applied to the inside surface of the crown. The crown was seated in its terminal position using finger pressure and the excess resin cement was removed carefully. Oxiguard II (Kuraray) was applied along the margin area for 3 minutes for complete polymerization of the resin cement. Specimens were stored in 37°C distilled water for 24 hours.

All specimens were subjected to 2,500 thermal cycles (5°C and 55°C, 60 seconds each). The root surface was coated with two layers of nail varnish (NA, Shiseido) and specimens were stored in 0.2% fuchsine aqueous solution at 37°C for 24 hours. Subsequently, specimens were embedded in epoxy resin (Epofix, Struers) and sectioned using a low-speed diamond disk (Isomet, Buehler) into eight to nine slices (Fig 1). The length of marginal leakage was assessed for each slice using an optical microscope at a magnification of ×40 (CH30, Olympus).

Fabrication of full-cast crowns, surface treatment, restoration placement, and marginal leakage quantification were completed by one experienced operator. Data on marginal leakage were analyzed by one-way analysis of variance and the Scheffé test.

Results

The means and standard deviations of marginal leakage were 3.23 ± 0.11 mm for the negative control group, 2.06 ± 0.12 mm for the positive control group, 1.68 ± 0.14 mm for the resin coating group, and 0.68 ± 0.07 mm for the NaOCl treatment group (Fig 2). Significant differences in marginal leakage were recorded between all surface pretreatments, except between the positive control group and the resin coating group. Intraspecimen differences in marginal leakage were also observed (Fig 3).

Fig 1 Example of a series of cross-sections through a crown-restored tooth subjected to the marginal leakage test. **(left)** A typical section of a specimen showing marginal leakage up to 3-mm deep along the dentin-cement interface. **(right)** Eight to nine slices could be obtained from a single tooth.

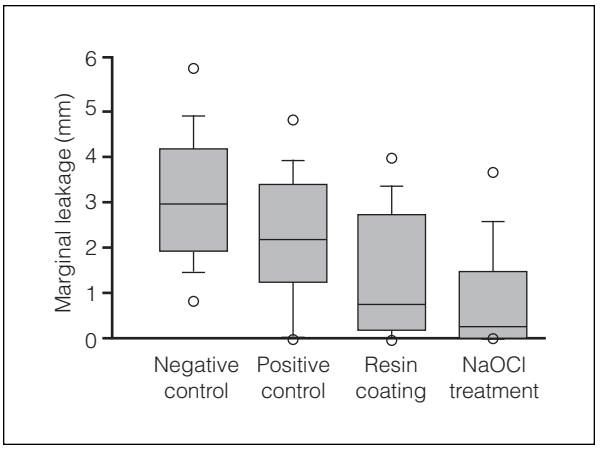

Fig 2 Box plot of mean marginal leakage per experimental group. Means connected with a horizontal line are not significantly different ($P > .05$, Scheffé test).

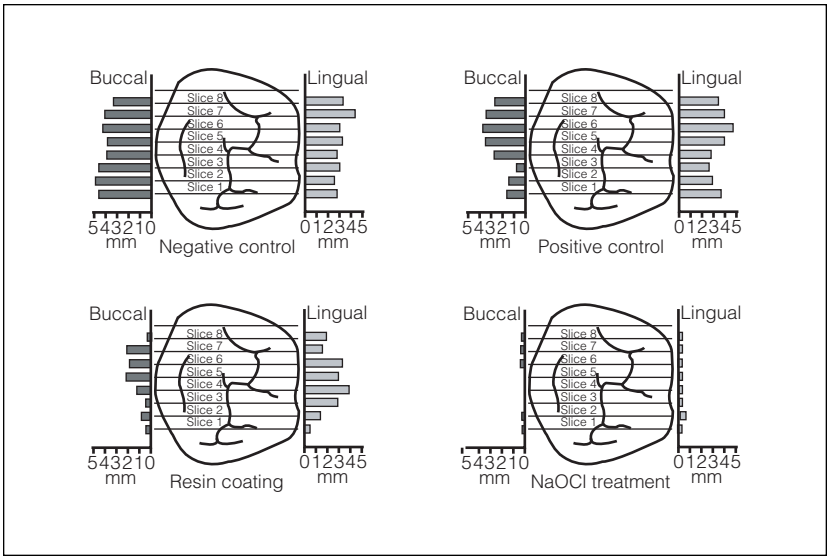

Fig 3 Marginal leakage measured at different sections through a crown-restored tooth for one tooth in each of the four different experimental groups. The horizontal bars on the left show the marginal leakage degree at the buccal aspect, and those on the right show the marginal leakage degree at the lingual aspect. In all specimens of the negative control group, leakage was detected (highest amount among all groups). No leakage was observed in some specimens of the positive control, resin coating, and NaOCl treatment groups.

Discussion

The null hypothesis that marginal leakage of full-cast crowns is not different for the four dentin surface pretreatments was rejected. In this study, marginal leakage decreased significantly, in order, in the negative control group, the positive control group, the resin coating group, and the NaOCl treatment group. Thus, the smallest marginal leakage was obtained when the surface was pretreated with sodium hypochlorite. Several studies have reported on the beneficial effect of removing the collagen layer by sodium hypochlorite prior to application of the adhesive resin.[3,4] Because almost all collagen fibrils are removed by sodium hypochlorite, no distinct hybrid layer is formed between the dentin and luting resin. Since resin infiltration is then expected to be poorer and lead to marginal leakage,[5] ED primer II (Kuraray) was used to produce a submicron hybrid layer that is typical of "mild" self-etching adhesives (pH: 2.1). This methodology has been shown to improve the marginal seal of the restoration.[4] Also, the technique's sensitivity is reduced since the critical step of drying the etched dentin surface with risks of over- or underdrying is avoided, as most of the collagen was removed from the surface beforehand. No significant difference in marginal leakage was found between the positive control group and the resin coating group. Since the margin was reprepared after resin coating over an area almost 1-mm wide but before taking the impression, this technique may have resulted in a similar surface effect as that obtained in the positive control group.

In the present study, finger pressure was used to seat the crown on the prepared tooth during cementation. Since the adherent surface was not flat but three-dimensional, the pressure for setting could be added properly to each specimen only through finger pressure. It was confirmed by observing the sections that the crowns were seated properly without tilting. Therefore, it can be estimated that the use of finger pressure for cementation did not affect the results significantly.

Surprisingly, big differences in marginal leakage were seen in the different sections originating from the same tooth (Fig 3). Traditionally, marginal leakage is assessed by slicing a restored tooth and scoring the leakage on the exposed surface only. This two-dimensional evaluation method, despite the leakage, is a three-dimensional phenomenon. Because of the variability of the results from this study, it is clear that marginal leakage analysis should be done at least in quasi–three dimensions, using several sections from the same tooth, if not in full three dimensions (eg, micro-CT technology).[6]

Conclusion

The formation of a reverse hybrid layer using sodium hypochlorite, followed by the application of a mild self-etching primer, results in the least amount of marginal leakage. Also, variations in marginal leakage between specimens originating from the same tooth were observed.

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