Repairing a Preveneered Stainless Steel Crown with Two Different Materials

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ABSTRACT

Purpose: The objective of this study was to determine the in vitro shear bond strength of 2 different repair materials for anterior preveneered stainless steel crowns (SSCs) after bond failure in the prefabricated veneers.

Methods: Sixteen preveneered anterior SSCs were used. Each of the preveneered crowns was cemented with a luting glass ionomer cement onto cast die. Each die was placed into a mechanical testing machine. A force was applied on the veneer at the incisal edge, with a crosshead speed of 0.05 inches/minute until the initial original facial facing material fractured or dislodged. Fracture or dislodgment failure of the initial original facial facings was evaluated and photographed. Specimens were divided into 2 equal repairing procedure groups. Group 1 was repaired using Tetric Flow, a flowable resin composite. Group 2 was repaired using Major Resin, a crown and bridge veneering resin. After the repairing procedure, crowns were stored in water at room temperature for 24 hours and then thermocycled. The crowns repaired were debonded in the test machine in the same manner as the initial facial facing fracture test. The debonding failure of the repaired crowns also was evaluated and photographed.

Results: There was a statistically significant difference between the initial original veneer material and groups 1 and 2 ($P<.000$) and between groups 1 and 2 ($P<.001$).

Conclusions: In this in vitro study, it was determined that shear forces of the repair materials were lesser than bond forces of the original veneer material to the stainless steel metal base. (*J Dent Child*. 2004;71:135-138)

KEYWORDS: REPAIRING PREVENEERED STAINLESS STEEL CROWNS, PREVENEERED STAINLESS STEEL CROWNS, PRIMARY TEETH ESTHETIC RESTORATIONS

Preformed stainless steel crowns (SSCs) have been widely used in the restoration of severely carious, malformed, or traumatically fractured primary teeth since 1950.[1] However, SSCs are overshadowed by their unsightly metallic appearance in the anterior teeth. Esthetic solutions include open-faced SSCs and chairside veneering/preveneered SSCs.[2-8]

Preveneered SSCs were developed and marketed for primary anterior tooth restorations in the mid-1990s (Cheng Crowns, Kinder Krowns, NuSmile Primary Crown, Whiter Biter II Crown, The Dura Crown). These crowns are preveneered by manufacturer and their veneer materials are not affected from hemorrhage and saliva.[9,10]

Investigators have evaluated the shear force required to fracture or dislodge the veneered facings from commercially available veneered primary incisor SSCs and obtained varying results, ranging from 362.5 N to 1051.6 N.[9-11] The veneer facings of these crowns have a fracture resistance greater than the average bite force of preschool children, for whom bite forces are 213.17±43.97 N.[12] Facings of these crowns, however, may be fractured or dislodged from the stainless steel base.[9-11] Studies of repairs applied due to fracture failures in the crowns' veneer materials are limited.[13] Al-Shalan et al[13] determined that the bond strength of composite rebonded to SSC metal using different bonding agents was greater than the original commercially produced bond.

The purpose of this study was to determine the in vitro shear forces required to dislodge a flowable composite resin and crown veneering resin applied to anterior preveneered SSCs after the prefabricated veneered had been dislodged.

METHODS

Sixteen preveneered incisor SSCs (NuSmile Primary Crowns, NuSmile Crowns, OT, Inc., Houston Tex) were used. NuSmile crown facing is bonded directly to the alumina-blasted stainless

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Figure 1. Original crown's facing's failure.

steel base, and, hence, facing is not dislodged completely when a force is applied to the veneer.[9,10] These crowns were kept in water for 1 year. Meanwhile, a specific waxup was prepared for each crown. Next, 16 cast dies were fabricated with chromium cobalt metal, and each veneered crown was cemented onto one of the cast dies with a luting glass ionomer cement (Aqua Meron, Voco, Cuxhaven, Germany) mixed to the manufacturer's specification.

Twenty-four hours following cementation, each die was placed into a mechanical testing machine and loaded with a force applied by a mechanical testing machine (Hounsfield, Test Equipment, Raydon, England) to obtain an initial fracture force value before 1 of 2 different repairing procedures. A stainless steel rod, 0.5-mm thick at the edge and 8-mm wide, applied a force on the veneer at the incisal edge at 148° (the primary interincisal angle),[9,10,14] with a crosshead speed of 0.05 inches/minute, until the veneer was fractured or dislodged.

When the failure point of the veneer was reached, the data were recorded in newtons (N). The fractured test specimens were photographed under ×10 magnification with a stereo microscope (Nicon SMZ-U multi-point-sensor system, Japan; Figure 1). Characterizations of the bond failure of the veneer material were scored (adhesive failure at the steel/resin interface), cohesive failure (within the facing material), or adhesive/cohesive failure (mixed).

REPAIRING PROCEDURE

The 16 specimens were divided into 2 equal repairing procedure groups in which the crowns had the same size. Repairing procedures were performed as follows:

GROUP 1

The fractured margins of the facial facings were prepared using contouring discs (Sof-Lex, 3M SP Dental Products, Seefeld-Germany), but exposed metal surfaces on the failed crowns were not prepared. Then, a 34.5% phosphoric acid (Vocosid, Voco, Cuxhaven, Germany) was applied to the prepared facial facing surface for 30 seconds. The surface was rinsed with a stream of water for 10 seconds and dried with compressed air. A bonding agent (Prime & Bond 2.1, Dentsply, Konstanz, Germany) was applied in ample amounts to both the etched veneer facing and the exposed metal surface. Excess bonding agent was removed by blowing gently with compressed air and light cured for 10 seconds. A second bonding agent layer was applied, excess removed, and cured for 10 seconds. Opaquer was not used to mask the metal color because Tetric Flow does not have an opaquer system.

Next, Tetric Flow (A2, Vivadent, Schaan, Lichtenstein), a flowable resin composite, was applied in 2 layers over the area. Each layer was cured for 40 seconds immediately after placement. Repair material applied on the labial facing was finished using Sof-Lex contouring and polishing discs. This group was named as NuSmile+Tetric Flow.

GROUP 2

Crowns were prepared as aforementioned. The prepared area was rinsed and blotted dry with compressed air. Veneering resin and its own opaquer were used as recommended by the manufacturer. Opaquer (Major Adhesive & Opaquer, A2, Moncalieri, TO-Via Luigi, Einaudi) was applied using fully saturated brush tips. A thin coat of opaquer was applied to the exposed metal surface and was self-cured. Veneering resin (Major, A2, Major Prodotti Dentari, Moncalieri TO-Via Luigi, Einaud) was placed directly over the opaquer and self-cured in open air for 5 minutes, and finished with Sof-Lex discs. This group was named as NuSmile+Major Resin.

After the repairing procedure, all crowns were stored in water at room temperature for 24 hours and then thermocycled at 4°C to 55°C for 250, 20-second cycles. The crowns repaired were debonded in the test machine in the same manner as the initial fracture test. The data obtained were recorded in newtons (N). The debonding failure of the repaired crowns also was evaluated under ×10 magnification using a stereo microscope. Repairs were made using A2 shades for both repair materials. These shades were distinctly different from the original veneer material shade. Hence, types of failure observed for both repair materials were easily scored:

1. adhesive failure=dislodgment at the SSC and/or the original veneer resin interfaces;
2. cohesive failure=failures within the repairing materials; or
3. adhesive/cohesive failure=mixed.

In addition, the fracture extents of original veneer and both repair materials were classified as: (1) a third; (2) half; or (3) complete. After the repair test procedure, one specimen from each repair group was selected to photograph the repair procedures' esthetic quality. Crowns were repaired using both repair materials, with a shade based on body color of fractured facings.

Recorded bonding forces were analyzed with an independent-sample *t* test using statistical software.

RESULTS

The mean values for the force in newtons required to separate the original veneer material and the 2 different repair materials from the alumina-blasted SSC base are shown in Table 1.

The independent sample *t* test indicated a significant difference between the mean values of initial fracture and the repair group (which includes NuSmile+Tetric Flow and

Table 1. Mean Bond Forces of the Initial Original Veneer Material and 2 Repair Materials (N=newtons)

Groups	N	Mean values (N)±SD
NuSmile*	16	385±25.82
NuSmile+Tetric Flow†	8	226.25±18.468
NuSmile+Major Resin†	8	158.75±24.408

*Original veneer material.
†Repaired group.

NuSmile+Major Resin; $P<.000$). Also, the NuSmile+Tetric Flow and NuSmile+Major Resin groups were (independent sample *t* test) significantly different at $P<.001$. The Major Resin repair material required the least amount of force to dislodge.

Failures that occurred in both the initial original veneer material and 2 repair materials were examined (adhesive, cohesive, mixed [adhesive/cohesive]). Results are shown in Table 2, as are failure types of the initial original veneer and the repaired groups. All of the original veneer material had mixed failure (adhesive/cohesive). Repaired groups demonstrated both adhesive and mixed failures. In addition, none of the repaired groups had cohesive failure.

NuSmile+Tetric Flow repair group was equal from the adhesive and the mixed (adhesive/cohesive) failures point of view. Almost all samples in the other repaired group experienced adhesive failures (Figure 5), except for one sample that demonstrated mixed failure. None of the repair groups demonstrated cohesive failure.

The extent of fracture of original veneer material was either a third (69%) or half (31%), but not complete (Table 2). Both repair groups exhibited modes of fracture extent similar to those of the original veneer material. None of the repaired samples, however, had complete facing dislodgement (Table 2).

Major Resin was more successful than Tetric Flow in masking the base metal color (Figures 2 and 3).

DISCUSSION

Preveneered SSCs in primary anterior tooth restorations have all the advantages of SSCs, but facing materials may be fractured or dislodged occasionally. The failed veneer material may be repaired as an alternative to replacement of failed restorations. Mjör[15] stated that the advantages of failed restoration repair include saving the restored tooth hard tissue and low cost.

Figure 2. Crown repaired using Tetric Flow.

Figure 3. Crown repaired with Major Resin.

In this study, before testing, the veneer material crowns were soaked in water for 1 year. Waggoner and Cohen[9] and Baker et al[10] evaluated the failure force of the veneer materials of different preveneered SSCs. The crowns in their studies were immersed in water for 24 hours and 90 days, respectively. In the aforementioned studies, it was noted that the mean bond strengths of only NuSmile veneer material (approximately 445 N) were unchanged over time.[9,10] In this study, however, the authors found that the initial mean force required to the separate the veneer material from the stainless

Table 2. Type of Failure and Extent of Fracture of the Original Veneer Material and Repair Materials

		Failure type			Fracture extent		
Groups	N	Adhesive	Cohesive	Mixed	A third	Half	Complete
NuSmile*	16	0	0	16	11	5	0
NuSmile+Tetric Flow†	8	4	0	4	5	3	0
NuSmile+Major Resin†	8	7	0	1	6	2	0

*Original veneer material.
†Repaired group.

steel base (385N) was less than other studies.[9,10] This may be explained by the fact that the NuSmile crowns' veneer material utilized a composite or a dimethacrylate resin for facing material that over time, tends to absorb water.[9]

In this study, failures of the NuSmile veneer material all displayed mixed, adhesive/cohesive failure. The veneer material separated from alumina blasted stainless steel base was characterized by a spalling. The observed failure modes were in agreement with previous studies.[9,10]

In the present study, the mean value of the initial original veneer material's fracture resistance was significantly better than those of 2 repaired groups ($P<.000$). The mean debonding force of the repaired veneer material was found to be approximately 58% to 48% of the initial original veneer material (groups 1 and 2, respectively). These findings agree with Shöderholm and Roberts.[16] The high bonding strength between Tetric Flow and original veneer material interfaces might be attributed to the etching, and applying adhesive agent on the veneer material utilized a resin composite or dimethacrylate.[13] Moreover, in this study, use of an adhesive agent, including phosphate in chemical composition, may have contributed to bonding strength underlying the alumina-blasted stainless steel of Tetric Flow.[17,18]

When comparing this study's repairing procedures of Tetric Flow with those of Major Resin, the latter provided a very low shearing strength. Almost all of the repairing veneer materials (86%) demonstrated adhesive failure. This may be explained by the fact that the repair material's monomer cannot diffuse into the veneer material's matrix.[19] Additionally, preparing without mechanical retention of exposed stainless steel surfaces could have played a role in low bonding strength of Major Resin. Some investigators have noted that mechanical retention of the veneering resins with retentive undercuts is as important as chemical bonding.[6,20,21]

Major Resin had self-hardening liquid opaquers with a high sealing power. An Opaquer-Major Resin combination may be presented as an excellent esthetic (Figure 3). Tetric Flow does not have an opaquer system. The assortment of Tetric Flow contains Dentin Shade A3.5, however, which, approximately 4 years ago used to be referred to by the manufacturer as opaque. In spite of its outstanding high bonding strength, the masking capability of the opaque resin's metal color is questionable (Figure 2).

The repairing procedures described in this in vitro study are easily and quickly applicable. Moreover, practitioners do not need to remove the crown and place another for repairing. The clinicians, however, have to take into consideration that the repair materials have weaker bond strength than the initial bond.

CONCLUSIONS

In this in vitro study, it was determined that shear forces of the repair materials were less than bond forces the original veneer material the stainless steel metal base.

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