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Scientific Article

Effects of Ultraviolet Irradiation on the Bond Strength of a Composite Resin Adhered to Stainless Steel Crowns

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Abstract: ***Purpose:*** *A technique whereby the practitioner could improve the esthetic appearance of anterior stainless steel crowns (SSC) could provide a cost-effective alternative to more expensive commercially available preveneered SSCs, which may not be uniformly available. The purpose of this study was to evaluate the effects of ultraviolet (UV) irradiation of the metal crown surface on the shear bond strength of composite resin adhered to stainless steel crowns.* ***Methods:*** *Seventy extracted anterior bovine teeth randomly divided into 2 groups (n=35/group), were restored with primary maxillary left central incisor SSCs. Surface roughening with a green stone was performed on the labial surfaces, and the crowns of the experimental group were exposed to UV irradiation for 80 minutes. All samples were treated with metal-composite adhesive, followed by composite opaquer. Standardized composite blocks were bonded on the treated surfaces, and the shear bond strength was tested at 1 mm/minute. The values were recorded in MPa and statistically analyzed.* ***Results:*** *The mean value of shear bond strength was significantly higher for the experimental group (19.7±4.3 MPa) than the control group (16.3±4.5 MPa).* ***Conclusion:*** *Ultraviolet irradiation of primary tooth stainless steel crowns significantly increased the shear bond strength of composite resin adhered to the facial surface.* *(Pediatr Dent 2013;35:23-6) Received May 25, 2011 | Last Revision September 15, 2011 | Accepted November 3, 2011*

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Dental caries is a common dental disease that affects all populations, regardless of age, race, or gender.[1] Children represent a high-risk group to develop caries,[2,3] known as early childhood caries (**ECC**), before they are 6 years old.[4] The characteristics of ECC include 1 or more decayed teeth, loss of teeth due to caries, filled surfaces of any primary tooth, and caries in maxillary anterior teeth and on the vestibular surfaces of posterior teeth.[5] ECC's major causes are related to the early acquisition of *Streptococcus mutans* and dietary risk factors during early childhood.[6] The prevalence of caries in the Mexican population is considered to be from 90% to 94%.[2,7] Weinstein et al.,[8] and Serwint et al.,[9] reported that the prevalence of Mexican American children living in Washington and California is approximately 20% of the pediatric population.

Loss of primary teeth is a common complication of ECC that can alter the development of occlusion, phonation, permanent tooth eruption, and esthetic appearance. Although the restoration of primary incisor teeth is a challenge to dentists due to severe tooth destruction, operative dentistry could solve these problems, especially for teeth restored with stainless steel crowns (**SSCs**), veneer crowns, polycarbonate crowns, and strip crowns.[10]

Currently, commercially available veneered crowns provided by different companies are used as esthetic restorations for children severely affected with ECC.[11,12] Baker et al.,[11] and Waggoner et al.,[12] however, reported that commercial crowns are susceptible to failures of esthetic materials. In addition, prefabricated crowns are not available in underdeveloped countries and are expensive for such populations. In-office veneering of crowns has been reported and involves bonding resin composite[13-15] and compomer[16] directly to the SSCs, and their shear bond strength (**SBS**) and fracture failure potential have been tested. Composite resins showed SBS values of 24.4Mpa,[14] and 20.7Mpa;[13] whereas the value of SBS of the nanocomposite resins was 21.0 MPa.[13] On the other hand, the conventional compomer has shown SBS of 2.9MPa, increasing the value with different surface treatment such as sandblasting (9.5MPa); sandblasting and dentin adhesive (9.3MPa); and spotwelded (13.9MPa).[16]

Recently, the photocatalysis effect by ultraviolet (**UV**) irradiation of titanium oxide (TiO_2) has been reported to enhance the attachment of different cell lines,[17-19] thus increasing the shear bond strength of the segmented polyurethane.[20] UV irradiation could be a suitable application for dental adhesives as well as composite resins, because, the exposure of titanium (**Ti**) and other materials to UV irradiation induces photoactivation by reducing carbon and increases the oxygen concentrations. Theoretically, the oxygen surfaces are hydrophilic.[21] Accordingly, diverse metals have been photoactivated, such as chromium (**Cr**),[22,23] Iron (**Fe**),[24] and nickel (**Ni**).[25] SSCs' alloy components are Ni, Cr, Fe, and other metals.[26] UV irradiation over these metals yields a clean and hydrophilic surface through the conversion of carbon to oxygen onto the outer layer. Thus it can be supposed that the UV light on the SSCs induces a photocatalytic effect and improves the metal-bonded resin composite.

The purpose of this study was to determine the effects of ultraviolet irradiation of the SSC surface on the shear bond strength of composite resin adhered to the SSCs using a simple, rapid, and inexpensive technique that could provide esthetic and functional properties.

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Methods

Seventy freshly extracted anterior bovine teeth were randomly divided into 2 groups (N=35/group) to be crowned with 70 maxillary left central incisor SSCs, size no. 5 (3M Unitek, Monrovia, Calif., USA). In preparation for crown placement, the incisal surfaces of the teeth were reduced with a diamond wheel bur (wheel no. 909, SS White Burs Inc, Lakewood, N.J., USA), and the proximal, vestibular, and palatal surfaces were prepared with a thin needle diamond bur (needle no. 859, SS White Burs Inc). All surfaces were reduced uniformly by approximately 1.5 to 2 mm, and the sharp angles were rounded. A thin layer of acrylic resin (NicTone 62, MDC Dental, Guadalajara, Mexico) was used to rebase and fit all crowns on the teeth, supporting a fit restoration. The crowns were adjusted and cemented with type 1 glass ionomer (Ketac-Cem 3M Unitek).

In order to improve retention of the facing, the vestibular surface of all crowns were roughened with a green mounted stone (Rhino, MDC, Guadalajara) at a low speed for 5 seconds. The samples were cleaned with 75% ethyl alcohol and 95% ethanol and dried by expressed air. The labial surfaces of the experimental group were exposed to UV irradiation for 80 minutes using 4 UV lamps that produced 36 watts of power to induce photoactivation (Professional, UV Lamp NTS-030, Zhenjiang, China).

A thin layer of metal-composite bond (SR Link Bonding System, Ivoclar Vivadent AG, Schaan, Liechtenstein) was applied to the crown surfaces of all teeth with a small brush and dried for 3 minutes. Two layers of opaquer (Opaquer A2, Adoro Ivoclar Vivadent, Schaan) were placed over the surface and light-cured (Optilight, Gnatus, Ribeirao Preto, Sao Paulo, Brazil) for 60 seconds. Standardized composite blocks (Filtek Supreme XT, Translucent, 3M Unitek) of 4 x 4 x 0.07 mm were fabricated using Teflon molds and light-cured for 60 seconds. Each composite block was bonded over the crowns with the composite and light-cured for 60 seconds. The samples were fixed in acrylic resin (NicTone 62), with a label bearing the number of each sample. A mounting jig was used to align each tooth's labial surface.

The samples were stored in a dry medium for 24 hours and tested using a universal testing machine (AGS-X, Shimadzu, Kyoto, Japan) in the shear mode (Figure 1). The force was applied at the interface of the composite resin block and the crown. Bond strengths were measured at a crosshead speed of 1 mm/minute, and the force of debonding was recorded in newtons (**N**) and converted into megapascals (**MPa**).

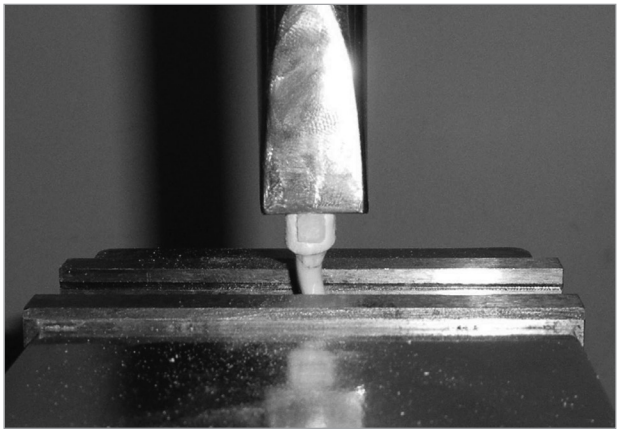

Figure 1. Shear bond strengths of composite bonded to UV-irradiated vs non-UV-irradiated surfaces of stainless steel crowns were measured at a crosshead speed of 1 mm/minute and the force was recorded in N and converted into MPa.

Table 1. DESCRIPTIVE STATISTICS OF SHEAR BOND STRENGTH

Shear bond strength (MPa)				
Group	**N**	**Mean±(SD)**	**95 % confidence interval**	**Student's *t* test‡**
Crowns*	35	16.3±4.5	14.7, 17.9	A
Crowns + UV†	35	19.7±4.3	18.1, 21.2	B§

* Control group.
† Experimental group with ultraviolet irradiation.
‡ Different letters show the statistical difference of each other.
§ *P*=.003.

All data were examined and tested for normality distribution using the Saphiro-Wilk test. The mean values and standard deviations were estimated. Student's *t* test was used to compare the shear bond strength between the groups. A value of 0.05 was considered to be statistically significant, which was obtained using SPSS 15.0 statistical analysis software (SPSS Inc., Chicago Ill., USA).

Results

The values and descriptive statistics of the shear bond strengths are shown in Table 1. The values of the experimental group showed almost a normal distribution compared to the control group, demonstrating less variability among the mean values. The crowns irradiated with UV light showed higher shear bond strength (19.7±4.3 MPa) than the non-irradiated crowns (16.3±4.5 MPa), with significant differences (*P*=.003) observed between the groups based on student's *t* test results.

Discussion

Over the last 50 years, SSCs have proved to be an excellent restoration treatment for primary teeth severely affected by caries. The anti-esthetic appearance that results, however, has major disadvantages.[10,27] Since the 1990s, some alternatives have been proposed to improve the esthetic appearance of pediatric crowns, such as pediatric commercially available crowns with esthetic facial surfaces (veneered crowns).[28] Some disadvantages identified in their use include: overlap-resin affecting the gingival margin; difficulty in fitting; fracture of the esthetic surface at crimping and trimming; and high costs.[14,26] Conversely, the technique described in this study could be an alternative to solve the problem of the gingival margin, as the veneer could be placed after adjusting the tooth's metallic crown.

Although the photocatalysis of Ni has not yet been clarified, some diverse metals have been photoactivated, such as Ti,[20] TiO_2,[29] Cr,[22] and Fe.[24] It has been reported that photocatalysis could be induced in Ti plates via UV irradiation for 20 minutes at 54 watts to enhance the adhesion and proliferation of MC3T3-E1 osteoblastic mouse cells.[19] Furthermore, vestibular surfaces of pediatric crowns built on SSCs were roughened with a mounted green stone and UV-irradiated for 80 minutes at 36 watts, producing a metastable surface before attachment to the composite. UV-irradiated crowns significantly enhanced the shear bond strength of bonded composite blocks vs the non-UV-irradiated group.

Presently, silanization and ionization of metals are the methods employed to adhere composites to metal surfaces

without significant differences.[30] In the present study, composites were bonded to SSCs by ionization of metal using the SR Link Bonding System (Ivoclar, Vivadent), and the material showed suitable results.

To date, there are some reports on the adherence of esthetic materials to metallic pediatric crowns. Baker et al.,[11] tested commercially available veneered primary incisor SSCs. A force was applied at the incisal edge at 148 degrees (0.05 inches/minute). The 4 types tested and their mean forces (**lbs**) are as follows: Cheng crowns, (107.8 lbs); NuSmile crowns, (100.2 lbs); Kinder Krown crowns, (91.3 lbs); and Whiter Biter crowns, (81.5 lbs). A similar study was performed by Waggoner et al.[12] at a crosshead speed of 1 mm/minute until the veneer was fractured or dislodged. The mean forces (in N) required to produce failure in the crowns tested were as follows: Kinder Krown crowns (397.2 N); NuSmile crowns (447.2 N); Cheng crowns (511.9 N); and Whiter Biter crowns (686.5 N). The mean values in these studies suggest that Cheng and Whiter Biter crowns require more force to debond or fracture the esthetic material. In the present study, the values were obtained in MPa and, subsequently, the area of the composite resin block was calculated. The mean values expressed in N, however, correspond to 220 N for the irradiated crowns and 185 N for the control group, respectively.

Wiedenfeld et al.,[14] in a related study, reported that the average shear bond strength of anterior veneering bonded with composite resin was 24.4 MPa; however, higher values have been reported. Khatri et al.,[13] reported that the shear bond strengths of composite and nanocomposite adhered to crowns presandblasted were 20.78±0.60 MPa and 21.04±0.56 MPa, respectively, which are slightly higher than our values obtained on UV-irradiated rough and photoactivated surfaces. In this context, the photoactivation was obtained after the irradiation with UV, and the shear bond strength significantly increasing in surfaces photoactivated. Furthermore, Salama et al.,[16] reported that compomers adhered onto the SSC surfaces by different bonding methods did not appear to be good enough to support forces higher than 9.5±2.46 MPa.

On the other hand, the shear bond strength of brackets bonded onto teeth with different bond methods can be significantly different. Scougall et al.,[31-34] reported that teeth surfaces etched with 37% phosphoric acid and conditioned with Transbond XT (3M Unitek) had shear bond strengths of brackets from 19 to 26.5 MPa; however, surface conditioning with Transbond Plus SEP self-etching primer (3M Unitek) showed an average force to dislodge brackets of from 16.6 to 21.1 MPa.[31-34] Direct bonding of brackets is a technique very similar to our method, in which standardized composite blocks are added to the metallic crown surface, which produces shear bond strengths of 19.7±4.3 MPa and 16.3±4.5 MPa for UV-irradiated and nonirradiated crowns, respectively.

Our experimental group showed almost normal distribution, and crowns irradiated with UV showed less variability among the mean values than the control group. Hence, the application of UV irradiation over crowns prior to bonding composite resin could produce similar results for orthodontic brackets bonded directly onto the vestibular surfaces. Nonetheless, clinical studies are necessary to evaluate the oral environment and occlusal forces.

In this study, UV-irradiated crowns achieved better surfaces onto which composite blocks could be bonded and also demonstrated statistical differences when compared with non-UV-irradiated surfaces, thus confirming the potential of UV light to activate the metallic surfaces. The time required for photoactivation of SSCs appears to be longer; clinically, it is not necessary to sterilize the crowns before irradiation because of the use of UV light that acts as a sterilizing agent.

The main limitation of this study was the storage medium; a dry medium does not simulate the oral conditions of a humid medium. In future studies, a powerful UV lamp could be used to enhance the photocatalytic effect. This study is preliminary, and further investigations must focus on the optimal time and distance needed to reach a quick and total photocatalysis and how to achieve optimum attachment of composites by increasing the layers covering the entire surface. This study's findings substantiate that UV-irradiated crowns show advantages over nonirradiated crowns, suggesting their clinical use in the evaluation of long-term restorations in a humid environment exposed to occlusion forces.

Conclusions

Based on this study's results, the following conclusions can be made:

1. Ultraviolet irradiation of pediatric stainless steel crowns was found to significantly increase the shear bond strength of composite resin.
2. UV irradiation of SSCs could provide suitable adhesion of composite resins to withstand forces of occlusion.

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