Effect of surface treatments on implant crown retention

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Background/purpose: There are several surface treatment methods to improve the bond strength between dental materials. The purpose of this study was to examine the effect of different surface treatments on the tensile bond strength of single crowns on Implant Direct abutments cemented with resin cement.

Materials and methods: In total, 28 Screw Plant implants and abutments were divided into four study groups: I, control; II, sandblasted abutment and crown; III, non-sandblasted abutment and alloy primer applied to a sandblasted crown; and IV, alloy primer applied to a sandblasted abutment and crown. Twenty-eight crowns were cemented to abutments of implants, and a uniaxial tensile force was applied to the crowns using a universal test machine until cement failure occurred. Retention values were statistically analyzed.

Results: All mean retention values significantly differed among groups. While the alloy primer applied to the sandblasted castings and abutments showed the highest mean value (564.73±13.66 N), the control group showed the lowest mean value (357.65±12.89 N). Sandblasting was not as effective as application of an alloy primer (P≤0.05).

Conclusion: Sandblasting is an effective method to increase the bond strength. Sandblasting plus alloy primer application is a very effective method of increasing the bond strength, and these groups significantly differed from each other.

Introduction

Crown retention is a very important factor in the success of fixed restorations. Today, implant-supported fixed prostheses have gained in importance over conventional fixed restorations. Manufactured implant abutments are often 5, 7 or 9 mm in height. The necessity for retention and the resistance of cement-retained restorations are related to the geometry of the abutment preparation, surface area, abutment height, surface roughness, and cementing medium.1-4

The metal substructure of a crown’s alloy may affect its retention. Because of the higher free surface energy of base metals, they form a thicker oxide layer,5 which provides potential locations for chemical bonding and also serves to roughen the metal surface and provide some micromechanical retention.6

Metal primers are specific adhesives containing active monomers that promote chemical bonding...
between resin-based materials and oxides present on the metal surface.\textsuperscript{7-11} They contain two different components to aid in the retention of resin to the metal surface. The compound, 6-(4-vinylbenzyl-n-propyl) amino-1,3,5-triazine-2,4-dithione, specifically enhances bonding to noble metals.\textsuperscript{11} Similarly, another compound with a phosphoric acid monomer, 10-methacryloyloxydecyl dihydrogen phosphate (MDP), provides enhanced retention of resin to a base metal alloy.\textsuperscript{6,12,13}

To improve the bond strength between an implant abutment and metal crown, a variety of surface treatments are available,\textsuperscript{6,14-17} including sandblasting, tin plating, silicoating, and metal primer application.

The purpose of this study was to examine the effects of different surface treatments on the tensile bond strength of single crowns on Implant Direct abutments cemented with resin cement.

### Materials and methods

In total, 28 Screw Plant implants (Implant Direct Systems, Calabasas, CA, USA) and their abutments were used in this study. Titanium abutments, 5.0 mm in height and 3.7 mm in diameter, were divided into four subgroups according to the surface treatment. Each group contained seven samples. In Group I, abutments and crowns remained unaltered as the control; in Group II, both abutments and crowns were sandblasted; in Group III, abutments were not sandblasted, but crowns were, and an alloy primer was applied; and in Group IV, abutments and crowns were both sandblasted and an alloy primer was applied (Table 1).

Each implant was mounted in a 2.54-cm diameter self-polymerizing acrylic resin block (Repair Material; Dentsply International, Milford, DE, USA) using a dental surveyor. Abutments were placed on each implant and torqued to 35 N·cm. The abutment screws were covered with a cotton pellet, and the access hole was closed with cavit (3M ESPE, St. Paul, MN, USA) flush with the occlusal surface of each abutment. Twenty-eight crowns were fabricated by the following method. Snap-on comfort caps (5 mm; Implant Direct Systems) were adapted to each abutment and waxed (Fig. 1). A loop of wax was added to the occlusal surface of the coping to allow for subsequent retention testing.\textsuperscript{18} All plastic copings were invested and cast in a conventional base metal alloy (Wiron 99; BEGO, Bremen, Germany) (Fig. 2). Castings were adapted to the abutments using disclosing wax to achieve the best possible fit. Steam was used to clean the wax from the castings. Sandblasting was applied using 50-μm aluminum oxide at 50 psi at a 10-mm distance (Korox 50; BEGO). Each crown was cemented with Panavia F 2.0 adhesive resin cement (Kuraray, New York, NY, USA); in Groups III and IV, an alloy primer plus Panavia F 2.0 was applied. Castings were cemented to the abutments using a uniform 2-kg load and placed in a humidified incubator at 37°C for 24 hours. After 24 hours, thermocycling was applied to simulate the oral environment. A uniaxial tensile force was applied to the crowns using a universal test machine (Instron, Lloyd

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**Table 1.** Samples according to surface treatments

<table>
<thead>
<tr>
<th>Group</th>
<th>Surface treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Non-sandblasted abutment and crown as the control</td>
</tr>
<tr>
<td>II</td>
<td>Sandblasted abutment and crown</td>
</tr>
<tr>
<td>III</td>
<td>Non-sandblasted abutment and alloy primer applied to the sandblasted crown</td>
</tr>
<tr>
<td>IV</td>
<td>Alloy primer applied to the sandblasted abutment and crown</td>
</tr>
</tbody>
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**Fig. 1** Snap-on comfort cap of the abutment.

**Fig. 2** A cast crown on the abutment.
abutments showed the highest mean value (564.73 ± 13.66 N). The alloy primer was also effective in non-sandblasted abutments and sandblasted crowns (501.21 ± 12.16 N). The control group showed the lowest retention (357.65 ± 12.89 N) value as expected. Group II (469.24 ± 20.64 N) showed a mean retention value higher than that of the control group (357.65 ± 12.89 N), but sandblasting was not as effective as alloy primer application (P ≤ 0.05).

Discussion

In the past 20 years, the range of implant indications has significantly widened, and partially dentate patients clearly represent the majority of patients seeking treatment with dental implants today. Patients presenting with missing teeth generally do not directly ask for implants. They want their teeth to be replaced in the most elegant and long-lasting way possible. Implant treatment satisfies patient’s expectations very well.

There are many factors that affect the success of implant therapy in surgical and prosthetic protocols. In prosthetic protocols, the success of cement-retained prostheses is influenced by the retention and resistance forms of the restoration. This is due to the abutment size, height, surface area and roughness, as well as the casting material type, the texture of the internal surface, and also the luting agent type. Since abutments of 4–5 mm in height are one of the primary requirements for retention and resistance for implant-retained restorations, in the present study, 4 mm in height and 3.7 mm in diameter were used.1,2,20

There are many treatment procedures such as sandblasting, tin plating, silicoating, and metal primer application that are used to produce irregularities on the internal surface of the casting and abutment. Sandblasting creates irregularities on the metal surfaces, increases the surface area, and mechanically removes debris.21,22 During sandblasting, alumina particles become encrusted on the metal surface because of the velocity and pressure with which they hit the surface, and they cannot be removed even by ultrasonic cleaning or acid etching. So, these non-removable alumina particles are responsible for the chemical bonds of the alloy primer and silane agents to themselves, thus increasing the bond strength of resin cements. The size of the aluminum oxide particles differed according to the authors.22 In our study, sandblasting was applied using 50-μm aluminum oxide at 50 psi at a 10-mm distance. Sandblasting is the easiest and most inexpensive method of surface treatment. Treatment with different chemical components such as tin plating and silicoating is not commonly used to

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**Table 2. Loads required to dislodge the crowns**

<table>
<thead>
<tr>
<th>Group</th>
<th>Diff †</th>
<th>Load (N) required to dislodge crown (subset for alpha = 0.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>a</td>
<td>357.65 ± 12.89</td>
</tr>
<tr>
<td>II</td>
<td>b</td>
<td>469.24 ± 20.64</td>
</tr>
<tr>
<td>III</td>
<td>c</td>
<td>501.21 ± 12.16</td>
</tr>
<tr>
<td>IV</td>
<td>d</td>
<td>564.73 ± 13.66</td>
</tr>
</tbody>
</table>

*Data are presented as mean ± standard deviation; † means for groups in non-homogeneous subsets are displayed with different letters.
increase bonding because of their requirement for additional equipment. Metal primer application is an easy method of surface treatment for metal substructures.

In a study by Sadig and Al Harbi, the highest retentive values were obtained with both sandblasted castings and abutments, pretreatment with Siloc Bond, and luting with Panavia 21 (517.62 N), or sandblasted castings and sandblasted abutments, pretreatment with alloy primer, and luting with Panavia 21 (572.74 N) over short implant abutments (3 mm). As we stated above in the reasons for this study, we did not need to use different chemical components like Siloc Bond treatment because sandblasting is a preferred system that is easy to apply. In this study, when an alloy primer was applied to a sandblasted casting and abutment (5 mm) and luted with Panavia F 2.0, the mean retention value (564.73 ± 13.66 N) was near that of Sadig and Al Harbi’s study but was not as high as their results despite their use of a short implant abutment.

Felton et al. noted that surface roughness enhanced crown retention by as much as 31%. The results of the present study are in accordance with their results. In this study, when the abutments and crowns were sandblasted, the bond strength values significantly increased (P ≤ 0.05). The group with the highest shear bond strength was the sandblasting plus alloy primer application group (IV).

The success of bonding between the implant and abutment depends on selecting the best combination of metal, metal primer, and resin cement. The use of light-cured resin cements might not be possible because visible light is blocked by the metallic abutment and casting structure. In addition, self-curing resin cements have low bond strengths in the first hour of the luting procedure. This means that the restoration cannot be submitted to mastication stress in the first hour to avoid its dislodgment. If the restoration moves, microleakage will result. Thus, dual-curing resin-based cements must be chosen as the luting material for cement-metallic prostheses. Therefore, in this study, Panavia F 2.0 adhesive resin cement was selected for implant abutment cementation.

The utilization of acidic resin monomers, like MDP contained in the Panavia F alloy primer, can produce an effective bond between adhesive resins and basic metals. This bond occurs through chemical links between the monomer phosphate radicals and the basic metal oxide layer. Ohno et al. described a mechanism which is responsible for this bond. In this mechanism, an electrostatic interaction between polymer acids or bases and hydroxyl groups of the metal surface occur, depending on the isoelectric point of the metal oxides and acid dissociation constants of the acidic adhesive monomers. In this study, when sandblasting plus Panavia F alloy primer was used, increased bond strength was achieved between the abutment and crown.

There are several methods such as shear bond strength and tensile bond strength tests to evaluate the bond strength between metallic alloys and substrates such as resin cements. A shear strength test should not be considered an ideal mechanical test for that purpose, since it leads to a non-uniform distribution of stresses in the adhesive area, with maximum occurrence of tensile forces close to the point of load application, which affects the substrate more than the adhesive interface itself. The tensile test is able to provide information on the global bond strength of adhesive materials, even though it has some restrictions related to the difficulty of aligning the samples in the testing machine and a tendency towards unequal distribution of tensions on the interface. In this study, a loop was added to the occlusal surface of the samples to apply a standard test method, and it was observed that the tensile test was a useful mechanism.

Within the limitations of this in vitro study, the following conclusions are drawn: (1) to increase the bond strength between implant abutment and crown, sandblasting and sandblasting plus alloy primer application are affective methods; and (2) sandblasting plus alloy primer application is recommended for the best bonding between the implant abutment and crown.

Acknowledgments

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References

Surface treatments and implant crown retention