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Original Research

Role of Sandblasting on Fracture Load of Titanium Ceramic Crowns

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ABSTRACT:
Background: Metal-ceramic restorations are still commonly used for reconstruction of tooth crowns, but patient demands for more esthetic and durable restorations led to the fabrication of all-ceramic restorations. Advances were made in the fabrication of these restorations following the introduction of novel materials and techniques. Surface treatment increases the surface roughness to obtain mechanical interlocking and chemically activates the surface to obtain a chemically strong bond. **Aim of the study:** To study the role of sandblasting on fracture load of titanium ceramic crowns. **Materials and methods:** For the study, a mandibular first premolar was carved on inlay wax with dimensions 8.5 mm cervicocclussaly, 7.0 mm mesiodistally and 7.5 mm labiolingually. After completion of wax pattern, the crown was then reduced by 1.5 mm on occlusal, proximal, buccal, and lingual surfaces. Now, 30 wax patterns were fabricated with inlay wax over the dies according to the prepared crown. These wax patterns were then sprued and invested. After this, 30 titanium copings with thickness of 0.3 mm were made from Cp-Ti. Out of 30 titanium copings, 15 were sand-blasted whereas 15 were not sand blasted. Ultra-low fusing porcelain was used to fabricate titanium ceramic crowns. **Results:** We observed that mean fracture load of group 1 was 701.32 N and mean fracture load of group 2 was 356.32 N. On comparing the results, it was found that the difference is statistically significant. The fracture toughness of Group 1 was almost twice that of Group 2. **Conclusion**: From the results of the present study, this can be concluded that the fracture load of titanium ceramic crowns increases significantly with sandblasting of titanium after fabrication.
Key words: Ceramic, Fracture load, Titanium.

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INTRODUCTION:

Since the 1960s, metal-ceramic restorations have been increasingly used in dentistry. Initially, high-gold alloys were applied, then low-gold alloys, followed by base metal alloys and then palladium-based alloys.[1] Three basic factors determine the success of metal-ceramic bond strength plausibility: interfacial chemistry, related interfacial morphologies, and mechanical stresses.[2] Residual stress gradients depend not only on differences in thermal expansion coefficients of metal and ceramics but also on reaction products generated during the fusing of dental ceramics to a metal alloy. Although several theories concerning the physico-chemical nature of metal-ceramic bonding have been introduced, the joint interface between covalently bonded material and metallic material is difficult to understand. It seems that pre-oxidation of the metallic member is needed for strong bonding between ceramic and a noble metal alloy, whereas the highest bond strengths for a titanium-ceramic system are obtained by fusion in a high vacuum.[3,4] Metal-ceramic restorations are still commonly used for reconstruction of tooth crowns, but patient demands for more esthetic and durable restorations led to the fabrication of all-ceramic restorations.[5] Advances were made in the fabrication of these restorations following the introduction of novel materials and techniques. Surface treatment increases the surface roughness to obtain mechanical interlocking and chemically activates the surface to obtain a chemically strong bond.[6] Sandblasting is among the most common and most efficient surface treatment methods, which enhance the bond of titanium to the veneering ceramic and luting cement via mechanical interlocking. However, it should be noted that during the process of sandblasting, microcracks might form in the titanium surface due to the impact of particles. These cracks may compromise the stability and durability of metal in the long term and degrade its strength.[7, 8] Hence, the present study was planned to study the role of sandblasting on fracture load of titanium ceramic crowns.

MATERIALS AND METHODS:

The study was conducted in the Department of Prosthodontics of the Dental institution. The ethical clearance for study protocol was obtained from ethical committee of the institution. For the study, a mandibular first premolar was carved on inlay wax with dimensions 8.5 mm cervicocclussaly, 7.0 mm mesiodistally and 7.5 mm labiolingually. After completion of wax pattern, the crown was then reduced by 1.5 mm on occlusal, proximal, buccal, and lingual surfaces. A shoulder margin of 1 mm was prepared with rounded edges. The pattern was then sprued and invested with phosphate bonded investment. Then the specimen was cast in Ni-Cr alloy using casting machine for fabrication of metal die. Now, 30 wax patterns were fabricated with inlay wax over the dies according to the prepared crown. These wax patterns were then sprued and invested. After this, 30 titanium copings with thickness of 0.3 mm were made from Cp-Ti. Out of 30 titanium copings, 15 were sand-blasted whereas 15 were not sand blasted. Ultra-low fusing porcelain was used to fabricate titanium ceramic crowns. The titanium ceramic crowns were grouped into two groups, crowns which were sand blasted were placed in Group 1 and crowns which were not sand blasted were placed in Group 2. To check the fracture load of the crowns, a universal testing machine was used. The reading was recorded in Newton.

The statistical analysis of the data was done using SPSS version 11.0 for windows. Chi-square and Student's t-test were used for checking the significance of the data. A p-value of 0.05 and lesser was defined to be statistical significant.

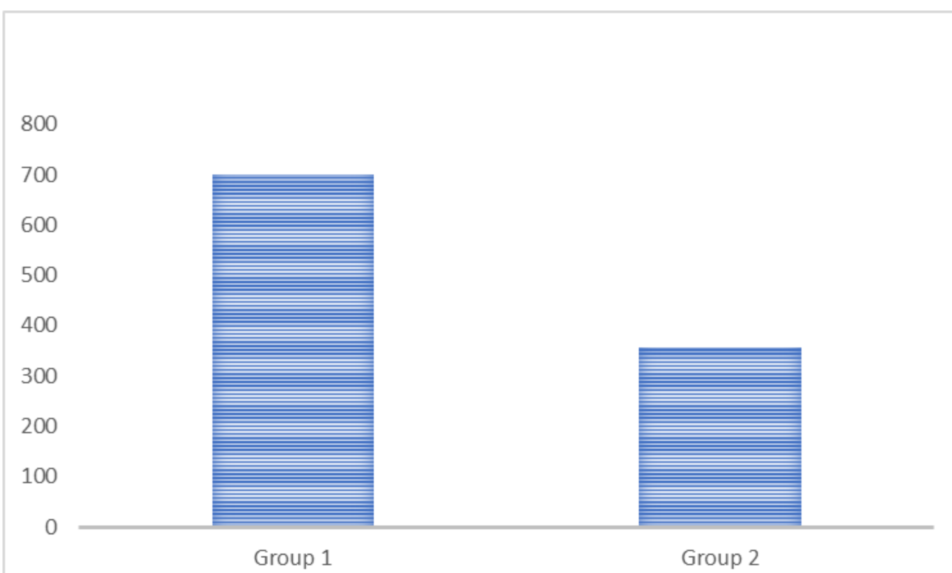
RESULTS:

Table 1 shows the mean fracture load of two groups. We observed that mean fracture load of group 1 was 701.32 N and mean fracture load of group 2 was 356.32 N. On comparing the results, it was found that the difference is statistically significant. The fracture toughness of Group 1 was almost twice that of Group 2. (Fig 1)

Table 1: Mean Fracture load of Group 1 and Group 2

Mean fracture load	Group 1	Group 2	p-value
	701.32 N	356.32 N	0.003

Figure 1: Mean fracture load



DISCUSSION:

In the present study, we observed that fracture load of titanium ceramic crowns with sandblasting was significant more as compared to titanium ceramic crowns without sandblasting. The results were seen to statistically significant. Moldi AI et al evaluated the bond strength between titanium ceramic crowns. The surfaces of titanium copings were divided in two groups. Group A sandblasted with 250 um (n = 10) and Group B without sandblasting (n = 10). Low-fusing porcelain was bonded over copings. A universal testing machine was used to determine the fracture load (N) of the crowns. All data were compared using Student's t-test. There was a significant difference in fracture toughness between two groups. The mean value of fracture strength for Group A was 721.66 N and for Group B was 396.39 N. They concluded that sandblasting improves the bond strength between titanium, and ceramic, mechanical bonding plays a crucial role in the bonding between titanium and ceramic. Lim HP et al investigated the effect of various treatments on the fracture load of bonded titanium and porcelain components of crown restorations. In this study, the surfaces of titanium copings (n=6) were either airborne-particle abraded with Al(2)O(3) particles, sputter coated with gold, or coated with TiN. Gold ceramic crowns served as the control group (n=6). The effects of these treatments on the fracture load of bonded titanium and low-fusing porcelain were investigated. A universal testing machine was used to determine the fracture load (N) of the crowns. All data were compared using 1-way ANOVA and the post hoc multiple range Tukey test. In addition, the metal ceramic interfaces were examined by scanning electron microscopy (SEM) and energy dispersive x-ray spectroscopy (EDS). The gold-coated titanium (1035 +/-41 N) and TiN-coated titanium (969 +/-93 N) had significantly higher fracture loads (P<.001) than the airborne-particle-abraded titanium ceramic crowns (865+/-44 N). The gold-coated and TiN-coated titanium specimens demonstrated fracture loads similar to that of gold ceramic crowns (1026 +/-50 N) [corrected]. SEM/EDS showed that after the crowns fractured, the gold control group and gold- and TiN-coated titanium specimens had more adherent porcelain on their surfaces than the uncoated titanium that was airborne-particle abraded with Al(2)O(3) particles. They concluded that in vitro fracture load of titanium crowns coated with gold or titanium nitride and bonded to low-fusing porcelain is comparable to that of gold ceramic crowns, and higher than loads observed with uncoated titanium airborne-particle abraded with Al(2)O(3) particles.[9, 10]

Al Hussaini I et al investigated the effect of bonding agent and surface treatment using airborne-particle abrasion and hydrochloric acid on the bond strength between a low-fusing porcelain and commercially pure cast titanium. A casting unit was used to cast 60 specimens of commercially pure titanium (25.0 x 3.0 x 0.5 mm). The specimens were equally divided into 3 groups. The first group received no surface treatment and served as the control, the second group was subjected to airborne-particle abrasion, and the third group was treated with hydrochloric acid. The specimens in each group were further divided into 2 subgroups of 10 each. Ten specimens were treated with bonding agent, and 10 specimens were not treated with bonding agent. Low-fusing porcelain was fired onto the surface of the specimens. A universal testing machine was used to perform the 3-point bending test. The titanium-ceramic interfaces were subjected to scanning electron microscopic analysis. The bond failure data (MPa) were analyzed with a 2-way analysis of variance and Tukey multiple range tests. Four specimens from each group were selected for scanning electron microscopic examination. The debonding test showed that surface treatment with airborne-particle abrasion followed by application of a bonding agent resulted in the strongest titanium-ceramic bond, followed by airborne-particle abrasion alone and bonding agent alone. Hydrochloric acid surface treatment provided no beneficial effect to the titanium-ceramic bond strength compared to untreated specimens. The photomicrographs of the titanium surface after debonding demonstrated residual porcelain retained on the metal surface for all groups. They concluded that surface treatment using either airborne-particle abrasion or bonding agent alone enhanced the bond strength of cast commercially pure titanium to low-fusing porcelain. The combination of airborne-particle abrasion and bonding agent provided the greatest improvement in titanium-ceramic bond strength. Titanium surface treatment with hydrochloric acid, with or without bonding agent, produced values that were not statistically different than the control. Tróia MG Jr et al evaluated the bonding characteristics of titanium porcelain bonded to commercially pure titanium (Ti-Cp) or titanium-aluminum-vanadium (Ti-6Al-4V) alloy as well as the effect of thermal cycling on bond strength. A three-point-flexure-test was used to evaluate the bond strength of titanium porcelain bonded to commercially pure titanium and Ti-6Al-4V alloy according to DIN 13.927. To evaluate the effect of thermal cycling on the samples, half were thermal cycled in temperatures ranging from 4 degrees C to 55 degrees C. Results were compared with palladium-silver (Pd-Ag) alloy bonded to conventional porcelain (control). Scanning electron microscope (SEM) photomicrographs were taken to characterize the failed surfaces in the metal-ceramic interface. Anova and Tukey's multiple comparison tests were used to analyze the data at a 5% probability level. Thermal cycling did not significantly weaken the bond strength of porcelain to titanium interfaces. There was no significant difference in bond strength between commercially pure titanium and Ti-6Al-4V groups. Bond strength values for the control group were significantly greater than those for commercially pure titanium and Ti-6Al-4V combinations. They concluded that the bond strength of low fusing porcelain bonded to cast pure titanium or Ti-6Al-4V alloy was significantly lower than the conventional combination of porcelain-Pd-Ag alloy. Thermal cycling did not affect the bond strength of any group.[11, 12]

CONCLUSION:

From the results of the present study, this can be concluded that the fracture load of titanium ceramic crowns increases significantly with sandblasting of titanium after fabrication.

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