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A Comparison of the Effect of Surface Treatment on Shear Bond Strength of Titanium Alloy

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Abstract

Aim: To comparison the shear bond strength of Titanium alloy with different surface treatment.

Materials and methods. cylindrical shaped samples composed of metal and ceramic were prepared by lost wax technique and ceramic build up, total 21 samples with different surface treatment, subgroup 7 samples for each group according to surface treatment, each sample was veneered performed by the conventional layering technique according to manufacturers` instruction. A universal testing machine was used to determine the shear bond strength. One- way ANOVA test (analysis of variance) to verify if there any statistical significant difference within each group and among the three groups. Least significant difference (LSD) test to compare between each two groups when ANOVA test showed significant difference. t- test to examine the source of differences. Results. On -way (ANOVA) test was used to analyse the results, there was highly significant differences between the groups. Conclusion. In this study, only treatment of sandblasting offered enough bonding strength, sandblasted with AL_2O_3 obtained the best results with Tic.

Introduction:

Furthermore, a recent attention has been focused on other alloys with exceptional properties which have entered to the dental application such as Titanium (Ti) and Titanium -based alloys. Those properties are biocompatibility, osseointegration, a high strength and corrosion and wear resistance which referred to the insoluble, thick titanium dioxide (TiO_2) layer[(1)].

Additionally, Ti has a good mechanical stability and strength in relation to the weight ratio, also a low density about 4.5 g/cm^3. For that reason, Ti and its alloys are the most extensively used nowadays, in both dental and orthopedic applications [(2).] Dental ceramics are one of most materials that are used for the fabrication of the dental prostheses that in turn, are used to restore missing/damaged teeth and dental structures [3].

Many studies have been carried out on ceramic restoration focusing at enhancing the bonding quality of the porcelain to metal system [4]. A mechanical treatment can be done by air borne particle abrasive (APA) with aluminium oxide AL_2O_3 and silica coated aluminium of different geometry.

Also, a surface treatment chemically to improve the bonding is depended, it includes acid treatment, hydroxylation and monomer [5]. Noteworthy, for improving the bond strength, sand blasting is the common surface treatment used. It increases the surface roughness and provides desirable undercuts [6].

Materials and Methods

Sample preparation

In this study (21) cylindrical shaped wax pattern (Renfert, Germany, GEO Crowax). were fabricated with dimension of the specification of the samples is as follows: the base is 5 mm in diameter and 1 mm in thickness and the step is 4 mm in diameter and 4 mm in length were constructed using custom made rubber mould (Iraqi), that consisted of stainless-steel ring and silicon impression material for one pattern [7] , as showed in Fig. (1), where divided in (three) groups according to surface treatment . Each group consisted of seven (7) samples. as show in Fig. (2).

Each two samples of wax pattern attached to major sprue by using direct technique using green wax wire (Rinfer ,Germany), the length of the major sprue (1,5cm) and (4,0 gauge), and each sample attached to the sprue at the thickest portion [8]. The major sprue and samples attached to base made from base plate wax (China) and sealing to the crucible former (Dentaurum, Germany). Casting of titanium was done in a vacuum centrifugal casting machine,[9] (i Series, china). see in Fig. (3). After the casting ring(China). Was cooled, the investment (Bego- Sol ®, Germany), was pushed out the investment from the casting ring and broken. Sandblasting machine (Gudi England). Was used to clean the sample from the remaining investment materials with (250µm) aluminum oxide particles (Renfert, Germany) according to the manufacturer instructions[10].

Finally, each sample was rechecked and measured by metal gauge (China), to adjust the required dimensions Fig. (4)

Sandblasting with AL_2O_3 group

Seven samples of titanium were air abraded with (50 µm) aluminum oxide (Al_2O_3) (Renfert, Germany) for ten seconds under pressure of 80 Psi at 10 mm distance from the nozzle opening of sandblast, using a sandblasting unite[10]. titanium samples was washed with hot water after sandblast treatment to remove the debris, oil, fingers stamp etc. On the metal surface before piling porcelain. [11].

Etching with potassium hydrogen difluoride acid group (KHF_2).

Seven samples of titanium were powder coated with KHF_2 acid (potassium hydrogen difluoride) (Germany). (70 mg) then, heated in a porcelain furnace at temperature of 280 C°. Steam cleaner then was used to clean all specimen for 15 second [12].

Combination of sandblasting with Al_2O_3 and etching with potassium hydrogen difluoride acid group (COMB)

Seven samples was sand blasted with Al_2O_3 followed by etching by KHF_2. The procedure of veneering was performed by the conventional layering technique according to manufacturers` instruction. All layers of veneering ceramic (GC initial Ti, Germany), were applied until obtained 4 mm length and diameter of samples Figure.

Shear Bond Strength Test

Each sample was placed in a custom-made holder made from stainless steel with screw as shown in. Fig. (6). The holder was attached to a universal testing machine (Laryee WDW-50, China), and the metal holder was held in a horizontal position in the lower member of the testing machine as shown in Fig. (7)

The maximum force that caused failure was recorded in newton for each sample and shear bond strength was calculated by dividing the force value at which the bond failure occurred by the sample bonding

area and expressed in MPa according to the following formula:
Shear bond strength (MPa) = Maximum force (N)/ bonding area (mm2).
The surface bonding area was calculated as follows:

Surface area = $(r)^2 \times \pi$

$(r)^2$ = radius. π =3.14

Surface area=$(2)^2 \times 3.14$ =12.56 mm

Carefully checked under the Deno-light microscope (DIGITAL MICROSCOPE) (X50) (Taiwan),to evaluate the mode of failure failures were classified into three modes:(adhesive, cohesive and mixed)[13, 14] as showed in Fig.(8).

Result:

The data collected were subjected to computerized statistical analysis use (SPSS, version 21) and Excel program for doing graphic presentation.
In Table (1), the highest mean value of shear bond strength was for (Ti c) group, while the lowest mean of shear bond strength values was for (Ti k) group.
In Table (2), One-way ANOVA test manifested that there was statically highly significant difference in shear bond strength all Titanium group at level $p<0.001$.
In Table (3), the results of the LSD manifested there is non- significant difference among (Ti k) group with (Ti comb) and both (Ti comb) and (Ti k) group was significant with (Ti c).

Discussion:

The results of the present study showed there was a high significant difference between control and combination, acid etch and combination groups these results could be explained that the metal surfaces were air-abraded with Al_2O_3 this uniform rough surface had increased the shear bond strength value.
The use of titanium for dental crown and bridge applications has increased the clinical importance of assessing their compatibility with ceramic systems. [15] This result is in agreement with Kulunk *et al*., 2011, found air-abrasion particles provided superior bond strength, compared study acid etch treatment Ti comb group. All the samples in this study were sandblasted 50 µm aluminium oxide that reported is to be the best sandblasting material that creates high mechanical bond strength [16].

It is often used to clean the surfaces of the materials and is used to achieve a micro retentive topography and to increase surface area of restoration [17]. The abrasion of alumina was performed to mechanically clean the surface and to increase the bonding surface area thereby increasing the surface energy [18] . The results of the current study showed that sandblasting alone significantly increased the shear bond strength between two groups. The effect of sandblasting may be attributed to an increase in the micromechanical retention that elevates the capability of bond strength [19] Moldim *et al*., 2015, found Airborne-particle abrasion likely improves the bond strength by removing loosely attached furrows, overlaps, and flakes of metal created by grinding procedures, provides mechanical interlocking, increases surface area, and increases wettability, this is in agreement with this study when Tic showed high bond strength among titanium group. Acid etching selectively scratching the metal surface and creates a microporous irregular surface, thereby roughening the surface area and facilitating penetration of ceramic into the etched ceramic surface [20] . The result of the present study disagreed with those of Al-Alawi 2005, a study claimed that the best shear bond strength was obtained by combination surface treatment in Ti comb, and the air abrasion with AL_2O_3 Tic gave the low shear bond strength than Ti comb. The result of the present study disagreed with Burnat *et al*., 2014. They claimed acid-treated samples require more energy to break the titanium-ceramic bonds than airborne-particle-abraded specimens. Abrasive blasting improves the bond strength of metal to ceramic, as it causes the formation of surface irregularities and, thus increases its roughness. This, in turn, improves mechanical retention and wetting of metal frame to porcelain surface. The sandblasted titanium samples (without chemical etching) have a corrosion potential value. This value derives from the presence of thin TiO_2 layer due to spontaneously passivation of titanium and Al_2O_3 grains stuck on the titanium surface as a result of sand blasting. These embedded corundum grains can be partially removed from the titanium surface by chemical etching, the etching of titanium surfaces reduces the corrosion potential.

Conclusion

In the present study the used of etch with KHF_2 the veneering surface of titanium showed the least value in shear bond strength. In this study, only treatment of sandblasting offered enough bonding strength, sandblasted with AL_2O_3 obtained the best results with Tic.

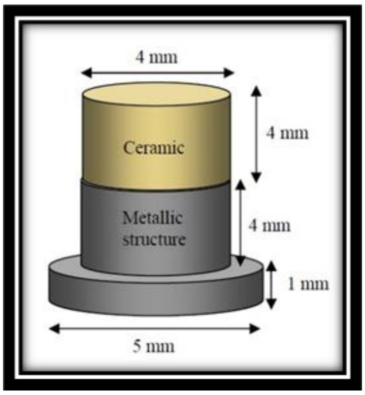

Fig. (1): Dimension of the sample.

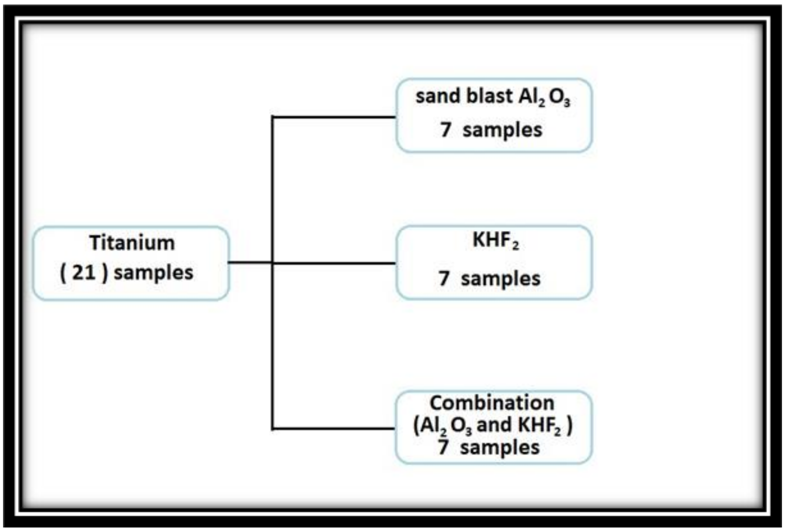

Fig. (2):sample grouping

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Fig. (3): casting machine for titanium alloy

Fig. (4): Metal samples.

Fig. (5): Final shape of the samples.

Fig. (6): Custom made metal holder.

Fig.(7): The sample in holder and universal testing machine.

Fig. (8): Mode of failure.

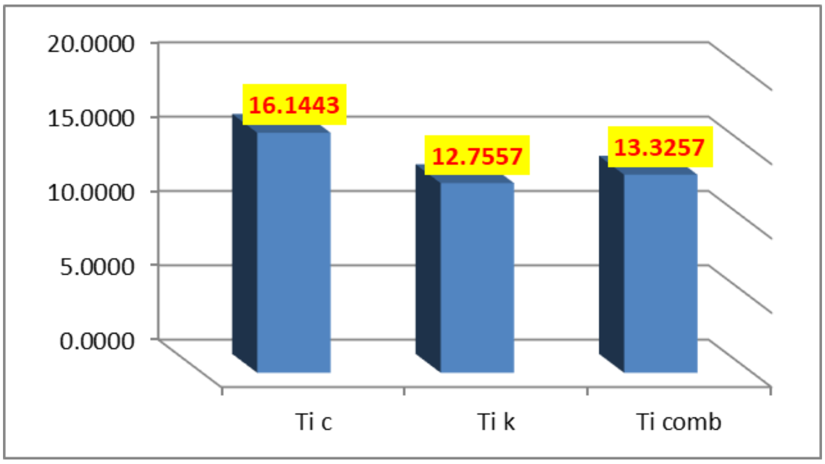

Fig. (9): Bar Chart Demonstrating the Means Difference in shear bond strength of Titanium Groups.

Table (1): Descriptive shear bond strength Titanium samples (Ti C, Ti K, and Ti comb) in newton.

	Statistic	Minimum	Maximum	Mean	Std. Error	SD
Ti c	7	15.48	17.12	16.1443	0.22585	0.59755
Ti k	7	11.54	13.93	12.7557	0.31296	0.82801
Ti comb	7	12.11	15.12	13.3257	0.42723	1.13035

Table (2): One-way ANOVA test for groups Nic, Nik, Ni comb

	F	P-value	Sig
Tic, Tik, Ti comb.	29.793	0.000	HS

Table (3): LSD for groups Tic, Ti k, Ti comb.

Groups		Mean Difference	Std. Error	P-value	Sig
Ti c	Ti k	3.38857*	0.47009	0.006	S
	Ti comb	2.81857*	0.47009	0.001	S
Ti k	Ti comb	-0.57000	0.47009	0.241	NS

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