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# The Effect of Sandblast and Plasma Surface Treatment of Titanium Abutment on Tensile Bond Strength with Ultra-translucent Zirconia Crown: A Comparative Study

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**ABSTRACT:**

**Aim:** Assess the tensile bond strength of the zirconia crown that has been surface treated with sandblast and plasma on a titanium implant abutment both before and after the surface treatment.

**Materials and methods:** Forty samples of implant analog and prefabricated titanium implant abutment of Dentium system with diameter (3.5mm) and height (5.5mm) were embedded vertically in auto-polymerizing acrylic resin blocks, were divided into five groups according to type of crown and abutment surface treatment (10 samples for each group) : Group I titanium abutments and zirconia crowns without any surface treatment, Group II sandblast treated abutments, Group III plasma surface treatment for both titanium abutments, Group IV combine sandblast and plasma treated titanium abutments. Forty zirconia crowns fabricated with CAD/CAM system and all crowns cemented to titanium abutment with Allcem resin cement dual cure, then stored in (5000) cycles of thermocycling between ($5^c$-$55^c$) degree, after that all samples evaluated it is tensile bond strength with universal testing machine. An analysis of variance (ANOVA test), Duncan's multiple range test and t-test at (p-value $\leq$ 0.01) were used for a statistical analysis for data obtain from universal testing machine.

**Results:** Group IV (combined sandblast and plasma treatment for titanium abutments) had the highest tensile strength value, followed by Group II (sandblast treated abutment) and Group III (plasma surface treatment for abutments). Tensile bond strength increased following sandblast and plasma surface treatment. The control group's tensile strength was lower.

**Conclusion:** Sandblast and plasma surface treatment had significant effect on retentive force between titanium abutment and zirconia crown, sandblast was the higher effect on tensile bond strength than plasma.

**Keywords:** Yttria stabilized zirconia, Cold atmospheric plasma, ear abrasion sandblast, titanium abutment.

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## INTRODUCTION

One alternative for replacing missing teeth is a dental implant, and treating whole and partial edentulous ridges has become a crucial element of dentistry.[1] Compared to fixed partial dentures, dental implants offer numerous benefits. Cost-effectiveness may be the primary drawback of dental implants, despite the fact that they have a success rate of over 97% for ten years, a lower risk of caries and endodontic defects in nearby teeth, preserve bone in the edentulous ridge, and eliminate the need to prepare nearby teeth, which reduces their sensitivity.[2]

longevity of the success of dental implant, both functionally and esthetically depends on various factors that related to various factors, the most important factor is the selection of connection between the implant abutment and the final prosthesis. This connection either screw-retained or cement-retained depending on the clinical situation of the particular case.[3]

Cemented-retained prosthesis is more popular than screw-retained due to several advantages such as loading along linear axis (accepted the angulation between abutment and prosthesis) , good passivity fit, small occlusal table and lower fracture of porcelain because of the lack of screw accessibility hole. The only observed advantage of screw-retained prosthesis is its retrievability of prosthesis . [4]

Zirconia is a polycrystalline material with numerous properties, including excellent fracture toughness and resistance. Zirconia's disadvantages include high opacity, a decreased fracture strength because of low temperature aging degradation, and the likelihood of veneering ceramic chipping. When compared to glass ceramics, zirconia lakes exhibit stronger wear behavior and lower antagonist wear following grinding operations, making it difficult to achieve satisfactory retention.[5,6]

There are several inexpensive and accessible superficial conditioning techniques that change the surface of materials and change their morphological properties. One such technique is mechanical surface treatment sandblasting with air abrasion of 50 micron of $Al_2O_3$ with (50mm) for 20 seconds under (2.0 bar) pressure. The nozzle was positioned 3 cm from and perpendicular to the spacemen .[7]

An energetic technique to changing a material's surface Cold atmospheric plasma (CAP), another strategy to improve retention between two bonded materials, is increasing surface reactivity with little modifications to the materials' intrinsic properties and without affecting their composition.[8]

The most common issue with implant single crowns is loss of retention brought on by decementation. 4.1% of cemented crowns still have this after five years of use. However, this ratio dropped from 7.3% before 2000 to 3.1% after that year.[9] This is frequently the result of decreased inter-arch space, which causes retention problems with cemented-retained prosthesis.[10]

This study aimed to evaluate tensile bond strength of (5) Yttria stabilized zirconia fixes on titanium abutment before and after surface treatment with sandblast and plasma, so null hypothesis was no effect of sandblast and plasma on tensile strength between zirconia crowns and titanium abutments.

## MATERIALS AND METHODS:

### Specimens preparation:

Forty standard titanium abutments with (5.5mm) height measured from the top of the abutment to the finish line and (3.5mm) diameter were used in this study. A screw was used to secure each titanium abutment to its laboratory analog. Forty laboratory analogs measuring 12 mm in height and 4.5 mm in diameter were employed in this investigation. These analogs were positioned vertically within an auto-polymerized acrylic mold with the assistance of a dental surveyor. Using an abutment screw and a torque-controlled ratchet, each titanium abutment was fastened to its laboratory analog and torqued to 35 N/cm.

**Study Design:**

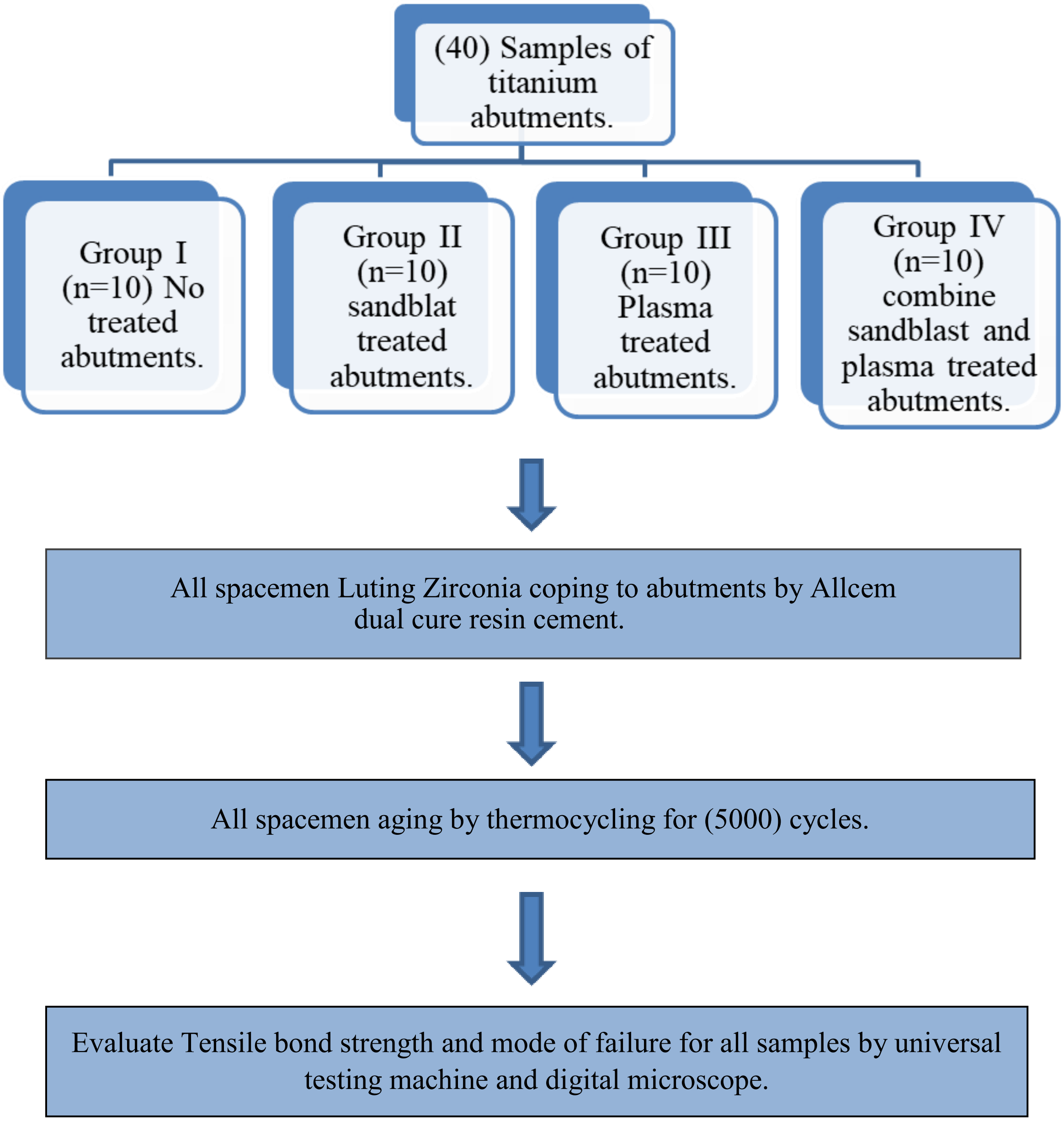


**Fig. 1**: Diagram represent design of this study.

**Zirconia Crowns Constriction:**
Utilizing a CAD/CAM system, we created zirconia crowns in this investigation using five Yttria tetragonal zirconia polycrystalline high transparent (5Y-TZP/VITA YZ® HT, shade white, VITA Zahnfabrik, Germany) in accordance with the measurements and design of the Kim et al. [11] study, as figure (1 ):

**Figure 1: Design of zirconia crown with occlusal ring.**

**Surface Treatment of Samples:**
Following their fixation on laboratory analogs, forty titanium implant abutment samples were split into four groups based on the type of surface treatment.:
*group I (n=10) no surface treatment for abutments act as control group.
*group II (n=10) Using a sandblasting device (MICROJATO, Bio-art, Brazil), the nozzle was positioned 3 cm from and perpendicular to the spacemen to sandblast titanium abutments with Al2O3 for 50 mm for 20 seconds at 2.0 bar of pressure. as figure (2):

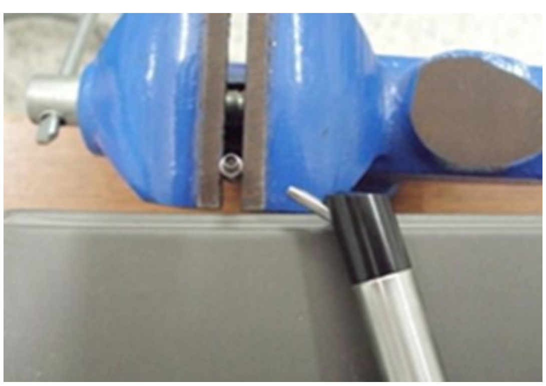

**Figure 2: MICROJATO device for sandblast treatment of samples abutments.**

*group III (n=10) plasma treated titanium abutments by plasms, we used CORE plasma activator device for (90 seconds) according to manufacture of this device as in figure (3):

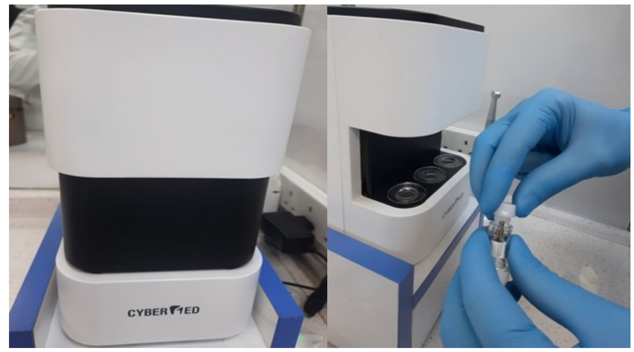

**Figure 3: CORE plasma activator device with placement of implant abutment in its capsules.**

*group IV (n=10) combine sandblast and plasma treated titanium abutments. All samples treated with sandblast should be clean by de-ionized water in ultrasonically cleaning device.
**Cementation and Thermocycling:**
Prior to cementation, a tiny piece of cotton and temporary filler material should be placed inside each abutment hole to seal it. Crowns were then luted with implant abutments using self-adhesive dual cure resin cement (Allcem Cimento Dual, FGM shade A2). The bonding material was then exposed to a light curing machine (Eighteeth, China) with an intensity of 1180 mW/cm2 and a wave length of 450 nm for approximately one minute while carrying a 1 kg weight.
After cementation is finished, all samples are kept in a thermocycling machine (100 SD Mevhatronic, Germany) for 5000 cycles. The machine has two containers of deionized water, one at 5 degrees Celsius and the other at 5 degrees. It has a dwell time of 30 seconds and a transfer time of 10 seconds.
**Tensile Bond Strength measurement:**
Each sample was drawn with a crosshead speed of 0.5 cm/min following cementation and thermocycling. The meter, which is directly connected to the tensile machine, recorded the force at which de-bonding between the crown and the abutment occurred. The data was then displayed on the computer and stored by the Universal Testing Machine (Gester, China) as shown in figure (4):

**Figure 4: Universal testing machine for measurement of tensile bond strength and samples pulled with this device.**

**RESULTS**

upon the completion of the trial process. The forces needed to separate the titanium abutments from the crown copings were measured in Newton for each group. The mean, standard deviation, minimum, and maximum values were among the descriptive analysis results, and listed in Table (1):

**Table 1: Descriptive analysis of bond strength values.**

| | N | Minimum | Maximum | Mean | Std. Deviation | Variance |
|---|---|---|---|---|---|---|
| Control (group I) | 10 | 50.00 | 81.00 | 64.1000 | 9.84829 | 96.989 |
| sandblast(group II) | 10 | 180.00 | 255.00 | 209.0000 | 21.83270 | 476.667 |
| plasma (group III) | 10 | 127.00 | 150.00 | 143.2000 | 6.49444 | 42.178 |
| sandblas+plasma (group IV) | 10 | 209.00 | 290.00 | 265.9000 | 23.51572 | 552.989 |

Table (1) demonstrated that group IV (combine sandblast and plasma treated abutment) was the highest retentive mean value (265) followed by group II (sandblast treated abutment) with mean value (209) then group III (pasma treated abutment) its mean value was (143), the lowest retentive mean value was in group I (control) with (64).

As indicated in Table (2), the analysis of variance (one way ANOVA) was performed to see whether there are any significant differences between the groups .

**Table 2: One way ANOVA of bond strength values.**

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 226496.500 | 3 | 75498.833 | 258.376 | .000 |
| Within Groups | 10519.400 | 36 | 292.206 | | |
| Total | 237015.900 | 39 | | | |

The One way ANOVA test results indicated that there is a significant differences between the groups for at (p-value < 0.01). This mean that one or all of groups of surface treatment used are different from each other.

In order to know which of group is significant from the other in each group of the study, Duncan's multiple range test was made, as shown in table (3):

**Table 3: Duncan's Multiple Range Test for surface treated groups.**

| | N | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| group1 | 10 | 64.1000 | | | |
| group3 | 10 | | 143.2000 | | |
| group2 | 10 | | | 209.0000 | |
| group4 | 10 | | | | 265.9000 |
| Sig. | | 1.000 | 1.000 | 1.000 | 1.000 |

The Duncan's Test for surface treatment groups revealed that all groups were significant difference from each other groups .

**DISCUSSION**

In the clinical situation, when the dentists are enforced to use short or narrow implant abutment due to short inter-arch space, presence of malocclusion, presence of opposing hyper-erupted teeth or due to esthetic condition, it is clear that they need to increase the retention of thefinal prosthesis by either surface modification of the titanium abutments or the internal surface of the casting (prosthesis).

This study aimed to investigate the effect of different surface treatment of Titanium abutments on tensile bond strength with (5) Yttria stabilized zirconia crowns. The null hypothesis was rejected because results showed that an elevation in tensile bond strength between zirconia crowns and titanium abutments after surface treatment methods application and there were significant differences between these surface treatment methods.

According to the results of our investigation, sandblasting titanium abutments (group II) increased their retentive force compared to the control group (group I), indicating a beneficial influence on the tensile bond strength between abutments and crowns.

Our findings are consistent with research by Turker et al.[12] and Kurt et al.[13] who found that sandblasting is the best surface treatment for strengthening the bond between titanium abutments. Alkhadashi et al.[14] found that sandblasting the abutment alone or in combination with another treatment method, like 9.5% HF, increased the shear bond strength between titanium abutments and lithium-disilicate. These findings are consistent with our findings in groups II (sandblasted titanium abutments) and IV (abutment surface treated with sandblast and plasma).

In a study by Seekaewsiu and Sirimethawong ,[15] Lubas et al.[16] used sandblast and various acid types and concentrations to treat the titanium abutment's surface. They discovered that the group treated with sandblast had a higher rate of cohesive failure than other groups, and they explained that their findings could be due to sandblast's ability to produce a rougher surface than acid and more mechanical interlocking with resin cement. These findings are consistent with our findings.

When comparing the effects of the two treatments, the results of this study showed that the abutment treated with sandblast (group II) had a higher tensile strength value than the abutment treated with plasma (group III). This is because sandblasting creates more surface roughness and surface area for adhesion than plasma treatment.

This result is consistent with a study by Ozyetim et al.[17]
An evaluation of the effect of surface modification to titanium abutment by plasma had been made by many researches, in our study results found that increase in value of retentive force after plasma treatment for titanium abutment (groups III) and also in group IV (which is combine sandblast and plasma treatment of abutment) compare to the control group. According to Śmielak et al.[18] , titanium without surface treatment results in low tensile bond strength between titanium and zirconia crowns. This finding is consistent with the current investigation, which discovered that the control group I had the lowest bond strength Seekaewsiu and Sirimethawong. [15] These findings concur with Seker et al.[19] found that bond strength increased following atmospheric plasma treatment applied to a titanium surface, but no structural changes were observed in the surface when compared to the sandblast, which alter the surface morphology. As in the control group, the roughness value did not change. Furthermore, our results are consistent with those of Ozyetim et al.[17], who found that the retention value between the crown and abutment was significantly higher after atmospheric plasma treatment compared to the control group (P <.05). According to a study by Lai Hui et al.[20], plasma can change the physico-chemical characteristics of titanium surfaces without changing their microstructure. It can also improve the hydrophilic surface characteristics of treated surfaces and reduce their water contact angle (WCA) in vitro. Additionally, I concur with a study by Ito et al. [21] that discovered an increase in surface energy (SE) after treatment with atmospheric plasma. The intermolecular forces at a material's surface that depend on the surface's polar and dispersion components are known as surface energy, or SE. A material's surface area (SE) and liquid contact angle measurement have an inverse connection; that is, an increase in SE will result in a decrease in contact angle measurement.
The combination of mechanical and energetic surface treatment (sandblast and plasma) of titanium abutment in group IV resulted in the highest tensile bond strength value among the other groups. All of the previously listed factors can be used to explain why combining sandblast and plasma application produced the highest retentive force. Sandblast increased surface roughness and wettability, while plasma treatment provided an active surface, increased surface energy (SE), and increased oxygen elements with more active peroxides. Both treatments can reduce organic impurities of the treated surface.

## CONCLUSION

1. Sandblast surface modification cause rough surface, change topography of surface of materials and increase surface area for adhesion.
2. Plasma treatment forms active surface by increasing energy of materials surface, decrease contact angle and increase wettability, this method is non-invasive technique and easy application.
3. Combination of sandblast and plasma method of surface modification can effective solution for increase retention between titanium abutment and zirconia crown.

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