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Retention of Zirconia Crowns with Different Surface Treatment and Adhesive Cements

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Abstract
Objectives: *The aim of this in-vitro study was to evaluate the effect of different surface treatment and resin cements on the retention of monolithic zirconia crowns.*
Materials and Methods: *A total of 40 maxillary premolars extracted for orthodontic cause from the outpatient dental clinic, Faculty of Dentistry, Mansoura University, Egypt, were used in this study. Teeth were randomly divided into 4 groups according to the surface treatment and cement used (n=10) into: Group AHP :(Airborne particles abrasion and hot acids + Panavia SA cement plus), Group AHL :(Airborne particles abrasion and hot acid + G-CEM Link Force Cement), Group AP: (Airborne particles abrasion + Panavia SA cement) and Group AL: (Airborne particles abrasion+ G-CEM Link Force cement).*
The preparations were performed using computer aided design/computer aided manufacturing (CAD/CAM) technology to standardize the preparation, the prepared teeth scanned by optical scanner, CubeX^2 zirconia crowns (Dental Direkt GbmH, Spenge,Germany) were fabricated for each preparation. Crowns cemented to preparations after surface treatment of its internal surfaces. And after 10,000 thermalcycles, retention test was performed using a universal testing machine (0.5 mm/min).
Results: *There was significance difference between two surface treatments and cements. Application of hot acids after airborne particles abrasion and using of MDP self-adhesive resin cement improved retention significantly*
Conclusion: *Retention of zirconia crowns improved by using hot acids after airborne particles abrasion.*
Key words: *Retention; Surface treatment; Resin cement, Zirconia crowns.*

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I. Introduction

Zirconia is widely used as a dental restorative material due to its proven biocompatibility and superior mechanical properties.[1] The development of computer-aided design and computer-aided manufacturing (CAD/CAM) technology has focused on the precise and consistent manufacturing of high strength and tough zirconia ceramics.[2] The problem of the clinical use of zirconia ceramic is a deficiency in luting with adhesive resin cements due to a lack of silicon dioxide (glass phase). Ordinary methods of cementation including ceramic silanization and hydrofluoric acid etching of low concentration do not work effectively for bonding to zirconia.[3] So that adequate adhesion of the restoration is very important. It has been shown that surface treatment prior to cementation can enhance the bond strength to indirect restorations. Current researches is therefore focusing on innovative adhesive techniques coupled with innovative surface roughening procedures and chemical bonding of Y-TZP ceramics.[4,5] For a long-standing strong bond between zirconia and cement material, there should be micro-mechanical retention and chemical bonding.[5]

Various surface conditioning methods are used nowadays. These methods are airborne particles abrasion with-aluminum oxide ($A1_2O_3$), tribiochemical silica coating, piranha solution, laser irradiation, and plasma.

Airborne particles abrasion is important to achieve durable bonding to zirconia through micromechanical interlocking between zirconia and resin cements. Airborne particles abrasion with $A1_2O_3$ particles is one of the most simple, functional, and widely used. This procedure cleans and roughens the surface to increase the bonding surface area for mechanical interlocking between the cement and the zirconia surface and the wettability of the zirconia surface for bonding agents. Airborne-particle abrasion may be performed with different sizes of $A1_2O_3$ particles.[4,6] Some studies have evaluated the effect of silica coating on the bond strength of acid-resistant ceramics bonded to resin luting agents.[7,8,9] They found that silica coating "energizes" the substrate surface, which allows the silica to adhere to it. Also, silane improves the bond between the silica adhered to the substrate and the resin matrix. The CoJet System (3M ESPE, Seefeld, Germany) may significantly increase the bond strength for high-alumina and zirconium-oxide ceramics compared to that of airborne-particle abrasion alone in a clinical condition.

Cement selection is prerequisite for ensuring effective bond strength to zirconia. Phosphate monomer-based luting agents have been proposed for cementation.[10] Using of 10-MDP containing luting systems have been previously investigated recording satisfactory results.[11,12] It's found that high and reliable resin bond to alumina and zirconia ceramics was achieved with airborne particle abrasion and by using phosphate monomer (MDP) containing resin composite luting cement. Atsu et al[13] found that tribochemical silica coating and the application of a 10- (MDP)-containing bonding/silane coupling agent mixture has been shown to increase the shear bond strength between zirconium-oxide ceramic and resin luting agent.

II. Material And Methods

A total of 40 extracted maxillary premolars teeth were randomly divided into 4 groups according to the surface treatment and cement used (n=10) into: Group AHP :(Airborne particles abrasion and hot acids + Panavia SA cement plus), Group AHL :(Airborne particles abrasion and hot acid + G-CEM Link Force Cement), Group AP: (Airborne particles abrasion + Panavia SA cement) and Group AL: (Airborne particles abrasion+ G-CEM Link Force cement). A specially designed centralizing metal device was used to allow an accurate centralization of the teeth in the acrylic resin blocks. The self-cured acrylic resin (Acrostone Dental & Medical Supplies, Egypt) was used. The preparations were performed using computer aided design/computer aided manufacturing (CAD/CAM) technology to standardize the preparation of all teeth.[14] The preparation was of 6° taper angles, 1mm for non-functional cusp, 1,5 mm for functional cusp and 0.5 mm chamfer finish line. The samples fixed on a special model holder, then placed inside the optical scanner (Identica hyprid, MEDIT corp, Korea) and scanned immediately. Crowns were designed with mesial and distal projections. These two projection used to assist crown removal after cementation during retention test. Monolithic zirconia crowns (CubeX^2 zirconia, Dental Direkt, GbmH, Spenge, Germany) then milled by milling machine (CORiTEC 250i touch, imes-icore Company, Germany). Crowns then sintered according to manufacturer instructions.

Surface treatment of the zirconia crowns:

Airborne particles abrasion

All crowns were air abraded with specific device (Basic classic fine sandblasting unit, Renfert, Germany). Alumina of 50 micron was used under pressure 2 bar for 10 seconds. Then, crowns rinsed well with distilled water.

Etching with hot acids

Only groups AHP and AHL were etched with a mixture of HF acid of concentration 48% and HNO_3 of concentration 69%. A mixture of two acids was taken with plastic syringes with proportion 1:1, then it injected into internal surface of crowns. The crowns then placed at specific oven (BINDER D78532 Tuttlingen Germany) at 100°C for 25 minutes .Crowns then rinsed well with distilled water.

Cementation of zirconia crowns

Then, each crown was bonded to its corresponding tooth initially with finger pressure and the universal testing machine (Instron Universal testing machine, 3345, USA, Universal bluehill software) used here for cementation using constant load of 10 N.[15] Then samples were subjected to thermocycling (SD Mechatronic thermocycler THE-1100 Germany). The thermocycling was performed for 10000 cycles between 5-55 $^oC \pm 2\ ^oC$ with a dwell time 25 seconds.

Retention test:

Crowns were subjected to dislodgment forces along the long axis of the abutment tooth until failure using a universal testing machine (Instron Universal testing machine, 3345, USA, Universal bluehill software Crosshead speed= 0.5 mm/min). The specimens were secured to the lower fixed compartment of the machine by tightening screws, then the crown was suspended from the upper movable compartment of the testing machine through specific tool was custom fabricated to accommodate the projections of crown . The crowns were subjected to a slowly increasing vertical load (0.5mm/min) until failure occurred, the load required to dislodgment was recorded in Newton.[16,17]

III. Results

One-way ANOVA omnibus test was used to assess the effect of different surface treatment and the type of resin cement on retention strength of zirconia restoration (MPa). It is indicated that surface treatment and the type of resin cement have significant effect on zirconia restoration retention (P=.000).

IV. Discussion

Results showed that using of hot acids after airborne particles abrasion improved retention significantly. These results can be explained by the fact that using of hot acids improved bonding between zirconia and resin cements. This results was in agreement with **liu et al. (2015)**[18] and **Haifeng et al. (2013)**[19] who observed higher bonding values of zirconia to resin cements over other surface treatments. This result can be explained by the fact that heating to a high temperature might increase the corrosive activity of HF solution as well as the dissolution rate of zirconia. For example, the so-called hot etching solution was found to widen the inter-grain regions and increase the surface roughness significantly, and they confirmed that the heating of HF solution could accelerate the removal of zirconia surface grains. The uneven removal of zirconia grains instead of a uniform disposal of the surface layer led to the formation of a rougher surface with micro-retentive structures, such as holes and pits with various sizes.

The result also in agreement with **Heikel et al**.[20] who found zirconia etching with hot acids mixture (69% nitric acid, 48% hydrofluoric acid) after airborne particles abrasion improved bonding of zirconia to resin cement. They observed using scanning electron microscope that the specimens treated with hot acids mixture after airborne particle abrasion revealed wider distribution roughness on the zirconia surface resulting in micromechanical retention and so better bonding strength.

The results of these study revealed that Panavia SA Cement Plus gave better retention of zirconia crowns. The possible explanation of is that this cement of good hydrolytic stability related to (10 MDP) functional monomer that have long carbonyl chain.[6] Also self-adhesive cement has low PH that after polymerization reaction form hydrophobic and stable cement of excellent mechanical properties so that better bonding of zirconia to resin cement, also G-CEM Link Force cement is a self-etch system required at least two steps; primer application then cement application which might increase the window of contamination and decrease bond strength.[21]

These results were not agree with **higashi et al**[22] who reported that a conventional-type adhesive resin cement showed higher microtensile bond strength values compared to a self-adhesive resin cement when used with zirconia, but these results can be explained that panavia SA cement in this study was hand-mixed that lead to formation of bubbles into the cement, these bubbles also very likely played a role in decreasing the mechanical properties of this resin cements.

V. Conclusion

Within the limitations of this in-vitro study, it was concluded that;

1-Using of hot acids as a surface treatment increased the bonding of resin cement to zirconia crown and improved the retention.

2-MDP self-adhesive resin cement improved the retention of zirconia crowns.

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