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Research Article

Effect of Surface Treatment and Type of Resin Cement on Retentive Force of Zirconia Crowns. A Comparative *In Vitro* Study

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Abstract

Objective: This *in vitro* study was conducted to evaluate effect of surface treatment of zirconia and two resin cements on retentive force of zirconia crowns.

Materials and Methods: Forty zirconia crowns (Amann Girrbach AG, Austria) were fabricated and divided into 2 groups according to type of resin cement, group (1) 1 Rely x ultimate clicker (3M Deutschland, Germany) and group (2) Rely x unicem (3M ESPE, USA), each group was then subdivided into 4 groups according to type of surface treatment, no surface treatment, sandblasting, sand-blasting with silane and sand blasting with MDP. After cementation retention was measured by Materials Testing Machine (Instron Industrial Products, Norwood, USA) with a load cell of 5 kN. Data were recorded using computer software (Bluehill Lite; Instron Instruments).

Results: Group (2) showed higher significant mean of retentive force than group (1). Self-adhesive resin cement showed higher mean of retention (82.72 ± 1 6.91) and (128.21 ± 19.88), compared to conventional (43.86 ± 5.89) and (92.95 ± 5.70), the difference was statistically significant. Sandblasting with MDP showed higher mean of retention (153.88 ± 12.07) and (166.19 ± 12.66), compared to group with no surface treatment (43.86 ± 5.89) and (82.72 ± 6.91) and the difference was statistically significant.

Conclusions: Group (1) Rely x ultimate clicker resin cement (conventional resin cement) showed less mean of retentive force than group (2) Rely x unicem resin cement (self-adhesive).

***Keywords:** Surface Treatment; Resin Cement; Zirconia*

Introduction

Increasing esthetic demands has made the pathway for developing metal free materials like zirconia, for fabrication of posterior crowns and fixed partial dentures [1]. With the continuing development of the current CAD/CAM systems, dentistry has also became proficient with different zirconia based applications like High strength frameworks, endodontic posts, implants abutments, orthodontic brackets etc.

Zirconium (Zr) is a radio-opaque transition metal element, with a melting point of 1,855°C and a boiling point of 4,409°C. It is found in the minerals as Baddeleyite and Zircon ($ZrSiO_4$) and does not exist in a pure state but in conjunction with silicate oxides or as zirconia oxide (ZrO_2).

It possesses excellent esthetics, good corrosion resistance, chemical stability, adequate strength and highest room temperature toughness. It is a polymorphic material occurring in 3 forms, monoclinic, tetragonal, and cubic. The monoclinic phase is stable up to 1,170°C then transforms into tetragonal phase which is stable up to 2,370°C and the cubic phase is stable up to 2,680°C, its high strength property is based on the Phase transformation effect [2,3].

This phase transformation is accompanied by volumetric expansion resulting in blunting the propagating crack tips thus increasing the fracture toughness of the material [4].

Success of an all ceramic restorations is highly dependent on achieving a bond of the resin with the underlying tooth structure as well as with the restoration. Bonding is required for improving the retention, marginal adaptation, fracture resistance and bond strength of restorations. Bonding also increases surface energy, surface area for bonding, and wettability [5].

During the fabrication or milling of the ceramic, sufficient bond strength values are not generated, therefore it requires surface pre-treatment [6].

Multiple methods were used to enhance bonding between zirconia restorations and tooth structure but combining mechanical and chemical surface pre-treatments of zirconia was considered the recommended technique [7].

Since zirconia is resistant to aggressive chemical treatment, very aggressive mechanical abrasion methods must be used to provide sufficient surface roughness. So, airborne particle abrasion in combination with the application of a zirconia primer provides a durable bond strength. Surface grinding is a commonly used alternative for roughening the surface of ZrO_2 to improve mechanical bonding [8].

The bond strength to high-crystalline content zirconia after different surface treatments reported a similar performance between traditional and self-adhesive resin cements; however, adhesive monomers present in the composition of some resin cements have affinity and react with dental zirconia, improving the adhesion of resin cement to zirconia which may increase the bond strength between zirconia and resin cement [9].

The most common resin cements are dual-cure luting agents used in combination with a bonding agent. Self-adhesive resin cements (SARC) were introduced years ago and do not need a bonding agent, thus facilitating the cementation procedure [10].

So the first NULL hypothesis for the present study was that the type of surface treatment does not significantly affect the shear bond strength of zirconia to tooth structure. The second NULL hypothesis was that the type of resin cement not have a determinant effect to increase bond strength.

Materials and Methods

Specimens Preparation

A machined standard stainless steel was used with 5 mm height and 5 mm diameter with 10 degrees convergent axial walls, the dye was prepared with 50° shoulder finish line (1 mm thickness). forty polyvinyl siloxane impressions (silibest via m. Bonarroti, cappanoli, Italy)

Fabrication of zirconia crowns

Crowns made of a partially sintered zirconia ceramic material by using CAD/CAM technology. After being sprayed, using model scanning via: desktop extra-oral scanner (map 400 Amanngirrbach). Crowns were designed via (Exocad software) with the following parameters; 0.05 mml cement gap starting 1 mml from the restoration margins, Milling the designed restoration with (ceramill motion 25 axix machine manufactured by Amann girrbach).

	Material	Composition	Manufacturer
1	Zirconia	Zirconia blocks	Amann Girrbach AG Herrschaftswiesen 1 6842 Koblach | Austria
2	RelyX ultimate clicker (conventional)	Base Paste: Methacrylate monomers, catalyst paste: Methacrylate monomers Radiopaque, silanated fillers Radiopaque alkaline (basic) fillers Initiator components Initiator components Stabilizers Stabilizers Rheological additives Pigments Rheological additives Fluorescence dye	3M Deutschland 41453 Neuss-Germany
3	RelyX Unicem (self-adhesive) (figure)	Methacrylate monomers containing Phosphoric acid groups Methacrylate monomers, Silanated fillers, Alkaline Initiator components, Stabilizers, Rheological	3M ESPE,2510 Conway Advenue, st. paul, USA
4	Al_2O_3	250 µ Al_2O_3 particles for 15 seconds .	3M ESPE, St. Paul, MN Henry Schein, Melville
5	Clearfil ceramic primer (figure)	Silane [3trimethoxysilylpropyl methacrylate (MPS primer)]	Kurari Noritake Dental Inc. 1621, Sakazau, Kurashiki. Okayama, japan
6	Panavia F2.	liquid A: 10-methacryloyloxydecyl dihydrogen phosphate (MDP), 2 -hydroxylethyl-methacrylate (HEMA), water	Kuraray Nuritake Dental, Okayama, Japan
7	Epoxy resin	Chemapoxy150	CMB, 43 Haram Street, Giza, Egypt

Table 1: *Materials used.*

Cementation of crowns

The copings then were gently air-sprayed, and cleaned. The specimen surface preparation, mixing and handling of the cements were accurately carried out according to the manufacturers' instructions. Prior to cementation, the prepared specimen was cleaned.

For RelyX ultimate clicker (conventional resin cement); two equal amounts of base and catalyst were used and mixed till homogenous color obtained according to manufacturer instructions. A thin layer of cement was applied to the inside surface of each coping. Rely x capsules (self-adhesive resin cement), were used to the other groups according to manufacturer instructions. The copings were seated firmly and the specimens were left undisturbed on the bench for another 15 minutes.

Testing procedures

Retention was measured by Materials Testing Machine (Model 3345; Instron Industrial Products, Norwood, USA*) with a loadcell of 5 kN. Data were recorded using computer software (Bluehill Lite; Instron Instruments).

The upper plate of the machine included the vertical arm of the specially designed retention measuring device to which and double orthodontic wire loop (0.7 mm diameter) that enclose and hanged the lateral projections of the crowns.

The device was subjected to a slowly Statistical analyses of the data were performed by using a one-way analysis of variance (ANOVA) to the mean retentive strengths of different surface treatments and cement materials.

Results

Group (2) Rely x Unicem showed higher retentive force than group (1) Rely X ultimate clicker with significant difference.

Effect of resin cements on mean Retention (N)

Self-adhesive resin cement showed higher mean of retention (82.72 ± 1 6.91) and (128.21 ± 19.88), compared to conventional (43.86 ± 5.89) and (92.95 ± 5.70), the difference was statistically significant. Mean and standard deviation (SD) for retention of zirconia crowns for resin used cements regardless other variables, were presented in table 2 and figure 1.

		Resin Cement				p-value
	Conventional		Self Adhesive			
	Mean	SD	Mean	SD		
Reten-tion (N)	No Surface ttt	43.86	5.89	82.72	6.91	≤ 0.001*
	Sand blasting	89.30	6.58	114.09	15.80	0.066 NS
	Silane	92.95	5.70	128.21	19.88	0.042*
	Sand blasting + MDP	153.88	12.07	166.19	12.66	

***Table 2:** Showing Mean and standard deviation of retention for different tested Surface treatment.*

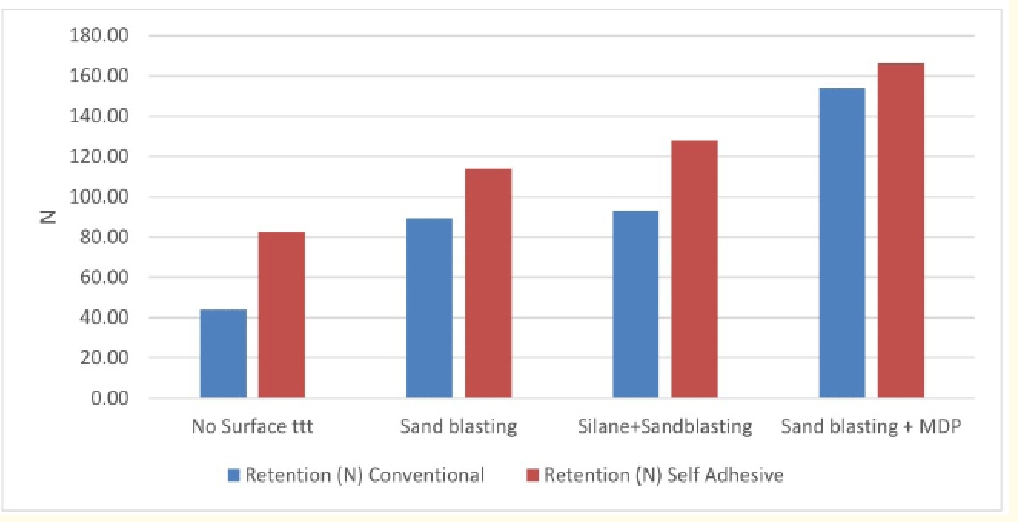

***Figure 1:** Bar chart showing the mean retention for different tested resin cements.*

Effect of Surface treatment on mean Retention (N)

Sandblasting with MDP showed higher mean of retention (153.88 ± 12.07) and (166.19 ± 12.66), compared to group with no surface treatment (43.86 ± 5.89) and (82.72 ± 6.91) and the difference was statistically significant. Mean and standard deviation (SD) for retention of zirconia crowns for resin used cements regardless other variables, were presented in table 3 and figure 2. The highest retention value was of sandblasting with MDP, while lowest was of specimen with no surface treatment, the difference was statistically significant according to table 3.

		Surface treatment								p-value
	No Surface ttt		Sand blasting		Sand blasting +Silane		Sand blasting + MDP			
	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
Retention (N)	Conventional	60.19	24.83	83.63	12.14	78.61	21.36	97.88	22.67	0.248 NS
	Self Adhesive	95.39	49.54	107.42	20.75	65.88	24.80	118.19	23.71	0.045*

Table 3: *Mean and standard deviation (SD) for Retention (N) for different tested Surface treatment.*

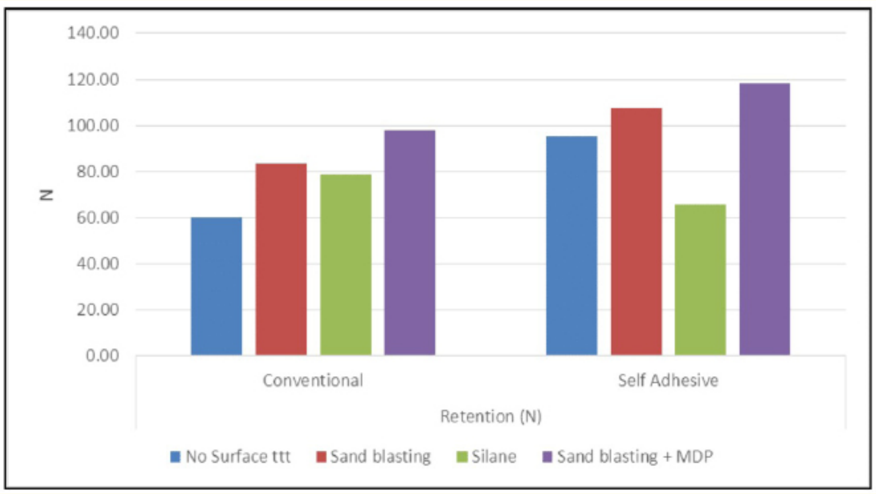

Figure 2: *Bar chart showing the mean retention for different tested resin cements.*

Discussion

There are many factors that may affect the retention of crown restoration including different tooth structure (enamel and dentin), surface roughness, axial wall height of tooth preparation, so in current study standard epoxy abutments had been used to minimize the variations among specimens [11]. Also different surface treatments (i.e. etching, sandblasting) and different luting agents affect the resulting retentive force of zirconia crowns [12].

With regard to the conditioning methods performed on the zirconia surfaces, several *in vitro* studies had shown that, airborne-particle abrasion, is an essential step for achieving a reliable bond to zirconia.

In the current study, the surface treated zirconia crowns showed higher bond strengths when compared crowns with no surface treatment which suggests that applying a physical and chemical conditioning methods are recommended for ensuring the success of bonding to zirconia, regardless of the type of resin cement used [13].

Considering surface treatment, airborne-particle abrasion removes loose contaminated layers and the roughened surface provides some degree of mechanical interlocking or keying with the adhesive. It can be due to the fact that the increased roughness has also increased the surface area for the bonding to occur produced an activated micro roughened zirconia surface, increased the bonding area and modifying the surface energy and wettability [14,15].

Crown retention in current study had a different range of retention results, when compared to adhesive resin cement data published in previous studies due to different zirconia brand, treatment of zirconia crown intaglio surface with different size of Al_2O_3 grain, aging conditions, and degrees of convergence, surface area measurement, and cement type are different from previous studies

In present study maximum retentive force found in zirconia crowns cemented by self-adhesive resin cement after sand blasting with MDP surface treatment. Which is in agreement with [9,16] which is due to the presence of micro hardens on the surface of zirconia crowns which enable micromechanical interlock between resin cement and crown surface in addition to that MDP primer has the ability to bond to zirconia and silica through chemical reaction providing chemical bond.

Conclusion

Within the limitation of this study the following can be concluded: Rely x unicem showed higher shear bond strength values than Rely x ultimate clicker. Surface treatment of inner surface of zirconia crowns increased retentive force. Surface treatment of inner surface of zirconia crowns with sand blasting and MDP was effective in increasing retentive force.

Conflicts of Interest

Authors deny any conflict of the study.

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