

## Evaluating the Effects of Different Surface Treatments and Different Resin Luting Agents in the Zirconia Post System which Produced by CAD/CAM for Retention

Derya Toprak Gunduz<sup>1</sup>, Zelal Seyfioglu Polat<sup>2\*</sup>, Filiz Keyf<sup>3</sup> and Gokhan Ozdemir<sup>4</sup>

<sup>1</sup>Ordu Agız Dis Sağlığı Merkezi, Ordu, Turkey

<sup>2</sup>Professor, Prosthodontics Department, Faculty of Dentistry, Dicle University, Diyarbakır, Turkey

<sup>3</sup>Professor, Prosthodontics Department, Faculty of Dentistry, Hacettepe University, Ankara, Turkey

<sup>4</sup>Assistant Professor, Dentistry Services Department, Vocational School of Health Services, Bahçeşehir University, İstanbul, Turkey

**\*Corresponding Author:** Zelal Seyfioglu Polat, Professor, Prosthodontics Department, Faculty of Dentistry, Dicle University, Diyarbakır, Turkey.

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### Abstract

At the last years especially the increase in the aesthetic necessities, it's required the using of the best materials as esthetically at the fixed partial dentures. Notably, at the tooth which has crown loss like tooth fracture, extreme tooth decay at the anterior, post kor treatment has been applied as getting support by tooth roots. As the metal post systems which used frequently is being dark colored and especially the reflection of metallic colour during the applying at the anterior tooth caused some aesthetic disadvantages. Nowadays removing the aesthetic disadvantages and making use of the metals resistance, the zirconia which is white colored metal is preferred. The zirconia metal which is quite hard be able to be shaped with some special techniques. Zirconia post systems has been produced by Computer Aided Design/Computer Aided Manufacturing (CAD/CAM) technique is applied currently. In the investigation, the zirconia posts which is produced with CAD/CAM technique, the retention of them was going to be evaluated.

120 maxillary central incisors' crown parts as being vertical 2 mm up to enamel cement margin going to be prepared with diamond disk and under irrigation. Root canals were going to be enlarged by Gates-Glidden drills and Snowpost systems drills as being at the same diameter. According to the enlarged canal, the zirconia posts were going to be prepared by the CAD/CAM Copy-milling technique and the zirconia posts surfaces be roughen up by different techniques (Hydrofluoric acid, Al<sub>2</sub>O<sub>3</sub> partial abrasion, CoJet silica coating). The roughen up posts were going to be cemented to tooth canal using tree different resin cement, MDP contain cement, Bis-GMA Based Resin, Adeziv Rezin Based. As the control group, the zirconia posts surfaces which no application were going to be fixed up using three different resin cement. The specimens were set down into the 25 x 25 x 25 mm fabricated blocks with acrylic resin materials. To the prepared sample, at the Instron Testing Machine by the help of appropriate equipment the tensile test and compressive-shear tests evaluated.

The end of the our study while adhesive cemented of the zirconia posts, the surface of the zirconia post need roughen up for retention and resistance. In the roughen up techniques Al<sub>2</sub>O<sub>3</sub> partial abrasion and CoJet silica coating were finding effective and in the adhesive cement, which is the contain MDP was finding effective.

**Keywords:** Post Core; Zirconia; CAD/CAM; Resin Cement

### Introduction

Increasing demand for aesthetic restorations has led to the development of several new tooth-coloured crown systems with characteristics similar to those of natural teeth, e.g., translucency and fluorescence. The introduction of yttrium-stabilised tetragonal zirconia

(Y-TZP) as a ceramic core material has extended the design and application limits of all ceramic restorations [1-3]. Clinical indications for zirconia-based ceramics include endodontic posts, implant abutments, complete crowns, and fixed partial dentures. Recently, nonmetallic aesthetic posts have become available, made of reinforced resin or high-strength ceramics such as zirconia-based ones [1,4-6].

For uniform and circularly-shaped root canals with sufficient bulk of dentinal walls, prefabricated zirconia posts are well suited to prepared canal walls along their entire length. However, in wide, noncircular, or extremely tapered canals, prefabricated cylindrical zirconia posts may not achieve sufficiently uniform contact with the canal, thereby possibly compromising the retention of the post and the crown. In such cases, custom-made ceramic posts and cores can be fabricated with presintered zirconia blocks using copy-milling or computer-aided design/computer-assisted manufacturing (CAD/CAM) techniques [7-10].

CAD/CAM technology has made the fabrication of complex restorations incorporating zirconia cores a relatively simple procedure. However, establishing a durable chemical or mechanical bond with zirconia has proven difficult. Because the material is acid resistant, it does not respond to the acid etching and silanisation procedures used for glass-containing ceramic materials that can react with silane coupling agents [6,11,12].

Several surface-roughening and coating methods have been proposed to condition zirconia surfaces to improve the adhesion of resin-based cements [13,14]. Airborne particle abrasion [15,16], tribochemical silica coating [16,18], Er:YAG laser irradiation [19], treatment with phosphate acidic [20] or functional silane monomers [12], and chemo-mechanical surface treatments [21] have been explored to achieve strong, reliable bonding to Y-TZP ceramic materials.

### Purpose of the Study

The purpose of this study was to evaluate the effects of different surface treatments and different resin luting agents on the retention of zirconia posts, using posts produced by CAD/CAM copy-milling fabrication techniques.

### Materials and Methods

#### Tooth specimens

One hundred twenty freshly extracted canines and centrals free of cracks, caries, fractures, and restorations were selected for the study. All external debris was removed using an ultrasonic scaler (Mini Piezon, EMS Piezon Systems, Nyon, Switzerland), and the teeth were stored in 37°C saline solution until use. The anatomic crowns of all teeth were removed perpendicular to the long axis of the tooth, from the most incisal point of the proximal cemento-enamel junction (CEJ) using a water-cooled diamond burr (R837.014; Diatech, Geneva, Switzerland) and an air turbine (Midvest 8000, Dentsply, York, PA) at 300,000 rpm. Root length was measured from the CEJ on the facial surface, and the widest faciolingual and mesiodistal dimensions of each specimen were determined using digital callipers accurate to 1 µm (Digimatic Caliper Model 500-196, Mitutoyo, Aurora, IL).

Twelve experimental groups were formed according to the different surface treatments and resin luting agents used in this study. Prepared tooth specimens were randomly assigned to these 12 groups, with 10 teeth in each group (Table 1). Root dimensions were assessed using two-way analysis of variance (ANOVA), and no significant differences in dimensions were found among the groups ( $\alpha = 0.05$ ).

Group no	Group name	Surface treatment type	Luting agents
1	CP	30 pm Al <sub>2</sub> O <sub>3</sub> with silica + Silan	Panavia F 2.0
2	CC	30 pm Al <sub>2</sub> O <sub>3</sub> with silica + Silan	Clearfil SA
3	CR	30 pm Al <sub>2</sub> O <sub>3</sub> with silica + Silan	RelyX ARC
4	AIP	125 p Al <sub>2</sub> O <sub>3</sub>	Panavia F 2.0
5	AIR	125 p Al <sub>2</sub> O <sub>3</sub>	RelyX ARC
6	AIC	125 p Al <sub>2</sub> O <sub>3</sub>	Clearfil SA
7	AP	Hydrofluoric acid %4	Panavia F 2.0
8	AR	Hydrofluoric acid %4	RelyX ARC
9	AC	Hydrofluoric acid %4	Clearfil SA
10	KP	No treatment (Control KP)	Panavia F 2.0
11	KC	No treatment (Control KC)	Clearfil SA
12	KR	No treatment (Control KR)	RelyX ARC

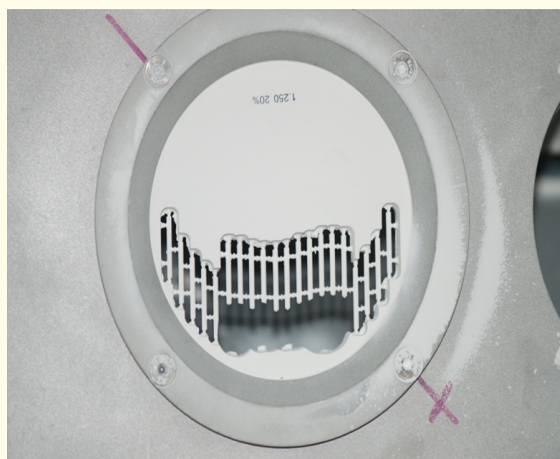
Table 1: The classification of the experimental groups.

### Post spacing

The SnowPost post system was used to obtain standard post spaces. Post spaces (1.6-mm diameter, 10-mm length) were prepared with progressively enlarging drills (Gates-Glidden). Final enlargements were accomplished using a 1.6-mm diameter drill (SnowPost, Schaan, Liechtenstein) to a depth of 10 mm.

### Post fabrication

A 1.6-mm-diameter SnowPost post was transferred to a dental laboratory (Stil Dental, Kayseri, Turkey) for duplication into zirconia posts using CAD/CAM techniques. A three-dimensional optical laser scanner (Dental Wings, Canada) was used to scan the patterns. Following scanning, presintered zirconia blocks (Zirkonzahn, Steger, Ahrntal, Italy) were placed into the computer-controlled milling machine, and the blocks were milled according to data provided by the scanner. After completion of milling, the specimens were subjected to a final sintering procedure, and 120 zirconia post specimens were obtained (Figures 1 and 2).



**Figure 1:** Specimens and final sintering.



**Figure 2:** Specimens and final sintering.

### Surface treatment of posts

The obtained zirconia post specimens were assigned to 12 experimental groups (n = 12). Groups 10, 11 and 12 served as controls and consisted of cemented zirconia post specimens that had not received any prior surface treatment.

The surface treatments were performed on the zirconia posts by:

1. Treating with a chairside tribochemical silica coating/silane coupling system (3M ESPE CoJet System). CoJet specimens were airbraded with 30- $\mu\text{m}$  silicatised  $\text{Al}_2\text{O}_3$  particles (CoJet Sand) for 20 s at 2.8 bar from a distance of 10 mm. Silane coupling agent (ESPE-SIL, 3M ESPE) was applied to the surface and allowed to dry for 5 min (Groups 1, 2 and 3).
2. Sandblasting with 125- $\mu\text{m}$   $\text{Al}_2\text{O}_3$  particles for 40s from a distance of 10 mm (Groups 4, 5 and 6).
3. Etching with 4% hydrofluoric acid for 5 minutes, washing thoroughly for 2 minutes under tap water, then air-drying for 15s (Groups 7, 8, and 9).
4. No pretreatment (Groups 10, 11, and 12).

The SEM view of the groups were seen in figures 3-6.

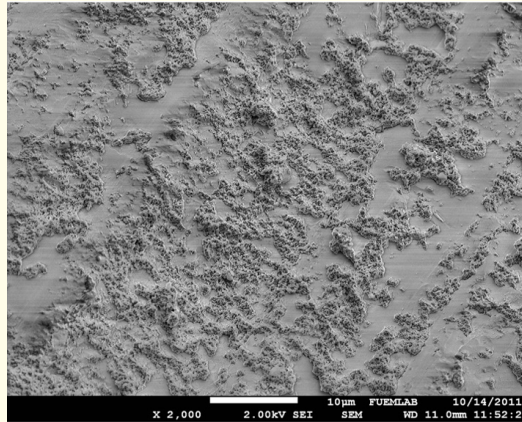


Figure 3: The SEM images of Cojet groups surfaces.

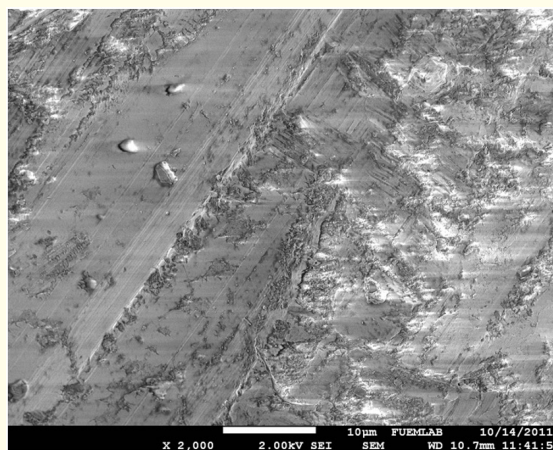


Figure 4: The SEM images of  $\text{Al}_2\text{O}_3$  groups surfaces.

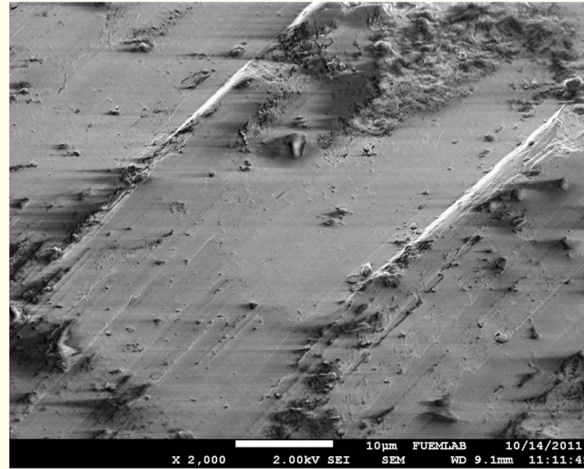


Figure 5: The SEM images of Hydrofluoric acid %4 groups surfaces.

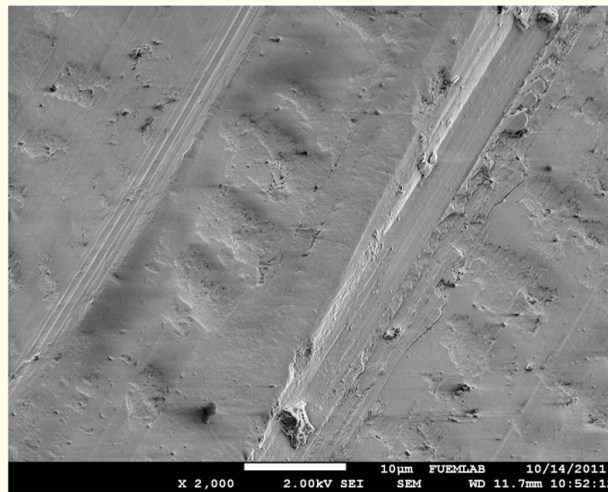


Figure 6: The SEM images of control groups surfaces.

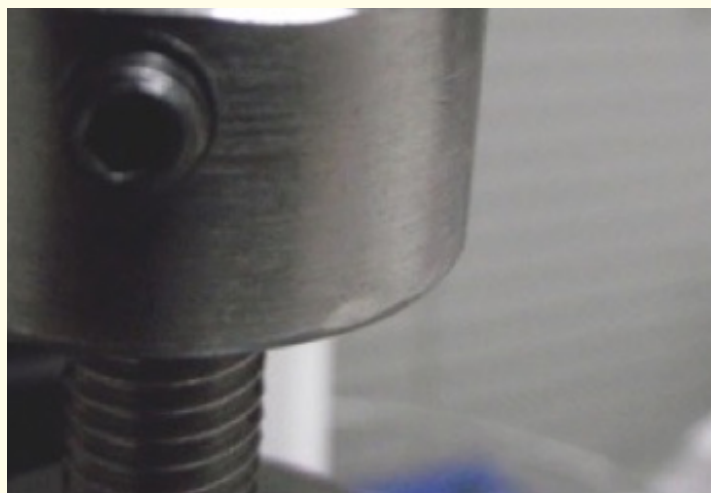
### Post insertion

Each post system was luted with three different dual-polymerising adhesive resin luting agents (Panavia F from Kuraray Dental, Osaka, Japan; Clearfil SA Cement from Kuraray Dental, Osaka, Japan; Rely X ARC from 3M Dental Products, St. Paul, MN) according to the manufacturers' guidelines. A thin layer of cement was also applied to the canal, and any excess cement was removed. The coronal end of the post was positioned in direct contact with the tip of a light unit (Polofil Lux Halogen Light; VOCO, Cuxhaven, Germany) and was polymerised for 40 sec. The light intensity was 800 mW/cm<sup>2</sup> and was calibrated using a built-in digital radiometer on the light unit before each exposure to ensure accuracy.

Each specimen was embedded in autopolymerising acrylic resin (Orthocryl EQ; Dentaaurum, Ispringen, Germany) using a 2.5 × 2.5 × 2-cm<sup>3</sup> standard acrylic matrix.

**Pull-out test**

The specimens were secured in an Instron universal testing machine (Model 3345; Norwood, MA) using a jig that held the tooth vertically. Tensile force was applied at a crosshead speed of 1 mm min<sup>-1</sup> (Figure 7). The pull-out threshold was defined as the point at which the specimen could no longer withstand the increasing load, at which time the post was pulled out of the tooth.



**Figure 7:** Applying tensile force.

**Statistical analysis**

The mean and standard deviation (x ± SD), and median values were calculated for continuous and discrete variables, respectively. Differences between groups were analysed using one-way ANOVA, followed by Tukey’s HSD and Dunnett t-tests. Two-sided p-values were considered statistically significant at p < 0.05. Statistical analyses were carried out using the statistical package SPSS 15.0 for Windows (SPSS, Inc., Chicago, IL, USA).

**Results**

The mean retention loads and their standard deviations for the 12 groups are listed in table 2 and figure 8. Among the groups, Group 4 had the highest (129.17 N), and Group 11 had the lowest median load (42.76 N).

Luting Agent		Cojet		X	Al <sub>2</sub> O <sub>3</sub>	Sd	X	Sd	X	Sd
		X	Sd							
Panavia F2.0	N	108.03	±11.43	129.17	±32.24	98.94	±5.97	75.41	±12.0	
	kg	11.01	±1.16	13.17	±3.28	10.08	+0.60	7.68	±0.20	
Clearfil SA	N	78.20	±12.63	81.55	±4.90	64.56	±11.65	42.76	±9.66	
	kg	7.97	+0.26	8.31	±0.49	6.58	±1.18	4.36	±0.98	
Re1yX ARC	N	101.61	±8.50	119.49	±18.59	94.93	±7.70	57.53	±13.00	
	kg	10.36	±0.86	12.18	±1.89	9.68	±0.78	5.86	±1.32	

**Table 2:** The mean retention loads and their standard deviations.

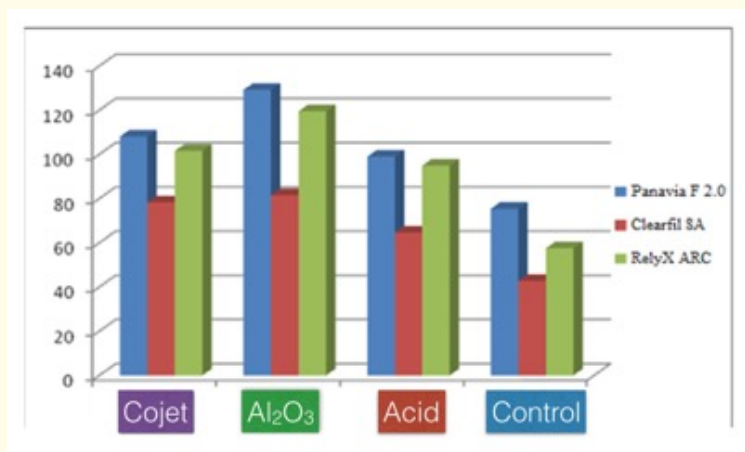


Figure 8: The mean retention loads.

### Surface-treated systems

Groups 1, 2, and 3 were surface-treated with the CoJet system. Group 1 had the highest median load (108.03 N). No significant differences were observed between the Panavia F (Group 1) and Rely X ARC (Group 2) groups, but significant differences were observed between these two groups and the Clearfil group (Group 3).

Groups 4, 5, and 6 were surface-treated with Al<sub>2</sub>O<sub>3</sub>. Group 4 had the highest median load (129.17 N). No significant difference was observed between this and the Rely X ARC (Group 6) group, but a significant difference was observed with the Clearfil group (Group 5).

Groups 7, 8, and 9 were surface-treated with 4% hydrofluoric acid. Group 7 had the highest median load (98.94 N). No significant differences were observed among the groups.

Groups 10, 11, and 12 had no surface treatments. Group 10 had the highest median load (75.41 N). No significant differences were observed between the groups.

### Luting agents

Groups 1, 4, 7, and 10 used the Panavia F luting agent. Group 4 had the highest median load (129.17 N). No significant differences were observed between the Cojet (Group 1) and Al<sub>2</sub>O<sub>3</sub> (Group 4) groups, but significant differences were observed between these two groups and the hydrofluoric acid-treated (Group 7) and control groups (Group 10).

Groups 2, 5, 8, and 11 used Clearfil SA luting agent. Group 5 had the highest median load (81.55 N). No significant differences were observed between the Cojet (Group 2) and Al<sub>2</sub>O<sub>3</sub> (Group 5) groups, but significant differences were observed between these two groups and the hydrofluoric acid-treated (Group 8) and control groups (Group 10).

Groups 3, 6, 9, and 12 used Rely X ARC luting agent. Group 6 had the highest median load (119.49 N). Significant differences were observed between the Al<sub>2</sub>O<sub>3</sub> (Group 6) group and the other groups, and especially compared with the control group (Group 12).

### Discussion

The application of CAD/CAM technologies to zirconium oxide-based ceramics has led to increased use of these materials in aesthetic dentistry [7,10]. Such ceramics were used in this study. Christel, *et al.* [19] investigated the zirconia material, which was introduced at the end of the 1980s, and noted its superior mechanical properties, chemical stability, and biocompatibility.

Considering surface treatments, Al<sub>2</sub>O<sub>3</sub> airborne-particle abrasion increases surface energy and wettability and enables a strong mechanical bond to form with the resin cement by means of mechanical interlocking. Kern., *et al.* [22] found that an Al<sub>2</sub>O<sub>3</sub> airborne-particle surface abrasion treatment provided higher bond strengths than did the application of a silane agent and a tribochemical silica coating. Sahafi., *et al.* [23,24] reported that Al<sub>2</sub>O<sub>3</sub> airborne-particle abrasion and Cojet surface treatments enhanced the cementation of zirconia posts. Herein, surface treatment with Al<sub>2</sub>O<sub>3</sub> airborne-particle abrasion also provided high bond strengths, in good agreement with those studies. Others have reported that sandblasting may initiate micro-cracking of the surface cementation, which may compromise long-term stability [11,25].

Different-sized Al<sub>2</sub>O<sub>3</sub> particles have been used for airborne-particle surface abrasion treatment of zirconia ceramics: Sahafi., *et al.* [23] used 50-µm particles, whereas Bitter., *et al.* [26] used 110-µm Al<sub>2</sub>O<sub>3</sub> particles. Our study used 125-µm Al<sub>2</sub>O<sub>3</sub> particles with Panavia F luting cement and achieved high bond strengths.

Silica coating and silane application significantly increased the bond strength compared with airborne particle abrasion or silica coating alone [27,28]. A chemical bond is created between the deposited silica and the cementing agent when a ceramic is blasted with silica. A silane coupling agent, which is a bifunctional molecule, links the silica to the hydroxyl groups of the surface of the ceramic, and also provides a degradable functional group that co-polymerises with the organic matrix of the resin cement. It is used to promote chemical bond formation between the ceramic and the bonding system. In our study, 30-µm silicatised Al<sub>2</sub>O<sub>3</sub> used with the Cojet coating system provided high bond strengths.

Conventional luting agents, such as zinc phosphate and modified glass ionomer cements, could be used for the cementation of zirconia post systems. Although zinc phosphate cement has been successfully used for many years, it has the disadvantages of microleakage and leaving an unpleasant gray appearance at the margins. The disadvantage of modified glass ionomer cements is their high solubility [6,11]. The advantages of resin luting agents include marginal adaptation, good retention, chemical adhesion, and improved fracture resistance. These characteristics have made them more frequently used for zirconia systems [6,11,16]. Kwiatkowski., *et al.* [29] reported that the zirconia post systems can have good bond strengths when resin cement and silanisation are used. In this study, various surface treatments and cement/adhesive agents were compared to identify those that could provide a strong and durable bond between the zirconia ceramic post and tooth tissue.

Huber., *et al.* [30] and O'Keefe., *et al.* [31] reported that using primers or resin cements containing 10-methacryloyloxydecyl dihydrogen phosphate (MDP) monomer increased the bond strength of zirconia. Our study herein demonstrated that sandblasting followed by the use of primers or resin cements containing MDP monomer increased the bond strength with zirconia. MDP is an acidic phosphate monomer originally designed to bond to metal oxides, but its use has been extended to zirconia. It has an affinity for metal oxides. Because a zirconia surface is covered with a passive oxide layer, its surface is somewhat similar to that of a metal. This explains why it can be effectively used to increase the bond strength between zirconia and resin cements [32,33].

## **Conclusion**

Zirconia posts produced using CAD/CAM techniques had good mechanical properties, aesthetic properties, and biocompatibility. They could be expected to provide successful and satisfying results in the clinic.

This study established that a surface treatment prior the cementing step is essential to achieve a reliable bond between the zirconia ceramic and the resin cement. Groups surface-abraded with Al<sub>2</sub>O<sub>3</sub> particles had the highest median load (129.17 N).

Within the limitations of this *in vitro* study, the results suggest that the use of Panavia F adhesive resin with Al<sub>2</sub>O<sub>3</sub> particle abrasion and Cojet silica coating surface treatments are optimal for the resin cementation of zirconia ceramic posts.

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