Research Article

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To Compare the Tensile Bond Strength of Zirconia Copings Subjected to Different Surface Treatment Methods with Different Luting Agents: An In Vitro Study

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ABSTRACT

Background: Zirconia, a high strength ceramic that has several properties such as esthetics and high functional demands thus making it popular amongst patients as well as dentists. The present study was conducted to compare the tensile bond strength of zirconia copings subjected to different surface treatment methods with different luting agents.

Material and methods: The present study includes 80 intact extracted human maxillary premolar teeth. The eighty zirconia copings milled were divided into 4 groups, containing 20 specimens each. The copings of Groups A1 and A2 were etched with hydrofluoric acid (HF) and cemented with 10-MDP self-adhesive resin, and 4-META adhesive resin, respectively. The copings of Groups B1 and B2 were surface air abraded and cemented with 10-MDP self-adhesive resin, and 4-META adhesive resin, respectively. The prepared tooth was cleaned thoroughly with pumice slurry, rinsed with a water spray, and air dried before the cementation. The cemented copings were subjected to tensile dislodgement with a crosshead speed of 0.5 mm/min in the universal testing machine. Data obtained were compiled on the MS Excel sheet. Statistical analysis was performed using the SPSS software, Version 21.0 at a significance level of 5% ($P = 0.05$).

Results: The result showed that the highest mean bond strength values among the Groups A1 and A2 with HF acid surface treatment of zirconia copings was shown by 4-META adhesive resin. The highest mean bond strength values with air abrasion Groups B1 and B2 were exhibited by 10-MDP self-adhesive resin. The comparison between the Groups A1 and B1 where 10-MDP self-adhesive resin was used for cementing the zirconia copings, the mean bond strength values were significantly higher with air abraded surface treatment. In the Groups A2 and B2, where 4-META adhesive resin was used for cementing the zirconia copings, the highest mean bond strength value was exhibited by HF surface treatment

Conclusion: This study concluded that when 10-MDP self-adhesive resin was used for cementing the zirconia copings, the mean bond strength values were significantly higher with air abraded surface treatment and when 4-META adhesive resin was used for cementing the zirconia copings, the highest mean bond strength value was exhibited by HF surface treatment.

Keywords: air abraded, HF, zirconia, 10-methacryloyloxydecyl dihydrogen phosphate, 4-methacryloxyethyl trimellitic acid.

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INTRODUCTION

Zirconia-based restorative materials have been used as core materials for single crowns and fixed dental prostheses due to their superior esthetics, biocompatibility, and high mechanical strength.[1] Zirconia has emerged as a versatile and promising ceramic material because of its biological, mechanical and optical properties. With a flexural strength of more than 900 MPa, fracture toughness of up to 10 MPa/m0.5, and an elastic modulus of 210 GPa, they exhibit better mechanical performance, superior strength and fracture resistance than do other ceramic materials.[2,3]

resistance of the restored tooth and the restoration, and improves longevity of ceramic restorations.[1,4] In addition, resin cements offer the advantage of sealing minor internal surface flaws created by acid etching or airborne particle abrasion, significantly strengthening ceramic materials.[5] The newer resin-based adhesives with phosphate monomers such as 10-methacryloyloxydecyl dihydrogen phosphate (10-MDP) and 4-methacryloxyethyl trimellitic acid (4-META) have also exhibited improved bonding of the zirconia restorations.[6-8] The present study was conducted to compare the tensile bond strength of zirconia copings subjected to different surface treatment methods with different luting agents.

MATERIAL AND METHODS

The present study includes 80 intact extracted human maxillary premolar teeth. Before the commencement of the study ethical approval was taken from the Ethical Committee of the institute. The extracted human maxillary premolar teeth with approximately similar diameter were included in the study. The teeth after extraction were placed in 0.5% sodium hypochlorite solution for 5 min, cleaned using ultrasonic scaler, and then stored under water. The roots of the selected teeth were notched for retention and embedded along their long axis with the cementoenamel junction positioned 1 mm above the custom-made mounting base fabricated using autopolymerizing acrylic resin. The mounted tooth base was then fixed in the custom-made template and positioned in the cast holder of the milling machine. The occlusal surface of each mounted tooth specimen was sectioned flat 4 mm from the cementoenamel junction using carborundum discs of dimension 25 mm × 0.6 mm × 1.8 mm. The high-speed handpiece (350,000–450,000 rpm) with a coarse diamond tapered rotary bur with 3° taper was oriented parallel to the vertical axis of the tooth and manually rotated to establish a standardized angle of convergence of 6°. The axial reduction of 1–1.5 mm and axial length of approximately 4 mm with deep chamfer finish line were achieved. The preparation was carried out under water spray, and for each tooth specimen, a new diamond bur was used. The surface area of each preparation was measured using a metal caliper to calculate the bond strength. The tray adhesive was applied to the intaglio surface of the custom trays fabricated using autopolymerizing acrylic resin. Impressions of the prepared tooth were made with polyvinyl siloxane putty and light body material and poured with scan-able die material. The master dies were trimmed and scanned in dental wing scanner which sent the command to the computer-aided manufacturing (CAM) machine for the milling of the zirconia copings from the presintered zirconia blanks. In each of the copings, a 2-mm diameter hole was drilled in the predesigned 6-mm projection of the abutments using a round rotary cutting instrument with copious water irrigation. The prescribed area for the hole was measured and marked for all the samples before the drilling procedure. The hole allowed a wire to be used as an attachment from the zirconia coping engaging the hook of the custom-made jig in the universal testing machine, which exerted the tensile forces to separate the zirconia copings from the abutments during the testing procedure. The zirconia copings were sintered and placed on the respective dies to evaluate the fit, and for proper alignment during the cementation procedure, a line was marked on the coping and the mounted teeth. The eighty zirconia copings milled were divided into 4 groups, containing 20 specimens each. The copings of Groups A1 and A2 were etched with hydrofluoric acid (HF) and cemented with 10-MDP self-adhesive resin, and 4-META adhesive resin, respectively. The copings of Groups B1 and B2 were surface air abraded and cemented with 10-MDP self-adhesive resin, and 4-META adhesive resin, respectively. The prepared tooth was cleaned thoroughly with pumice slurry, rinsed with a water spray, and air dried before the cementation. The cemented copings were subjected to tensile dislodgement with a crosshead speed of

0.5 mm/min in the universal testing machine. The dislodgment values recorded in Newton (N) was converted to the tensile bond strength in MPa unit. Data obtained were compiled on the MS Excel sheet. Statistical analysis was performed using the SPSS software, Version 21.0 at a significance level of 5% ($P = 0.05$).

RESULTS

The result showed that the highest mean bond strength values among the Groups A1 and A2 with HF acid surface treatment of zirconia copings was shown by 4-META adhesive resin. The highest mean bond strength values with air abrasion Groups B1 and B2 were exhibited by 10-MDP self-adhesive resin. The comparison between the Groups A1 and B1 where 10-MDP self-adhesive resin was used for cementing the zirconia copings, the mean bond strength values were significantly higher with air abraded surface treatment. In the Groups A2 and B2, where 4-META adhesive resin was used for cementing the zirconia copings, the highest mean bond strength value was exhibited by HF surface treatment.

Table 1: Mean and SD bond strength values of the groups

Groups	Mean±SD	P value
A1	1.67±0.54	<0.05
A2	1.86±0.27	
B1	2.65±0.36	
B2	1.78±0.46	

DISCUSSION

Mechanical and chemical modifications of the prepared surface of fixed restorations are well-documented methods of establishing a reliable bond between the restoration and the adhesive cement. Adhesive resin cements are used not only to prevent the dislodgement of ceramic restorations but also to obtain a strong and long-lasting cementation between tooth and ceramic restoration.[9]

The eighty zirconia copings milled were divided into 4 groups, containing 20 specimens each. The copings of Groups A1 and A2 were etched with hydrofluoric acid (HF) and cemented with 10-MDP self-adhesive resin, and 4-META adhesive resin, respectively. The copings of Groups B1 and B2 were surface air abraded and cemented with 10-MDP self-adhesive resin, and 4-META adhesive resin, respectively.

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Akshay et al in their study, 72 extracted human molars were collected, cleaned and divided into two groups. All teeth were prepared with a 15∘ total convergence angle for group 1 and a 30∘ total convergence angle for group 2, a flat occlusal surface, and approximately 4-mm axial length. Each group was divided by surface area into three subgroups. All zirconia copings were abraded with 50- µmAl2O3, then cemented using Panavia F 2.0 (PAN-1) (PAN-2) Rely X Unicem (RXU-1) (RXU-2), and Clearfil SA (CSA-1) (CSA-2). After cementation, the copings were thermocycled for 5000 cycles between 500C and 550C with a 15-second dwell time. Then the copings were subjected to dislodgment force in a universal testing machine at 0.5 mm/min. The force of removal was recorded, and the dislodgement stress was calculated. Mode of failure was mixed, with cement remaining principally on the tooth for PAN. For CSA and RXU, mode of failure was mixed with cement remaining principally on the zirconia copings.[10]

Yang *et al.* reported that 10-MDP-containing luting system was the most suitable to bond zirconia surfaces compared to self-adhesive or conventional resin cement, and it did not require any pretreatment on the ceramic surface before luting.[11] Phark *et al.* reported that air abrasion increased the bond strength of the zirconia regardless of the abrasive particle size.[12] Chen *et al.* reported that hot acid etching with $H_2SO_4/(NH_4)_2SO_4$, HF/HNO_3, has shown to have improved the initial bond strength of Y-TZP to Bis-GMA-based resin cement compared to alumina sandblasting.[13]

Oyagüe et al[14], and Blatz et al.[15], assumed that AL2O3 abrasive particles removed any organic contaminants, produced an activated micro-roughened zirconia surface, increased the bonding area, modifying the surface energy and wettability[16], so they improve the bond strength by allowing for micromechanical interlocking of the resin cement.[17]

CONCLUSION

This study concluded that when 10-MDP self-adhesive resin was used for cementing the zirconia copings, the mean bond strength values were significantly higher with air abraded surface treatment and when 4-META adhesive resin was used for cementing the zirconia copings, the highest mean bond strength value was exhibited by HF surface treatment.

CONFLICTS OF INTEREST

The authors declare they have no potential conflict of interests regarding this article.

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