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Influence of Different Primer/Resin Cement Systems on Retention of Monolithic Zirconia Crowns

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Abstract:

Statement of problem: Zirconia is a polycrystalline non etchable ceramic material therefore, there are difficulties to achieve a stable and durable bond.
Objectives: The aim of this in vitro study was to determine the retention strength of zirconia crowns cemented using different MDP-containing primers and resin cements.
Materials and Methods: Thirty natural extracted molars were fixed in epoxy resin and prepared with a flat occlusal surface, 20^{o} degree angle of convergence, approximately 3 mm teeth preparation height, and with roundation of the axio-occlusal line angles. Zirconia crowns were fabricatedwith the aid of CAD/CAMwith an added occlusal bar to facilitate removal of the cemented crowns. The internal surfaces of crowns were abraded with 50 µm aluminum oxide particles at 2.5 bar pressure for 10 seconds. Zirconia crowns were divided into 3 groups (n=10) according to the different cements and primers into; Group M:Multilink Speed/Monobond N, Group P: Panavia V5/Clearfil ceramic primer plus, Group D: Duo-Link universal/Z-Prime plus. Crowns were cemented and then thermal cycled for 10,000 cycles of 5^{o}C to 55^{o} C with a dwelling time of 20 seconds. The crowns with its occlusal bar were adapted to gear wire hooks device and removed vertically along path of insertion with the aid of universal testing machine at 0.5 mm/min crosshead speed. Maximum load was recorded and retention strength was calculated. One-way ANOVA was used to analyze the data of maximum load and retention strength and Monte-Carlo test was used to analyze failure mode.
Results: Group D showed the lowest retention strength (1.42±0.23 MPa) and differed significantly (*P*=<0.001) from of Group M (2.71±0.45 MPa) and Group P (2.47±0.41MPa). Also, Group P showed a non-significant difference in retention strength compared to that of Group M (*P*=0.34). Modes of failure showed mainly cohesive failure for Group M and Group P, and adhesive failure for Group D.
Conclusions:MDP-containing primers enhanced retention strength of the resin cements to zirconia crowns,however, retention strength of Multilink Speed and Panavia V5 resin cements was significantly higherthan Duo-Link Universal resin cement.
. **Key words:**Primer; Resin cement; Retention test;Monolithic zirconia.

Introduction

In dentistry, monolithic zirconia has recently become popular owing to its biocompatibility, esthetic appearance, high strength, fracture toughness, semi-translucency, radiopacity and overcoming veneer cracking or chipping problems in veneered zirconia.[1-5]

Unlike lithium disilicate, monolithic zirconia has a great surface stability and high acid resistance to etching with hydrofluoric acid due to absence of glassy matrix and incapability of silane application due to absence of silica content. [6-9]

A definitive cementation protocol for monolithic zirconia has not been validated yet, although zirconia can be cemented conventionally but bonding of zirconia to tooth could improve marginal seal and retention strength.[10-15]Improving the bond strength of resin cement to zirconia can be achieved with several techniques such as airborne-particle abrasion with aluminum oxide, silica deposition methods, application of 10-MDP primer, plasma spraying and selective infiltration etching.[8,16,17]

Airborne-particle abrasion with 50 µm aluminum oxide particles combined with the use of MDP containing primer with resin cement has been recommended for bonding a zirconia crown.[10,18] Benefits of airborne-particle abrasion are making ceramic surface roughresulting in micromechanical interlocking between zirconia and resin, also increasing in surface energy and surface area of zirconia surface.[9-21]Moreover, the benefit of using MDP containing primers is a chemical interaction between the MDP acidic groups (phosphoric acid) and the oxide layer of the zirconia.[22-26]

Kuraray company invented the original MDP monomer in 1981 to improve the bond strength to hydroxyapatite, MDP monomer can be incorporated into various bonding and luting products, such as primers, adhesives, and resins such as kuraray products (Clearfil Ceramic Primer,Clearfil SE bond,Panavia F2.0) respectively.[27]

Various MDP‐based primers have been introduced such as (Monobond plus, Clearfil Ceramic Primer plus, Z-Prime Plus) and it acts as adhesion promoters as it is based on MDP molecule that consists of methacrylate group that polymerized to resin, hydrophobic group that resist hydrolysis and degradation by water uptake and hydrophilic group that react with zirconia and form P-O-Zr covalent bond.[28,29]

Materialsand Methods

Thirty freshly extracted mandibular molarsfree from caries and cracks, were collected for this study. The mesio-distal, bucco-lingual and occluso-cervical height of all teeth were measured in millimeters using a digital caliper (Accessotech 6" Digital Vernier Caliper Gauge, Accessotech, China).

Teeth preparation: All teeth were mounted in epoxy resin blocks(Kemapoxy 150, CMB International, Egypt) and prepared with the aid of a dental surveyor (Marathon-103 surveyor, Saeyang Co., Korea) for standardization. The occluso-gingival height was reduced to 3 mm with a flat occlusal surface using a diamond wheel shaped stone bur (WR-13, ISO 068/042, MANI INC, Japan) and axial surfaces were prepared using a rounded-endtapered diamond bur(TR-14-198/022, Mani Inc., Japan) to produce a 10^o taper angle of each wall with 20^o angle of convergence with 0.5 mm chamfer finish line.[30-32]

All prepared teeth were divided into three groups (n=10) according to the different cements and primers in to;Group M: Multilink Speed/Monobond N, Group P: Panavia V5/Clearfil ceramic primer plus, Group D: Duo-Link universal/Z-Prime Plus.

Crown fabrication: Each mounted tooth was scanned with an optical scanner (Identicahyprid, Meditcorp, Korea) then crowns were designed (exocad Plovdiv2, exocad GmbH, Germany) with a bar on the occlusal surface with dimensions of 15×3.5×3.5 mm. Katana zirconia block (Katana zirconia STML A2, T14, Kuraray Dental, Japan) with size of 98.5×14 mm was milled in the milling machine (Cori Tec 250i, imes-icore GmbH, Germany) then all zirconia crowns were sintered in a sintering furnace(Tabeo-100, Mihm-Vogt, Germany). The internal surfaces of all crowns were abraded with 50 µm aluminum oxide particles under pressure of 2.5 bar for a maximum of 15 seconds at working distance of 10 mm.[33,34] Surface area of each preparation was calculated with the aid of MeshLab software program(Meshlabsoftware, Istituto di ScienzaeTecnologiedell'Informazione, Italy).

Cementation of Crowns: Group M: Crowns were treated by applying a thin coat of Monobond N (IvoclarVivadent AG, Schaan, Liechtenstein) with a micro-brush and allowed to react for 60 seconds then excess was removed with a strong stream of air, then Multilink Speed (IvoclarVivadent AG, Schaan, Liechtenstein) cement paste was dispensed from the automix syringe and the desired amount was appliedonto the crowns.Group P:Panavia V5 tooth primer (Kuraray Dental-Kurashiki, Okayama, Japan) was applied to the teeth and left for 20 seconds, then gently air-dried, after that,Clearfil Ceramic Primer plus (Kuraray Dental-Kurashiki, Okayama, Japan) was applied in one coat over a micro-brush to the crown surface, left undisturbed for 10 seconds and gently air-dried for 5 seconds, then Panavia V5 cement paste (Kuraray Dental-Kurashiki, Okayama, Japan) was dispensed from auto-mix syringe into the crowns.Group D: All-Bond Universal(Bisco Inc. Schaumburg, IL, USA) was applied to the teeth with a micro-brush for 20 seconds, air sprayed to remove excess solvent for 20 seconds then light cured for 20 seconds, after that,Z-Prime Plus(Bisco Inc. Schaumburg, IL, USA) was applied in 1-2 coats to the crown surface and dried with an air syringe for 3-5 seconds then Duo-Link universal cement paste(Bisco Inc. Schaumburg, IL, USA) was dispensed from auto-mix syringe into the crowns.All crowns of these groups were seated with static standardized force (40 N) using universal testing machine (Instron Universal testing machine, 3345, USA, Universal bluehill software)that was pointed to the center of each specimen and light cured for 20 seconds from each surface.[35]All specimens were thermal cycled(Thermocycler The-1100/ The-1200, SD Mechatronic, Westerham, Germany) for 10000 cycles between 5^o C and 55^o C in tap water with 20 seconds dwell time.

Retention test:Each specimen was secured with tightening screws to the lower fixed compartment of the universal testing machine (Instron Universal testing machine, 3345, USA, Universal bluehill software), then the crowns was suspended from the upper movable compartment of the testing machine through a custom-made double loop device thatfabricated from gear wire (Gear wire, BAKR GENUINE Parts, Egypt), this device hooked around the occlusal bar of each specimen. The crowns were subjected to a slowly increasing vertical load along the path of insertion at a crosshead speed of 0.5mm/min until failure occur. The force at dislodgment was recorded in Newton,retention strength was recorded in MPa.

Selected specimens from each group were examined by scanning electron microscopy (JEOL JSM 6510 Iv, JEOL Ltd., Japan) at several magnification powers to determine failure mode.

Results

One-way ANOVA was usedto assessretentive maximum load and retentionstrength and surface area. For maximum load and retention strength, Group D showed significant decrease compared to that of Group Mand Group P (P=<0.001), while Group P showed non- significant difference compared to that of Group M (P=0.55).For surface area, Group M, Group P and Group D was non-significant difference (P=0.68) in (Table 1).Monte Carlo test was used to illustrate failure frequency between different studied groups and overall comparison between Group M, Group P and Group D showed significant difference (p=<0.001).

Discussion

Results showed that the highest retentive bond strength value was recorded for the Group M, followed by Group P, and the least retentive bond strength value was recorded for Group D. This finding is in accordance with previous studies that showed application of MDP-containing primer to sandblasted zirconia surface could enhance physico-chemical interaction between zirconia and cement so increased both the initial bond strength and resistance of the thermal stress on the bond.[6,23-25,33]

Group M showed the highest retentive bond strength, this may be due to the composition of Monobond N that contains different methacrylate monomers with a functional phosphoric acid group in MDP molecule, that can create a very stable phosphate link that resist hydrolysis and hence a durable strongadhesive bond to zirconia.[20] Also, Multilink Speed contains an adhesive monomer that consists of a long-chain methacrylate with a phosphoric acid group, this acidic groups bind to calcium in the hydroxyapatite of the demineralized smear layer of dentin, creating a bond to the resin network.[15] This finding comes in agreement with the results obtained from the study of Amaral et al[29] which had compared the effects of Z-Prime plus and Monobond Plus on polished and sandblasted zirconia surface and determined higher bond strength of Monobond Plus than Z-Prime plus due to an MDP monomer and a silane monomer 3-MPS content of Monobond Plus.Also, with agreement with the results obtained from the study ofElsaka[15] that determined higher bond strength of Multilink Speed to monolithic zirconia than Multilink N, also determined that pretreatment of zirconia surface with Monobond Plus enhance retention strength of Multilink Speed as in Monobond Plus, the functional monomer is methacrylated phosphoric acid ester.

There is no significant difference between Group M and Group P although Panavia V5 cement paste lack monomers with phosphate groups but Panavia V5 tooth primer contains co-initiators, that initiate conversion without light curing when they are in contact with an initiator of the resin cement, this is called touch-cure that leads to good polymerization of resin cement paste and provide superior dentin bonding performance.[36]Moreover, Panavia V5 resin cement is less affected by thermal cycling and provide stable bonding due to its low water sorption and it is potentiality to release fluoride provide durable and strong bond to dentin.[13]Also, Clearfil Ceramic Primer plus that containing MDP and silane increase chemical bonding to sandblasted zirconia crowns.[14] This finding comes in agreement with the results obtained from the study of Inokoshi et al[21] which had determined that pre-treatment of zirconia with Clearfil Ceramic Primer or Monobond Plus yielded the best results, they explained that these primers contained silane monomer and low bonding values were registered for Z-Prime Plus.Also, with agreement with the results obtained from the study ofValente et al[9]which had determined higher bond strength of Panavia V5 resin cementprovided that pretreatment of zirconia surface with Clearfil Ceramic Primer plus.

Group D showed the lowest retentive bond strength. This might be explained by the fact that Duo-link is a Bis-GMA-based cement and bond strength of Bis-GMA-based resin cement and zirconia has been reported to be lower than that of adhesive phosphate monomer-based resin cements.[31] Also, Z-prime plus contains two adhesive monomers (carboxylate and MDP) presence of carboxylic acid monomer can weaken the connection between this primer and methacrylate groups found in this resin cement.[26]This finding comes in agreement with the results obtained from the study of Pitta et al[17] which had determined lower bond strength of Duo-link and Z Prime plus that might be due tochemical differences in base monomers or solvents of priming agents, differences in initiation systems of priming agents, a possible difference in the purification process (that is solvent extraction) of 10-MDP between the manufacturers, or differences in the concentration of 10-MDP.

In the present study, the mode of failure was predominantly cohesive failure for Group M (Figure 1) which directly reflects its capacity for bonding to zirconia, this is in agreement with the study of Elsaka[15] that showedpredominant mixed and cohesive failure within monolithic zirconia and Multilink Speed resin cement.Predominantly cohesive failure within resin cement was observed in Group P as when cement remnants are seen on both dentin and interior surfaces of the crown, this could be regarded as a cohesive failure in the cement indicating a high bond strength since it is assumed that the bond strength to the crown and dentin is higher than the tensile strength of the cement, this is in agreement with the study of Halabi et al[14] that showed predominantly cohesive failure within resin cement in Panavia V5 resin cement in comparison with adhesive failure at the interface of resin and dentin of Estecem II and Rely X Ultimate which seemed to be the weakest part of the bonded specimens.Also, predominantly adhesive failure for Group D that provided lowest bond strength, this result is in agreement with the study of Saryazdi et al[31]that revealed adhesive failure mode of Duo-Link Universal in comparison with cohesive failure within cement in RelyXUnicem 2 and Panavia F2.0.

Conclusions

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

1- MDP-containing primers enhanced retention strength of the resin cements to zirconia crowns.

2-Retention strength of Multilink Speed and Panavia V5 resin cements was significantly higher than Duo-Link Universal resin cement.

Table 1. Summarize (Mean ±SD) of retentive maximum load (N), surface area (mm^2) and retentive strength (MPa) of three differentgroups

Groups	Retentive maximum load (N)	Surface area (mm^2)	Retention strength (MPa)
Group M	422.00±78.48	155.61±16.28	2.71±0.45
Group P	390.95±50.43	158.10±13.91	2.47±0.41
Group D	216.85±67.44	152.91±8.76	1.42±0.23

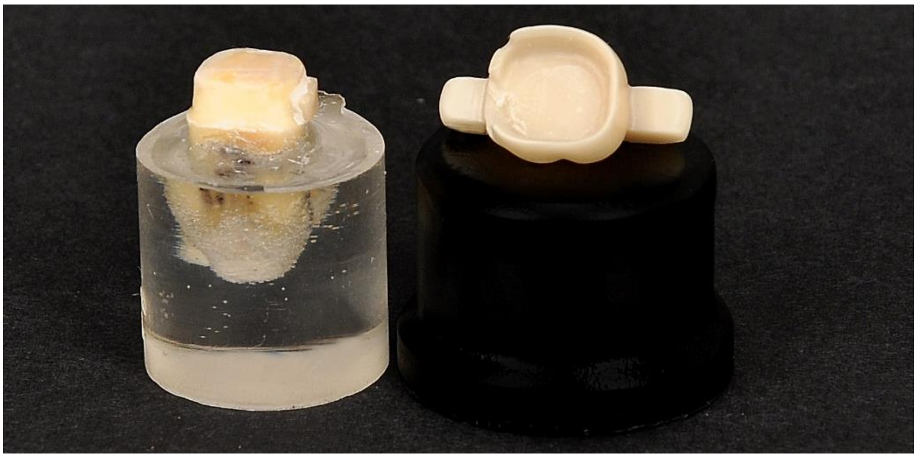

Figure 1. axial wall fracture of zirconia crown from Group M

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