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Study of the effect of 4 Primers on the Shear Bond strength of Non Translucent Zirconia Bonded with Resin Cement

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Abstract

Aim: Zirconia is the most widely used indirect restorative material in the present scenario. The luting of Zirconia is most commonly done in the traditional way by many dentists due to lack of reliable scientific data on the best materials and methods to lute Zirconia for its increased longevity. Though type I GIC is the preferred luting agent, reliable bonding between resin composite cements and Zirconia ceramics has been the advised luting agent. But it is difficult to achieve Zirconia-Resin bond because of their chemical inertness and lack of silica content that makes etching impossible. Purpose of this study was to compare and evaluate of Shear bond strength between Non Translucent Zirconia and Resin cement after surface treatment with 4 different Phosphate based bonding agents.

Material and methods: Zirconia substrates were used for bonding procedures. 128 samples were prepared. Presintered non translucent zirconia blanks were milled and sintered at 1600oC. Zirconia surfaces are surface treated with Monobond N (Ivoclar, VivadenT), AZ Primer (Shofu dental corporation, Germany.),Z Prime Plus (Bisco, Inc. Schaumburg, IL U.S.A.) and G Multi Primer(GC corp.japan). Resin stubs were prepared using flowable resin (Te Economy of, Ivoclar, Vivadent.) and are bonded to zirconia substrate. Samples are four groups groupMB, groupAZ, groupZP and GC.Shear bond testing is done using universal testing machine.

Results: Data was analyzed using SPSS version 23. Kolmogorov-Smirnov test was done to know the distribution of data weather normal or non-normal distribution. Descriptives, Independent t test was done to compare between material and One Way Anova with post hoc bonferrini and Tukey B test were done for comparison between various groups. There was significant difference in shear bond values between group MB, group AZ,group ZP & GC. Pair wise comparison showed significantly higher values for group GC.

Conclusion: Surface treatment of non-translucent zirconia with Phosphate based primers showed increase in bond strength in combination with air abrasion.

Keywords: Bonding Agents, Zirconia, Resin, Shear Bond Strength.

Introduction

Zirconia Ceramics are used in dentistry because of its aesthetic properties, ability to mimic natural teeth, chemical resistance, hardness and biocompatibility[1]. The demand for all-ceramic restorations led to the development of ceramic materials with optimized mechanical properties like densely sintered alumina and zirconia ceramics[2].

After cementation, Y-TZP restoration-resin and cement-dentin combine tightly to form a "sandwich-like" structure consisting of two bonding interfaces. Both these interfaces are important and methods have been developed to strengthen bonding at each of those interfaces.[4]

Unlike conventional cementation, the retention capacity of adhesive cementation is not just related to its physical properties but also to the adhesive quality of the cement to the preparation and intaglio surface of the crown. To overcome this problem continuous efforts have been done on the development of an effective surface treatment on zirconia for enhancing the resin zirconia integration. Silane coupling agents which are used to improve bonding of glasses and porcelains cannot be used for zirconia as zirconia do not contain silica[5].

One of the commonly used bonding agents in recent years is Monobond, which contain 10methacryloyloxy decyl dihydrogen phosphate (MDP) an organophosphate monomer. It has been reported that air-abrasion in combination with surface treatment with Phosphate based bonding agents could improve adhesion of zirconia. But there is lack of information about the effectiveness of these bonding agents. In this study, other than Monobond two other phosphate based primers are selected which contain phosphate monomer and carboxylate monomer and compared for shear bond strength.

Methodology

Y-TZP Non Translucent Zirconia Blank was used as the substrate for the bonding experiments. An STLfile ios created in EXOCAD software. Pre sintered zirconia blanks are milled and sintered at 1600^{o} C. The fully sintered specimens were of the size 8 mm x 6 mm x 39 mm. One of the surfaces of a fully sintered specimen is sandblasted with aluminium oxide particles in a sandblasting device.

Prior to the bonding procedure the surfaces were treated with commercially available bonding agents which are selected for the study. Bonding agents used were Monobond N (Ivoclar) , AZ Primer (Shofu), Z Prime Plus (Bisco) & GC Multi Prime(GC Corp). The blocks were divided into four groups, each block in the groups were surface treated by applying the bonding agent with applicator tip.

A flowable resin composite (Te Econom Plus, Ivoclar, Vivadent) was carefully packed into a cylindrical polyethylene mould and cured using a curing light which emitted blue light from light emitting diodes 20s in three different directions (top and two lateral sides) for a total exposure time of 60s. This created a resin stub (with a height of 4mm and a diameter of approximately 3.5mm) and the stubs were thereby bonded to the zirconia surface which is treated.

Each substrate allowed bonding of four stubs.

Fig. 1: Resin stubs bonded on zirconia substrate.

Shear Bond Strength Test: The shear bond strength is tested by using Universal testing machine. The samples are centred and the loading plunger is brought down at a crosshead speed of 1.0 mm/min with a constant load of 1000 N until the the resin stub separated. The Shearbond strength is calculated by the following formula: SBS = F/A

F – Force at which the separation occurred A – Cross – sectional area of the Resin stub.

Fig. 2: Sample testing

Results

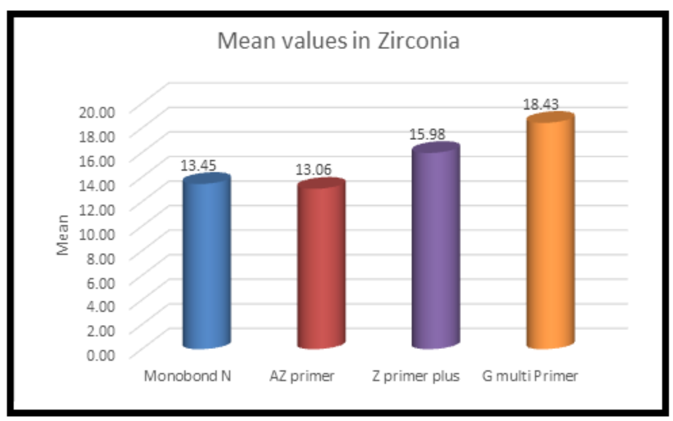
Data was analyzed using SPSS version 23. Kolmogorov-Smirnov test was done to know the distribution of data weather normal or non-normal distribution. Descriptives, Independent test was done to compare between material and One Way Anova with post hoc bonferrini and Tukey B test were done for comparison between various groups.

Table 1: Mean comparison of shear bond strength values among study groups

Group	N	Minimum	Maximum	Mean	Std. Deviation
Monobond N	32	10.09	21.00	13.45	2.78
AZ primer	32	10.31	16.13	13.06	1.67
Z primer plus	32	12.29	20.79	15.98	2.54
G multi primer	32	11.60	24.40	18.43	3.68

Table 1: Descriptive values of Shear bond strength in various groups of Zirconia

The above table shows the descriptive values of various groups in Zirconia ST group. In Monobond N group, the mean is 13.45 ± 2.78 N/mm^2, with a minimum value of 10.09 N/mm^2 and maximum of 21.0 N/mm^2. In AZ primer group, the mean is 13.06 ± 1.67 N/mm^2, with a minimum value of 10.31 N/mm^2 and maximum of 16.13 N/mm^2.In Z primer plus group, the mean is 15.98 ± 2.54 N/mm^2, with a minimum value of 12.29 N/mm^2 and maximum of 20.79 N/mm^2.In G multi primer group, the mean is 18.43 ± 3.68 N/mm^2, with a minimum value of 11.60 N/mm^2 and maximum of 24.40 N/mm^2.



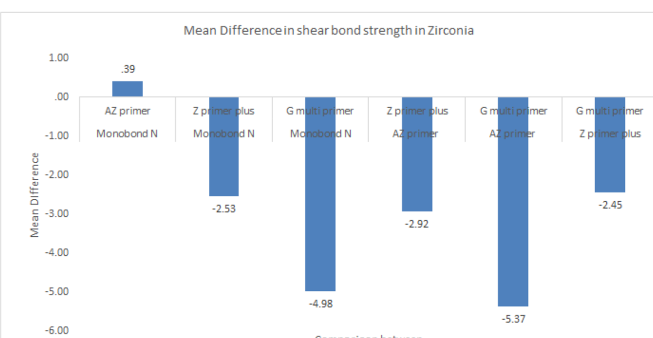
Graph: 1 Comparison of Mean Values among Study Groups

Table 2: Individual pair wise comparison of shear bond strength in Zirconia

Comparison between		Mean Difference	Std. Error	Sig	95% CI lower	95% CI upper
Monobond N	AZ primer	.39	.69081	1 NS	-1.4582	2.2463
Monobond N	Z primer plus	-2.53	.69081	0.002*	-4.3804	-.6759
Monobond N	G multi primer	-4.98	.69081	<0.001**	-6.8288	-3.1243
AZ primer	Z primer plus	-2.92	.69081	<0.001**	-4.7744	-1.0699
AZ primer	G multi primer	-5.37	.69081	<0.001**	-7.2229	-3.5184
Z primer plus	G multi primer	-2.45	.69081	0.003*	-4.3007	-.5962

**-Highly significant ($p<0.001$), *-Significant ($p<0.05$), NS- Not significant ($p>0.05$)

The above table shows the comparison of mean Shear bond strength in between various resin groups of Zirconia. The mean difference of Mean shear bond strength in comparison between Monobond N and AZ primer is 0.39 N/mm^2, in between Monobond N and Z primer plus is -2.53 N/mm^2, in between Monobond N and G multi Primer is -4.98 N/mm^2, in between AZ primer and Z primer plus is -2.92 N/mm^2, in between AZ primer and G multi primer is -5.37 N/mm^2 and in between Z primer plus and G multi primer is -2.45 N/mm^2. Post Hoc Bonferroni test was done to assess the significance between the comparisons. All the comparisons showed statistically significant difference in mean shear bond strength ($p<0.001$), except between Monobond N and AZ primer ($p=1$ NS)



Graph: 2 Mean differences in Shear Bond Strength

Zirconia

Table 3: Order of shear bond strength in Zirconia

Group	N	Subset for alpha = 0.05		
		Low	Medium	High
AZ primer	32	13.06		
Monobond N	32	13.45		
Z primer Plus	32		15.98	
G multi primer	32			18.43

The above table shows the order of mean shear bond strength in Zirconia with highest shear bond strength in G multi primer and least in AZ primer. Post Hoc TukeyB test was done to assess the order of significance. The order of Mean shear bond strength of zirconia is

AZ primer ≤Monobond N < Z primer plus < G multi primer.

Conclusions and Discussion

Zirconium-oxide ceramics are famous in their ability to withstand high fracture loads, but this also depends on a reliable adhesive bond[10]. A strong resin bond relies on chemical adhesion between the cement and ceramic, and on micromechanical interlocking created by surface roughening. Current roughening techniques are:

(1) Grinding, (2) abrasion with diamond rotary instruments, (3) air abrasion with alumina particles, (4) acid etching, and (5) a combination of any of these techniques. 8 The composition and physical properties of ZrO2 differ from conventional silica-based materials like

porcelain. Zirconia is not readily etched by Hydrofluoric acid and Phosphoric acid, and requires very aggressive mechanical abrasion methods to be used to zirconia surface, allowing for micromechanical interlocking of the resin cement[16]. Although there are studies indicating that air abrasion affects the surface of zirconia ceramic which leads to a reduction of the flexural strength of these ceramics, there are other authors who showed that air abrasion might even strengthen zirconia ceramics[17]. Some studies have evaluated ceramics with different microstructures, and reported that high strength ceramics are compact materials that are difficult to grit-blast[11]. Ozcan et al reported that surface roughness of zirconia samples was the highest with 50µm aluminium oxide sandblasting than that of silica coated samples, Scanning Electron Microscopy images (x500) showed rougher surface of sandblasted group compared to silica coated one[18].

Beatrice Jane Ho et al sandblasting at different distances and angles contributes differences in surface roughness when it comes to both zirconia and titanium materials. However, when it comes to the adhesive strength, there is a significant difference in strength for both titanium and zirconia materials at varying degrees but not varying the distance , sandblasting at 75° seems to be optimal to increase the adhesive strength[9].

Shane et al the film thicknesses of new adhesive luting agents. Resin cement met the ADA type II specification for film thickness of less than 40 µm[6.]

Levine et al after bonding more than 600 resin-bonded, acid-etched restorations with many different resin cements concluded that any resin cement with a film thickness of 40 µm or less shows no clinically perceptible occlusal discrepancies after the restoration is bonded in place[15]. Barceleiro et al analyzed the shear bond strength of feldspathic ceramic to bovine enamel luted with dual-cured resin cement and light- cured flowable composite. It was concluded that both luting agents presented similar results and that flowable composites are a suitable alternative when used for porcelain laminate veneer bonding, since these veneers are generally slim (less than 2 mm) and light polymerized luting agents can be light cured, providing satisfactory bond strength to these substrates[16].

The results of the present study are in consistent with Sadet Atsu et al who concluded the hypothesis of his study that the bonding could be increased by the application of a silica coating and an MDP–containing bonding/silane coupling agent mixture. The results of his study confirm the hypothesis that silica coating increases the bond strength between zirconium-oxide ceramic and a phosphate monomer– containing resin composite[7].

Treating the Y-TZP surface with Monobond N increased the bond strength in this present study. Nagaoka et al. evaluated the chemical interaction and the bond strength between MDP and zirconia; they found that the bond between 10-MDP and zirconia was not only ionic bonding, but also hydrogen bonding; as well they stated that the 10- MDP monomer could be adsorbed onto the zirconia particles via hydrogen bonding or ionic interaction between the P-OH and Zr-OH groups or between P-O− and partially positive Zr, respectively[20].

This affinity is explained by the capacity of the phosphate group to react with zirconium, forming zirconium phosphate, where each phosphate group is bound to three zirconium atoms (tridentate bridging mode) or to one zirconia atom (tridentate chelating mode), conferring a thermally and hydrolytically stable interface[19].

The other monomers contained in the primer, such as the carboxylic acid monomer, cooperate in the bond process.

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