



COMPARATIVE EVALUATION OF SHEAR BOND STRENGTH BETWEEN ZIRCONIA AND RESIN AFTER SURFACE TREATMENT WITH DIFFERENT PHOSPHATE BASED BONDING AGENTS"- AN INVITRO STUDY

Prosthodontics

Dr.L.Satya sri*	Post graduate student, Department of Prosthodontics,*Corresponding Author
Dr.K.Satyendra Kumar	Professor, Department of Prosthodontics,
Dr.R.Avinash	Sr.Lecturer, Department of Prosthodontics,
Dr.A.Kalyan Chakravarthy	Professor & HOD, Department of Prosthodontics,
Dr.B.Veerendra Prasad	Reader, Department of Prosthodontics,
Dr.V.Bhanu Chander	Sr.Lecturer, Department of Prosthodontics,

ABSTRACT

Aim: Purpose of this study was to compare and evaluate of Shear bond strength between Zirconia and Resin after surface treatment with different Phosphate based bonding agents.

Material and methods: Zirconia substrates was used for bonding procedures. 96 samples were prepared. Pre sintered zirconia blanks were milled and sintered at 1600°C. Zirconia surfaces are surface treated with Monobond N (Ivoclar,Vivadent), AZ Primer (Shofu, Shofu dental corporation, Germany.), Z Prime Plus (Bisco, Inc. Schaumburg, IL U.S.A.). Resin stubs were prepared using flowable resin (Te Econom flow, Ivoclar,Vivadent.) and are bonded to zirconia substrate. Samples are three groups group M, group AZ, group Z. Shear bond testing is done using universal testing machine.

Results: There was significant difference in shear bond values between group M, group AZ, group Z. Pair wise comparison showed significantly higher values for group M and group Z.

Conclusion: Surface treatment of zirconia with Monobond N and Z Prime plus showed increase in bond strength in combination with air abrasion

KEYWORDS

Bonding Agents, Zirconia, Resin, shear Bond Strength

INTRODUCTION

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.

II.METHODOLOGY

Y-TZP Blank was used as the substrate for the bonding experiments. an STL file ios created in EXOCAD software. Pre sintered zirconia blanks are milled and sintered at 1600° 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). The blocks were divided into three 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.

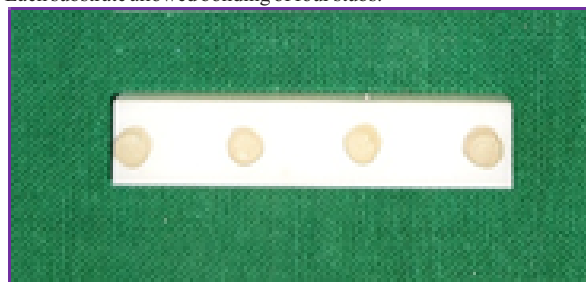


Fig : 1 Resin stubs bonded on zirconia substrate.

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 resin stub separated.

The Shear bond 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

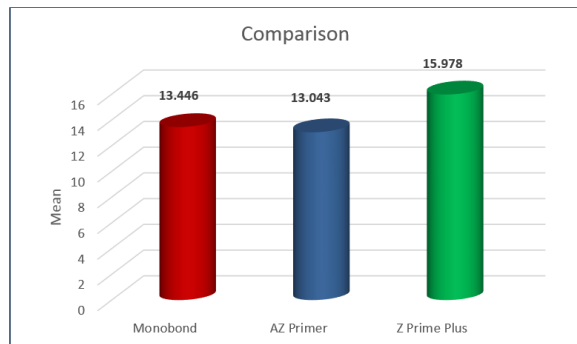
III.RESULTS

There was significant difference in bond strength values between the groups. Pair wise comparison of the groups showed group M (Mean-13.44), group Z (Mean -13.04), showed significantly high bond strength values than group AZ (Mean-15.97).

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

	N	Mean (N/mm ²)	Std. Deviation	Std. Error	F,df	p value*
Monobond	32	13.446	3.569	.892	4.40,2	0.018(S)
AZ Primer	32	13.043	1.808	.452		
Z Prime Plus	32	195.78	3.408	.852		
Total	96	14.156	3.247	.469		

F-one way ANOVA test statistic, df- degree of freedom; p – value – probability value; S- significant



GRAPH: 1 Comparison of mean values among study groups

IV.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 increase surface roughness.¹³

Neither etching with hydrofluoric acid nor a silane coupling agent is reliable in improving bond strength between zirconia ceramics and resin cements because of the high resistance of Zirconia to acids.¹¹ There are only a few studies on the bonding methods of zirconia ceramics to resin luting cements.¹²

Blatz et al assumed that Al₂O₃ abrasive particles removed any organic contaminants, produced an activated micro-roughened

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.⁵

Barcelheiro 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.

REFERENCES

1. Deepak Mehta, Rohit Shetty. Bonding to Zirconia elucidating the Confusion. International dentistry SA 2010;12 (2):1-7.
2. Ramez Shahin, Matthias Ker. Effect of air-abrasion on the retention of zirconia ceramic crowns luted with different cements before and after artificial aging. Dental materials 2010; 26 : 922–928.
3. Khalil Aleisa a, Khalid Alwazzan. Retention of zirconium oxide copings using different types of luting agents. Journal of Dental Sciences 2013;8: 392-398.
4. Haifeng Xiea, Qiao Lib. Comparison of resin bonding improvements to zirconia between one-bottle universal adhesives and tribochemical silica coating, which is better. Dental materials 2016;32(3):403-11.
5. Mehdi Karimipour-Saryazdi, DMD, Ramtin Sadid-Zadeh. Influence of surface treatment of yttrium-stabilized tetragonal zirconium oxides and cement type on crown retention after artificial aging. J Prosthet Dent 2014; 111:395-403.
6. Shane N White, Zhaokun Yub. Film thickness of new adhesive luting agents. J Prosthet Dent 1992;67:782-785.

7. Saadet Saglam Atsu, Mehmet A. Kilicarslan, H. Cenker Kucukesmen. Effect of zirconium-oxide ceramic surface treatments on the bond strength to adhesive resin. *J Prosthet Dent* 2006;95:430-6.
8. Jeffrey Y Thompson, Brian R. Stoner, Jeffrey R. Piascik, Robert Smith. Adhesion/cementation to zirconia and other non-silicate ceramics: Where are we now? *Dent Mater*. 2011;27(1):71–82.
9. Liang Chen and Byoung In Suh. Bonding of Resin Materials to All-Ceramics: A Review. *Current Research in Dentistry* 2012;3 (1): 7-17.
10. Tarek Salah and Shereen Nossair. "Effect of Surface Treatment Protocols on Bonding of Resin Luting Agents to Zirconia Based Ceramics". *Acta Scientific Dental Sciences* 2018;2(11): 54-62.
11. Kern M, Wegner SM. Bonding to zirconia ceramic: Adhesion methods and their durability. *Dent Mater* 1998;14:64–71.
12. Wegner SM, Kern M. Long-term resin bond strength to zirconia ceramic. *J Adhes Dent* 2000;2:139–147.
13. Luthardt RG, Holzhuter M, Sandkuhl O, Herold V, Schnapp JD, Kuhlisch E, Walter M. Reliability and properties of ground y-tzp-zirconia ceramics. *J Dent Res* 2002;81:487–491.
14. Barceleiro M de O, De Miranda MS, Dias KR, Sekito T Jr. Shear bond strength of porcelain laminate veneer bonded with flowable composite. *Oper Dent*, 2003;28(4):423-428.
15. Levine, W. A. An evaluation of the film thickness of resin luting agents. *J. Prosthet. Dent* 1989;62(2) 175-178.
16. Blatz MB, Chiche G, Holst S and Sadan A. Influence of surface treatment and simulated aging on bond strengths of luting agents to zirconia. *Quintessence Int* 2007;38(9):745–53.
17. Kosmac T, Oblak C, Jevnikar P, Funduk N, Marion L. The effect of surface grinding and sandblasting on flexural strength and reliability of Y-TZP zirconia ceramic. *Dent Mater* 1999;15:426–33.
18. Ozcan M, Melo RM, Souza ROA, Machado JPB, Valandro LF and Bottino MA. Effect of air-particle abrasion protocols on the biaxial flexural strength, surface characteristics and phase transformation of zirconia after cyclic loading. *J Mech Behav Biomed* 2013;20:19–28.
19. Pilo R, Kaitas V, Zinelis S, Eliades G. Interaction of zirconia primers with yttria-stabilized zirconia surfaces. *Dent Mater* 2016; 32(3):353-62.
20. N. Nagaoka, K. Yoshihara, V. P. Feitosa et al. Chemical interaction mechanism of 10-MDP with zirconia. *Scientific Reports* 2017;7:1-7.