

Comparing Shear Bond Strength of Ceramic and Dentin towards Three Different Luting Cements for All Ceramic Restorations- An In-Vitro Study

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Abstract- Many conventional types of luting cement are available for the dental clinicians to choose and restore luting of ceramic crowns. But not all the available luting cements are ideal for all situations. All ceramic restorations do benefit from resin cements bonding to the tooth. Hence it necessitates comparing the bonding ability of different luting cements to ceramic and dentin. The main objective of this study was to compare and evaluate the shear bond strength of three different luting cements to both ceramic and dentin and then to evaluate the mode of bond failure by scanning electron microscopy

Index Terms- Resin cements, bonding, all ceramics, shear bond strength, bond failure.

I. INTRODUCTION

Bonding between a fixed prosthesis and the supporting prepared tooth structure is provided by dental luting cements. The ideal property of luting cement includes fracture resistance, low solubility, and colour stability, adhesive bond to tooth structure, adequate working and setting time¹. Charles Land in 1886 developed the first all ceramic crowns which was popular as the porcelain jacket crown. For many decades it was the most aesthetic full veneer restoration dentistry had to offer². The clinical performance of all ceramic restorations is mainly influenced by the shape of tooth preparation and surface treatment of crown and abutment, type of luting agents and the adhesion between tooth structure and restorative material. However ceramic restorations are very brittle which results in debonding and fracture of the restoration³. This can be compensated by increasing the bond strength with tooth structure

While bonding ceramic to tooth structure, two different interfaces need to be considered: the dentin/cement interface and the ceramic/cement interface. If the adhesive seal in the above interfaces fails, it results in micro leakage jeopardizing the clinical performance and longevity of the restorations, leading to staining, recurrent caries, adverse pulpal response and postoperative sensitivity and finally the debonding of the restoration⁴. There are several variety of cements, each with advantages and disadvantages. Nevertheless, it is necessary to choose the right material from the various cements available for the long term service of the restoration. Hence the comparison of the bonding ability of different luting cements to ceramic and dentin is thus deemed necessary.

The aim, purpose and objective of this study was,

1. Evaluate and compare the shear bond strength of three different luting cements to ceramic and dentin on the universal testing machine.

2. Evaluate the mode of bond failure by scanning electron microscopy.

II. MATERIALS AND METHODS

IPS Empress 2 [Ivoclar vivadent, Germany] Ceramic disc specimens of 3mm diameter and width of about 2mm were fabricated. Intact, Non carious, human maxillary premolars extracted were collected and stored. Theteeth were then sectioned at cement-enamel junction with diamond disc at 90 degrees to long axis of the tooth and 2mm coronally to obtain tooth disc specimen of thickness 2mm with sufficient area of dentin. Plastic mounting plates (approximately 40mm X 4mm) with machined screw fittings were fabricated. Each pair has upper and lower plates. Upper plate has a bevelled area of 15mm in diameter and a hole of 3mm in diameter which will hold the ceramic disc specimen. The lower plate has a trough of about 8mm in diameter which holds the tooth specimen. The ceramic disc specimens were embedded in the upper plastic plate and the tooth specimens embedded in lower plate with auto polymerizing acrylic resin (Cast don, Dreve). To standardize the cement thickness, a Mylar strip was interposed between the specimens. Thirty disc specimens of all ceramic and dentin were fabricated and randomly divided into three groups of 10 each named as Group A, B and C.

GROUP A –LUTING WITH Glass ionomer cement

Surface of tooth specimen was treated with conditioning paste (proxyt paste,IvoclarVivadent,liechtenstien).Then ceramic and tooth specimen were luted with Type I GIC cement (Ketac cem glassionomer cement, 3M ESPE, USA)

GROUP B –LUTING WITH CALIBRA

Surface of the tooth specimen was etched with 37%phosphoric acid (Scotchbond, 3M ESPE, USA) for 15 seconds, rinsed for 10 seconds and gently air dried. Dentin bonding agent (Adper Single bond,3 M ESPE,USA) was applied and light polymerized for ten seconds. Surface of ceramic specimen was etched with 9% hydrofluoric acid (Ultradent Porcelain Etch) for twenty seconds followed by silane

application (Monobond S, Ivoclar Vivadent, Liechtenstien) and then luted with Calibra luting cement (Dentsply, USA) and plates were clamped with machined screws and light cured for twenty seconds.

was significantly higher than the mean value in Group A ($P < 0.05$) (Table.II).

GROUP C - LUTING WITH PANA VIA F2.0

Surface of the tooth specimen was etched with 37% phosphoric acid (Scotchbond, 3M ESPE, USA) for 15 seconds, rinsed for 10 seconds and gently air dried . Dentin bonding agent (Adper Single bond,3 M ESPE,USA) was applied and light polymerized for 10 seconds. Surface of ceramic specimen was etched with 9% hydrofluoric acid (Ultradent Porcelain Etch) for twenty seconds followed by silane application (Monobond S, Ivoclar Vivadent, Liechtenstein) and then luted with Panavia f 2.0 luting cement (Kuraray, USA) and light cured for twenty seconds.

III. TESTING PROTOCOL

An isotonic saline solution was prepared and all the specimens were immediately placed in it. The machined screws were removed after 1 hour. After 24 hours, the specimens of Group A, Group B and Group C were subjected for shear bond strength using Llyods universal testing machine. Shear load at failure was recorded in Newton’s and converted to stress in Megapascal. Then the fractured specimens were further evaluated for Scanning electroscopic examination. Specimens were sputter-coated with gold alloy and examined under SEM at 20kv and the specimens were viewed and photographed at original magnification(x 1000).

IV. RESULTS

The specimens were subjected to shear bond strength testing using universal testing machine (Llyods) (Table. I). Mean and standard deviation were estimated from the sample for each study group(Table. II).. Mean values were compared between different study groups by using One way ANOVA followed by scheffe’s multiple range procedure. In the present study , $P < 0.05$ was considered as the level of significance Scanning electron microscopic study was done on fractured specimens and mode of bond failure was analyzed .The results showed that the Mean value in Group C (16.65 ± 0.72) was significantly higher than the mean values in Group A (4.76 ± 0.37) and in Group B (14.85 ± 0.65) ($P < 0.05$) . Further, the mean value in Group B

TABLE - I
Shear bond strength of three groups

NO. OF SPECIMENS	GROUP A (mpa)	GROUP B (mpa)	GROUP C (mpa)
1	5.3	15.11	16.28
2	4.7	15.46	17.30
3	4.2	14.18	15.20
4	5.2	14.58	16.70
5	4.9	14	16.40
6	4.6	14.42	16.48
7	4.8	15	17.14
8	4.2	14.72	17.40
9	5.1	15.90	16.20
10	4.6	15.20	17.50

TABLE II
Mean, Standard deviation and Test of significance of mean values between three groups.

GROUPS	MEAN ± S.D	P- VALUE *	SIGNIFICANT GROUPS AT FIVE PERCENT LEVEL
A B C	4.76 ± 0.37 14.85±0.65 16.65±0.72	< 0.0001 Significant	C VS A , B VS A

V. DISCUSSION

The currently available most predominant highly aesthetic restorative material with optimal properties that can simulate the appearance of natural dentition is dental ceramics. Even though it has many advantages, ceramics are fragile under tensile strain. This weakness can be attributed to the presence and propagation of microflaws present on the surface of the material, making the ceramic susceptible to fracture, thereby making the cementation process very important for the clinical success of all ceramic restorations. The purpose of this study was to evaluate the shear bond strength of three different luting cements to both ceramic and dentin and then to evaluate the mode of bond failure by scanning electron microscopy. Due to its widespread popularity and usage, IPS Empress 2 is used in this study. IPS Empress 2 is a lithium disilicate, heat pressed all ceramic material

Human premolars extracted for orthodontic purpose were collected. It was then sectioned and mounted on plastic mounting plates with machined screw fittings. Mylar strips ensured uniform film thickness of 40 µm⁵. The luting agents selected for comparative evaluation were Glass ionomer cement and two commercially available resin cements- Panavia f2.0 luting cement (Kuraray, USA) and Calibra luting cement (Dentsply, USA). Glass ionomer cements were formulated in 1976 as a dental restorative material and has been in major use for more than 30 years for increased patient acceptance. These are primarily adhesive cements containing acid soluble calcium fluoroaluminosilicate glass and aqueous solution of polyacrylic acid in a concentration of about 0-50 % ⁶.

Dual cured cements are found to have higher hardness values when compared to chemically cured cements⁷.The major advantages of resin luting agents include increased bond strength when used in conjunction with silane coupling agents^{8,9,10,,} increases the fracture resistance of the tooth and the restoration itself and minimizes the microleakage due to better wettability and bonding to tooth structure ¹⁰.

In Group A (luted with GIC) – the dentin surfaces were surface treated with conditioning agent (proxyt paste Ivoclar Vivadent,liechtenstien) to remove the smear layer and surface debris. Its removal results in higher bond strength of dentin adhesives⁵. In Group B and C – the dentin surfaces were first acid etched with 20% phosphoric acid (Gluma etch 20 gel,

Hereaus Kulzer, Germany) to remove the mineral phase and increase the porosities of the tissues resulting in the formation of resin tags which are extension of adhesion resin in to open dentinal tubules⁶.This is followed by the application of dentin bonding agent to fill the resin tags and form a chemical bond between resin cement and dentin⁵.

According to Holand et al, the main crystal phase of IPS Empress 2 glass ceramic is formed by elongated crystals of lithium disilicate. A second phase is composed of lithium orthophosphate. A glass matrix surrounds both crystalline phases. Hydrofluoric acid removes the glass matrix and the second crystalline phase creating irregularities within the lithium disilicate crystals and thereby results in increased bonding¹¹. This is followed by silanization with Monobond S (Ivoclar Vivadent, Liechtenstein). Silane coupling agents enhances the formation of chemical bond between the inorganic phase of the ceramic and the organic phase of the resin and increases the wettability of ceramic surface⁶.Other methods of surface treatment of ceramics include sandblasting with 50µm aluminium oxide particles,surface roughening with coarse diamond bur, etching with 40% phosphoric acid solution ^{9,12}. In this in vitro study, the shear bond strength of conventional glass ionomer cements and 2 commonly used resin luting cements to IPS Empress 2 all ceramic and dentin was evaluated. Shear loading was performed using universal testing machine and maximum shear load at the point of failure was recorded. Shear bond strength were calculated by dividing the force at which the bond failure occurred by the specimen bonding area⁶. The results obtained were then statistically analyzed by one way analysis of variance (ANOVA). The testing was performed at a significant level of p – 0.05.

Maximum bond strength was obtained for Group C specimens followed by Group B specimens. Increased bond strength of Group C can be attributed to higher filler content of the cement compared with other cements¹³.Failure analysis through SEM examination revealed predominantly cohesive failures at the resin-dentin and ceramic-resin interfaces for both Group B and Group C luting cement in accordance with studies done by R.Janda(2002)¹⁴

These resin cements form a hybrid layer which is a molecular level mixture of collagen and resin polymers. It is formed by the diffusion of monomers that have been placed on the conditioned dentinal surface and subsequently polymerized in

situ (Nakabayashi 1982)15. Bond strength of both Group A was found to be inferior to that of both Group B and Group C. Although conventional glass ionomer cements has many advantages to its merit, lower bond strength was reported when compared to resin cements. On SEM examination, Glass ionomer cements exhibited cohesive failures at cement – dentin interface. This is due to the formation of chemical bond to tooth tissue by reaction with the calcium salts in the tooth structure7. But adhesive failures were predominant at cement/ceramic interface due to lack of chemical and mechanical union between glass ionomer cement and ceramic surface. This in vitro study allowed an immediate assessment of the bond created between the cement and the restorative material. It is acceptable, to compare the measured in vitro results obtained in a controlled environment. But, these tests cannot adequately simulate clinical situations with all the detail. The compulsive and final evaluation of material performance should be determined using long term clinical studies and trials.

VI. CONCLUSION

With the limitations of this study, it has been concluded that;

1. Maximum shear bond strength values were obtained for Panavia f2.0 resin cement followed by Calibra cement. Glass ionomer cement showed least bond strength values.

2. On SEM examination, the mode of failures seen was predominantly cohesive for both Calibra and panavia f2.0 resin luting cements at resin-dentin and resin-ceramic interface suggesting improved bond strength.

3. Glass ionomer cement showed cohesive failures at dentin-cement interfaces. However, adhesive failures were predominant at cement-ceramic interface suggesting inadequate bond strength with the ceramic surface.

REFERENCES

- [1] Stephen F.Rosenstiel, Martin F.Land And Bruce J. Crispin: Dental Luting Agents: A Review Of The Current Literature. J Prosthet Dent 1998 ;80:280-301. W.-K. Chen, Linear Networks and Systems (Book style).Belmont, CA: Wadsworth, 1993, pp. 123–135.
- [2] Herbert T. Shillingburg, Sumiya Hobo, Lowelld. Whitsett : Fundamentals Of Fixed Prosthodontics. Second edition, Quintessence Publishing Co. Inc Pg.483 – 484, 117-118. B. Smith, “An approach to graphs of linear forms (Unpublished work style),” unpublished.
- [3] Gokhan Akgungor, Begum Akkayan, Hubert Gaucher: Influence Of Ceramic Thickness An Polymerization Mode Of A Resin Luting Agent On Early Bond Strength And Durability With A Lithium Disilicate Based Ceramic System. J Prosthet Dent 2005; 94: 234-41.

- [4] M Turkun, E Cal, M Toman, S Toksavul:Effects Of Dentin Disinfectants On The Shear Bond Strength Of All Ceramics To Dentin. Oper Dent, 2005, 30-4,453-460.
- [5] Gregory P.Stewart, Poonam Jain, Jim Hodges: Shear Bond Strength Of Resin Cements To Both Ceramic And Dentin. J Prosthet Dent 2002; 88:277-84.
- [6] Kenneth J. Anusavice :Phillips’s Science Of Dental Materials eleventh edition, Saunders. Pg.684 -685, 472-473, 475, 383.
- [7] Wafa A. El-Badrawy, Omar M. El-Mowafy: Chemical Versus Dual Curing Of Resin Inlay Cements. J Prosthet Dent 1995; 73:515-24.
- [8] Nehir Ozden, Funda Akaltan, Gulsen Can: Effect Of Surface Treatments Of Porcelain On The Shear Bond Strength Of Applied Dual Cured Cement. J Prosthet Dent 1994; 72 : 85-8.
- [9] Mehdi Madani, Frederick C. S. Chu, Aible V. Mcdonald,Roger J. Smales: Effects Of Surface Treatments On the Shear Bond Strength Between A Resin Cement And An Alumina Core. J Prosthet Dent 2000;83: 644-7.
- [10] Alfredo Meyer Filtho, Luiz Clovis Cardoso Vieira, Elito Araujo, Sylvio Monteiro Junior: Effect Of Different Ceramic Surface Treatments On Resin Microtensile Bond Strength. J Prosthodont 2004; 13: 28-35.
- [11] Gilberto Antonio Borges, Ana Maria Sophr, Mario Fernando De Goes, Lourenco Correr Sobrinho: Effect Of Etching And Airborne Particle Abrasion On The Microstructure Of Different Dental Ceramics. J Prosthet Dent2003;89: 479-88.
- [12] Hideo Matsumura, Hidetachi Kato, Mitsura Atsuta : Shear Bond Strength To Feldspathic Porcelain Of Two Luting Cements In Combination With Three Different Surface Treatment. . J Prosthet Dent 1997; 78: 511-17.
- [13] R. R. Braga, P. F. Cesar , C. C. Gonzaga: Mechanical Properties Of Resin Cements With Different Activation Modes. J Oral Rehabil 2002, 29; 257-262.
- [14] R.Janda,J. F. Roulet,M. Wulf, H.J. Tiller: A New Adhesive Technology For All Ceramics. Dent Mater 19 (2003) 567-573.
- [15] Nakabayashi : Hybridization of dental tissues, Quintessence publishing Co. Inc. pg 23-24.

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