Effects Of Light Curing Bonding Agent With Dual Cure Cement On The Retention Of Zirconia And Lithium Disilicate Crowns: An In-Vitro Study.

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EFFECTS OF LIGHT CURING BONDING AGENT WITH DUAL CURE CEMENT ON THERETENTION OF ZIRCONIA AND LITHIUM DISILICATE CROWNS: AN IN-VITRO STUDY.

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A THESIS

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EFFECTS OF LIGHT CURING BONDING AGENT WITH DUAL CURE CEMENT ON THERETENTION OF ZIRCONIA AND LITHIUM DISILICATE CROWNS: AN IN-VITRO STUDY

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ABSTRACT

Objective: To measure and compare the bond strength of zirconia and lithium disilicate crowns bonded to human teeth (enamel and dentin) using universal adhesive with resin cement anddifferent light curing protocols.

Methods: Sixty extracted sound non carious human teeth (second premolars) were stored in formalternate solution (Formalternate™, Concentrate, 500 mL, Canada) and the roots werenotched and mounted into acrylic resin (Yates Motloid, USA). Flat surface preparation was doneon the occlusal surface of the samples using model trimmer. The surface area of the specimens was measured with digital light microscopy. Samples were randomly divided into six groups of 10 specimen each according to equal surface area. Specimens were scanned using IOS Trios 3 scan(3Shape Dental Desktop v1.6.4.1; 3Shape). A total of 30 fully sintered monolithic zirconia (3Y- TZP Zirlux 16+) crowns and 30 lithium disilicate crowns of uniform thickness (1.2mm) were designed and fabricated. Adhesive (Scotch Bond Universal; 3M Oral Care, St Paul, MN, USA) and dual-cure resin cement, Rely X Ultimate (RXU; 3M Oral Care) were used for bonding the zirconia and lithium disilicate crowns to natural teeth using three different methods: 1) light-curingof adhesive and cement, 2) light curing of adhesive through the crown, or 3) complete chemical- cure (no light cure). Each crown was seated with 15N of load and allowed to self-cure for 10 minutes. After water-storage (1 week, 37◦C) and thermocycling (5-55C for

10,000 cycles), the bond strength was measured using a universal testing machine. The crowns were gripped by handles on the side of the crown and debonded using a wire loop at a speed of 1mm/min. Pull offstrength (in megapascals) was analyzed with 2-factor ANOVA, separate single-factor ANOVA models for cure, and Tukey's Honestly Significant Differences multiple comparison procedure. Alltesting was performed at the 5% significance level (n=10).

Results: The 2-way ANOVA determined that factor “cure” was significante (p=.023) but factors “material” (p=.964) and their interaction (p=.935) were not. A separate 1-way ANOVA for factor “cure” determined that there were significant differences between groups (p=.019) and a Tukey's Honestly Significant Differences test revealed that the groups in which both adhesive and cementwere cured were significantly greater than the groups in which neither adhesive or cement were cured.

Conclusion: In conclusion, the results of the crown pull test suggest that separately light curing the adhesive and cement in zirconia and lithium disilicate restorations leads to higher bond strength compared to not light curing the adhesive of cement. This finding highlights the importance of carefully optimizing the light curing process during adhesive cementation procedures to ensure optimal bond strength and long-term clinical success.

Keywords: Adhesion, Light Cure, Cements, Zirconia, Lithium Disilicate

DEDICATION

I would like to dedicate this thesis to my incredible family and friends, whose unwavering supportand encouragement have been instrumental in my academic journey. To my parents, who have always believed in me and pushed me to reach for the stars, thank you for your endless love and sacrifices. To my siblings, for being my constant cheerleaders and for inspiring me to pursue my dreams, I am grateful beyond words. To my friends, who have stood by my side through the highsand lows, thank you for your unwavering loyalty and for bringing joy and laughter into my life. This accomplishment would not have been possible without each and every one of you, and I am forever grateful for your presence in my life.

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LIST OF ABBREVIATIONS

DC: Degree of Conversion GIC: Glass Ionomer Cement

RMGI: Resin Modified Glass Ionomer

10- MDP: 10-Methacryloyloxydecyl Dihydrogen Phosphate

Y-TZP: Yttrium-Stabilized Tetragonal Zirconia

CHAPTER 1

INTRODUCTION

Zirconium dioxide (ZrO_2), recognized as zirconia, is a white crystalline oxide of zirconium. Beingone of the most favorable restorative biomaterials, zirconia has been widely used in dentistry dueto its promising chemical and mechanical properties, optical benefits, and biocompatibility of yttrium-stabilized tetragonal zirconia (Y-TZP). [1][2]

Zirconia:

Zirconia is a very strong material being physically and mechanically similar to titanium. [3] Startingwith the first generation of 3Y-TZP (Y-TZP: yttria-stabilized tetragonal zirconia polycrystal) which was characterized with extraordinary flexural strength but reduced optical properties, threemore materials were introduced. [3] By reducing the Al_2O_3 content from 0.25 wt.% to 0.05wt.%, the second generation of 3Y-TZP zirconia presented a slight variation in the light transmittance degree. The tetragonal phase of the material becomes less stable due to lower content of alumina,it is therefore more liable to low-temperature degradation. Later, a third generation (5Y-TZP) was developed in 2015 fulfilling the demand of highly translucent zirconia. Like the first two generations, the 5Y-TZP is partially stabilized zirconia, except that it nearly contains 50% cubic phase in line with tetragonal phase. Because the mechanical properties for long span restorations were not met by the third generation of zirconia, a novel, fourth generation (4Y-TZP) having almost 30% cubic to tetragonal phase was developed. [3]

Not only is zirconia utilized as framework for all-ceramic crowns and bridges, but lately also as monolithic "full- contour" zirconia restorations. Primarily, one of the major limitations of dental zirconia remains the challenge of bonding it to tooth structure. If fully attainable, bonded zirconia would clearly limit the macro-retention necessity and therefore allow less invasive tooth preparation. A systematic review by Inokoshi et al. showed the most durable and effective bonding to zirconia are achieved by zirconia mechanical pretreatment utilizing the tribo-chemical silica sandblasting, which is the followed by chemically pretreating the surface with 10-MDP/silane primer before the actual luting procedure using a hydrophobic composite cement. [4]

Lithium disilicate:

Lithium disilicate glass ceramic (SiO2-LiO2) is highly recommended for various dental restorations due to its improved mechanical properties, which effectively withstand the forces generated during chewing. Additionally, it offers desirable optical properties, including color, gloss, value, and chroma, allowing for the closest possible resemblance to the natural nuances andpolychromatism of dentin and enamel. This makes it suitable for a wide range of applications, suchas veneers, anterior and posterior crowns, 3-unit fixed partial denture prostheses with the second premolar as a distal pillar, and frameworks for three-unit implant-supported bridges. [5]

In addition to this, the microstructure of lithium disilicate includes a glassy matrix rich in SiO2, which plays a crucial role in the widely accepted bonding technique of hydrofluoric (HF) etchingfor attaching it to tooth preparations. [5]

Cements:

Nowadays, glass ionomer (GIC) and resin-based cements are mainly selected to bond ceramic restorations to the remaining tooth structure. GIC and resin-modified GIC (RMGIC) are frequently used to cement acid-resistant ceramics. [6] Dental materials for indirect restorations luting primarilyhave to fulfil three requirements: (1) to seal the space between the indirect material and the prepared tooth; (2) to retain the restoration in place (retention) and prevent dislodging; and (3) to provide satisfactory aesthetical conditions for the indirect restoration [7]. Because of the improvedzirconia-luting techniques, the first choice of cements to lute zirconia-based restorations in the future may become composite cements, replacing the conventional glass-ionomer cements that arestill used nowadays for conventional cementation. [8] Depending on the polymerization initiation mode, composite cements can be classified into three categories; 1. Two-component self-curing orchemical composite cements; 2. Two-component dual-curing composite cements (curing both chemically and by light); 3. One-component solely light-curing composite cements. While the latter composite cements are usually used to cement porcelain veneers that are thin and transparent enough in order to transmit light, the dual-curing composite cements are suggested for thicker, more opaque, most frequently posterior restorations, where the cements also adequately cure in areas that are largely inaccessible for light. [8] As dual-cure materials combine the benefits of light -curing along with the chemical polymerization ability to compensate for the insufficient irradiation, they have become very popular. [9] However, it was reported that for the resin cements to reach the maximal degree of conversion (DC), light exposure is necessary. This is significant,since higher solubility and lower mechanical properties result due to the deficiency of polymerization in the self-curing modes of dual-cure resin cements. [9] Lower bond strength valuesin the self-curing mode compared with the light-curing mode were obtained in previous studies [10,11] and another study showed that even when a chemical initiator is added to an adhesive system, sufficient polymerization without light-curing was not obtained [12]. Because of the ambiguity in the results of the previous studies, this study is planned to evaluate different light curing protocols and determine which protocol will be most efficient in bonding zirconia crowns to human teeth (enamel and dentin) using universal adhesive.

CHAPTER 2

OBJECTIVE AND HYPOTHESIS

To measure and compare the retention of zirconia and lithium disilicate crowns bonded by a universal adhesive (Scotch bond Universal, 3M Oral Care) adhesive and dual cure resin cement (Rely X Ultimate, RXU; 3M Oral Care) to human extracted teeth following thermocycling using different bonding protocols.

The null hypothesis is:

The curing mode of the resin cement and universal adhesive will not affect the bond strength of zirconia and lithium disilicate crown to the prepared tooth.

CHAPTER 3

MATERIALS

The materials, methods and groups for this study are summarized in the following tables andassociated descriptions.

Instructions			
RelyX Ultimate	3M ESPE	Methacrylate monomers, radiopaque silanated fillers, initiators, radiopaque alkaline fillers,stabilizers, rheological additives, fluorescent dye,dual-cure activator for SBU.	Apply the mixed pasteto the restoration and press it to the tooth. Light-cure mode: Light-cure for 20 s per __ surface. Self-curing mode: Remove the excess paste and wait for 6 min after seating.
Scotchbond Universal	3M ESPE	10-MDP, DMA, HEMA, polyalkenoic acid, copolymer, silane, ethanol, water, filler, initiators.	1. Apply to the tooth and rub for 20 s. Gently air dry for 5 s. 2.7 3. Light cure 10 s (optional step with RXU).

Table 1: materials

CHAPTER 4

METHOD

Sixty extracted sound non-carious human teeth (maxillary/mandibular first/second premolars) were collected following IRB approval and stored in formalternate solution (Formalternate™, Concentrate, 500 mL, Canada). Samples were notched at the roots (to prevent debonding from mounting resin) and mounted into acrylic resin (Yates Motloid, USA).

Tooth preparation and measurement:

Flat surface preparation was done on the occlusal surface of the samples using model trimmer. The surface area of the specimens was measured with digital light microscopy (Keyence) using the internal measurement software. Samples were divided intosix groups of 10 specimen each according to equal surface areas.

Crown Fabrication:

Specimens were scanned using (3Shape Dental Desktop v1.6.4.1; 3Shape).A total of 30 samples of fully sintered monolithic zirconia 3Y-TZP and 30 samples of lithium disilicate of 1.2mm thickness copings were designed using 3shape Design Software (each containing mesial and distal "handles"). Zirconia (Zirlux16+, Henry Schein, shade A2) crowns were milled and sintered in the UAB 3rd floor dental lab. Lithium disilicate (IPS e.max, Ivoclar Vivadent, shade A2 LT) crowns were milled and crystallized in a Primemill (Dentsply Sirona) inthe Biomaterials laboratory.

Crown preparation:

The intaglio surfaces of zirconia specimens were roughened with 50 micro alumina sandblasting at 2 bar pressure for 10 seconds from a distance of 10mm and rinsed with water for 10 seconds followed by drying. The intaglio surfaces of lithium disilicate specimens were etched with 5% hydrofluoric acid (IPS Ceramic Etching Gel, Ivoclar) for 20 seconds and rinsed. Scotchbond Universal (MDP containing primer) was applied to intaglio of zirconia crownswithout light curing. Lithium disilicate crowns were treated with 1 coat of silane (Calibra Silane, Dentsply Sirona).

Bonding:

The teeth were rinsed and dried to leave moist dentin. No phosphoric acid was applied, followed by the application of the universal adhesive, SBU in the following manner: (20 seconds,agitation, 30 seconds then air dry). The adhesive was either cured or left uncured based on the different groups (described in next section). Dual-cure resin cements, Rely X Ultimate (RXU; 3MOral Care) was applied. Each crown was seated with 15N of load and the cement was either curedor left uncured based on the different groups (described in next section). All crowns were allowedto self-cure for 10 minutes.

Light curing:

The experimental groups involved 3 different "curing modes" all performed with the same light curing unit (3M™ Elipar™ Deep Cure-S LED Curing Light, wavelength range 340-480nm). Irradiance verified to be at least 1200mW/cm2 with a radiometer each day.

Groups

1. **Zr-LC-Both:** Application of SBU to tooth, light cure (20 sec), apply cement,

remove excess cement (using micro-brush), light cure through crown (40 sec).

2. **Zr-LC-Cem:** Application of SBU to tooth, NO light cure, apply cement, remove excess cement (using micro-brush), light cure through crown (40 sec).
3. **Zr-No-LC:** Application of SBU to tooth, NO light cure, apply cement, remove excess cement (using micro-brush), NO light cure.
4. **Emax-LC-Both:** Application of SBU to tooth, light cure (20 sec), apply cement, remove excess cement (using micro-brush), light cure through crown (40 sec).
5. **Emax-LC-Cem:** Application of SBU to tooth, NO light cure, apply cement, remove excess cement (using micro-brush), light cure through crown (40 sec).
6. **Zr-No-LC:** Application of SBU to tooth, NO light cure, apply cement, remove excess cement (using micro-brush), NO light cure.

Storage:

All samples were stored for one week at 37C in water. Specimens were then thermocycled for 10,000 cycles in thermocycler (5-55ºC 15 second dwell time).

Crown pretention:

The specimens were placed into a universal testing machine (Instron, Canton MA). A wire loop was attached to the load cell and used to grasp the zirconia crown handles (these wires self-levels the applied force). The crowns were debonded at a speed of 1mm/min. The maximum force used to debond the crowns was recorded. The maximum force was divided by thesurface area of the preparations to calculate the retention strength.

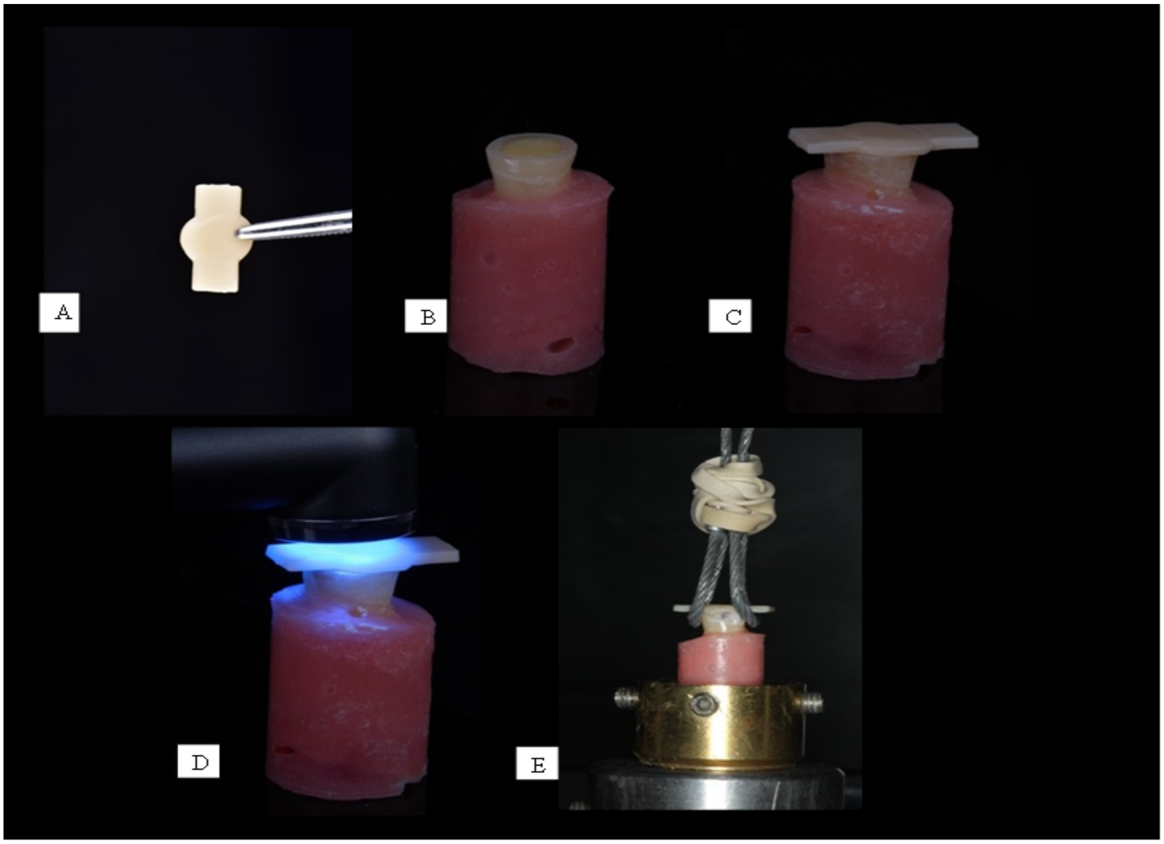


Figure 1 Shows different steps of the experiment done on the zirconia samples. (A)Milled Zirconia non anatomic crown. (B)Prepared flat tooth mounted into acrylic block. (C) Bonding of zirconia crown. (D) Light curing through zirconia crown. (E) Debonding using wire grasping the zirconia crown handles.

CHAPTER 5

STATISTICAL ANALYSIS

Pull out strength was analyzed with 2-factor ANOVA, separate single-factor ANOVA models for cure and material, and Tukey's Honestly Significant Differences multiple comparison procedure. All testing was performed at the 5% significance level (n=10).

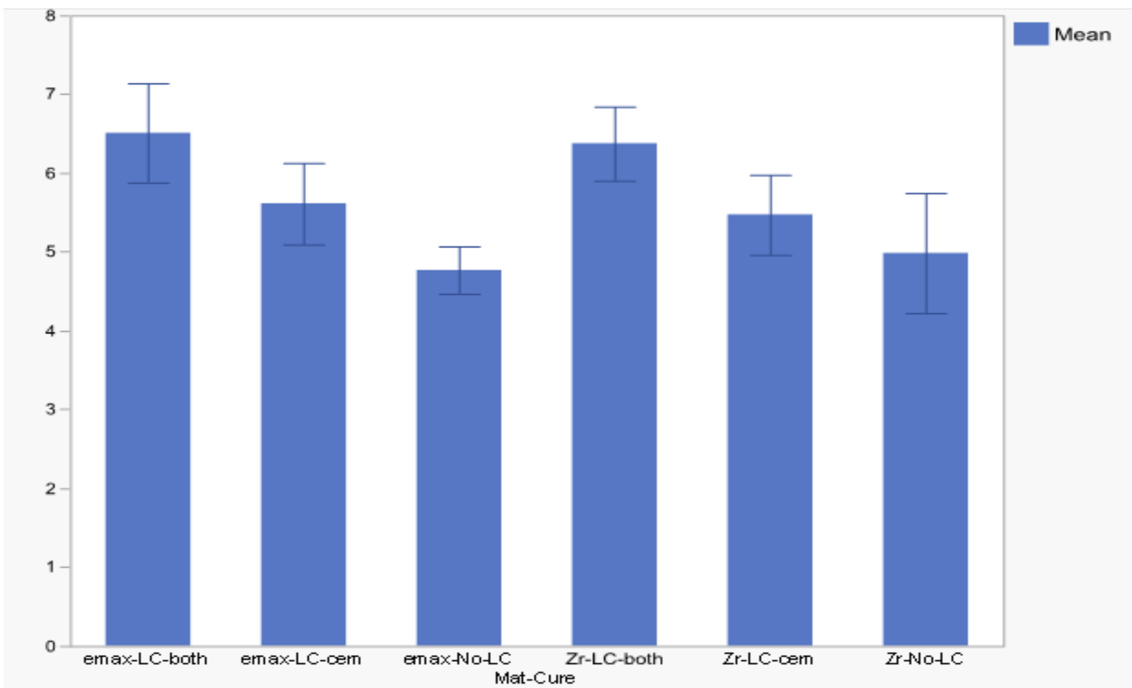
Materials were ranked into significantly different groups. Statistical analysis was completed with JMP Statistical Software (V.17). JMP (SAS Institute Inc., Cary North Carolina).

CHAPTER 6

RESULTS

Test results for the crown removal are summarized below. Mean and standard deviations of bonding strength for different groups are summarized.

Zirconia crowns with light cured both adhesive and cement showed the nominally highest pull-out strength with mean and standard deviation of 6.37+/-1.49 megapascals (MPa). Whereas lithium disilicate crowns left without applying light cure showed the least pull-out strength with the mean value of 3.81+/-2.14 MPa.



Graph1 Mean (Pull Strength) vs. Mat-Cure

Two Way ANOVA:

A 2-way ANOVA was performed for factors material (zirconia or lithium disilicate) and curingcondition (no light curing, light curing cement only, light curing adhesive and cement).

The 2-way ANOVA showed that material was not significant (p=.964), curing condition wassignificant (p=.023), but the interaction material*curing was not significant (p=.935).

RSquare	0.152623
RSquare Adj	0.060516
Root Mean Square Error	1.601243
Mean of Response	5.642614
Observations (or Sum Wgts)	52

Table 2: Summary of fit

Source	**DF**	**Sum of Squares**	**Mean Square**	**F Ratio**
Model	5	21.24294	4.24859	1.6570
Error	46	117.94306	2.56398	**Prob > F**
C. Total	51	139.18600		0.1641

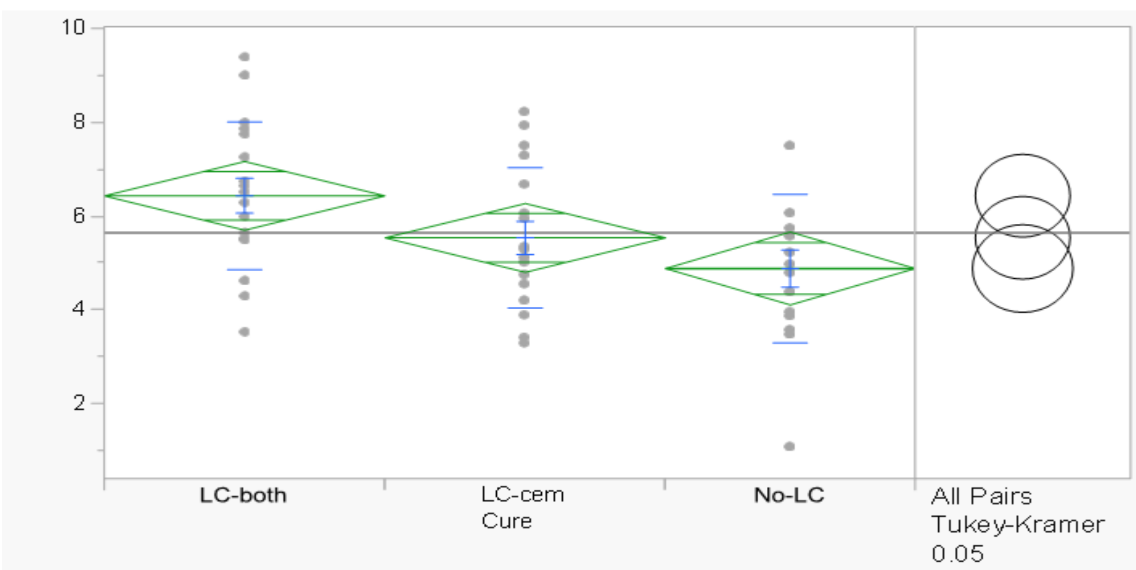
Table 3: Analysis of Variance

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Material	1	1	0.005236	0.0020	0.9642
Cure	2	2	20.928507	4.0813	0.0234*
Material*Cure	2	2	0.344632	0.0672	0.9351

Table 4: Effect Tests

One Way ANOVA by Cure:

Since the interaction was not significant, a post-hoc test was done to tell us which curing conditionshave statistically greater retention strength. Tukey test (table 10) shows that no light curing is notdifferent than light curing cement only. Also, Light curing only is not different than light curing both. But not light curing has lower retention strength than light curing both.



Graph 2: One-way Analysis of Pull Strength By Cure

Rsquare	0.150072
Adj Rsquare	0.115382
Root Mean Square Error	1.553784
Mean of Response	5.642614
Observations (or Sum Wgts)	52

Table 5: Summary of Fit

Source	**DF**	**Sum of Squares**	**Mean Square**	**F Ratio**	**Prob > F**
Cure	2	20.88798	10.4440	4.3260	0.0186*
Error	49	118.29802	2.4142		
C. Total	51	139.18600			

Table 6: Analysis of Variance

Level	Number	Mean	Std Dev	Std E rrMean	Lower 95%	Upper95%	Std Dev Lower 95%	Std Dev Upper 95%
LC-both	18	6.4337048	1.5787682	0.3721192	5.6486018	7.2188077	1.184688	2.3668008
LC-cem	18	5.5331087	1.4982507	0.3531411	4.7880462	6.2781712	1.1242687	2.2460935
No-LC	16	4.8758312	1.5867058	0.3966764	4.0303354	5.721327	1.1721073	2.4557306

Table 7: Means and Standard Deviations

	LC-both	LC-cem	No-LC
LC-both	-1.2518	-0.3512	0.2676
LC-cem	-0.3512	-1.2518	-0.6330
No-LC	0.2676	-0.6330	-1.3277

Table 8: HSD Threshold Matrix

Level			Mean
LC-both	A		6.4337048
LC-cem	A	B	5.5331087
No-LC		B	4.8758312

Table 9: *Connecting Letters Report*

Bond_str

Tukey HSD[a,b,c]

Curing	N	Subset 1	Subset 2
No LC	16	4.8758	
LC cement	18	5.5331	5.5331
LC both	18		6.4337
Sig.		.455	.234

Table 10: *Tukey Test*

CHAPTER 7

DISCUSSION:

In this study, the effect of the two experimental variables 'material' and 'curing mode' on the bond strength of bonded crowns was investigated. A null hypothesis of no difference in pull out bond strength between groups of zirconia and lithium disilicate cemented with dual cure resin cement was tested. Within the limitations of this study, the results demonstrated that the light curing the adhesive and cement separately in both the zirconia and lithium disilicate groups resulted in higher bond strength compared to no light curing. This finding suggests that the bonding process involving separate light curing of the adhesive and cement contributes to stronger bond strength in both materials. These findings are in agreement with previous studies (13,14), and they can be attributed to the higher DC of both the adhesive and resin cement after light irradiation.

The factor 'curing mode' significantly affected the bonding strength, by which the null hypothesis was partially rejected. The highest bonding strength in both zirconia and lithium disilicate crowns was achieved when the adhesive and cement were light cured separately and consecutively, with the restored teeth being exposed from the top surface. This finding is corroborated by a study from Asmussen and Peutzfeldt (15), who recorded a higher bond strength after dual-curing as compared to solely self-curing of composite cements.

Based on the findings of the present study, the mean crown retention values ranged from 4.76 MPa (Emax-No-LC) to 6.5 MPa (Zr-LC-both) after subjecting the crowns to 10,000 thermal cycles at temperatures of 5°C and 55°C. Light curing both the adhesive (SBU) and the dual cure resin cement (RelyX Ultimate) separately in both lithium disilicate and zirconia crowns resulted in higher retention strength compared to light curing the cement only in both material groups. However, these differences were not statistically significant. On the other hand, there was a statistically significant difference when comparing the groups that received light curing for both the cement and adhesive versus those that did not receive any light curing.

Finally, autocuing both the adhesive and the resin cement exhibited the significantly lowest bonding strength for both lithium disilicate and zirconia crowns.

In terms of the ranking of the groups, irrespective of the material being zirconia or lithium disilicate, the groups can be arranged in descending order as follows: LC-both > LC-cem > No- LC.

These findings indicate that the use of light curing for both the cement and adhesive can potentially improve crown retention strength, but the choice of specific materials did not significantly impact the results.

Dual-cure resin cements have been suggested as suitable choices for the cementation of indirect restorations due to their ability to offset the limitations of inadequate light irradiation(16). Nevertheless, prior research has indicated that the polymerization process of dual-cure resin cements is suboptimal when light curing is absent. This deficiency in polymerization may lead to diminished mechanical properties, increased postoperative sensitivity, as well as issues such as microleakage and recurrent caries. Additionally, self-curing has been associated with reduced bond strengths of adhesives to dentin. To address these concerns, recent advancements in material development have incorporated innovative polymerization accelerators that initiate the polymerization reaction upon contact between the adhesive and the corresponding resin cement. (17)

A study conducted by Hodges et al. to examine the influence of dual-cured adhesives on the bond strength of dual-cured resin cement to dentin under various polymerization conditions. The findings of their study align with this research, demonstrating that different dual-cured adhesives displayed diverse performances. Notably, Clearfil SE Bond 2 exhibited significantly enhanced results when both the adhesive and cement were subjected to light curing. In contrast, the impact of different combinations of light-curing and self-curing techniques was less pronounced with ExciTE F DSC or Universal Primer. It is worth emphasizing that when neither the adhesive nor the cement underwent light curing, all three adhesives exhibited inadequate performance, leading to a notable reduction in bond strength (18).

Prior to the bonding procedure, the abutments were immersed in a PBS water bath at a temperature of 37°C to simulate the oral environment accurately. This temperature was selected as it can potentially enhance the polymerization process of the resin cements.

By applying light to the adhesive and cement separately, each component can undergo sufficient curing, leading to improved bond strength. This is particularly relevant for zirconia and lithium disilicate, which are widely used materials in restorative dentistry. Additionally, the separate light curing approach may provide better control over the polymerization process. By curing the adhesive and cement independently, any potential interference between the materials during the curing process can be minimized. This reduces the risk of incomplete polymerization or compromised bond strength that could occur when the materials are cured simultaneously.

The light attenuation through indirect restorations during adhesive cementation is a crucial factor that must be taken into account. This attenuation depends on various characteristics of the restoration, such as its thickness, color, chemical composition, structure, presence of defects, porosity, or pigments. The current study found no significant difference in the curing modes of the adhesive using lithium disilicate and zirconia crowns, contrary to previous studies that have shown variations in the effect of light on the polymerization process of dual-cured resin cements depending on the specific materials used. (19)

In several cases, additional light curing has shown positive effects on the modulus of elasticity of these materials and the bond strength to various dental ceramics, including aluminum oxide, leucite-reinforced, lithium disilicate, and zirconia ceramics. However, there is currently no consensus on the optimal radiant exposure required for adequate polymerization of these materials. (20)

In previous studies performed on bond strength of zirconia and lithium disilicate, different loading weight on the cement has been used, 50N, 750g, 15 N (21,22,23). When cementing zirconia and lithium disilicate crowns to teeth in this study, a standardized 15Ncm seating load was applied. Normally this should result in a uniform cement space for all specimens which will not influence the results. In addition, this study utilized airborne-particle abrasion as a bonding protocol for both lithium disilicate and zirconia ceramic surfaces. A study conducted by Piwowarczyk et al, which concluded that the highest shear bond strength was achieved when the ceramic surface was subjected to airborne particle abrasion and resin cements containing methacrylates with phosphoric acid were used (24).Similarly, another study by Piwowarczyk et al evaluated the shear bond strengths of various cements and found that the application of airborne particle abrasion yielded the highest bond strength values when using resin cements (25).These findings collectively emphasize the significant impact of airborne particle abrasion on enhancing the bond strength between ceramic surfaces and resin cements.

The results of our study revealed a surprising finding, as the mean values for bonding zirconia were found to be similar to those for bonding lithium disilicate. This is contrary to the prevailing notion that zirconia, being a more inert and more resistant to aggressive chemical agents (strong acids, alkalis, organic and inorganic dissolving agents), would exhibit weaker bond strengths compared to silica-based ceramic materials. However, Kansal et al conducted a study to assess the impact of various resin cement types on the shear bond strength between high strength ceramics and cut dentin following thermocycling. The results of their study contradict previous studies that have indicated zirconia exhibits higher shear bond strength, both with and without thermocycling, compared to lithium disilicate. (26)

Additionally, it is important to note that during the adhesive cementation of indirect restorations, the adhesive and resin cement at the outer restoration margins are typically adequately light cured. This leads to the prompt sealing of the outer restoration margins, effectively protecting the adhesive and composite cement from external water infiltration. Consequently, the degree of conversion (DC) in these distant areas can gradually increase over time.

Pekkan and Hekimoglu and Strub and Beschnidt(27) who suggested that the polymerization of dual- polymerizing resin cement is not complete until after 1 week of placement. Hence, bond strength evaluations were performed 1 week after specimen preparation, assuming the polymerization of the resin cement to be complete, and the maximum bond strength would have been achieved.

The relatively low pH (2.7; according to technical information provided by 3M ESPE) of SBU may thus have interfered with the auto-cure of the composite cement. Indeed, auto-cure polymerization is known to be affected by acidic one-step self-etch adhesives due to inactivation of the amine initiator through acid-base reaction.

On the other hand, light curing the cement only and no light cure are associated with lower bond strengths in this study. This could be due to incomplete polymerization of the cement, leading to weaker bonding properties. Insufficient light exposure or inadequate light penetration may result in inadequate conversion of the cement's resin matrix, compromising the overall bond strength. (It is important to note that these findings are specific to the crown pull test conducted in this study. The results may vary depending on the specific adhesive and cement materials used, the light curing protocols employed, and other factors such as surface treatment of the restoration and tooth structure.

CHAPTER 8

LIMITATIONS:

1. No load cycling: One limitation of the study is the absence of load cycling, which is a dynamic mechanical stress simulation that replicates chewing forces. Load cycling is important as it can affect the bond strength between ceramics and dentin in a more realistic manner. The lack of load cycling in the study may limit the generalizability of the findings to real-life conditions.
2. Low sample size: Another limitation is the relatively small sample size used in the study. A small sample size may reduce the statistical power of the study and limit the ability to detect significant differences. Increasing the sample size would enhance the reliability and robustness of the results.
3. Lack of long-term evaluation: The study example does not mention the evaluation of the pull- out bond strength over an extended period. Long-term evaluations are important to assess the durability and stability of the bond between ceramics and dentin. The absence of long-term data limits the understanding of the long-term performance of the tested resin cement types.

CHAPTER 9

FUTURE STUDIES:

Could address the limitations mentioned and further contribute to the understanding of shear bond strength in high strength ceramics and dentin bonding. Here are some potential directions for future research:

1. Load cycling: Conducting studies that incorporate load cycling would provide a more realistic simulation of the oral environment. Investigating the effects of cyclic loading on the shear bond strength between ceramics and dentin can help determine the long-term stability and durability of the bond.
2. Increased sample size: Increasing the sample size in future studies would enhance the statistical power and improve the generalizability of the findings. Including a larger and more diverse sample population would provide a more representative assessment of the shear bond strength between high strength ceramics and dentin.
3. Comparative evaluation of resin cement types: Comparing a wider range of resin cement types would provide a more comprehensive understanding of their influence on shear bond strength. Including a variety of commercially available resin cements and assessing their performance in bonding high strength ceramics to dentin would help identify the most effective options.
4. Long-term evaluation: Conducting long-term evaluations of shear bond strength is essential to assess the stability and durability of the bond over time. Future studies

could consider extended follow-up periods to investigate the performance of different resin cement types beyond short-term assessments.

CHAPTER 10

CONCLUSION:

In conclusion, the results of the crown pull test suggest that separately light curing the adhesive and cement in zirconia and lithium disilicate restorations leads to higher bond strength compared to light curing the cement only or no light cure. This finding highlights the importance of carefully optimizing the light curing process during adhesive cementation procedures to ensure optimal bond strength and long-term clinical success. Further research and clinical trials are recommended to validate these findings and explore the optimal light curing protocols for different restorative materials and clinical scenarios.

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