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Shear Bond Strength of Resin Cement with Color Indicator vs Conventional Resin Cement (*In-vitro* study)

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ABSTRACT

Aim: This in vitro study was conducted to compare shear bond strength (SBS) of resin cement with color indicator vs conventional resin cement. **Methods:** 40 zirconia blocks were prepared, 40 bovine incisor teeth were gathered, roots were separated from crowns, each crown was mounted on self-cure acrylic resin, enamel was entirely removed from crowns to expose dentin, zirconia blocks were luted to the exposed dentin surfaces, divided into two groups based on the cement that was used (n=20): Group I – was luted with Conventional resin cement(Maxcem Elite™) and Group II – was luted with Resin cement with color indicator (Maxcem Elite Chroma™), each group was subdivided into two subgroups according to with or without thermocycling(TCs) (n=10). SBS test was conducted by a universal testing machine with a crosshead speed of 1.0 mm/min using a mono-beveled chisel. Data was collected and IBM® SPSS® Statistics Version 20 was used for analysis. The significance level was established at $P \leq 0.05$. **Results:** Higher mean of control group I (3.90MPa±0.45) than group II (3.07MPa±0.93) with no statistically significant difference between them (p=0.111) and higher mean of thermocycled group I (2.66 MPa ±0.79) than group II (2.57MPa ±1.05) with no statistically significant difference between them (p=0.873). **Conclusions:** There was no difference in shear bond strength between Maxcem Elite™and Maxcem Elite Chroma™and thermocycling decreased shear bond strength.

Keywords: Shear bond strength, thermocycling, resin cement, conventional resin cement.

1. Introduction

The application of all-ceramic restorations in clinical dentistry has grown because they offer superior mechanical performance along with excellent aesthetics. The establishment of a strong bond between ceramic restoration and tooth structure is a critical factor in determining their clinical success. Both traditional and resin-based adhesive techniques can be used to lute all-ceramic restorations, however adhesive cementation is preferred in order to produce a strong and stable bond (Lima *et al*., 2019).

With the development of adhesive dentistry, restorative procedures may be carried out with less tooth preparation, protecting the dental substrate and increasing the lifespan of the restoration. By enhancing retention and lowering solubility, resinous luting agents have enhanced indirect restoration, so strengthening the restoration and the tooth structure (Miotti *et al*., 2020).

Self-adhesive resin cements bond to the teeth without the need for an additional adhesive or etchant. Acid functional monomer is an essential ingredient in self-adhesive resin cements. Although these cements cannot completely dissolve or demineralize the smear layer to achieve mechanical

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retention, they can effectively form a chemical bond with the tooth through the acid-base reaction. When compared to other multistep resin cements, the effects of self-adhesive resin cements were satisfactory (Sun *et al*., 2018).

Both the removal of excess cement and the timing of that removal are crucial. It might be challenging to judge when it is best to remove excess cement, however some manufacturers provide a color cleanup indicator to help with this decision. Any excess material can be safely removed once the indicator's color has faded, and light curing will then produce the ultimate bond strength between the tooth and restoration (Niemi *et al*., 2020).

Artificial aging variables such as temperature, humidity and ultraviolet light have been utilized to assess the stability of color in dental restorations under mimicked clinical situations. Thermocycling is a popular in vitro aging technique that simulates temperature changes in a humid oral cavity (Yamali *et al*., 2023).

The study aimed to compare shear bond strength of resin cement with color indicator vs conventional resin cement.

2. Materials and Methods

2.1. Ethical consideration

This study was approved by Ethics Committee of Faculty of Dentistry, Minia University RHDIRB2017122004 under the protocol number (803), 2023. All steps of the study were caried out regarding to this protocol.

2.2. Grouping and Samples preparation

Forty sample of zirconia were luted to dentin crown surface and divided to 2 group according to the cement that was used(n=20), each cement group was subdivided -according to the use of thermocycling or not- into 2 subgroup (n=10). The materials, brand name, description, Composition, manufacturer and batch number were represented in (Table 1).

Table 1: Materials used in this study**.**

Brand name	Description	Composition	Manufacturer	Lot No.
Maxcem Elite™ Universal Resin Cement	A dual cure, self-etch/self-adhesive cement.	Methacrylate esters, GPDM, UDMA, HEMA, Mineral fillers and ytterbium fluoride (filler load 69% weight), activators, and stabilizers.	Kerr dental Corporation, California, USA.	**9526700#**
Maxcem Elite™ Chroma Universal Resin Cement with Cleanup Indicator	A dual cure, self-etch, adhesive cements. dispenses pink before fading at the gel state — indicating the optimal time to clean up excess cement.	Methacrylate ester monomers, GPDM, 1,1,3,3-tetramethylbutyl hydroperoxide (TEGDMA), HEMA, GDM, UDMA, proprietary self-curing redox, camphorquinone, fluroaluminosilicate glass filler, silica, barium glass filler, (filler load 67% weight), activators, stabilizers.	Kerr dental Corporation, California, USA.	**9259309#**
UPCERA HT White zirconia block	UPCERA HT WHITE high translucent zirconia blanks.	$ZrO_2 + HfO_2 + Y_2O_3 \geq 99$; Y_2O_3 4.5-6; $Al_2O_3 \leq 0.5$; other oxides ≤ 0.5%	UPCERA, CHINA.	**L2221111002-086(98-18) #**

Acrostone acrylic material	Self-cured acrylic resin.	Powder: polymethyl methacrylate (PMMA) and a small amount of benzoyl peroxide as an initiator. Liquid: methacrylate with a trace of hydroquinone as an inhibitor.	Acrostone dental &medical supplies, Egypt.

2.3. Specimen's preparation:

2.3.1. Zirconia blocks preparation

A total of forty zirconia blocks measuring 2 mm × 3 mm × 5 mm were milled using an isomet (Isomet 4000, BUEHLER, Germany). After being sintered at 1530°C, they were sandblasted for 15 seconds at 0.25 MPa using 50 µm aluminum oxide particles and then they were glazed (Vivek *et al*., 2022).

2.3.2. Teeth preparation

Forty bovine incisor teeth were gathered, cleaned and kept at 4°C in a 0.1% Thymol solution until they were prepared. Under running water, a low-speed air turbine handpiece with a wheel-shaped disc was used to separate the roots from the crowns. According to Rodrigues *et al*. (2015), all crowns were placed on self-cure acrylic resin within a 48 mm × 24 mm × 10 mm mold for easier handling and testing. The dentin was exposed through the complete removal of enamel from the crowns using a diamond wheel-shaped disc. The dentinal surface was smoothed using a 600-grit followed by a 1000-grit silicon carbide paper. An ultrasonic instrument (HOUSEHOLD ULTRASONIC CLEANER, VGT-800, CHINA) was used to clean the samples.

2.3.3. Aging and test procedure

Zirconia blocks were luted to the exposed dentin surfaces by using custom made loading device (5kg), divided into two groups based on the cement that was used (n=20): Group I was luted using conventional resin cement, while Group II was luted using resin cement with color indicator. Both groups were polymerized for ten seconds using an LED light curing unit (Woodpecker, light cure, LED.D, China), in accordance with the manufacturer's instructions. Each group was subdivided into two subgroups according to with or without thermocycling (n=10). samples were stored in 37°C distilled water for 24 hours in the dark for the control subgroup, while thermocycled subgroup samples were artificially aged for 1000 TCs at 5°C and 55°C with a 30-second dwell period in the thermocycler device (SD Mechatronic thermocycler, Germany). Using a mono-beveled chisel that delivered pressure until failure, SBS test was carried out by a universal testing apparatus at a crosshead speed of 1.0 mm/min (Yang *et al*., 2022).

(A) **(B)** **(c)**

Fig. 1. (A) Zirconia sample, B) Crown embedded into acrylic resin and C) zirconia block luted with dentin surface by loading device.

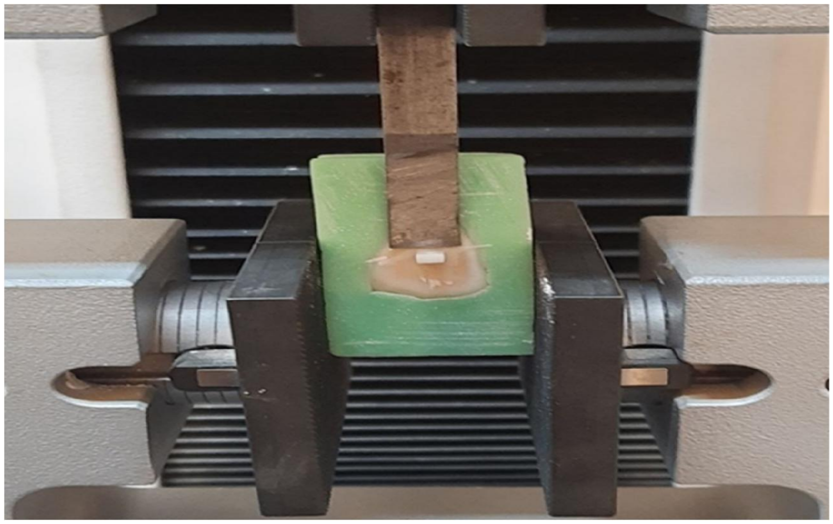

Fig. 2. Load applied to Sample in universal testing machine.

2.4. Statistical analysis

Data was collected and analyzed with IBM® SPSS® Statistics Version 20 for Windows. After the data were checked for normality using the Shapiro- Wilk and Kolmogorov-Smirnov tests, a parametric (normal) distribution was found. In unrelated samples; the independent sample t-test and the one-way ANOVA test were used to compare the two groups and more than two groups respectively. In related samples; the paired sample t-test and Two-way ANOVA were used to compare two groups and to assess the effect of the interactions between different variables respectively. A significant level $P < 0.05$ was established.

3. Results

Comparing the statistical results of both groups I and II the data revealed that there was no statistically significant difference between control (Group I) and (Group II) where (p=0.111). The mean value of control Group I (3.90 MPa ±0.45) higher than mean value of control Group II (3.07MPa±0.93) and there was no statistically significant difference between thermocycled (Group I) and (Group II) where (p=0.873). The mean value of control Group I (2.66 MPa ±0.79) higher than mean value of control Group II (2.57 MPa ±1.05).

Within each group; Maxcem Elite^{TM} (Group I); the statistical results revealed that Shear Bond Strength (SBS) value was (3.90 ± 0.45) for control sub group and (2.66±0.79) for thermocycled sub group. There was a statistically significant difference between (Control) and (Thermocycled) where (p=0.016). Regarding Maxcem Elite^{TM} Chroma (Group II); the statistical results revealed that Shear Bond Strength (SBS) value was (3.07±0.93) for control sub group and (2.57±1.05) for thermocycled sub group. There was no statistically significant difference between (Control) and (Thermocycled) where (p=0.443) as shown in Table 2 and Figure 3.

Table 2: The Shear bond strength values of control and thermocycled of group I and II.

Variables	Shear bond strength (MPa)				p-value
	Group I		Group II		
	Mean	SD	Mean	SD	
Control	3.90	±0.45	3.07	±0.93	0.111ns
Thermocycled	2.66	±0.79	2.57	±1.05	0.873ns
p-value	0.016*		0.443ns		

*; Significant (p<0.005) ns; Non-significant (p>0.005)

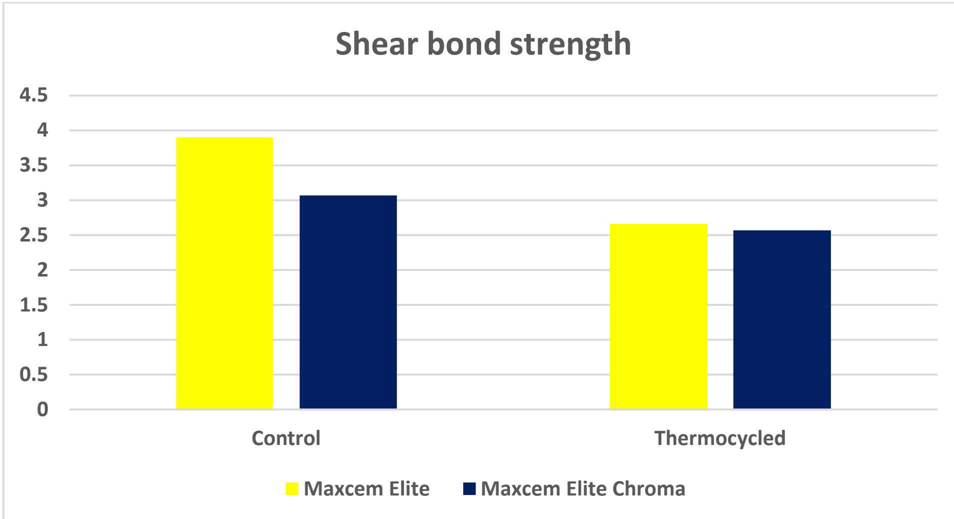

Fig. 3. Bar chart show shear bond strength (SBS) values of Group I and Group II

4. Discussion

One of the most important clinical aspects of ceramic reconstruction is providing a good bond strength between ceramic surface and tooth tissues. The strong adhesion achieved by proper cement selection. So durable ceramic-tooth tissue connection depends on chemical bonding and micromechanical interlocking (Malysa *et al*., 2022).

Self-adhesive resin cement is being used more frequently due to the convenience of single-step cementation, reduced procedural sensitivity and decreased postoperative sensitivity. This new type of resin cement was developed to overcome some drawbacks of both traditional cements and conventional resin cements. Because they combine the convenience of handling of traditional cements with the good mechanical properties, bonding strength and aesthetic of conventional resin cements, they have a wide range of applications. Because self-adhesive resin cement contains acidic monomers in its composition, it eliminates the need for separate etchant, primer and adhesive steps in the bonding process (Ling *et al*., 2022).

Resin Cement with Cleanup Indicator was used in this study dispensed pink before fading at the gel state — indicating the optimal time to clean up excess cement as its difficult although material manufacturers offer time estimates. A color cleanup indicator is provided by certain manufacturers to help determine when it is best to remove excess cement. The manufacturer states that it is safe to remove any excess material once the indicator's color has faded. Light curing is then used to get the ultimate bond strength between the restoration and the tooth material. (Niemi *et al*., 2020).

It was challenging to find enough human teeth with no caries that came from the same environment. Unlike human teeth; bovine teeth available, has bigger flat area on their labial surface, lack of cavities and originate from similar regions and environments so utilized in this study instead of human teeth, resulting in a more accurate reading for shear bond strength (Ishak *et al*., 2021).

The bond strength between zirconia and cement has been measured using a variety of methods, including macroshear, microshear, macrotensile, and microtensile tests. Moreover, thermocycling at various cycle, temperatures, dwell times and at short- and long-term water storage, are techniques to assess bond stability by mimicking oral circumstances (Comino-Garayoa., *et al*., 2021).

The macroshear test was used in this study due to its simplicity of use (Otani *et al*., 2015) said that because of the larger adhesion surface, the macro tests (macroshear and macrotensile) showed more heterogeneity in the distribution of stress and loads.

Thermocycling is a technique used in in-vitro research to simulate clinical situations through artificial aging. Samples are submerged in alternating baths of hot and cold water to mimic the temperature fluctuations present in the mouth. The purpose of it is to create thermal fluctuations in water baths that range from 5 to 55 °C in order to create thermal stress at the interface. During the treatment, the water that the dental materials absorb and the temperature gradient cause changes in the material's characteristics. A suggestion was made to employ 10,000 thermal cycles to simulate one year of in vivo restorative care (Alrabeah *et al*., 2023). As a result, in the current study the effect of 1000 thermal cycles were chosen to represent a duration of around one month of service.

Considering the findings of this investigation, control Group I (Maxcem Elite^{TM}) showed a higher mean SBS (3.90MPa) than control Group II (Maxcem Elite^{TM} Chroma) SBS of (3.07MPa). However, this was not statistically significant where (p=0.111). There were low shear bond strength values reported after thermocycling of both types of resin cement where Group I (Maxcem Elite^{TM}) showed a higher mean SBS (2.66MPa) than Group II (Maxcem Elite^{TM} Chroma) (2.57MPa) however, this was not statistically significant where (p=0.873). This might be explained by the cement's filler content; according to the manufacturers, the filler content was as follows:(Maxcem EliteTM =69%wt. and Maxcem EliteTM Chroma = 67%wt) in line with Yang *et al*. (2022) who revealed that increasing amount of filler lead to increase bond strength and Malysa *et al*. (2022) who revealed that thermocycling significantly reduced the bond strength of dental cements. The performed statistical analysis showed that the bond strength of self-etching, self-adhesive cements were strongly dependent on the use of artificial aging.

Also, the result was agreed with Sokolowski *et al*. (2023) who reported that after 5000 thermocycles, shear bond strengths decreased significantly in comparison with initial values (24 h, water 37 °C). As long-term water storage and thermocycling are common methods of assessing bond durability. In thermocycling aging, the materials' contraction and expansion as a result of temperature changes contribute to the degradation in addition to the reactivity of water molecules with the bond interface/resin cement. Due to the differing thermal coefficients of zirconia and resin cement, there may be more stress buildup at the interface and a reduction in bond strength and also agreed with Alrabeah *et al*. (2023) in which the shear bond strength of all the materials tested was reduced after 1500 cycles. This could be explained by the fact that high heat applied in alternating cycles diminishes the material's physicochemical properties and lowers the total number of unreacted double bonds in the resin's structure and on its surface and in disagreement with Vivek *et al*. (2022) who claimed that after 2000 thermal cycles, there were no any failures during thermocycling procedures within cement and that the functional monomer 10-MDP, which is phosphate-based, may be the cause of the enhanced bonding. It reacts with collagen and hydroxylapatite crystals giving a durable bond to dentin. It has been suggested that the monomer may also has some affinity for and capacity to form a chemical bonding with the surfaces of the zirconia.

5. Conclusions

There was no difference in shear bond strength between Maxcem Elite^{TM} and Maxcem Elite Chroma^{TM} and thermocycling decreased shear bond strength.

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