

Bond Strength of CAD/CAM Ceramic by Various Modern Resin Cements in Multilayer Technique

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ABSTRACT

BACKGROUND

The purpose of the study was to assess bond strength of various modern resin cements based on CAD-CAM ceramic in multilayer technique.

METHODS

CAD-CAM blocks specimens, IPS e.max ZirCAD (core, n=60) and IPS e max CAD (veneer, n=60) were fabricated. All specimens were divided into 3 groups (n=20). By multilayer technique, zirconia core and veneer were cemented with 3 different cements, RelyX U200 (MR), Panavia V5 (MP), and Multilink N (MM). Ageing was performed for (5-55°C, 5000). The shear bond strength test was performed with a universal test unit. The data were analyzed using the analysis of variance (ANOVA) and Tukey significant difference test (alpha =0.05).

RESULTS

The SBS differed substantially depending on the resin cement used. Group MP had the highest bond strength ($P < .001$) and lower MM. No significant differences were found between the groups MR and MM.

CONCLUSIONS

Significant differences were found in the shear bond strength of the veneer luted to zirconia base in multilayer technique using self-adhesive and conventional cement. The bond strength depended on the combination of ceramic and cement. The Panavia V5 had the highest bond strength.

KEY WORDS

Shear Bond Strength, Multilayer Technique, CAD-CAM Ceramic, Self-Adhesive Resin Cement

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BACKGROUND

Computer-aided design/computer-aided manufacturing (CAD/CAM) technology is used in modern prosthodontics. It has numerous advantages, including ease of use, little invasiveness, a standardized production process, and long-term clinical success.^[1-4] CAD-CAM restorations are incredibly biocompatible and aesthetic; nevertheless, because of the large amount of stress in the oral environment,^[3,4] dental restorations must have adequate mechanical characteristics to avoid fracture.^[4-6]

Recently the multilayer techniques^[7,8] by CAD/CAM technology have advanced for fabricated veneer ceramic restorations.^[9] These techniques are more advantageous than the conventional technique because it offers high-speed accuracy.^[7] Furthermore, liner application and shrinkage-related issues are eliminated, as are the effects of future sintering procedures.^[10,11]

All-ceramic restorations' clinical effectiveness and durability are influenced by the resin cement and the cementation process utilized. A suitable luting cement should create strong adhesion between the ceramic and the dentin. Resin cement is divided into self-etch cement and total-etch, which must be completely bonded to the tooth or ceramic surface, and self-adhesive resin cement.^[12-16] Knowledge about the efficiency of the multilayer technique aided by the CAD/CAM technology bonded and with the resin cement is limited.

Objectives

This in vitro study intended to compare the bond strength of zirconia-based ceramic restorations using multilayer veneering techniques by different resin cement. The null hypothesis stated that different resin cement did not affect zirconia-based ceramic restoration bond strength.

METHODS

Sixty specimens (15 x 12 x 0.7mm) of pre-sintered zirconia CAD-CAM blocks (IPS e.max ZirCAD) were sliced using a slow-speed diamond saw (ISOMET, Buehler Ltd, Lake Bluff, IL USA) under running water. The upper surfaces of the zirconia specimens were created by consecutively polishing with #240, 400, 600, and 1200 grit silicon carbide paper (English Abrasives Ltd, London, United Kingdom) under cooling water.^[17,18] All specimens were abraded with airborne particles (Korox 50, BEGO, Bremen, Germany) for 15 seconds from approximately 10 mm, using 50 µm aluminium oxide (Al₂O₃) particles at 2.5 bar. The specimens were then ultrasonically cleaned in distilled water for 10 minutes before air-drying.^[18]

The zirconia core specimens were split into three groups at random for various cement resins: MP, MR, and MM groups (n=20 per group) (Table 1). Sixty superstructure specimens (IPS e.max CAD Refill; Ivoclar, Vivadent) (8 x 6 x 1mm) were prepared by using a slow-speed diamond saw (ISOMET, Buehler Ltd, Lake Bluff, IL USA). All specimens were sintered in a high-temperature sintering furnace (InFire HTC Speed; Sirona) at 1581 °C for 86 min by the manufacturer's instructions, and a glazing procedure was performed.^[18]

The cement was applied according to the manufacturer's instructions. For MP [Panavia V5, (Kuraray Noritake) (adhesive)] cementation, it was necessary to prepare both the veneer layer and core of ceramic surfaces. The core surface was washed with distilled water and dried after digestion with 37 percent orthophosphoric acid (3M ESPE).

The inner surfaces of veneer specimens were etched with 9.5 % hydrofluoric acid (Porcelain Etchant Gel, Bisco, Schaumburg, USA) for 20 s and then rinsed with water for 60 s. After the etching procedure, a silane coupling agent (Pre-Hydrolyzed Silane Primer; Bisco, Schaumburg, USA) was dried onto the treated surfaces.^[18]

For MR [RelyX U200, (3M ESPE) (self-adhesive, self-etching)] and MM [Multilink N, (Ivoclar Vivadent) (self-adhesive, self-etching)] groups, it's important to dry the connected surfaces. As a result, the sample surfaces were dried using compressed air after washing them under a stream of distilled water.

The lower and upper structures were fixed under a manual dynamometer with a constant force of 50 Newtons for 10 min. They were polymerized with a light-curing unit (ELIPAR S10, 3M ESPE, Seefeld, Germany) with an output of 1200 mW / cm² for 3 s. After carefully cleaning the excess resin cement, the specimens were polymerized for 20 s on all surfaces. Acrylic resin (3 x3 cm) (Meliodent; Kulzer, Hanau, Germany) was used to embed all of the specimens. The SBS test was then performed on a universal testing machine (M500-25KN; Testometric) at a crosshead speed of 1 mm/min until a fracture occurred.

The failure mode of all specimens after the SBS test was examined by using a field emission scanning electron microscopy (SEM; JSM-840A 6335 F, Jeol, Japan) at a magnification of ×50 (Figure 1-3).

Statistical Analysis

The data were statistically analyzed using IBM SPSS V23 (IBM Corp.). The mean SBS values were analyzed by analysis of variance (ANOVA) and sample t-test (for all tests).

RESULTS

One-way ANOVA indicated that resin cement affected the bond strength within the ceramic veneer to zirconia (P < .001) (Table2). The highest bond strength values were obtained for Group MP (28.98). No significant differences were found between MR (22.59) and MM (21.85) groups.

Cement	Composition	Groups
Panavia V5	Bisphenol A diglycidyl methacrylate (Bis-GMA), Triethylene glycol dimethacrylate (TEGDMA), Hydrophobic aromatic dimethacrylate, Hydrophilic aliphatic dimethacrylate, Initiators Accelerators, Silanated barium glass filler, Silanated fluoroaluminosilicate glass filler, Colloidal silica Bisphenol A, Silanated aluminium oxide filler, dl-Camphorquinone, Pigments	MP
RelyX U200	Methacrylate monomers containing phosphoric acid groups, silanated fillers, initor components stabilizers, silanated fillers	MR
Multilink N	DEPT, Dimethacrylate, HEMA, fillers, Na-benzene sulfinate, BPO, t-amine, water.	MM

Table 1. The Chemical Composition of the Types of Cement

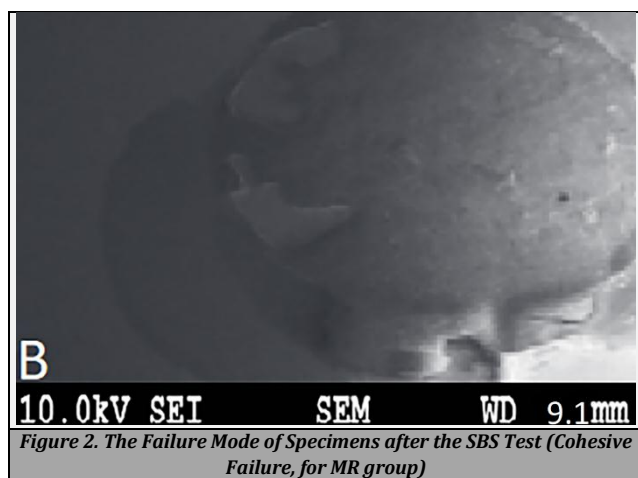
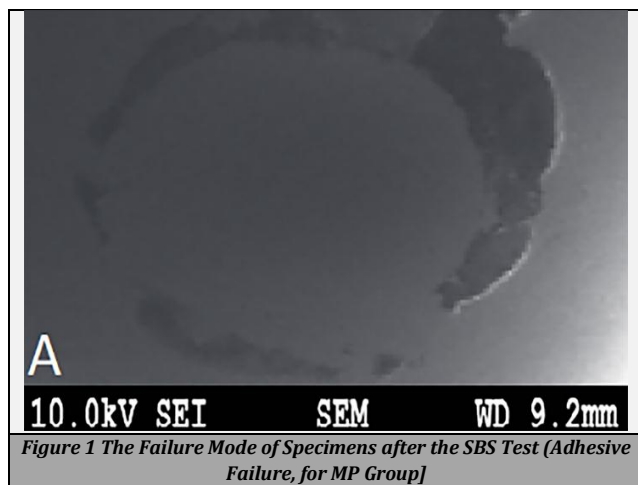
The failure mode of all specimens after the SBS test was adhesive, cohesive, and mix failures. (Table 3)

Group	Mean \pm SD	Test Statistics	P
Group MR(RelyX U200)	22.59 \pm 0.91 ^a	t=133.904	<.001
Group MP(Panavia V5)	28.98 \pm 0.99 ^b		
Group MM(Multilink N)	21.85 \pm 0.85 ^a		
Table 2. One-Way ANOVA for the Effect of Different Resin Cements on Bond Strength			

The same superscript letters indicate no significant difference

Group	Adhesive Failure	Cohesive Failure	Mix Failure
Group MP	18 (80)	-	2 (20)
Group MR	3(3)	10 (50)	7(70)
Group MM	1 (10)	16 (60)	3 (30)
Total	22 (45.3)	26 (46.1)	12(8.6)
Table 3. The Analysis of Failure Mode[%]			

SEM photomicrographs of failure types:



DISCUSSION

In the present study, the null hypotheses were rejected because different veneering techniques had effects on the bond strength and colour change of ceramic veneer to zirconia after hydrothermal ageing ($P < .001$).

According to the report, multilayered restorations made from CAD/CAM blocks also had significantly higher fracture strength values.^[7,21]

The variations in the physical properties of ceramics and resin cement under mechanical load were used to explain this result. Interfacial properties and variations influence the crack propagation and mechanical behaviour of the layered structure in the elastic modulus of the materials.^[7,8] The rigid zirconia's supportive impact on the brittle veneering ceramic may have been reduced due to the resin cement's lower elastic modulus.^[21] However, for the porcelain-based crowns it is well known that using resin cement to blunt the defects of ceramic restorations can improve fracture resistance.^[22] Additionally, resin cement type can affect the bond strength of the two different surfaces or materials. There is no universal resin cement presented yet, which can be applied in all restorative procedures. Therefore, clinicians should know resin cement properties, such as water sorption, bond strength, polymerization shrinkage, application procedures, etc. For this reason, these properties were investigated by the previous study and they can affect the bond strength of veneering ceramic to zirconia core^[23] using suitable cement to establish a strong connection between a ceramic material and the supporting tooth structure. Because they do not require a separate etching, priming, or bonding process, new-generation self-adhesive self-etching resin cement appears to be a perfect alternative for this purpose. They are easier to handle and less technique-sensitive. However, according to a prior study, self-adhesive resin cement has a lesser bonding capacity than adhesive cement.^[14]

According to the current study by Małysa A et al.^[13] ceramics cemented to dentin with the traditional Panavia V5 cement has a substantially greater shear bond strength than those bonded using self-adhesive self-etching cement. This study observed similar findings in their investigation.^[12,13] The highest bond strength values were obtained for group MP (Panavia V5) (28.98), and the lower was obtained for MM (21.85). However, no significant differences were found between the groups MR (RelyX U200) (22.59) and MM (Multilink N).

The difference between filler content can be one explanation. Arango et al.^[15] also found that the prosthodontic substrate's nature influenced the cement's shear bond strength. The varied particle of resin cement components might be one of the causes of the variations in the measured bonding forces of the selected cement.

Therefore, this result showed that the self-adhesive resin cement used for bonding veneering ceramic to zirconia might affect the bond strength. Additional selected resin cement with application methods of surface treatment, such as hydrofluoric acid etching, silanization, heat treatment, and silanization^[24] by laser or only laser, can effectively improve the bond strength of dental restorations.^[23]

CONCLUSIONS

In this study, the adhesive resin cement affected the bond strength of veneering ceramic to zirconia. The mix of ceramic and cement determines the bond strength. The results suggest that Panavia V5 has the strongest bond after cementation.

Limitations

The absence of anatomic crown use and artificial environment are limitations to consider when evaluating the results.

Recommendations

The current study provides the scientific basis for the assessment. The findings will serve as a baseline data guide for future studies.

The authors' data sharing statement is available with the full text of this article at jemds.com. Financial or other competing interests: None. Disclosure forms provided by the authors are available with the full text of this article at jemds.com.

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