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Evaluation of The Adhesion of Different CAD/CAM Materials with Self Etch/Adhesive Resin Cements

İdris Kavut, Mehmet Uğur, Özgür Ozan Tanrıkut[1]
[1]*Department of Prosthodontic, Dentistry Faculty, Van Yuzuncu Yil University, Turkey*
Corresponding Author: Özgür Ozan Tanrıkut

Abstract: *The aim of this in vitro study was to compare the shear bond strengths of different CAD/CAM materials with self etch/adhesive resin cements. Ceramic specimensfrom Vita Mark II (VIT), IPS Empress (EMP), IPS e.max CAD (MAX), Vita Suprinity (VTS) and Brilliant Crios (BRC)blocks were used in this study, respectively (n=20).Surfaces of the VIT, EMP, MAX and VTS ceramic specimens were etched with %5 HF and G Multi Primer were applied to ceramic surfaces. BRC were sanblasted and One Coat 7 Universal bond was applied to BRC surfaces. Self etch/adhesive Panavia SA and MaxCem Elite resin cements were applied to all ceramic surface with a transparent plastic mold (2 mm hight, 3 mm diameter) and polymerized. All specimens were stored in incubator at 37°C for 24 hours. Then, shear bond strength were performed with a Universal test machine (0.5 mm/min).Data were analyzed by one- or two-way analysis of variance and Tukey's test (all a=5%). The highest values were obtained in BRC reinforced composite (p<0.01). Ceramics cemented with PSA showed lower shear bond strength values(p<0.01). Resin composite reinforced CAD / CAM materials showed stronger shear bond strength with resin cements.*

Keywords: *CAD/CAM, resin cement, shear bond strength, glass ceramic, reinforced block*

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I. Introduction

Computer aided design (CAD) and computer aided manufacturing (CAM) tecnology have been used in dentistry since 1985 and allow dental prostheses to be produced and applied to patients in a single session.[1,2] With the advances in technology, CAD/CAM technology has become popular over the years and dental companies have been producing ceramic blocks with different color options and mechanical properties for this digital system.[2,3]

Feldspathic ceramic blocks, which are the first blocks produced for use in CAD/CAM systems, have widespread usage.[4] Although it has a high biocompatibility and translucency, in some cases its inadequate mechanical properties has led to the development of new blocks from various materials with different properties and areas of use, with a stronger mechanical properties.[5] The ongoing optimization of CAD/CAM systems has supported the further development of dental ceramics, which have increased in popularity due to their aesthetic and mechanical properties, and reinforced glass ceramics have been developed.[6] To improve the mechanical properties of glass ceramics without losing high translucency, reinforced glass ceramic blocks were produced with leucite added firstly.[7]

Later, lithium disilicate glass ceramics were produced due to the failure of leucite reinforced glass ceramics to show the desired mechanical strength in partial fixed dental prosthesis. Lithium disilicate reinforced glass ceramics also showed inadequate mechanical strength in posterior partial fixed dental prosthesis where masticatory forces were effective.[8]Therefore, a certain amount of zirconium was added to the dental ceramics to increase stronger ceramic strength and fracture resistance.[9]

Reinforced glass ceramic restorations cause natural teeth wear in the opposite dentition. In addition, in CAM units, when machining restorations from fully sterilized blocks, the cutters used due to their hardness can be deformed early.Due to the difficulty in the production of glass ceramics, the development of mechanical complications and the difficulty of repairing, the manufacturers have searched for different materials and finally the reinforced resin composite CAD/CAM blocks took their place in the markets. Indirect resin restorations have been developed differently depending on their mechanical properties over the years.[10]CAD/CAM resin blocks have some advantages over glass ceramic blocks. They cause less wear and tear on opposite enamel, are less fragile, have less micro-cracks during machining, and have better marginal adaptation.[10,11] Zinc phosphate cement and glass ionomer cements were used in the cementation of full ceramic restorations but adhesive resin cements were developed due to breakage, retention problems and aesthetic problems.Thanks to the development of adhesive bonding agents and cements, teeth and CAD/CAM restorations are better supported and protected against mechanical complications. In addition, because of a durable adhesion between tooth and dental restoration, tooth hypersensitivity and secondary caries are also prevented. Thus, aesthetic complications are also minimized.[12]

The aim of this study was to compare the shear bond strengths of different CAD/CAM materials with self etch/adhesive resin cements.

II. Material and Methods

Vita Mark II (VIT), IPS Empress (EMP), IPS e.max CAD (MAX), Vita Suprinity (VTS), Brilliant Crios (BRC) CAD/CAM blocks were used in this study (Table 1).The CAD/CAM ceramic blocks were cut to 1.5 mm thickness by using a low speed cutting device (Isomet; Buehler, Lake Bluff, USA) set at 150 rpm and twenty ceramic specimens were obtained for each group (n=20). The specimens were kept in the ultrasonic device for 5 minutes at a vibration rate of 40 kilohertz (kHz) in distilled water. Specimens surfaces were polished with a 600 silicon carbide papers (SiC) to ensure standardization on all surfaces. MAX and VTS ceramic discs were sintered according to the manufacturer's parameters and BRC specimens were sanblasted. Specimens in each group were embedded in the center of the 25 mm diameter and 15 mm high plastic cylinder molds and embedded with autopolymerizing acrylic. The surfaces of the VIT, EMP, MAX and VTS ceramic specimens were etched with 5% hydrofluoric acid for 20 s and then acid were removed from the ceramic surfaces. G Multi Primer was applied to all ceramic surfaces before cementation and dried 5 s, but according to the manufacturer's instructions, surfaces of BRC were sanblasted with 25-50 µm aluminium oxide at 1.5 bar and the company's own universal bond (One Coat 7 Universal Bond, Coltene/Whaledent, Germany) was applied to BRC surface.

Ceramic specimens from VIT, EMP, MAX, VTS and BRC blocks were divided into two subgroups according to the resin cements (PSA: Panavia SA and MXM: Maxcem Elite) to be bonded (n = 10). Panavia SA and Maxcem Elite self etch/adhesive resin cements were applied to ceramic surfaces with 3 mm diameter and 2 mm height plastic molds and kept in oven at 37 ° C for 24 hours. Specimens were subjected to thermocycling between 5°C and 55°C for 60 s each with a dwell time of 12 s maintained by a thermostatically controlled liquid circulator. Then, shear bond strength values were measured with a universal test machine (Shimadzu, Kyoto, Japan) with a head speed of 0.5 mm/min and values were converted to megapascals. In addition, failures types were examined in a stereo microscope at x30 magnification. Data were analyzed with a statistic programme (SPSS 22). The shear bond strength values were evaluated with two way ANOVA test. The confidence interval was set at 95%.

Table 1. Materials in use

Materials	Composition	Manufacturer
Vitablocks Mark II	Feldspar-reinforced aluminosilicate glass	VITA Zahnfabrik
IPS Empress CAD	Leucite-reinforced glass ceramic	Ivoclar Vivadent
IPS e.max CAD	Lithium disilicate (LS_2) glass–ceramic	Ivoclar Vivadent
Suprinity	Zirconia reinforced lithium silicate glass ceramic (Zr; approximately 10% by weight)	VITA Zahnfabrik
Brilliant Crios	Particle-filled composite (Bis-GMA, BIS-EMA, TEGDMA), 71 wt% barium glass, and silicia particles)	Coltene/Whaledent
Panavia SA	10-Methacryloyloxydecyl dihydrogen phosphate (MDP), Bis-GMA, triethyleneglycol dimethacrylate (TEGDMA), hydrophobic aromatic dimethacrylate, silanated barium glass filler, silanated colloidal silica, dl-camphorquinone, benzoyl peroxide, initiators, hydrophobic aliphatic dimethacrylates, surface treated sodium fluoride, accelerators, pigments	Kuraray Noritake Dental
MaxCem Elite	HEMA, GDM, UDMA, 1,1,3,3-tetramethylbutyl hydroperoxide TEGDMA, fluoroaluminosilicate glass, GPDM, barium glass filler, fumed silica (69 wt %)	Kerr
G Multi Primer	MPTMS, 10-MDP, MDTP, BisGMA, TEGDMA, Ethanol	GC Corporation
One Coat 7 Universal	Methacrylates, Photoinitiators, Ethanol, Water	Coltene/Whaledent

III. Results

The values and standard deviations (MPa) of the shear bond strength of self etch/adhesive resin cements to CAD/CAM materialis obtained from the study were shown in Table 2 (Table 2). The highest bond strength values were observed in the MXM bonded resin composite BRC and MAX ceramic CAD / CAM groups, while the lowest values were measured all of PSA resin cement groups except for reinforced composite BRC group ($p<0.01$).

Data were not statistically significant between BRC-PSA, EMP-MXM, VIT-MXM and VTS-MXM groups ($p>0.01$); EMP-PSA, MAX-PSA, VIT-PSA and VTS-PSA groups ($p>0.01$). Adhesive type failure was observed in all PSA cemented specimens except for BRC group. Even though a little mixed type failure was observed in the other groups, mostly adhesive type failure was determined.

Table 2. Mean values and st. deviations

GROUPS	VIT	EMP	MAX	VTS	BRC
PSA	11,59 ± 2,03[a]	13,8 ± 2,31[a]	11,85 ± 3,54[a]	11,57 ± 1,77[a]	21,17 ± 2,26[b,c]
MXM	17,78 ± 2,98[b]	18,5 ± 2,95[b]	23,98 ± 2,31[b,c,d]	17,62 ± 2,21[b]	25,43 ± 2,52[b,c,d]

IV. Discussion

In this study, feldspathic Vita Mark II, leucite-reinforced IPS Empress, lithium disilicate-reinforced IPS e.max CAD, zirconia-reinforced Vita Suprinitiy glass ceramics, composite-reinforced Brilliant Crios CAD/CAM blocks were used to evaluate the shear bond strength of self-adeziv resin cements and there was a significant difference between the bond strengths of CAD/CAM ceramics ($p<0.01$).

All ceramic restorations can be produced both by conventional laboratory methods and CAD/CAM technology.The traditional methods of ceramic restorations are both time consuming and have some complications unpredictable due to high technical sensitivity.CAD/CAM technology produces powerful ceramic restorations by reducing production time and is a good alternative for dentists and dental technicians. With the development of CAD/CAM technology, it is possible to apply fixed restorations to patient in chairside time. In addition, the ceramic blocks produced for CAD/CAM are homogeneous and have very few defects as they are obtained industrially.[13,14]

Feldspathic ceramics, one of the first materials used, are silica-based and have high biocompatibility, translucency and aesthetic success. VIT is a CAD/CAM feldspathic ceramic that was introduced for the CEREC system in 1991 and was used single crown, laminate veneers, inlays and onlays.The biggest disadvantage of feldspatic ceramics is low fracture strength (130 Mpa) and easy breakage.[15]

Leucite-reinforced glass ceramics show higher fracture strength (160 Mpa) than feldspatic ceramics due to the addition of leucite to the positive properties of feldspatic ceramics.Leucite-reinforced glass ceramics used for crowns and laminate veneers do not have sufficient mechanical strength in partial fixed dental prosthesis.[16] Therefore, it has developed lithium disilicate-reinforced glass ceramics to increase fracture strength (360±60 MPa). IPS E.max CAD is lithium disilicate ceramic that was introduced in 2006 for chairside use.The fracture strength of lithium disilicate-reinforced glass ceramics is three times that of feldspathic ceramics. Lithium disilicate glass ceramics are used with single restorations and frameworks, implant restorations, anterior and posterior partial fixed dental prosthesis extending up to 2nd premolar.[17]

Recently, zirconia-reinforced CAD/CAM blocks with higher mechanical strength (370-420 Mpa) are obtained adding 8-10 % zirconium is added to lithium disilicate reinforced glass ceramics. The glass ceramic blocks reinforced with lithium disilicate and zirconium have a high fracture strength thanks to the glass ceramic matrix with zirconia added. El saka and El naghy stated that mechanical properties of the VTS is higher than the MAX in their study.[17]

Nowadays, resin composite CAD/CAM materials can be used in inlays, onlays, crowns both anterior and posterior regions and single implant restorations. It is especially preferred in the patients with complaints of bruxism, because the ceramics cause more abrasion on tooth but reinforced resin composite CAD/CAM materials have high shock absorption.[18]

Self-adhesive resin cements are frequently used in crown and fixed partial denture cementing in the clinic because they do not require an additional procedure, adhesive application or step, clinical application time is short, and eliminates technical errors in the process by reducing technical sensitivity in the cementation process. The clinical success of glass ceramic restorations is based on a strong and durable adhesion between ceramic and resin cement. The content of resin cement and micro retention to the ceramic surface determine the quality of the adhesion. In many studies it has been stated that self-adhesive resin cements exhibit lower bonding values than traditional resin cements to CAD/CAM ceramics.[19-21]HF etching and ceramic primer applying remains the gold standard for pretreatment of glass ceramics for resin-luting cementation.[22]Meenes et al. reported that uniform and better distrubbed surface variability of HF etching affected lithium disilicate ceramics positively.[23]Lithium disilicate ceramics showed high shear bond strength values in this study.Ustun et al., said that 10% Zr-containing VTS could not be sufficiently acidified with HF in their study and also stated that silanization may adversely affect the bond strength.[24]In a study by Peumans et al., they etched EMP and VIT ceramic surfaces with HF and applied silane to surfaces and cemented PSA.[21] However, they said that any statistical differences between the bond strengths were not obtained. They said that, after HF acid etching and silane, resin cements significantly increased the bond strength of MAX glass ceramics. They stated that after HF etching and silaneapplication to the MAX, resin cements significantly increased the bond strength. They also said that HF etching of lithium disilicate glass ceramic CEltraDUO reinforced with zirconia, was useful in enhancing the bond strength but silane application did not affect as well as expected, and Panavia SA showed lower binding values with cement.In this study, lower bonding values were measured in zr-reinforced lithium disilicate ceramics cemented self adhesive resin cements, after HF etching and ceramic primer.[17,21]

In a study, Reymus et al. compared the bond strength composite with ceramic primer and resin primer on reinforced CAD/CAM composites and obtained higher bond strength in resin primer specimens.[18] This high bond strength, strong carbon-carbon bonds on the surface strengthened the adhesion between resin primer and BRC composite, and this situation based on producing by the same company because of chemical adaptation of materials linked to each other. In another study, it showed higher binding strength values with resin-containing Lava Ultimate self adhesive Panavia SA. The surface topography of this ceramic, the surface energy of the CAD / CAM material, the surface tension of the resin cement can be developed depending on the surface tension and other factors. In our study, the highest shear bonding values were obtained in reinforced resin composites. In addition, MaxCem values are higher than Panavia values in this study because of the decrease in mechanical strength of MDP by absorbing water after thermal aging process.[18,25]

V. Conclusion

Within the limitations of the study, high mechanical strengths were measured in reinforced resin composite CAD/CAM materials. However, adhesive failures were observed mostly in CAD/CAM materials adhered with self adhesive resin cement.

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