 DOI: 10.21608/adjalexu.2024.246549.1434

COLOR MATCHING AND SHEAR BOND STRENGTH OF CAD/CAM ZIRCONIA REINFORCED LITHIUM SILICATE COMPARED TO LITHIUM DISILICATE CERAMICS (IN VITRO STUDY)

Ahmed M. Marie [1*] M.Sc, Yehia Y. Aboushady[2] PhD, Sonia M. Elshabrawy[3] PhD, Naguib A. Elfawal[4] PhD

ABSTRACT

INTRODUCTION: Vita Suprinity had improved mechanical properties, but color matching and bonding properties are to be investigated.

OBJECTIVES: Testing color matching and shear bond strength of Suprinity versus E-max CAD.

MATERIALS AND METHODS: Total sample size was 60 specimens (n=60). Color matching test (n= 40) discs were divided to Group 1 (n=20) contained E-max discs and Group 2 contained Suprinity discs (n=20) which were subdivided to two subgroups (n=10), subgroups A contained discs sized 10mm in diameter and 0.5mm thickness and subgroups B contained discs sized 10mm by 1mm. Composite discs were prepared sized 10mm by 2mm as background material and their L*a*b* values were recorded for verification. The ceramic discs were cemented to the composite discs and L*a*b* were recorded and ΔE calculated. Shear bond strength test (n=20) discs divided into two groups (n=10). Group 3 contained E-max discs sized 5mm by 3mm. Group 4 composed of Suprinity discs with the same dimensions which were cemented to dentinal surface of premolars with the occlusal surface ground off under static load of 2kg and subjected to 2000 thermocycles followed by shear bond testing using a universal testing machine.

RESULTS: Regarding color matching mean ΔE values for E-max were non-perceivable, while for Suprinity were perceivable but acceptable, both materials showed higher values at 1mm thickness. No significant statistical difference was found regarding shear bond strength.

CONCLUSION: E-max showed better color matching than Suprinity which is considered as perceivable but acceptable, with no statistically significant difference regarding shear bond strength.

KEYWORDS: Color matching, shear bond strength, E-max CAD, Vita Suprinity.

RUNNING TITLE: Color matching and shear bond strength Vita Suprinity

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1-Oral and Maxillofacial Surgery Department, Faculty of Dentistry, Alexandria University, Egypt.
2 -Professor of Fixed Prosthodontics, Dean Faculty of Dentistry Alamein International University
3-Professor of Dental Biomaterials, Faculty of Dentistry, Alexandria University, Alexandria, Egypt.
4 -Lecturer of Fixed Prosthodonics, Conservative Dentistry Department, Faculty of Dentistry, Alexandria University

Corresponding author:
drahmadmaray@gmail.com

INTRODUCTION

In esthetic dentistry all ceramic restorations proved to have better esthetic appearance and improved retention to the natural dentition by achieving chemical and micromechanical retention using resin cements (1,2). Esthetic monolithic restorations with improved mechanical properties were made easier with Computer-aided designing (CAD) and Computer-aided manufacturing (CAM) abbreviated to CAD/CAM (3,4). IPS E-max CAD was commercially introduced 2006 as a monolithic all ceramic restorative material which provides good esthetic outcome and flexural strength of 360-400 MPa (5,6).

In dentistry the use of (2-3%) yttria stabilized zirconium in its tetragonal form achieves a restoration with flexural strength of 900-1200 MPa (7,8). In an effort to achieve esthetically acceptable restorations with improved mechanical properties, Vita Suprinity was introduced to the market commercially by VITA Zahnfabrik as a zirconia reinforced lithium silicate ceramic material which consists of a glassy matrix embedded in it lithium metasilicate (25%), lithium disilicate (11%) and zirconium dioxide (10%). The final restoration achieved a flexural strength of 320-420 MPa (9,10).

Color is a major factor in achieving optimum esthetic appearance of the restorations. In order to express color in a numerical form, la Commission International de I'Eclairage (CIE) an international organization developed CIE $L^*a^*b^*$ system. (11,12). In dentistry due to the difficulty of controlling the light conditions intraorally, an average difference of up to ΔE 3.7 was considered to acceptable and cannot be perceived easily by the human observer (11,12). In other studies an average difference of up to ΔE of 5.5 to be considered as perceivable but acceptable difference (13).

Successful all ceramic restorations particularly partial coverage restorations and restorations with minimum retention depend mainly on the mechanical properties and the bonding ability of the luting resin cement. A durable and strong bond between the ceramic surface and the resin cement can be achieved by micromechanical interlocking via etching creating a porous surface and chemical bonding by silane treatment of the ceramic surface (14,15).

Esthetically zirconium based restorations are considered to be opaque, extremely white in appearance and inferior to glass ceramic restorations (1,16,17). Zirconium based restorations are resistant to conventional etching and silane bonding (18,19).

The aim of this study was to test the effect of addition of zirconium dioxide 10% by weight in lithium silicate (Vita Suprinity) on color matching and shear bond strength compared to lithium disilicate (E-max CAD). The null hypothesis states that the addition of zirconium dioxide will not affect the color matching ability and the shear bond strength ability.

MATERIALS AND METHODS

Twenty sound first maxillary premolar teeth collected from the Oral Surgery Department, Faculty of Dentistry, University of Alexandria. The teeth were collected from patients referred from the Department of Orthodontics. The teeth were thoroughly cleaned by scaling and polishing and placed in saline for storage until time of experiment.

A copper mold was custom designed and fabricated with 3 mold spaces with the dimensions 10mm in diameter and 0.5mm in thickness, 10mm X 1mm and 5mm X 3mm. The mold was brushed with petroleum jelly as separating medium and a mix of white self-cure acryl (Acrostone Dental & Medical Supplies, Egypt) was prepared in a small glass cup and covered by a glass slab until dough stage was reached and the mix was packed into the mold cavities and covered with a glass slab and pressed firmly to ensure even thickness of the discs. After complete setting the discs were retrieved. A digital caliber (Electronic Digital Caliper, Shan, China) was used to verify the size of the acryl discs. (Figure 1) show the copper mold and the acrylic discs.

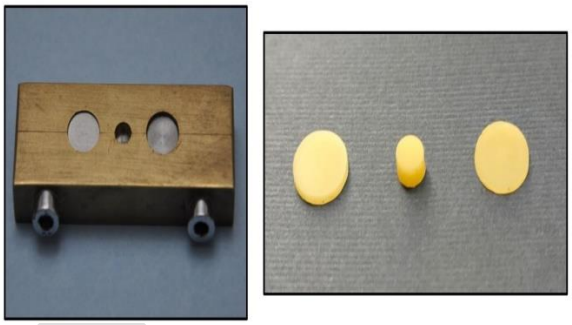

Figure 1 show the copper mold and the acrylic discs.

The acrylic discs were scanned into a CAD/CAM Amann Girrbach (Amann Girrbach AG, Herrschaftswiesen 1, 6842 Koblach, Austria.) machine. Presintered E-max CAD blocks Shade A3 were fitted in the machine and E-max CAD discs were milled from each size. The milled discs were cleaned using an ultrasonic cleaner to clean milling debris and on one side of the discs IPS E-max CAD Crystall./Glaze Spray was sprayed. The discs were sintered in Programat EP 3010 (Ivoclar Vivadent, Schaan, Liechtenstein) furnace following recommended manufacturer's instructions. A similar process was carried out for Vita Suprinity using presintered blocks Shade A3. After milling and cleaning the discs were sprayed with VITA AKZENT Plus glaze spray on one side and sintered in the same furnace following manufacturer's instructions.The composition of the materials used in the study is shown in Table 1. (Figure 2) show E-max CAD and Vita Suprinity discs.

Table 1: shows the composition of the materials used in the study.

Materials	Composition
Tetric-N-Ceram	Dimethacrylates, additives, catalyst, stabilizers, sand pigments, barium glass, ytterbium trifluoride, mixed oxide and prepolymerized filler (prepolymer) (56% vol.)
Eco-Etch	Phosphoric acid (37 wt. % in water), thickening agent and color pigments.
All-Bond Universal	HEMA, MDP, Bis-GMA, Ethanol.
Porcelain Etchant	Hydrofluoric acid, polysulfonic acid

Porcelain Primer	Acetone (> 45%), Ethanol (> 45%), Silane (> 1%)
Rely X Ultimate Clicker	Base: Methacrylate monomers, radiopaque silanated fillers, initiator, stabilizers, rheological additives Catalyst: Methacrylate monomers, radiopaque alkaline fillers, initiator, stabilizers, pigments, fluorescence dye, dark cure activator.
E-max CAD	SiO_2 (57-80%), Li_2O (11-19%), K_2O (0-13%), P_2O_5 (0-11%), ZrO_2 (0-8%), ZnO (0-8%), Al_2O_3 (0-5%), MgO (0-5%) by wt.
VITA Suprinity	SiO_2 (56-64%), Li_2O (15-21%), K_2O (1-4%), P_2O_5 (3-8%), Al_2O_3 (1-4%), ZrO_2 (8-12%), CeO_2 (0-4%), La_2O_3 (0.1%), Pigments (0-6%)

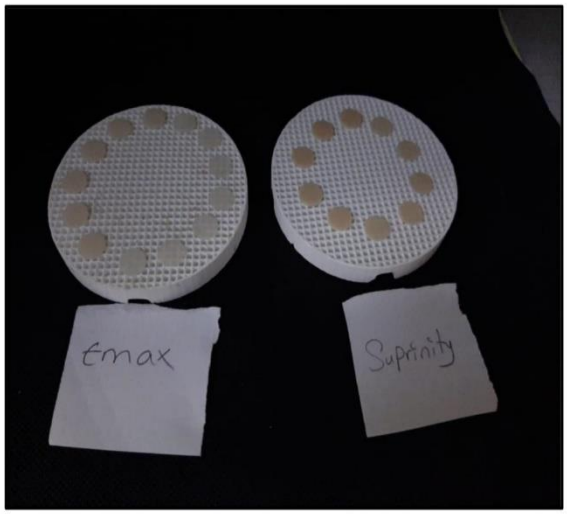

Figure 2 shows E-max and Suprinity discs.

Ten discs were prepared from each material for each size, giving a total of 60 discs. The specimens are grouped as follows:

Color matching test The test was intended to evaluate the color matching properties of Vita Suprinity (Shade A3 Translucent) compared to E-max CAD (Shade A3 High Translucency) with composite shade A3 as a background material.

Group 1 A consists of 10 E-max CAD discs with the size 10 mm by 0.5 mm.

Group 1 B consists of 10 E-max CAD discs with the size 10 mm by 1mm.

Group 2 A consists of 10 Vita Suprinity discs with size 10 mm by 0.5mm.

Group 2 B consists 10 of Vita Suprinity discs with size 10 mm by 1 mm.

Shear bond strength test: Group 3 consists of 10 E-max CAD discs with size 5 mm by 3mm. Group 4 consists of 10 Vita Suprinity discs with size 5mm by 3mm.

Color Matching Test

A polytetrafluoroethylene (Teflon) mold was custom fabricated with two disc spaces of size 10 mm in diameter with thickness of 2 mm. Tetric-N-Ceram composite shade A3 was packed into the mold cavities and covered with polyethylene strip. A glass slab was placed over the strip and a static load of 1kg was placed on the glass slab to ensure even thickness of the composite discs and the discs were cured by 3M Elipar S10 (3M ESPE, Seefeld, Germany) light cure device. (20).

VITA EasyShade (VITA Zahnfabrik, Germany) device was used to record the $L^*_1a^*_1b^*_1$ values of the composite surface. Figure 3 shows VITA EasyShade device. Following manufacturer's instructions, the composite surface was etched using Eco-Etch and bonded using All-Bond. Porcelain Etchant 9.5% was used to etch the unglazed ceramic surface and a double thin layer of Porcelain Primer was applied. Figure 4 shows Rely X Ulimate resin cement Shade Translucent which was used under static load of 2 kg and cured. The glazed surface of the ceramic discs was recorded for the second $L^*_2a^*_2b^*_2$ values and ΔE was calculated.

$\Delta L^* = L^*_1 - L^*_2$

$\Delta a^* = a^*_1 - a^*_2$

$\Delta b^* = b^*_1 - b^*_2$

$\Delta E = (\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2})^{1/2}$

Figure 3 shows VITA EasyShade device recording the $L^*a^*b^*$ values

Figure 4 shows Rely X Ulimate resin

Shear Bond Strength Test

The test was intended to evaluate the shear bond strength of Vita Suprinity and E-max CAD.

A specially designed copper mold was fabricated to mount the teeth in acrylic resin. A mix of self cure pink acryl mix was prepared in a glass slab and when it reached the dough stage it was packed in the mold the premolar teeth were embedded in the acryl mix with the roots embedded up to the cemento-enamel junction. After complete setting the acryl cylinders were retrieved and a model trimmer (Model Trimmer, Aurora Labs, Aurora, CO, USA) was used to grind the occlusal surface of the premolar teeth up to the dentine perpendicular to the long axis of the tooth. The exposed dentine surfaces were etched and bonded following recommended manufacturer's instructions. The unglazed surface of the ceramic discs were etched using HF and silane applied following manufacturer's instructions as stated before and the ceramic discs were cemented to the dentinal surface using resin cement under static load of 2 kg and the resin cement was cured. Figure 5 shows the specimens under the static load device. The cemented specimens were subjected to thermocycling for 2000 cycles at temperatures of 5˚C and 55˚C with dwell time of 30 seconds. The specimens were subjected to shear bond stress by placing the specimens in a Universal testing machine (5ST, Tinius Olsen, England 2018) as shown in Figure 6 and the results were calculated using the following equation:

$\tau = F/A$

τ is the shear stress in Megapascals (MPa), F is the force at which failure occurred in newtons (N) and A is the surface area of the cemented discs in square millimeters (mm^2).

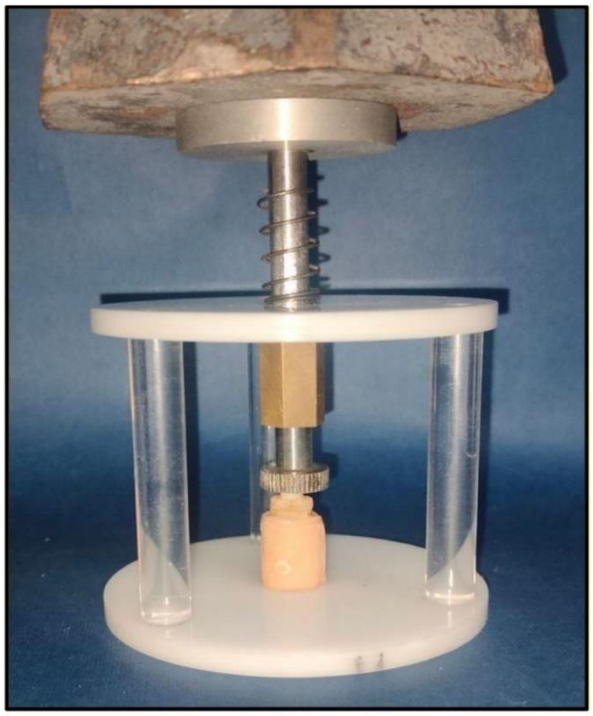

Figure 5 shows the specimens under the static load device

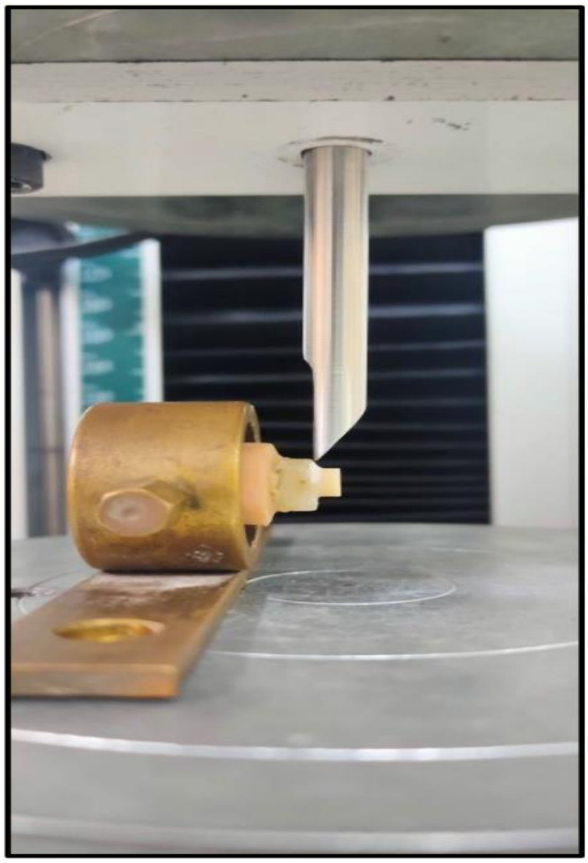

Figure 6 showing shear bond strength testing machine

Statistical Analysis

The collected data were fed to a computer and analyzed using IBM SPSS software package version 20.0 (Armonk, NY: IBM Corp).

The normality of distribution of Quantitative data was verified using Kolmogorov-Smirnov test. The data for each test was represented as: range (minimum and maximum), mean, and standard deviation, median and interquartile range (IQR). The significance of the obtained results was judged at the 5% level.

RESULTS

Color matching test was carried out by recording L^*, a^* and b^* values using VITA EasyShade device of the composite discs and the L^*, a^* and b^* values of the cemented ceramic discs after cementation in groups 1 A, 1 B, 2 A and 2 B. The ΔE values were calculated using the following equation.

$\Delta E = (\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2})^{1/2}$

Group 1A (E-max CAD 0.5mm) showed mean ΔE value of 1.37 with SD (standard deviation) of 0.21. The values for E-max CAD 1 mm (Group 1B) thickness was 2.54 with SD 0.22.

The values for Vita Suprinity 0.5 mm (Group 2A) were mean value of 4.12 with SD of 0.44, whereas at thickness of 1 mm (Group 2B) the mean value of 4.85 with SD of 0.55. E-max CAD showed mean ΔE values that were considered to be non-perceivable and the thickness of 1mm showed greater ΔE values. Vita Suprinity showed values that were considered perceivable but acceptable and 1mm thickness showed greater values. Comparing the result there was a statistically significant difference comparing the two different thicknesses of the same material and statistically significant difference between both materials at the same thickness. Table 2 shows the mean and SD values for E-max CAD and Vita Suprinity.

A Universal testing machine was used to evaluate the shear bond strength of both materials cemented to resin cement. Table 3 shows the mean values, SD, Interquartile range and the minimum and maximum values of both materials.

As demonstrated in Table 3 the mean value for E-max CAD is 10.66 MPa and SD of 0.63. The mean value for Vita Suprinity is 10.05 MPa with a SD of 0.57.

Regarding shear bond strength the mean values of both materials demonstrated no statistically significant difference.

Table 2: Demonstrating ΔE of both materials at each thickness

ΔE	E-max CAD (n = 10)	Vita Suprinity (n = 10)	t	p
0.5 Min. – Max.	0.85 – 1.57	3.38 – 4.66	17.939*	<0.001*
Mean ± SD.	1.37 ± 0.21	4.12 ± 0.44		
1.0 Min. – Max.	2.17 – 2.91	3.96 – 5.80	12.449*	<0.001*
Mean ± SD.	2.54 ± 0.22	4.85 ± 0.55		
t0	12.144*	3.313*		
p0	<0.001*	0.004*		

SD: Standard deviationt: Student t-test

p: p value for comparing between E-max CAD and Vita Suprinity

p_0: p value for comparing between 0.5 and 1.0

*: Statistically significant at $p \leq 0.05$

Table 3: comparison between studied materials regarding shear bond strength

	E-Max CAD (n = 10)	Vita Suprinity (n = 10)	t	p
Min. – Max.	6.76 – 16.89	9.10 – 10.89		
Mean ± SD.	10.66 ± 0.63	10.05 ± 0.57	0.506	0.624*
Median (IQR)	10.02 (7.43 – 14.73)	10.11 (9.72 – 10.40)		

IQR: Inter quartile range

SD:Standard deviation t: Student t-test

p: p value for comparing between the studied groups

*: Statistically significant at $p \leq 0.05$

DISCUSSION

The use of has been growing rapidly due to its improved mechanical properties compared to glass ceramic restorations but regarding esthetics zirconia based restorations are still considered inferior to glass based ceramic restorations (1). This study was aimed to test the effect of the addition of zirconium dioxide 10% by weight on the color matching ability and shear bond strength ability of zirconia reinforced lithium silicate Vita Suprinity and lithium disilicate E-max CAD (9).

According to the results from the current study, the null hypothesis was partially accepted.

As it is difficult to control the light conditions intraorally, an average ΔE of 3.7 was considered to acceptable and cannot be perceived easily by the human observer (11,12). Recent studies state that ΔE values up to 2.6 are considered to be non-perceivable and difference in ΔE values between 2.6 to 5.5 are considered to be perceivable but acceptable and ΔE values over 5.5 are considered non-acceptable (13,21).

The results for color matching in this study showed ΔE values for E-max CAD at thicknesses of 0.5 mm and 1 mm to be 1.37 ± 0.21 and 2.57 ± 0.22 which are considered to be non-perceivable, while Vita Suprinity showed ΔE values of 4.12 ± 0.44 at 0.5 mm thickness and 4.85 ± 0.55 which are considered to be perceivable but acceptable. Both materials showed higher ΔE values at higher thicknesses. Statistical results showed significant difference when comparing Vita Suprinity to E-max for the same and different thicknesses.

The results obtained in this study agreed with the results obtained by multiple studies Su et al (2021), Mostafa et al (2019) and Saker (2016) in which statistically significant lower ΔE values were found in E-max CAD compared to VITA Suprinity. The ΔE values for E-max CAD ranged from 1.86 to 2.16 while Vita Suprinity showed values ranging from 3.88 to 5.36 which are considered as perceivable but acceptable. These studies were considered to be in agreement due to similarities in the used materials and similar methodology. The higher ΔE values for group 2 (Vita Suprinity) can be correlated to the reinforcement of lithium silicate ceramic with 8-12 % zirconium which has a higher refractive index causing light to scatter as it passes through the material, whereas lithium dilisilicate particles has a lower refractive index (13,22,23).

The recent advancement in CAD/CAM technology and all ceramic materials made all ceramic restorations a very popular and important selection in the past decade (3,24). All-ceramic restorations had superior retention compared to zirconium based restorations due to the improved mechanical properties of the resin cement and on its ability to strongly bond to the ceramic surface (16). The current study aimed to evaluate the presence zirconia in lithium silicate glass ceramic Vita Suprinity on the shear bond strength ability to resin cement compared to E-max CAD.

The results obtained in this study agreed with the results obtained by multiple studies Martins et al (2022), Cinar et al (2019) and Sutil et al (2018) as the results concluded that no statistically significant difference was found between both materials regarding shear bond strength (25,26,27).

The results obtained in the current study are in partial agreement with Kavut et al (2019), as their results showed that regarding shear bond strength no statistically significant difference was between zirconium reinforced lithium silicate and E-max CAD using Panavia SA. However E-max CAD showed higher statistically significant values in than zirconium reinforced lithium silicate when using self-etching adhesives. The difference was justified that self-etch adhesives could not sufficiently etch the zirconium component of Vita Suprinity and therefore decreasing the shear bond strength (28). The results obtained in the current study are also partially in agreement with Secilmis et al (2016) as their results showed no statistically significant difference regarding shear bond strength between Vita Suprinity and E-max CAD when using Panavia 2.0, however when using Multilink N E-max CAD had significantly higher values than Vita Suprinity. This difference between Panavia F and Multilink N was related to the different compositions of both types of resin cements. Another factor that may contribute to the difference is that the particles of the lithium silicate glass ceramic are smaller and more round in shape compared to the larger and needle like shaped lithium disilicate particles, which causes greater roughness and higher surface area available for bonding in lithium disilicate compared to zirconium reinforced lithium silicate (29).

The results obtained in the current study was in disagreement with Bahgat et al (2015) study as their results showed regarding shear bond strength Vita Suprinity had statistically significant higher values in than E-max CAD. The difference in results can be correlated to the difference in cementation techniques and difference in composition of the used resin cement (1).

In the current study regarding shear bond strength test the addition of approx. 10% zirconium dioxide by weight to lithium silicate glass ceramic matrix did not affect the shear bond strength ability compared to lithium disilicate E-max CAD. Despite the inert nature of zirconia and its ability to resist HF etching, the remaining glass ceramic matrix created enough surface porosity to provide adequate strong bonding surface area to bond to resin cement material. The introduction of zirconium into lithium silicate glass ceramic matrix affected the optical properties of the material.

CONCLUSIONS

The results of the current study indicated that within its limitations the following can be concluded:

E-max CAD showed better color matching and its ΔE values were considered as non-perceivable, while Vita Suprinity values were considered as perceivable but acceptable. Both materials showed better color matching in lower thicknesses.

For shear bond strength E-max CAD and Vita Suprinity values had no statistical significant difference.

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