IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 23, Issue 4 Ser. 1 (April. 2024), PP 28-37
www.iosrjournals.org

Translucency And Bond Strength Of Laminate Veneers Fabricated From Different Cad/Cam Ceramic Materials: An In Vitro Study

Dr. Arwa Najib Alhumikani , Dr. Ghada Abdel Fattah
(B.D.S) Aden University –Yemen
Associate Professor Of Fixed Prosthodontics -Faculty Of Dentistry-Ain Shams University-Egypt

Abstract
Aim: *The aim of this study was to evaluate the shear bond strength, translucency, and color change of two different zirconia materials (Zir-CAD-Prime and Katana UTML-Zirconia) compared to that of common Lithium Disilicate (LDS) glass ceramic.*
Material and Methods: *By using CAD/CAM milling, 42 ceramic disc samples of dimensions 10 X 10 mm in diameter and 0.5mm in thickness from ultra-high transparent zirconia (n=14), hybrid lithium reinforced zirconia (n=14) , and IPS-Emax CAD (n=14)were fabricated. These disc-shaped were further split into two subgroups (n=7) based on the test procedure (shear bonding strength and translucency). All specimen underwent aging procedure for five hours in an autoclave set at 134 °C and 2 bar of pressure, respectively. A spectrophotometer was used to measure the color shift and translucency of each group. Utilizing a universal testing apparatus, the shear bond strength was evaluated.*
Results: *Zir-CAD-Prime had the lowest translucency value whereas IPS-Emax and Katana UTML had the greatest and lowest values, respectively. The translucency value after aging was considerably greater than the pre-aging value for all tested ceramics. In addition, there was a notable variation in color shift across the various groups. Katana-UTML had the greatest value, followed by Zir-CAD-Prime, while IPS-Emax had the lowest value. On the other hand, there was a notable variation in the shear bond strength among the various groups. Zir-CAD-Prime had the lowest value whereas IPS-Emax and Katana-UTML had the greatest and lowest values, respectively. Moreover, the percentage of IPS-Emax samples with adhesive failures was substantially greater than that of other materials.*
Conclusions: *the kind of ceramic, independent of aging, influenced the translucency . Ageing had an impact on the translucency of the material and colour change of tested ceramics. The higher the translucency of the material the higher shear bond strength*
Keywords: *Bond strength, Ceramic materials, Laminate veneers, Translucency*

Date of Submission: 23-03-2024 Date of Acceptance: 03-04-2024

I. Introduction

Dental ceramics are continually evolving, giving professionals a wide range of possibilities for producing aesthetics attractive and useful porcelain veneers. [1, 2] Due to its favorable optical characteristics, lithium disilicates ceramics are favoured in areas with high aesthetic standards. But the main drawback of glass-ceramic restorations is that they are less fracture resistant than metal-ceramic restorations. Some of this problem was solved when zirconia ceramic was initially used in dentistry. [3, 4]

Dental professionals are always monitoring developments in restorative materials, which should be as robust, minimally intrusive, and aesthetically pleasing as possible. [2] The 3 mol% Y-TZP, which seems to have poor translucency upon sintering. [5] As "high translucent" or "super translucent," a new variant of yttria-partial stabilised zirconia (Y-PSZ) with improved aesthetics has been launched (4 mol% Y-PSZ, 5 mol% Y-PSZ, or 6 mol% Y-PSZ). Known as "KATANA Cubic," the zirconia is very transparent. Additionally, it is produced in a pre-shaded, multi-layered state. [6] In an effort to mimic the progressive shift in shade seen in natural teeth from the incisal to gingival level, certain recently developed multilayered zirconia types contain larger concentrations of yttria and cubic phase of zirconia (c-ZrO_2). [7, 8] Nonetheless, Zir-CAD-Prime is a hybrid material that combines the best mechanical and aesthetic properties of zirconia with glass ceramics. [9, 10]

A significant obstacle facing contemporary dentistry is attaining the ideal visual characteristics of authentic teeth using synthetic materials. [17] Since dentin and enamel are naturally translucent, replicating the optical characteristics (translucency) of natural teeth should be taken into account while creating new restorations. [1] Furthermore, as subsurface light scattering is necessary to replicate natural enamel, the material's translucency is crucial to achieving an excellent aesthetic result in dental prosthetic restorations. (7) The material seems opaque if the majority of the natural light is absorbed. This can be related to the material matrix crystals' chemical makeup. (7, 18) Translucency permits light to flow through, but with scattering because photons of light scatter internally or at either of the two interfaces where the index of refraction changes. (1, 2) It has been determined that achieving high aesthetics requires a ceramic's translucency, which is greatly influenced by both "material structure and thickness". (19, 20)

Moreover, one crucial aspect of laminate veneers is their shear bond strength at the ceramic resin interface, this is due to the fact that successful ceramic restorations depend on the appropriate polymerization of resin-based cementation materials. (17) Therefore, in order to achieve long-term functional and aesthetic results, it may be helpful to understand how the translucency of ceramic veneers affects the degree of conversion of resins used for cementation. (21) Because the type and thickness of the ceramic material might affect the qualities of light-cured resin-based products, this is a therapeutically crucial issue. (21-23) This is because if the ceramic restorations greatly reduce the light-curing unit's irradiance, it could have an impact on the polymerization of light-cured luting materials during the cementation of ceramic veneers. (17)

This study examined three different dental materials to find the one with the best translucency and shear bond strength: Zir-CAD-Prime and KATANA-UTML zirconia in comparison to traditional ceramics made of lithium disilicate glass (IPS-Emax CAD). The null hypothesis proposed that the material's translucency and shear bond strength would not be impacted by the kind of ceramic.

II. Materials And Methods

Exemption from the ethical committee: Fpr21 -(151) - M

A power analysis was designed to have adequate power to apply a statistical test of the null hypothesis that there is no difference would be found between different tested groups regarding translucency. By adopting an alpha level of (0.05), a beta of (0.2) (i.e. power=80%) and an effect size (f) of (0.682) calculated based on the results of a previous study[1]; the predicted sample size (n) was a total of (24) samples (8 samples per group). Sample size calculation was performed using G*Power version 3.1.9.7[2]

(NB (1): The calculated number is a minimum estimation of the required sample size. Sample size can be safely increased to any number of choice as long as it's higher than the estimation)

(NB (2): References for the paper and the program used for the calculations are in footnotes at the bottom of the page if not visible on mobile try opening on a computer) .

42 ceramic disc samples (n=14) of LDS (IPS-Emax CAD), hybrid lithium reinforced zirconia (Zir-CAD-Prime), and ultra-high transparency zirconia (KATANA UTML) were produced using CAD/CAM milling. These disc-shaped specimens were 0.5 mm in thickness and 10 X 10 mm in diameter. Subsequently, each group was further divided into two subgroups (n=7) according to the test protocol (translucency and shear bonding strength).

Specimens' fabrication

Cubes of Katana-UTML (Kuraray Noritake Dental Inc., Miyoshi, Japan), IPS-Emax CAD (Ivoclar Vivadent AG, Schaan, Liechtenstein), and Zir-CAD-Prime (Ivoclar Vivadent AG, Schaan, Liechtenstein) were produced using the Roland Milling Unit. The cubes were cut into 21 ceramic slices measuring 10 x 10 mm and 0.5 mm thick using a low-speed saw (IsoMet 1000, Buehler, USA) that was lubricated with water and used a diamond disk with a thickness of 0.6 mm at a cutting speed of 2500 rpm. The arrangement of the slices made in compliance with the manufacturers' suggestions and the instructions outlined in ISO 6872: 2015-Dentistry-Ceramic Materials. A 0.5µm finish was achieved by grinding and polishing (using diamond-impregnated discs from DGD Buehler, USA).

In order to provide the proper final thickness for the materials that need to be sintered (Zir-CAD-Prime and KATANA-UTML), the specimen thickness was adjusted to account for the material contraction during the sintering process. Following that, sintering firing was carried out in a furnace (Mihmvogt TABEO-1) in accordance with the manufacturer's instructions. As directed by the manufacturer, samples of KATANA-UTML were sintered for two hours at a temperature of 1550˚C / 2822F, and samples of Zir-CAD-Prime for two hours at a temperature of 1530˚C. Prior to measurements, all of the specimens were polished with yellow, red, and white polishing bures set to 8000–1000 rpm for 60–90 seconds, followed by an ultrasonic cleaning in distilled water for 10 minutes, and then allowed to air dry on a bench.

Utilizing a Programat CS2 furnace and according to the manufacturer's recommendations for the crystallization settings specific to each material, the IPS-Emax CAD was entirely crystallized. To ensure that the

[1]Vichi, Alessandro, et al. "Translucency of ceramic materials for CEREC CAD/CAM system." *Journal of Esthetic and Restorative Dentistry* 26.4 (2014): 224-231.

[2] Faul, Franz, et al. "G* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences." *Behavior research methods* 39.2 (2007): 175-191.

specimens had the same surface texture, they were smoothed once more. The specimens were then prepared for the bonding procedure after being cleaned using an ultrasonic cleaner and 99% isopropanol for the maximum CAD. After finishing the specimens as previously described, they were ready for further transparent light-polymerizing protective coatings (Ceramotion). To remove air bubbles, a thin layer of glaze was applied with a gentle brush in a single direction. Ceramotion paste glaze was applied, and twenty seconds later it was polymerized under ultraviolet light for ninety seconds.

Surface treatments

Before applying any surface treatments, each of the 21 slices had its surface thoroughly cleaned of any dirt and dried with 70% ethyl alcohol. For better standardization, sandblasting was done on zir-CAD-Prime and KATANA-UTML samples using 50 microns aluminium oxide powder at an angle of 90 and a distance of about 10 mm. A cylindrical metal holding device allowed the sandblaster tip to move in the right, left, up, and down directions without changing the distance, which improved standardization. This was carried out for every ceramic disc in this subgroup for 20 seconds at 2.8 bar of pressure. After that, slices were covered with 97% alcohol and allowed to air dry using an oil-free air/water syringe until the surface was matte.

After 30 seconds of etching with 9.5% hydrofluoric acid (PORCELAIN ETCHANT), the IPS-Emax CAD slices were cleaned and allowed to air dry using an oil-free air/water syringe. For sixty seconds, a silane coupling agent was administered. The specimens were then air dried using an oil-free airway syringe.

Cementation procedures

A specifically made Teflon mold that was split cylindrically was made. The mold has an exterior cupper ring that was used to assemble the Teflon mold's two parts, and a circular central hole that is 2 mm in diameter and thickness. The twenty-one A2 shade ceramic samples were made in compliance with the manufacturer's specifications. Sitting atop a dry, clean glass slab, the Teflon mold was covered with a thin coating of separating media. With the use of a non-metallic plastic device, 3 mm increments of composite resin (Choice 2 Veneer Cement) were applied. To achieve the best level of smoothness, a mylar strip was pushed into the glass plate after the increment was applied. For 40 seconds, composite resin activation was carried out using an LED light curing unit (Miraj, LED.D curing light, Korea) with a mean light intensity of 1400 mW/cm^2 and an optical wavelength of 420-480 nm.

The seven specimens' etched surfaces were completely cleaned for sixty seconds with water spray, then for an additional sixty seconds with ultrasonic washing in distilled water, and finally for thirty seconds with oil-free compressed air to dry them. The etched surface was coated with a coating of silane coupling agent for sixty seconds, and then air was thinned. After being manually finished with wet silicon carbide paper (320,600 grit; Norton S.A., São Paulo, Brazil), the cemented side of the zirconia ceramic samples were ultrasonically cleaned in distilled water for ten minutes and then rinsed with tap water for one minute. Every ceramic sample was subjected to a bond brush application of Bisco All-Bond Universal for 20 seconds, followed by moderate oil-free air drying for five minutes and curing.

To ensure uniform load application, a specially designed cementation device was machined from stainless steel. It consists of: a) two rectangular horizontal metal plates (upper and lower); b) two supporting vertical metal arms attached to the upper and lower horizontal metal plates; c) a T-shaped metallic rod attached to the upper metal plates that can move freely vertically; it also carries a disc-shaped plate at its upper end over which the required load will be placed; at its lower end, a Teflon rod with a 10 mm diameter tip was attached; and d) a 1 kg load was placed on the disc-shaped plate.

The syringe was used to inject the cement onto each composite substrate's prepared surface in accordance with the manufacturer's instructions. To guarantee that the cementation mold was put in the same spot every time during cementation, it was placed on the rectangular iron base of the cementation device and fixed in a central position using a fixation screw. With its prepared surface directed toward the luting cement, each composite disc was placed within the Teflon mold cavity section (a). To hold the ceramic disc in place, part (b) of the metal was placed over part (a), and part (c) was placed over them. Ultimately, while loading, the Teflon ring held the three pieces (a, b, and c) together.

The disk-shaped plate at the top of the T-shaped metallic portion of the cementation apparatus was subjected to a steady force of 1 kg for three minutes. The resin material was then polymerized from three directions for 40 seconds using a light cure device at a power of 3.200 mW/cm^2 after the surplus cement was removed with a sharp lancet from the corner of the square hole of the metal portion (b). Following the curing process, the cementation mold components were disassembled by removing the outer Teflon ring and the cemented ceramic discs. Finishing was then applied using a finishing bur. For uniformity, the same operator finished and polished each ceramic disc sample in accordance with manufacturer instructions.

Aging (low thermal degradation) of the samples

Before measuring color and translucency once more, all of the specimens were kept for a period of time at 37°C. They were then artificially aged using autoclave aging, which promotes 15-20 years of aging at 37°C for 5 hours under 0.2 MPa pressure.

Translucency measurement

Samples were dried using compressed air after being ultrasonically cleaned in distilled water for ten minutes before to each measurement. Translucency (TP) and color (ΔE) changes were estimated for each sample both before and after aging. Translucency was measured using a Cary 5000 UV-Vis-NIR double-beam spectrophotometer. The SCE mode eliminated the specular reflectance component. In the visible range, from 380 to 780 nm, relative reflectance data were taken at intervals of 5 nm. Without bonding, each ceramic slice was erected against bright (A2) and dark (A4) substrates that had already been produced. The aperture of a spectrophotometer was placed against the flat ceramic surface of each specimen-substrate assembly to measure shade. The apparatus emits or absorbs illuminating light that permeates materials.

The Commission International de l'Eclairage (CIE) documented the measurement. After obtaining the diffuse reflectance data for each sample, the CIE-Lab color values were determined using the color software application that is compatible with the Cary WinUv instrument and allows for a wide range of color calculations and standards. Using computer software (Carry WIN UV), color coordinates, CIE L*a* and b*, were calculated from the transmittance and reflectance date. Every value was measured by moving the specimen one millimetre in each quadrant direction, covering five distinct areas of the specimen, including the center. The required parameters were calculated using the average L*a* and b*values.

Before and after aging, the translucency (TP) of every ceramic sample was measured. Each specimen's post-aging color shift was measured and compared to its pre-autoclave aging baseline color. An Excel spread sheet was utilized to record the color measurements and formulas were added to determine the color changes for every specimen across all coordinates (ΔL*, Δa*, and Δb*).

Each ceramic specimen's translucency (TP) was determined by applying the following equation to determine the color difference between the specimen when it was placed against a black backdrop (b) and a white background (n): TP = $[(L_b*-L_w*)]2+$ (a_b*-a_w*) L* stands for lightness, a* for redness to greenness, and b* for yellowness to blueness in $2+(b_b*-b_w*)2]^{½}$.

Shear bond strength test

For the purpose of the shear test, each specimen was implanted in an acrylic block to facilitate handling and fixation. On the acrylic resin blocks, letter codes were inscribed to help distinguish between the three materials during the remaining procedures: letter {z} denotes the Zir-CAD-Prime specimen, letter {k} denotes the KATANA-UTML specimen, and letter {E} denotes the IPS-Emax CAD specimen. PVC water tubes were used to create the molds, which were then cut into 25 mm internal diameter and 20 mm length with a specially constructed Teflon cover. After ceramic samples were placed over a Teflon cover, the epoxy resin was poured over them, allowed to cure, the Teflon cover was taken off, and the epoxy resin base was completed to remove any remaining material.

Data were recorded using computer software (Instron® Bluehill Lite Software) and each block with its own bonded specimen was secured horizontally with tightening screws to the lower fixed compartment of a universal testing machine (Model 3345; Instron Industrial Products, Norwood, MA, USA) with a loadcell of 5 kN. Using a material testing equipment, a tensile mode of force was delivered as a hearing load at a crosshead speed of 1 mm/min. Newtons were used to measure the load necessary for debonding. Equation $\tau= P/\pi r2$ was used to represent the bond strength in MPa by dividing the load at failure by the bonding area. Here, π stands for shear bond strength (in MPa), P is the load at failure (in N), π=3.14, and r is the micro-cylinder's radius (in mm).

The deboned specimens' failure mode was examined using the Zeiss S7(V11) stereomicroscope at 30X magnifications to determine the deboned region and confirm if the mechanism of failure is cohesive, adhesive, or mixed.

Statistical analysis

The chi-square test was used to evaluate the categorical data, which were then reported as frequency and percentage values. Pairwise comparisons using multiple z-tests with Bonferroni correction were then performed. The mean and standard deviation figures are used to show numerical data. Shapiro-Wilk's test was used to determine their normality, and the results showed that they were normally distributed. Two-way mixed model ANOVA was used to assess the translucency data. Using the pooled error term from the main ANOVA model and the Bonferroni correction, simple effects were compared. One-way ANOVA was used to assess the color change and shear bond strength data, and Tukey's post hoc test was then performed. For every test, the significance threshold was set at P<0.05. R statistical analysis software, version 4.3.1 for Windows, was used to conduct the statistical study.

III. Results

Regarding translucency: there was a statistically significant difference (P<0.001) in the translucency findings between the various materials both before and after aging. Zir-CAD-Prime had the lowest translucency value, whereas IPS-Emax and KATANA-UTML had the greatest values. Furthermore, the aging process produced noticeably increased translucency values for each material(Table 1).

Aging	Translucency parameter (TP) (Mean± SD)			P-value
	Zir-CAD-Prime	KATANA-UTML	IPS-Emax	
Before	9.46 ± 0.28^{C}	12.36 ± 0.32^{B}	14.35 ± 0.48^{A}	<0.001*
After	10.63 ± 0.19^{C}	13.80 ± 0.23^{B}	15.15 ± 0.24^{A}	<0.001*
P-value	<0.001*	<0.001*	<0.001*	

Values with different superscript letters within the same horizontal row are significantly different *; significant (p<0.05) ns; non-significant (p>0.05)

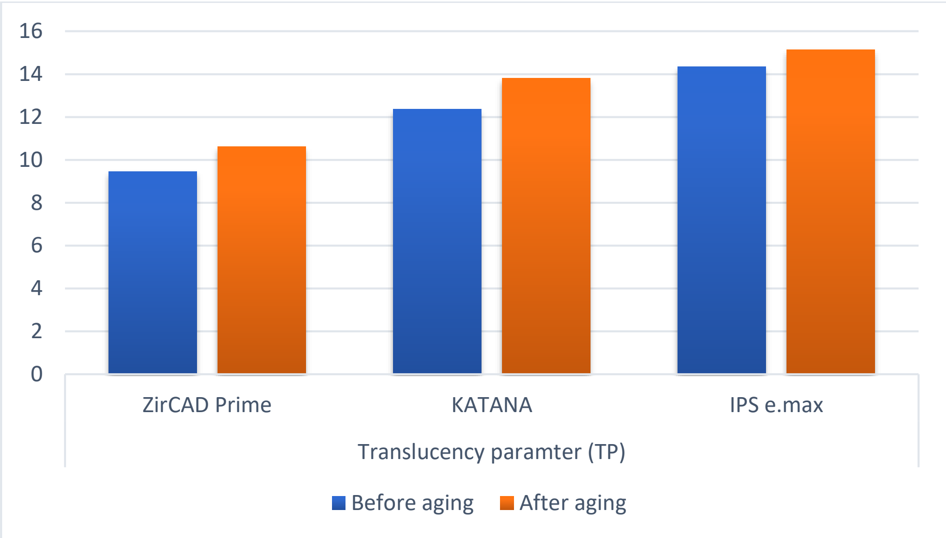


Figure (1): Bar chart showing average translucency parameter (TP) for different materials before and after aging (B)

Regarding color changes : the color change results showed that there was a statistically significant difference between the materials after ageing (P<0.001). IPS-Emax had the lowest color change value, followed by Zir-CAD-Prime, and KATANA-UTML had the highest value.(Table 2).

Color change (ΔE) (Mean± SD)			P-value
Zir-CAD-Prime	KATANA-UTML	IPS-Emax	
2.69 ± 0.13^{B}	3.38 ± 0.14^{A}	2.16 ± 0.11^{C}	<0.001*

Values with different superscript letters within the same horizontal row are significantly different *; significant (p<0.05) ns; non-significant (p>0.05)

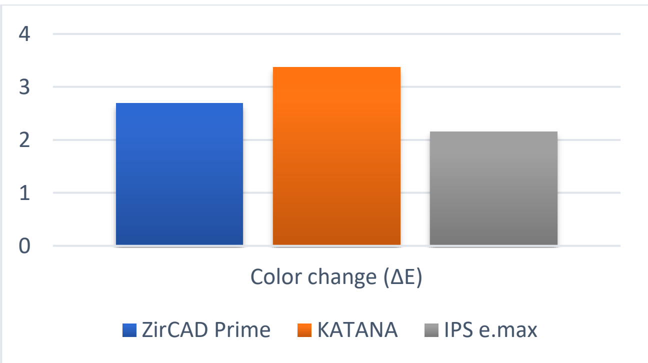


Figure (2): Bar chart showing average color change (ΔE) for different materials.

Regarding shear bond strength : the shear bond strength data showed a statistically significant difference (P<0.001) between the materials. The highest value was found in IPS e.max (20.79±4.41), followed by KATANA (11.23±3.27), while the lowest value was found at ZirCAD Prime (6.36±1.67). (Table 3).

Shear bond strength (MPa) (Mean± SD)			P-value
Zir-CAD-Prime	KATANA-UTML	IPS-Emax	
6.36±1.67^{C}	11.23±3.27^{B}	20.79±4.41^{A}	<0.001*

Values with different superscript letters within the same horizontal row are significantly different *; significant (p<0.05) ns; non-significant (p>0.05)

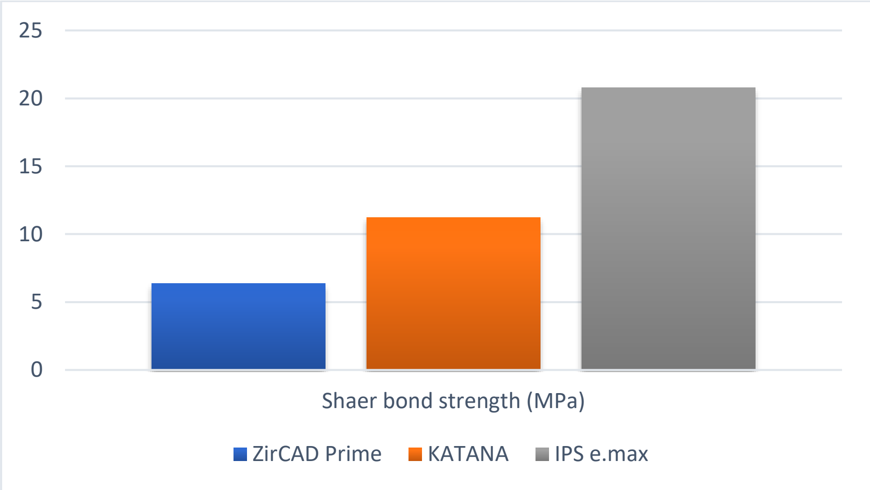
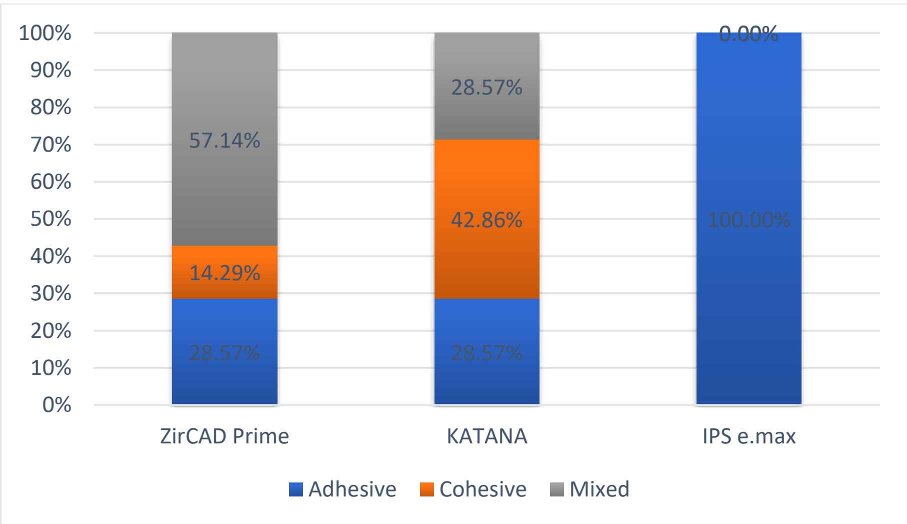


Figure (3): Bar chart showing average shear bond strength (MPa) for different materials.

The mode of failure: results showed that the percentage of IPS-Emax samples with adhesive failures was substantially greater than that of other materials (P=0.017), (Table 4).

Failure mode	n (%)			p-value
	Zir-CAD-Prime	KATANA-UTML	IPS-Emax	
Adhesive	2 (28.57%)^{B}	2 (28.57%)^{B}	7 (100.00%)^{A}	0.017*
Cohesive	1 (14.29%)^{A}	3 (42.86%)^{A}	0 (0.00%)^{A}	
Mixed	4 (57.14%)^{A}	2 (28.57%)^{A}	0 (0.00%)^{A}	

Values with different superscript letters within the same horizontal row are significantly different *; significant (p<0.05) ns; non-significant (p>0.05)



Figure(4): Stacked bar chart showing mode of failure distribution in different materials.

Correlation

Correlation between translucency and shear bond strength is presented in table (5)

There was a strong positive correlation between translucency and shear bond strength that was statistically significant (rs=0.786, p<0.001).

Table (5): Correlation between translucency and shear bond strength.

Variables	Correlation coefficient	p-value
Translucency -Shear bond strength	0786	<0.001

*; Significant (p< 0.05).

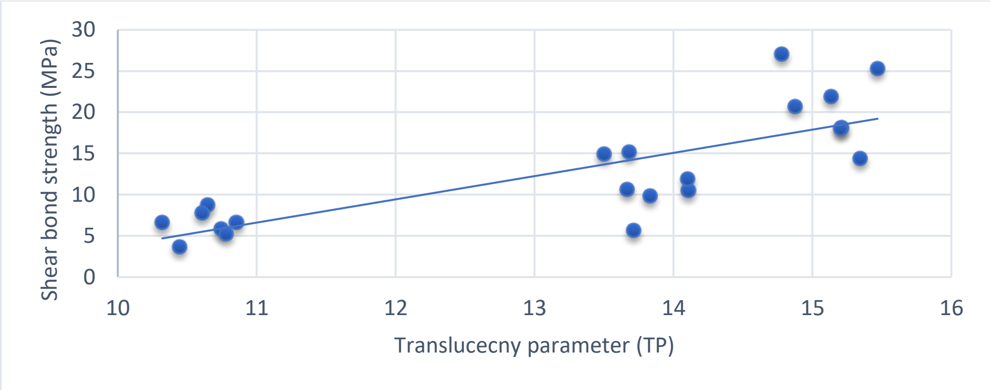


Figure (5): Scatter plot showing the correlation between translucency and shear bond strength.

IV. Discussion

In order to achieve long-term functional and aesthetic results, it may be helpful to understand how the optical properties of ceramic material affects veneers shear bond strength. [21] Because the type and thickness of the ceramic material might affect the qualities veneers , which is a therapeutically crucial issue. [21-23] This is because if the ceramic restorations greatly reduce the light-curing unit's irradiance, it could have an impact on the polymerization of light-cured luting materials during the cementation of ceramic veneers. [17] Therefore, in this present study three distinct materials: Zir-CAD-Prime, KATANA-UTML zirconia, and IPS-Emax glass ceramic were utilized in this study in order to investigate the translucency, color change, and shear bond strength of these different CAD/CAM ceramics.

Translucency permits light to flow through, but with scattering because photons of light scatter internally or at either of the two interfaces where the index of refraction changes. [1, 2] Therefore, translucency of the ceramic material was selected as a test property in this current investigation. Since shade A2 is the most frequently chosen shade by patients and a universal colour, it was adopted for all tested ceramics in this experiment. [24] The spectrophotometer, which is straightforward, easy to use, and accurate, was utilised in this present study to measure every sample as suggested by earlier research. [25-27] According to Dozić et al. (2007) [28], spectrophotometer was the most dependable shade matching appliance in both in vitro and in vivo settings. Previous investigations employed the CIELab technology to capture colour changes; ΔE values indicated whether or not this colour change would be observed clinically. [3, 25, 29] Therefore, in this present study ΔE value was used as indicator for color change as it indicates whether or not a colour variation is perceptible to the human eye. [30]

In this current investigation, the resin cement was selected because they have good mechanical and aesthetic qualities, are less soluble in the oral environment, and can be adhesively linked to tooth tissues, resin cements are frequently employed to cement all-ceramic restorations. [17] Moreover, to rule out the possibility of colour shift, light-cured translucent resin cements were utilised in this investigation because it is better than dual-cured cements in terms of optical qualities and colour stability when it comes to cementing translucent and thin ceramic restorations as veneers [17, 31] as well as because of their extended working period and colour stability. [32, 33] Furthermore, Bisco All-Bond Universal cement is free of Camphorquinone, which causes light polymerization to result in a yellowish tint. [3] It was stated that any amine molecule during its autopolymerisation, undergoes an oxidation process that results in discolorations. [34]

In this present study the utilized ceramic thickness was (0.5 mm) in order to avoid the effect of the ceramic thickness on the degree of conversion of the resin cement.

In order to better replicate clinical settings and improve stress distribution at the ceramic resin interface, about 0.1 mm (100 µm) of cement was selected as the thickness of the resin cement in this current investigation. [3] However, the cement thickness was not standardized using spacers, as reported in prior investigations, in an attempt to mimic clinical settings. [17, 36] Prior in vitro investigations have similarly documented cement thicknesses akin to ours, ranging roughly between 100 and 160 µm. [17, 22, 37]

In this present investigation, the specimens in this study underwent artificial thermal ageing using autoclave ageing at 134 °C under 0.2 MPa pressure for 5 hours [11, 38, 39] because it being the most extensively documented technique for specimen ageing and long-term colour stability assessment. [17] This accelerated ageing process stimulates 15-20 years of clinical ageing in the oral environment. [4, 40]

The results of this current investigation revealed that the IPS-Emax glass ceramics had the highest translucency , followed by KATANA-UTML zirconia and then Zir-CAD-Prime zirconia ceramics. These findings are consistent with the findings of Harada et al. [41], who reported that IPS-Emax CAD ceramic was significantly more translucent than KATANA-UTML, however, KATANA-UTML much more translucent than other tested zirconia at a thickness of 0.5 mm. This could be related to the significant difference in refractive indices between the ceramic matrix, ZrO_2, and pores, the simultaneous presence of cubic and tetragonal phases may increase light scattering. This can impact the optical properties of the restorations by decreasing translucency values and increasing light scattering. [42, 43] This could explain the low translucency Zir-CAD-Prime zirconia ceramics in this current investigation. Also, Casolco et al. (2008) [44] stated that higher amounts of light absorption and scattering can be caused by minute geometrical, structural, or chemical variations in the grains and grain borders, which can result in significant opacity. The apparent discrepancy in optical characteristics between Zir-CAD-Prime and KATANA-UTML zirconia could potentially be explained by additional factors such as the presence of cubic phase and variations in particle size and density. [24]

Moreover, the low translucency of KATANA-UTML zirconia ceramics in this current investigation when compared to the IPS-Emax glass ceramics could be attributed to the presence of cubic and tetragonal phases may increase light scattering and increase the translucency of KATANA-UTML zirconia ceramics acing to Mourouzis et al. [38]. However, leucite-reinforced ceramic (IPS-Emax CAD) with uniformly distributed leucite crystals within a glassy matrix to aid in their increased translucency. [45]

According to a study by Harada et al. [41], the alumina concentration in KATANA-UTML zirconia was lowered to 0.11 weight percent. Also, Mourouzis et al. [38] reported that the change in translucency could be attributed to the formation of more cubic phases in the KATANA-UTML zirconia ceramics. This also could explain the higher translucency of Katana Ultra Translucent zirconia when compared with Zir-CAD-Prime zirconia in this current investigation. Alghazzawi [24] stated that the shift from tetragonal to monoclinic cause the surface roughness and light scattering of the ceramic material. However, the microstructure of Zir-CAD-Prime lacked the cubic phase, which induces greater tetragonal to monoclinic change in zirconia by increasing its sensitivity to ageing and decrease its translucency.

Additionally, the ageing data in this study showed that there were notable colour changes following several firings. However, these finding in agreement with the finding of several studies that examined the impact of firing frequency on colour change and found no discernible colour change following several firings. [24, 30] In contrast to other zirconia brands, the LDS exhibited the least amount of colour shift since its metallic oxide colouring was more stable and could take on an orange hue over time. [24] In agreement with the finding of current study Yılmaz et al. [30] found that the surface colour of IPS Classical metal ceramic, Empress Esthetic and Empress 2 ceramics was significantly affected by multiple firings.

The results of shear bond strength of the tested ceramics in this current investigation revealed a significant difference between different groups. The highest value was found in IPS-Emax, followed by KATANA-UTML, while the lowest value was found at Zir-CAD-Prime. The high bond strength of the LDS ceramics could be attributed to the increased glass matrix content of this material when compared with KATANA-UTML and Zir-CAD-Prime as well as increase of translucency KATANA-UTML when compared with Zir-CAD-Prime ceramics as it was stated the translucency of the material had a significant effect on the degree of conversion and complete polymerization of the bonding agent. [21-23]

Gugelmin et al. [17] stated that the proper polymerization of resin-based cementation materials is essential to the success of ceramic restorations. Moreover, Runnacles [21] reported that the translucency of ceramic veneers affects the degree of conversion of resins used for cementation. This is because if the ceramic restorations greatly reduce the light-curing unit's irradiance, it could have an impact on the polymerization of light-cured luting materials during the cementation of ceramic veneers. [17]

The results of mode of failure in this current investigation revealed that in zirconia group the failure modes were mostly cohesive or mixed failure, however, in LDS ceramic the mode of failure was purely adhesive. This could be attributed to resistance of the base to surface tensile stresses, or the tensile strength of the base material, rather than the strength of the adhesive interface, controls the shear bond strengths determined in this work. This will continue to be the case for as long as the adhesive interface is robust enough to withstand the conditions that are locally stressful. [46] The production of high tensile stresses within the sample base as a result of the uneven stress distribution caused by the shear test setup is hypothesised to be the cause of this kind of failure, which were primarily cohesive or mixed fractures in the zirconia groups, are consistent with these observations. [46] Moreover, the strength of the bond was unaffected by the additional use of a conditioner for zirconia surface processing, according to Gerdzhikov et al. [10]

Correlation between translucency and shear bond strength revealed a strong positive correlation between translucency and shear bond strength that was statistically significant ($r_s=0.786$, $p<0.001$).

This study had some limitations as it compared several ceramic microstructures independent of the thickness and anatomical shape of the restorations. It is anticipated that anatomical crowns or veneers will have varying translucent and bond strength values. Furthermore, in comparison to clinical settings, the transparent parameter and bond strength might have been impacted by the absence of mechanical ageing and thermocycling.

V. Conclusions

Within the limitation of this study, it could be concluded that the kind of ceramic, independent of aging, influenced the translucency. Ageing also had an impact on the translucency of the material and colour change of tested ceramics. The higher the translucency of the material the higher shear bond strength

References

[1] Kursoglu P, Karagoz Motro Pf, Kazazoglu E. Translucency Of Ceramic Material In Different Core-Veneer Combinations. J Prosthet Dent 2015; 113:48-53.

[2] Korsel Am. Translucency Of Ceramic Laminate Veneers Fabricated With Different Ceramic Materials And Techniques. Egypt Dent J 2019; 65:3627-35.

[3] Abdullah M. Effect Of Ceramic Thickness, Translucency And Cement Shade On Color Masking Ability Of Pressable Zirconia Based Lithium Silicate Laminate Veneer. Egypt Dent J 2021; 67:2535-46.

[4] Walczak K, Meißner H, Range U, Sakkas A, Boening K, Wieckiewicz M, Et Al. Translucency Of Zirconia Ceramics Before And After Artificial Aging. J Prosthodont 2019;28: 319-24.

[5] Stawarczyk B, Keul C, Eichberger M, Figge D, Edelhoff D, Lümkemann N. Three Generations Of Zirconia: From Veneered To Monolithic. Part I. Quintessence Int 2017;48:369-80.

[6] Malkondu Ö, Tinastepe N, Akan E, Kazazoğlu E. An Overview Of Monolithic Zirconia In Dentistry. Biotechn & Biotechnolog Equip 2016; 30:644 - 52.

[7] Kolakarnprasert N, Kaizer Mr, Kim Dk, Zhang Y. New Multi-Layered Zirconias: Composition, Microstructure And Translucency. Dent Mater 2019; 35:797-806.

[8] Sheng Y, Shi Y, Wang L, Narasimhan Sg. Translucent Radiosity: Efficiently Combining Diffuse Inter-Reflection And Subsurface Scattering. Ieee Trans Vis Comput Graph 2014; 20:1009-21.

[9] Ban S. Classification And Properties Of Dental Zirconia As Implant Fixtures And Superstructures. Materials 2021; 14:4879-84.

[10] Gerdzhikov I, Radeva E, Uzunov T. Comparative Study Of The Bond Strength Of Zircad Multi And Zircad Prime Ceramics With Different Types Of Cements. Biotechn & Biotechnolog Equip 2023:42:733-37.

[11] Cokic Sm, Vleugels J, Van Meerbeek B, Camargo B, Willems E, Li M, Et Al. Mechanical Properties, Aging Stability And Translucency Of Speed-Sintered Zirconia For Chairside Restorations. Dent Mater 2020; 36:959-72.

[12] Ahmed Wm, Troczynski T, Mccullagh Ap, Wyatt Ccl, Carvalho Rm. The Influence Of Altering Sintering Protocols On The Optical And Mechanical Properties Of Zirconia: A Review. J Esthet Restor Dent 2019; 31:423-30.

[13] Dolev E, Bitterman Y, Meirowitz A. Comparison Of Marginal Fit Between Cad-Cam And Hot-Press Lithium Disilicate Crowns. J Prosthet Dent 2019; 121:124-28.

[14] Boitelle P, Mawussi K, Tapie L, Fromentin O. A Systematic Review Of Cad/Cam Fit Restoration Evaluations. J Oral Rehablit 2014; 41:853-74.

[15] Sailer I, Makarov Na, Thoma Ds, Zwahlen M, Pjetursson Be. All-Ceramic Or Metal-Ceramic Tooth-Supported Fixed Dental Prostheses (Fdps)? A Systematic Review Of The Survival And Complication Rates. Part I: Single Crowns (Scs). Dent Mater 2015; 31:603-23.

[16] Konstantinidis Ik, Jacoby S, Rädel M, Böning K. Prospective Evaluation Of Zirconia Based Tooth- And Implant-Supported Fixed Dental Prostheses: 3-Year Results. J Dent 2015;43:87-93.

[17] Gugelmin Bp, Miguel Lcm, Baratto Filho F, Cunha Lfd, Correr Gm, Gonzaga Cc. Color Stability Of Ceramic Veneers Luted With Resin Cements And Pre-Heated Composites: 12 Months Follow-Up. Braz Dent J 2020; 31:32-39.

[18] Sulaiman Ta, Abdulmajeed Aa, Donovan Te, Ritter Av, Vallittu Pk, Närhi To, Et Al. Optical Properties And Light Irradiance Of Monolithic Zirconia At Variable Thicknesses. Dent Mater 2015; 31:1180-87.

[19] Bagis B, Turgut S. Optical Properties Of Current Ceramics Systems For Laminate Veneers. J Dent. 2013;41: 24-30.

[20] Wang F, Takahashi H, Iwasaki N. Translucency Of Dental Ceramics With Different Thicknesses. J Prosthet Dent 2013; 110:14-20.

[21] Runnacles P, Correr Gm, Baratto Filho F, Gonzaga Cc, Furuse Ay. Degree Of Conversion Of A Resin Cement Light-Cured Through Ceramic Veneers Of Different Thicknesses And Types. Braz Dent J 2014; 25:38-42.

[22] Montero J, Gómez-Polo C. Effect Of Ceramic Thickness And Cement Shade On The Final Shade After Bonding Using The 3d Master System: A Laboratory Study. Clin Exp Dent Res 2016; 2:57-64.

[23] Zeighami S, Hemmati Y, Falahchai M. Effect Of Ceramic Thickness And Cement Color On Final Shade Of All Ceramic Restorations: A Systematic Review. Sch Acad J Biosci 2017; 5:425-32.

[24] Alghazzawi Tf. The Effect Of Extended Aging On The Optical Properties Of Different Zirconia Materials. J Prosthodont Res 2017; 61:305-14.

[25] Çömlekoğlu Me, Paken G, Tan F, Dündar-Çömlekoğlu M, Özcan M, Akan E, Et Al. Evaluation Of Different Thickness, Die Color, And Resin Cement Shade For Veneers Of Multilayered Cad/Cam Blocks. J Prosthodont 2016; 25:563-69.

[26] Liberato Wf, Barreto Ic, Costa Pp, De Almeida Cc, Pimentel W, Tiossi R. A Comparison Between Visual, Intraoral Scanner, And Spectrophotometer Shade Matching: A Clinical Study. J Prosthet Dent 2019; 121:271-75.

[27] Yildirim B, Recen D, Tekeli Simsek A. Effect Of Cement Color And Tooth-Shaded Background On The Final Color Of Lithium Disilicate And Zirconia-Reinforced Lithium Silicate Ceramics: An In Vitro Study. J Esthet Restor Dent 2021; 33:380-86.

[28] Dozić A, Kleverlaan Cj, El-Zohairy A, Feilzer Aj, Khashayar G. Performance Of Five Commercially Available Tooth Color-Measuring Devices. J Prosthodont 2007; 16:93-100.

[29] Kandil Bsm, Hamdy Am, Aboelfadl Ak, El-Anwar Mi. Effect Of Ceramic Translucency And Luting Cement Shade On The Color Masking Ability Of Laminate Veneers. Dent Res J (Isfahan) 2019; 16:193-99.

[30] Yılmaz K, Gonuldas F, Ozturk C. The Effect Of Repeated Firings On The Color Change Of Dental Ceramics Using Different Glazing Methods. J Adv Prosthodont 2014; 6:427-33.

[31] Turgut S, Bagis B. Colour Stability Of Laminate Veneers: An In Vitro Study. J Dent. 2011;39: 57-64.

[32] Hekimoğlu C, Anil N, Etikan I. Effect Of Accelerated Aging On The Color Stability Of Cemented Laminate Veneers. Int J Prosthodont 2000; 13:29-33.

[33] Nathanson D, Banasr F. Color Stability Of Resin Cements--An In Vitro Study. Pract Proced Aesthet Dent 2002; 14:449-55.

[34] Jung H, Friedl Kh, Hiller Ka, Furch H, Bernhart S, Schmalz G. Polymerization Efficiency Of Different Photocuring Units Through Ceramic Discs. Oper Dent 2006; 31:68-77.

[35] Hernandes Dk, Arrais Ca, Lima E, Cesar Pf, Rodrigues Ja. Influence Of Resin Cement Shade On The Color And Translucency Of Ceramic Veneers. J Appl Oral Sci 2016; 24:391-96.

[36] Mourouzis P, Tolidis K. Effects Of Milling Method And Artificial Ageing On Optical Properties Of High Translucent Zirconia For Chairside Restorations. Dent Mater 2021; 38:34-39.

[37] Fathy Sm, El-Fallal Aa, El-Negoly Sa, El Bedawy Ab. Translucency Of Monolithic And Core Zirconia After Hydrothermal Aging. Acta Biomater Odontol Scand 2015; 1:86-92.

[38] Alzebdah A, Hamdy Am, Naguib Am. Effect Of Aging On Translucency And Flexural Strength Of Different Zirconia Materials (An In-Vitro Study). Egypt Dent J 2021; 67:3305-11.

[39] Harada K, Raigrodski Aj, Chung Kh, Flinn Bd, Dogan S, Mancl La. A Comparative Evaluation Of The Translucency Of Zirconias And Lithium Disilicate For Monolithic Restorations. J Prosthet Dent 2016; 116:257-63.

[40] Putra A, Chung Kh, Flinn Bd, Kuykendall T, Zheng C, Harada K, Et Al. Effect Of Hydrothermal Treatment On Light Transmission Of Translucent Zirconias. J Prosthet Dent 2017; 118:422-29.

[41] Kontonasaki E, Rigos Ae, Ilia C, Istantsos T. Monolithic Zirconia: An Update To Current Knowledge. Optical Properties, Wear, And Clinical Performance. Dent J (Basel) 2019; 7:43-49.

[42] Casolco Sr, Xu J, Garay J. Transparent/Translucent Polycrystalline Nanostructured Yttria Stabilized Zirconia With Varying Colors. Scripta Materialia 2008; 58:516-19.

[43] Cattell Mj, Chadwick Tc, Knowles Jc, Clarke Rl, Samarawickrama Dy. The Nucleation And Crystallization Of Fine Grained Leucite Glass-Ceramics For Dental Applications. Dent Mater 2006; 22:925-33.

[44] Della Bona A, Van Noort R. Shear Vs. Tensile Bond Strength Of Resin Composite Bonded To Ceramic. Journal Of Dental Research 1995; 74:1591-96.