SHEAR BOND STRENGTH OF GLASS CERAMIC TO TRANSLUCENT ZIRCONIA USING TWO VENEERING TECHNIQUES: AN IN VITRO STUDY

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ABSTRACT

Aim: To investigate the shear bond strength of Glass ceramic to translucent zirconia using press-on versus layering technique.

Methodology: Twenty-four Samples of translucent zirconia were formed from partially sintered zirconia discs that were fully sintered as per the manufacturer's instructions. All samples were divided into 2 groups based on the veneering technique and layered using fluoro-apatite glass ceramic. Group A: The Free-hand layering technique. Group B: The press-on veneering technique. All steps were done following the manufacturer's instructions. Shear bond strength testing was performed using a universal testing device. The total surface area for each sample was measured and divided by the deboning load to produce shear bond strength values in MPa.

Results: Using an independent t-test, a comparison between them was made, and it was found that Group A (Layering technique) (9.03 ± 2.64 MPa) was significantly lower than Group B (Press-on technique) (11.2 ± 1.17 MPa) with the mean difference (2.17) as P=0.02*.

Conclusion: The translucent zirconia veneered using the press-on technique had a significantly higher Shear bond strength than the layering technique. However, both values are within the clinically accepted range. Moreover, the press-on technique formed a third chemical structure between glass ceramic and translucent zirconia.

Keywords: Translucent Zirconia, Glass ceramics, Veneering techniques, Shear bond strength test.

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INTRODUCTION

Metal-Ceramic Fixed Partial Dentures (FPD) were considered the gold standard as a reliable restoration. However, a significant increase in patient demand for aesthetic awareness and beauty brought dental materials and construction techniques into rapid development in dental restorations' art and science Daou **(2014), Papia et al. (2014).**

Dental ceramics are commonly used nowadays because of their biocompatibility combined with superior aesthetic qualities that closely mimic the optical properties of tooth structure. It can be utilized in the oral cavity without risk thanks to its chemical and mechanical qualities, which include a high modulus, a low heat coefficient of expansion, and strong wear resistance **Kontonasaki et al. (2020); Sriharan et al. (2021); Papia et al. (2014); Tang et al. (2019); Warreth and Elkareimi (2020).**

Different types of ceramic materials and commercial products can be used in dentistry. The high-strength core or framework of an all-ceramic restoration can be covered with a more aesthetically pleasing ceramic in a bi-layered restoration. At the same time, Dental ceramics made of high-strength materials can be utilized as a full-contour (monolithic) restoration. Compared to bi-layered restorations, monolithic restorations often have great mechanical qualities. A bi-layered all-ceramic restoration, on the other hand, yields great aesthetic effects. Since aesthetics are less essential in the posterior region, monolithic

Restorations are more frequently used. Concurrently, bi-layered restorations are applied in the aesthetic areas of **Warreth and Elkareimi (2020).**

There are many techniques and methods to veneer the zirconia restorations, such as the Free-hand layering technique, press-on technique, CAD-On technique, and Rapid layering technique. Each has its advantages and disadvantages. But generally speaking, the bi-layered restorations suffered from the chipping of the veneer ceramic **Daou (2014); Shahin et al. (2017); Zaher et al. (2017); Hallmann L. and Daniel M. (2019); and Gseibat et al. (2022).**

Even with the introduction of different generations with improved translucency to be suitable for use as a monolithic restoration in aesthetic areas, the esthetic properties of glass-ceramic are still superior to those of translucent zirconia. Making veneering of zirconia restorations necessary to enhance the restorations' aesthetic results **Harada et al. (2016) Michailova et al. (2020); Ban (2021); Ibrahim et al. (2022).**

The importance of the research lies in testing the shear bond strength of the corrected translucent zirconia material using the same approach as veneering conventional zirconia. Translucent zirconia has high aesthetic properties. Veneering techniques could provide more aesthetic outcomes, be time-saving, increase patient satisfaction, and eliminate re-making.

MATERIALS AND METHODS

1.1 Trial design: A comparative in vitro study.

2.1 Ethical considerations:

The ethics committee (EC), Faculty of Dentistry, Cairo University, accepted the in-vitro study protocol in terms of its scientific substance and compliance with the laws and regulations governing practise with human subjects. The approval number was (17-12-21).

3.1 Sample size calculation:

The purpose of this study was to compare pressing on translucent zirconia veneers to multilayer veneers in terms of shear bond strength. The estimated difference in shear bond strength between the two approaches was 8.458 0.845 MPa, with a minimal clinical difference, according to a prior study by Subash et al. (2015). We needed to study 12 participants in each group using 80% power and a 5% significance level. PS: Power and Sample Size Calculation Software Version 3.1.2 (Vanderbilt University, Nashville, Tennessee, USA) was used to calculate the sample size.

4.1 Sample size grouping:

Twenty-four Samples of translucent zirconia of standardized dimensions were formed from partially sintered zirconia that were fully sintered as per the manufacturer's instructions.

All samples were divided into two groups based on the veneering technique used.

Group A: A layering technique for translucent zirconia (n = 12).

Group B: A press-on veneering technique for translucent zirconia (n = 12).

5.1 Sample preparation:

A total of 24 square multicolour zirconia plates were constructed from an IPS e.max ZirCAD Prim**e** blank (Ivoclar Vivadent AG, Liechtenstein) using an isomet saw 4000 (Buehler Ltd., Lake Bluff, Illinois, USA). **Ibrahim et al. (2018); Habib et al. (2021).** The samples were cut at larger dimensions to compensate for 20% shrinkage after sintering (**Ibrahim et al., 2018; P et al., 2019).**

The translucent zirconia samples were speed sintered at a temperature of 1500°C in accordance with the manufacturer's instructions. A digital calliper (TOTAL TMT321501 DIGITAL CALIPER INOX 150 mm 6-inch item 6164, China) was used to standardize the translucent zirconia specimens after the final cut before and after the sintering cycle to standardize the dimensions of the specimen as well as the dimensions before sintering.

5.2 Scanning electron microscope study of zirconia samples (before the intervention):

High resolution scanning electron microscopy (SEM) at magnifications of 15000X and 30000X were used to examine the surface and structural morphology of the samples.

EDX is an X-ray method used to determine a material's elemental composition. In EDX systems, the scanning electron microscope's imaging capabilities were used to identify the specimen of interest so that its surface composition can be recorded before veneering.

5.3 Standardization of the veneering dimensions:

The CAD wax (BiLkiM;co.LTD, IZMIR, TURKEY) was milled into two blocks of (7mm length, 6mm width, 14mm length). then sawed using an isomet under cooling system to produce wax slices of (7 mm length, 6 mm width, and 1.5 mm thickness) that were checked using Digital caliper (TOTAL TMT321501 DIGITAL CALIPER INOX 150) to be used for construction of press-on technique samples and production of window like device for construction of layering technique samples

Ibrahim et al. (2018) Jalalian et. al. (2018).

A silicon putty index (Elite HD+, Zhermack SpA, Badia Polesine, Italy) was constructed using the sawed CAD-wax to build up the layering technique samples.

5.4 Construction of layering technique samples:

5.4.1 Glaze Flue paste and IPS e.max Ceram foundation:

The translucent zirconia samples were cleaned with distilled water and air dried immediately before foundation layer application to ensure the absence of debris. One clinician layered all samples for standardization. The Glaze FLUO paste (Ivoclar Vivadent AG | Liechtenstein) was mixed with the respective liquid using a spatula to a creamy consistency and applied as a single thin layer to each zirconia sample using a camel hair brush.

Then, with a dry brush, an IPS.e.max Ceram power dentine powder (Ivoclar Vivadent AG | Liechtenstein) was sprinkled as per manufacturer instructions. The zirconia sample with foundation layer was stabilized on a honeycomb tray in the programat EP 5000 (Ivoclar Vivadent AG | Liechtenstein). **Figure (1).**

Figure (1): Sprinkled powder.

The wash firing (foundation) was carried out according to the manufacturer firing parameters**.**

5.4.2 Layering procedures:

The IPS e.max Ceram power dentin powder (Ivoclar Vivadent AG | Liechtenstein) was mixed with the respective modeling liquid and placed inside the previously constructed window-like device secured over the glass lab. The translucent zirconia sample was placed over the packed mold, and another glass lab was placed over the sample parallel to the first one. The two-glass lab held together and gently switched to the opposite side, and then the first glass lab and window-like device were gently removed to obtain a layered translucent zirconia sample. The layered zirconia sample was stabilized on a honeycomb tray in the programate EP 5000 furnace (Ivoclar Vivadent AG | Liechtenstein. The dentine layer was fired as per the manufacturer's instructions. The final dimensions (7 mm length, 6 mm width, and 1.5 mm thickness) for each sample after firing were checked using a window-like device and a digital caliper (TOTAL TMT321501 DIGITAL CALIPER INOX 150) for dimension standardization.

5.5 Construction of Press-on veneering technique samples:

5.5.1 Zirliner Foundation:

Before applying the foundation layer, the samples of translucent zirconia were thoroughly washed with distilled water and allowed to air dry to guarantee no debris was present. Zirliner (Ivoclar Vivadent AG | Liechtenstein) was mixed with the respective modelling liquid to a creamy consistency and applied on the surface of the translucent zirconia sample using a camel hair brush before waxing. Just one clinician layered all samples with only one zirliner layer for standardization. The sample was fired at 960°C on Programat EP 5000 (Ivoclar Vivadent AG | Liechtenstein). The firing cycle of the zirliner foundation before wax-up was selected. The thickness of the foundation layer was about 0.1 mm after firing.

5.5.2 Press-on technique procedures:

The previously sawed wax was fixed using modeling wax of the same material molten using electric wax carver onto the zirconia sample. The wax was sprued with a wax wire length of 3 mm with an axial angle of 45° between the wax object to the investment ring base. The sprued sample invested by Brevest Ecospeed (GmbH & Co. KG · Weissenhorner, Senden · Germany) placed in a silicon ring as per manufacturer instructions. **Figure (2).**

The ring was placed in the furnace tipped with the opening facing down to be subjected to Burnout for wax elimination at 700°C in the Muffle Furnace (UGIN DENTAIRE Programix TX 50 Muffle, Seyssinet-Pariset, France) for 30 minutes.

IPS e.max ZirPress ingot (Ivoclar Vivadent AG | Liechtenstein) pressed into the mold using a plunger dispersed into an Alox separator, then placed in the Programat EP 5000 (Ivoclar Vivadent AG | Liechtenstein) using investment tongs. The firing cycle were selected for 100 g ring.

The investment ring was taken out of the furnace as soon as the zirpress cycle was complete, and it took around 60 minutes for it to reach room temperature. After that, divestment was carried out with polishing beads of 25-70 µm, 120 V at 2 bars in the fine sandblasting unit (Renfert GmbH, Hilzingen, Germany). After divesting completed, the excess material and sprue were cut using a diamond disc (Acurata, Thurman's Bang, Germany). The dimensions of the Finished veneered zirconia with the press-on veneering technique were measured using a digital caliper (TOTAL TMT321501 DIGITAL CALIPER INOX 150).

6.1 Construction of acrylic blocks for zirconia mounting:

All zirconia samples were placed in pink acrylic molds before the shear bond strength

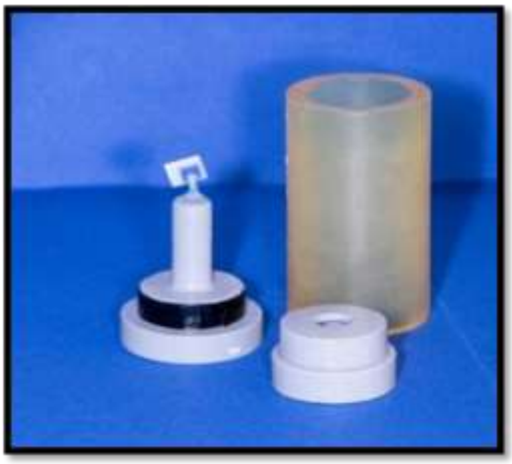

Figure (2): Sprued wax with the crucible former and ring.

test. The molds were fabricated with Polyvinylchloride (PVC) water tubes (25 mm internal diameter,12 mm length) on which acrylic resin bases were made to hold zirconia specimens.

Per the manufacturer's instructions, the pink acrylic resin was mixed in a 3:1 powder-to-liquid ratio and then poured inside the mold with the Zirconia sample placed over a glass lab. The acrylic base was flattened using another glass lab to remove any excess resin and ensure the horizontal stability of the base. The Acrylic resin was allowed to fully set before being pushed from the tube.

8.1 Shear bond strength test:

A mono-beveled chisel-shaped metal rod attached to the upper moveable portion of a universal testing machine (Model 3345; Instron Industrial Products, Norwood, USA) with a load cell of 5 KN that was connected to the computer software at a cross-head speed of 0.5mm/min was used to evaluate the shear bond strength at the zirconia-veneer interface. After recording the deboning load in Newton, the total surface area was divided by MPa. The following equation was used to calculate shear bond strength: A is the area of bonding, P is the load at failure (N), and is the shear bond strength (MPa). **Figure (3)**

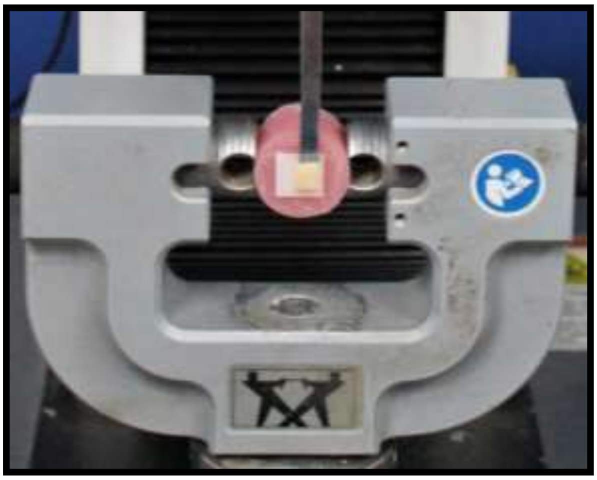

Figure (3): The zirconia sample mounted on the universal testing machine.

7.1 Scanning electron microscope study of veneered zirconia samples (after shear bond strength):

After de-bonding, the surface topography of magnifications of 1000X. and 15000X. In addition, EDX was done to detect the failure samples was investigated under SEM with mode wither adhesive, cohesive or mixed by elemental analysis of the sample surface.

RESULTS

1.1 Statistical analysis

Statistical analysis was performed with SPSS 20 *(Statistical Package for Social Science, IBM, USA*, Graph Pad Prism (*Graph Pad Technologies, USA*), and Microsoft Excel 2016 *(Microsoft Co-operation, USA)*

The Shapiro-Wilk Normality test was used to determine the normality of all quantitative data, which were then given as minimum, maximum, median, means, standard errors, and standard deviation (SD) values. The Shapiro-Wilk Normality Test, Kolmogorov tests, and independent t-tests were used to explore the data, and the t-test was utilized to compare two groups.

2.1.1 Normality test:

Shapiro-Wilk and Kolmogorov-Smirnov tests were used to examine the given data for normality. The significant level (P-value) was determined to be insignificant as P-value > 0.05, indicating that the data came from a normal distribution (parametric data) that resembled a normal Bell curve in both groups. **Table (1)**

Table (1): Normality Data Exploration of both groups using Kolmogorov–Smirnov test and Shapiro–Wilk test:

Group	P-value	Indication
Group A: Layering technique.	>0.05 (ns)	Normal data
Group B: press-on technique.	>0.05 (ns)	Normal data

Ns; Insignificant Difference as P>0.05.

2.1.2 Group A: Layering technique:

The mean, 95% confidence interval (CI), standard deviation, minimum and maximum, of all the descriptive results for group A (Layering approach) were reported in **Table (2)**

Table (2): Descriptive results of group A (Layering technique):

Group A: Layering technique		
Mean		9.0257
95% Confidence Interval for Mean	Lower Bound	7.3482
	Upper Bound	10.7033
Std. Deviation		2.64031
Minimum		4.42
Maximum		12.68

2.1.3 Group B: Press-on technique:

The mean, 95% confidence interval (CI), standard deviation, minimum and maximum, of all the descriptive results for group B (Press-on technique) were reported in **Table (3)**

Table (3): Descriptive results of group B (Press-on technique):

Group B: press-on technique		
Mean		11.1999
95% Confidence Interval for Mean	Lower Bound	10.4566
	Upper Bound	11.9431
Std. Deviation		1.16976
Minimum		9.64
Maximum		13.21

2.1.4 Comparison between both groups.

Mean and standard deviation of both groups were presented in **Table (4) and Figure (4).** Comparison between them was performed by using independent t test which revealed that Group A (Layering technique) (9.03 ± 2.64) was significantly lower than group B (Press-on technique) (11.2 ± 1.17) with mean difference (2.17) as P=0.02*.

Table (4): Mean and standard deviation of both groups and comparison between them using independent t test:

Group	**N**	**M**	**SD**	**Difference (Independent t test)**				
				MD	SED	95%CI		P value
						L	U	
Group A: Layering technique	12.00	9.03	2.64	2.17	0.83	-3.90	-0.45	0.02*
Group B: press-on technique	12.00	11.20	1.17					

N: frequency M: mean SD: standard deviation

MD: L mean difference SED: standard error difference

CI: confidence intervals L: lower U: upper

**Significant difference as P<0.05.*

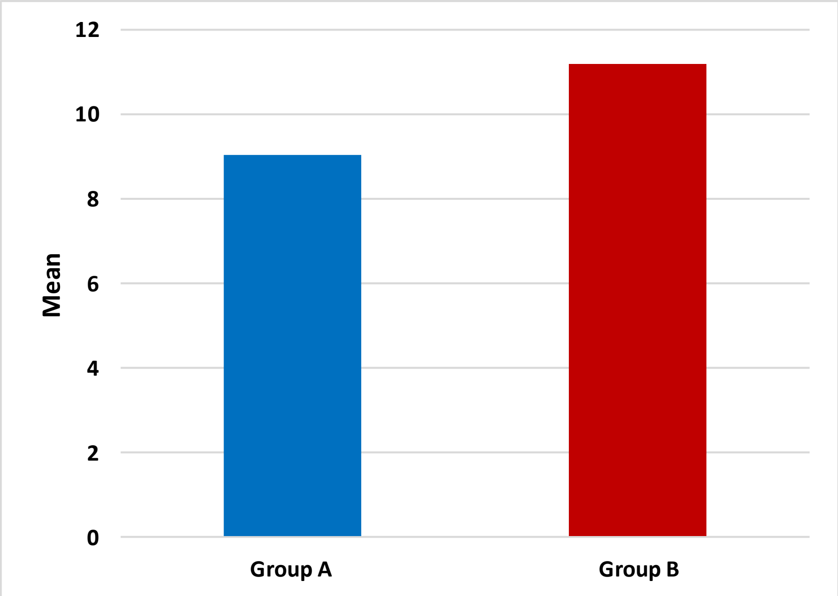

Figure (4): Bar chart showing comparison between both groups**.**

2.1 Results of SEM and EDX analysis before veneering and de-bonding:

Scanning Electron microscope (SEM) photos of the Translucent zirconia samples before veneering showed in **Figures (5).**

The EDX elemental analysis of Translucent zirconia samples before veneering shown in reveled higher percentage of zirconium oxide concentration (ZrO_2) and presence of Oxygen (O), carbon (C), Yttrium (Y), Nitrogen (N), Alumina (Al) small percent of silica (Si).

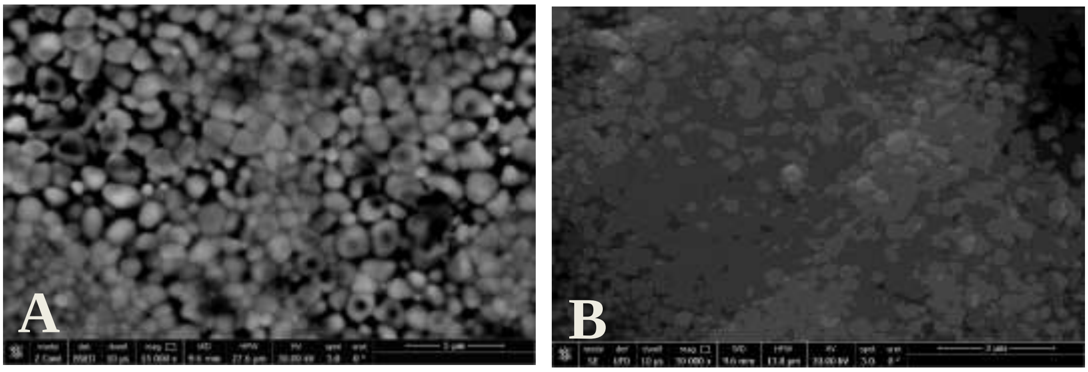

Figure (5): Representative SEM images of translucent zirconia polycrystalline structure. **(A)** x15000 magnification. **(B)** x30000 magnification.

2.2 SEM and EDX Analysis after veneering and de-bonding:

2.2.1 SEM and EDX of de-bonded samples of layering technique group:

After the shear bond strength test (SBS), the De-bonded veneered translucent Zirconia was scanned for surface morphology investigation, revealing the failure mode. In Free-Hand layering Technique samples, the glass ceramic was spreading over the surface of translucent zirconia with detached smooth fractured part denoting that the mode of failure was mixed as shown in **figures (6) and (7).**

EDX spectrum showed high percentage of Oxygen (O) followed by Silica (Si). In addition, it is reveled presence of other elements as follows: Zirconium (Zr), Carbon (C), potassium (K), Calcium (Ca), Aluminum (AL), Hafnium (HF), Titanium (Ti), Yttrium (Y) and, Fluoride (F).

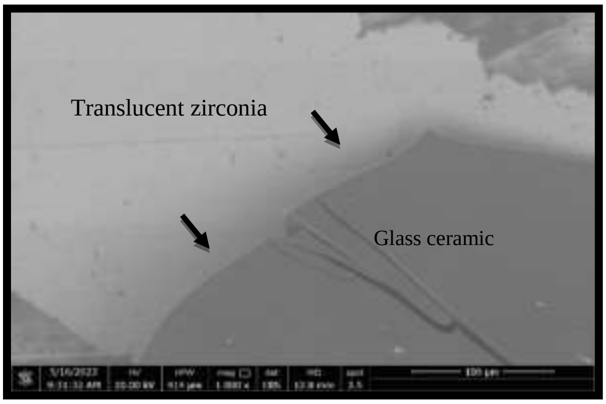

Figure (6): Representative SEM image x1000 magnification of de-bonded veneered translucent zirconia using Free-Hand Layering technique.

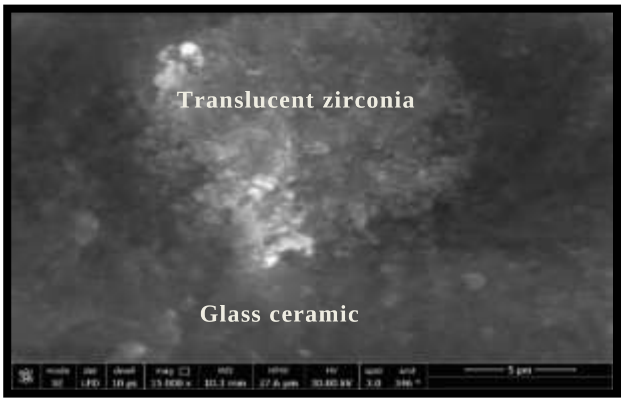

Figure (7): Representative SEM image x15000 magnification of de-bonded veneered translucent zirconia using Free-Hand Layering technique.

3.2.2 SEM and EDX of de-bonded samples of press-on technique group:

After the shear bond strength test (SBS), the de-Bonded translucent zirconia using the press-on technique was scanned for surface morphology investigation and revealed the failure mode.

The glass ceramic was spreading over the surface of the Translucent zirconia irregularly with punched areas on the detached glass-ceramic part, and the presence of islands of glass ceramic spread irregularly all over the surface of the Translucent zirconia and appeared to bind with it, denoting that the mode of failure is mixed as shown in **Figure (8) and (9).**

EDX spectrum showed high percentage of Oxygen (O) followed by Silica (Si). In addition, its reveled presence of other elements as follows: Zirconium (Zr), potassium (K), Aluminum (AL), Carbon (C), Titanium (Ti), Yttrium (Y).

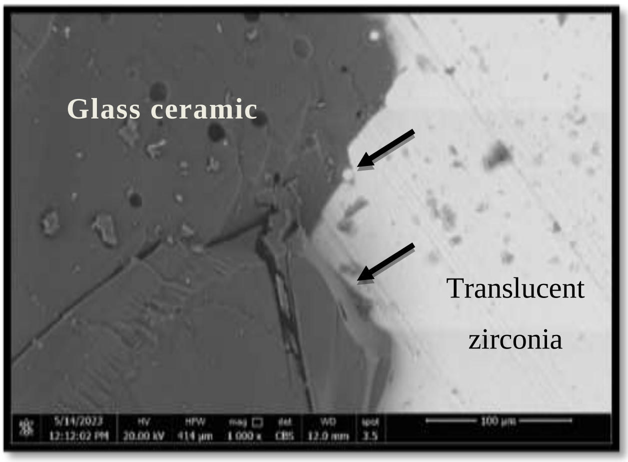

Figure (8): Representative SEM image x1000 magnification of de-bonded veneered Translucent zirconia using press-on technique.

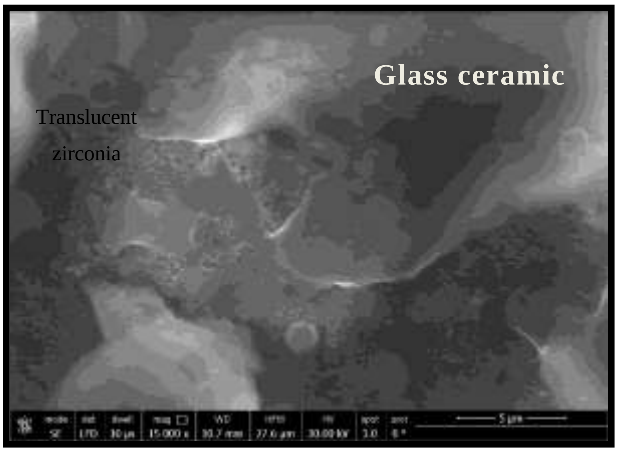

Figure (9): Representative SEM image x15000 magnification of de-bonded veneered Translucent zirconia using press-on technique.

DISCUSSION

Metal-Ceramic restorations were considered the gold standard as a reliable material. However, Dental ceramics are commonly used nowadays because of their biocompatibility and superior aesthetic qualities that closely mimic the optical properties of natural tooth structure. All ceramic restorations exhibited high mechanical properties such as high modulus and good wear resistance **Daou (2014) Kontonasaki et al. (2020) Warreth and Elkareimi (2020).**

All-ceramic restorations were available as Monolithic and bi-layered restorations. The monolithic All-ceramic restorations exhibit excellent mechanical properties but less esthetic properties than bi-layered restorations. However, the chip-off failures of veneering material have been the most frequent complication of bi-layered zirconia restorations **Daou (2014) Stawarczyk et al. (2017) Kontonasaki et al. (2019) Warreth and Elkareimi (2020) Sridharan. et al. (2021) Chiang et al. (2021).**

The researchers studied the factors that may contribute to increasing the esthetic properties of zirconia restoration to be used as a translucent monolithic restoration to eliminate the bi-layered zirconia restoration complications. However, the aesthetic qualities of glass ceramics are still superior to those of the most recent generations of translucent zirconia. Therefore, zirconia restoration veneering is unavoidable. Polychromatic translucent zirconia (IPS, e.max ZirCAD

Prime, Ivoclar Vivadent AG | Liechtenstein) manufactured with gradient technology has been recently introduced. It combines highly translucent 5Y-TZP in the enamel/outer area with high flexural strength 3Y-TZP in the dentin/body area, broadening the clinical applications of translucent zirconia to be starting from single crown to the construction of fourteen units of the Fixed partial denture (FPD). However, the studies concerned with their veneering are scarce **Harada et al. (2016) Michailova et al. (2020) Ban (2021) Ibrahim et al. (2022).**

This study aimed to assess the press-on or layering-based veneered shear bond strength of recently introduced translucent zirconia to glass ceramic.

In the current study, square plates of final dimensions (12 x 12 x 1 mm^2) of Translucent zirconia were prepared to be easily fixed in the acrylic mould and mimic the recommended zirconia restoration thickness. The discs were cut using an isomet saw for standardization **Ibrahim et al. (2018) P et al. (2019)**

The pre-sintered discs were speed-sintered following the manufacturer's recommendations. The speed sintering was performed to save time and cost, making the translucent zirconia restoration possible to be one of the chair-side restorations without reducing their optical and mechanical properties **Michailova et al. (2020).**

The free-hand layering technique was chosen since it is considered the conventional method with outstanding aesthetic qualities. On the other hand, the press-on veneering technique was selected because of its excellent mechanical and reasonable aesthetic qualities **Shahin et al. (2016) Moses et al. (2020).**

The shape and dimensions of the veneering layer for both techniques had to be standardized with dimensions of (6 X 7 X 1.5 mm^2) to ensure an even distribution of forces of the applied chisel at the point of interface between the veneering glass ceramic and translucent zirconia sample to obtain more accurate SBS results **Ibrahim et al. (2018) Jalalian et al. (2018).**

For **dimensional** standardization, CAD-wax (BiLkiM; co.LTD, IZMIR, TURKEY) was used with the press-on technique instead of free-hand wax-up and sawed to the required dimensions of the veneering material. After that, the window-like device was constructed on the previously cut CAD wax to construct layering technique samples **Ibrahim et al. (2018).**

The manufacturer recommended a Fluro-apatite glass ceramic material. The IPS e.max Ceram (Ivoclar Vivadent AG | Liechtenstein) of 9.4 ± 0.5 10-6/K CTE and IPS. e.max ZirPress ingots (Ivoclar Vivadent AG | Liechtenstein) of 9.75 ± 0.25 10-6/K CTE matched the coefficient of thermal expansion of IPS. emax Zircad prime (Ivoclar Vivadent AG | Liechtenstein) of 10.5 ± 0.5 10-6/K.

Accordingly, the core material's CTE was slightly higher than the veneering material's CTE, resulting in a desirable residual compressive stress and eliminating the intolerable tensile stress **Gostemeyer et al. (2010) Sui et al. (2013) Ibrahim et al. (2018) Kambiranda et al. (2023).**

The surface of IPS e.max Zircad Prime (Ivoclar Vivadent AG | Liechtenstein) was sprinkled with IPS. e.max Ceram Power Dentin powder (Ivoclar Vivadent AG | Liechtenstein) after being applied with Glaze Flue paste following the manufacturer's instructions. It has been noted that using slurry dentine as a base improves the bonds of veneered zirconia. On the other hand, Zirliner (Ivoclar Vivadent AG | Liechtenstein) of low fused nano-fluoro-apatite glass-ceramic was used as a foundation material with the press-on technique to improve the wettability and adjust the CTE for better bond strength **Macedo et al. (2014) Wattanasirmkit et al. (2015) Pathania et al. (2020)**

The shear bond strength (SBS) test was used to measure and investigate the bond strength between translucent zirconia and glass ceramic. The SBS test is the most reliable method to evaluate bond strength in the literature. Moreover, it is a quick and straightforward test. To provide a uniform shear force on the bonded surface, the original loading technique recommended by ISO standards was the knife-edged chisel **Mojtahedzadeh et al. (2006) Komine et al. (2012) Ismail et al. (2021) Sasany et al. (2021)**

The results of the current study showed that there was a statistically significant difference between the two groups, as the press-on technique showed a higher SBS mean value (11.19987667 ± 1.226 MPa) compared to SBS mean value obtained in the layering technique (9.0257425 ± 2.314 MPa). However, the mean values of shear bond strength of both techniques are more than the minimum clinically accepted range of SBS values (6 to 8 MPa) **Reynolds (1975)**

The null hypothesis of the present study was rejected, and the results were in accordance with the results reported by **Subash et al. (2015), Hafez et al. (2017), Hallmann and Mark-Daniel (2019), Moses et al. (2020), Jabeen et al. (2022).**

The press-on technique has several advantages over the layering technique. It improves the final bond strength by eliminating the volumetric shrinkage that occurs in the layering technique, ensuring higher stability and accuracy. Furthermore, the press-on technique, pressed at higher temperature and pressure, reduces the defects by increasing the surface contact between the veneering material and zirconia restoration, enhancing the bond strength **Tripathi et al. (2016) Hallmann and Mark-Daniel. (2019) Moses et al. (2020).**

SEM and EDX were used in the present study to examine the zirconia samples before veneering and after de-bonding. The surface morphology of the samples was studied using a scanning electron microscope (SEM). While The EDX was used to make an elemental analysis and revealed the chemical composition to detect the failure mode of each group **Mangano et al. (2017) Scimeca et al. (2018)**

In the present study, the SEM of the de-bonded samples showed the presence of islands of glass ceramic over the translucent zirconia samples of the free-hand layering technique group. At the same time, in the press-on group, the islands were found to be more numerous and attached to the translucent zirconia surface.

Silica has been added to the translucent zirconia to form zirconium silicate ($ZrSiO_4$) to reduce low thermal degradation (LTD).

Silica was evident in a small percentage when checking the samples before veneering using EDX. Silica particles were significantly increased upon an investigation by

EDX of de-bonded samples from both groups, with a higher percentage of silica found in the press-on group. The results of both SEM and EDX support that the failure mode was a mixed failure. **Gremillard et al (2000) Gremillard et al (2002) Drożdż et al. (2016).**

Based on SEM images and EDX analysis, we hypothesize that the active oxides (SiO_2. Moreover, ZrO_2) were involved in a solid-phase reaction during the firing and pressing of glass ceramic containing a high percentage of SiO_2 to ZrO_2 and silica presented in the translucent zirconia at 960 °C to form a third chemical structure between translucent zirconia and glass ceramic which is a Di-zirconium silicate (Zr_2SiO_4) **Drożdż et al. (2016) Pasiut and Partyka (2017).**

The composition of the ceramic and the type of crystallized phases determine the characteristic temperature and their influence on the bond strength. A chemical reaction may occur due to the phase's transformation at high temperatures. The effects of temperature rise in the studied techniques are more evident in the translucent zirconia restorations veneered using a press-on technique. This could be explained by the synergistic effect of high firing temperatures (over 960 °C) and the high pressing pressure resulting in a stronger bond. **Pasiut and Partyka (2017) Salman et. al. (2017).**

The formation of a third chemical structure between translucent zirconia and glass ceramics constructed using the press-on technique is in accordance with previous studies **Pretorius et al. (1978) Froberg et al. (2009) Drożdż et al. (2016) Pasiut and Partyka (2017)** that reported that the silica could react chemically with zirconia at high temperatures. These hypotheses support the significantly high SBS results of the press-on group over the free-hand layering group.

Nevertheless, the best shear bond strength veneering technique for translucent zirconia is still controversial. Results inconsistency existed may be due to differences in samples dimensions, samples surface geometry, samples preparation, mechanical testing procedure, blade designs of the SBS test, surface treatments as well as the type of zirconia and the veneering material used **Özkurt et al. (2010) Kim et al. (2011) Komine et al. (2012) Powers and Sakaguchi (2012) subash et al. (2015) Moses et-al. (2020) Ergin et al. (2021).**

Our results disagree with those of **Ibrahim et al. (2018),** who showed that the free-hand layering technique had a significantly higher SBS value than the press-on technique. This could be attributed to the usage of different types of zirconia by different generations (IPS e.max ZirCAD, Ivoclar Vivadent AG, Liechtenstein). Also, they used zirpress liner foundations for both techniques.

In addition, **Sindhavajiva (2022)** reported that the mean of SBS values of the Layering technique is more than the press-on technique, with no statistical difference between both techniques. This may be because they used different types of zirconia (3Y-TZP Procera®, Nobel Biocare, Goteborg, Sweden) with manufacturer-recommended veneering materials as the NobelRondo™ Zirconia for base liner and layering technique groups and NobleRondo™Press Zirconia for press-on technique. Furthermore, they use different veneering shapes and dimensions (3mm in thickness and 2.38 mm in diameter) for cylindrical-shaped samples that may affect the results.

The current study is not free from limitations as it is an In-vitro study and may not reveal the exact clinical situation, and the results need to be confirmed by further clinical studies **Koletsi et al. (2019).**

Finally, we can come to the conclusion that both veneering techniques were acceptable and provided good shear bond strength. However, in clinical situations of high stresses and heavy mastication forces, we recommend a press-on technique for its surpassing SBS values and evidence of a chemical bond between the veneering material of zirconia.

CONCLUSIONS

Within the limitations enforced through the current study, it could be concluded that:

1- The type of veneering technique influences the shear bond strength (SBS) of translucent zirconia veneered with glass ceramic.

2- The shear bond strength values of glass ceramics to translucent zirconia constructed with the press-on technique surpass the SBS values of those contracted with the layering technique.

3- Both techniques showed shear bond strength values more than the minimum clinically accepted range.

RECOMMENDATIONS

· **Recommendations for clinicians and technicians:**

1- Using both techniques as a correction veneering technique in case of

2- Construct defective monolithic translucent zirconia. For example, open contact or/and out-of-occlusion restoration.

3- To ensure maximum bond strength, the press-on veneering technique is recommended in high-stress-bearing areas and/or restorations with large defects.

- **Recommendations for researchers:**

1. More research is required to determine how veneering affects the colour and translucency of veneered translucent zirconia.

2. Further in-vitro studies with anatomical samples and simulation of the oral cavity conditions are needed.

Additional clinical research is required to support the findings of the current in-vitro investigation.

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