"A Comparative Evaluation Of Bond Strength Of Veneering Porcelain To Zirconia And Metal Cores - An In Vitro Study."

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INTRODUCTION

For the past forty years, the porcelain-fused-to-metal systems have been extensively used in fixed partial dentures (FPDs) and still represents the gold standard. The PFM systems have the advantage of integrating the metal substructure's fracture resistance with the porcelain's aesthetic property. However, the growing demand for attractive restorations, combined with concerns about the biocompatibility of various dental metal alloys, has hastened the development and improvement of metal-free restorations.[1]

While veneering zirconia frameworks with ceramics has enhanced aesthetic appeal, the core-veneer interface is a pain because it leads to ceramic chipping and cracking, which is one of the weakest parts of zirconia-based restorations. The zirconia framework, unlike metals, has a higher hardness, which causes more catastrophic stress to build in the veneer layer of zirconia-based restorations. In this regard, the veneering ceramic's strength is a significant feature for long-term clinical success. [2]

There are several elements that contribute to veneering ceramics delaminating from zirconia cores. CTE mismatch between core and ceramic, ceramic firing shrinkage, inadequate wetting by veneering on core, and suboptimal heating and cooling rates are among these factors.In view of this, manufacturers have created specific veneer ceramics with reduced or similar CTE to zirconia to reduce the adverse complication of veneer chipping.[3]

In recent years, Y-TZP (Yttria-stabilized Zirconia polycrystal) has been employed as a core material for all-ceramic restorations. In comparison to other materials like alumina and feldspathic porcelains, it has a high mechanical strength (flexural strength of 900-1200 MPa and fracture toughness of 9-10 MPa). Because of the properties of Y-TZP, the majority of the mechanical strength comes from the change of a monoclinic to a tetragonal structure. It may be able to withstand occlusal loading. For the frames of fixed-dental prosthesis, traditional procedures (cupping) such as slip-casting and CAD-CAM are used (FPDs).

This study aims to compare and evaluate the shear bond strength of zirconia and metal core to veneered porcelain after thermocycling. The hardness of the cores are also to be compared and evaluated using Vicker's hardness test The null hypothesis has been stated as no significant differences in the mean shear strength values between core and veneer of two all-ceramic and metal ceramic group.

MATERIALS AND METHODS:

This study was conducted to compare and evaluate the shear bond strength between two groups of zirconia and base metal cores to veneered porcelain.

Study Setting

The study was conducted in the Department of Prosthodontics and Crown and bridge at Mar Baselios Dental College, Kothamangalam.
Amrita Institute OfNanotechnology, Kochi

SreeChithiraThirunalBiomedical and Technology Wing,Trivandrum

Study Design

The study conducted was a cross-sectional study.

Sample Size Calculation

Minimum sample size required for the study is calculated by using the formula:

$N = \underline{2 [Z\alpha + Z\beta]^2 [Sd]^2}$

d^2

Average standard deviation for the group is expected as 2.5 and expected difference between the means are set at 2.4, therefore

$\mathbf{\underline{2 (1.96+.84)^2 (2.5)^2} \;=\; 16/\ group}$

$\mathbf{\underline{(2.4)^2}}$

Number of samples per group = 16

MATERIALS USED:

Three types of core-veneer combinations were fabricated according to the manufacturer's instructions.The total number of samples was 48 and there were 16 samples per group.

For Group I Amann Girrbach zirconia core ,the veneer was E max ceram porcelain, for Group II Aidite zirconia core the veneer was Shofu Vintage porcelain, and for Group III Scheftnar cobalt-chromium metal alloy core, the veneer was Ivoclar Classic IPS material.[Table 1].

Sl.No	Material	Core	Veneer
1	Group I High Translucent HT,ZolidgenX, mann Girrbach zirconia core veneered with E max Ceram Porcelain		
2	Group II Aidite zirconia core veneered with Shofu Vintage porcelain		
3	Group III Co-Cr Alloy core (Scheftnar,Germany) Veneered with Ivoclar IPS classic porcelain		

Table:1 Core-Veneer Materials

1. Specimen Preparation Of The Zirconia Core-Veneer For Group I And Group Ii:

A total of 32 zirconia blocks measuring 9x4x4mm length, breadth. and height were fabricated and collected using CAD/CAM (Exocad's Dental CAD and HyperDENTCAM) system.

First, samples were fabricated using Exocad's Dental CAD and HyperDENTCAM with the dimension of 9x4x4mm length, breadth, and height respectively.The Group I zirconia cores was milled from fully sintered zirconia blanks of High Translucent HT,ZolidgenX, Amann Girrbach, USA, and Group II core material used was milled from AiditeHonorZir, Germany

i. The zirconia core of the samples were fabricated as follows:

a)Designing:The rectangular design with the dimension of 9x4x4mmlength,breadth and height, appears on the screen after geometric modeling, engineering analysis, design review and evaluation, and automatic drafting. Any additional design or modelling required was completed with the software support. The data was then transferred on to milling unit.

b)Milling: The blocks were milled from a zirconium oxide blank using hard metal tools. The average milling time was 15-20 minutes.

c)Sintering: The fully-automated, monitored sintering process was carried out with no manual intervention in a special furnace. The sintering program started automatically and heated the furnace to 1,500°C. The sintering time was approx.9.5 hours.

ii. Porcelain build up for Group I and Group II:

Porcelain build-up was started according to the manufacturing instructions. Each zirconia sample was veneered with its own ceramic material. The irregularities and excess veneering material were removed using a micro motor handpiece. The blocks were cleaned in an ultrasonic bath. Ceramic was layered onto the zirconia blocks with no additional surface treatment. An appropriate amount of ceramic powder and liquid was mixed to get a creamy consistency mix. Using a damp brush the mix was layered onto the surface of the zirconia blank. For both groups, the veneering was built up to a final thickness of 3mm. The ceramic was dried for 5 minutes then placed in a ceramic firing unit. The firing was done from temperature 6000°C to 9300°C under the vacuum. Hold time under the vacuum was two minutes. Three consecutive firings were required to compensate for the shrinkage of the porcelain. The rectangular blocks were cut off from respective zirconia blanks into the following dimensions: 9x4x4mm length, breadth, and height and respectively with 3mm veneer at one end. A caliper was used to assess the dimension of the porcelain before SBS testing.

iii. Preparation of the Co-Cr core veneer specimens for Group III:

The DMLS technology was used to fabricate the Co-Cr rectangular blocks (Scheftnar,Germany)according to the manufacturer's specifications. The laser-sintered Co–Cr specimens were prepared from Co–Cr powder using the PM 100 system. The material dispensing platform along with a re-coater blade was used to move new powder over the build platform. The metal powder was fused into a solid part by melting it using the focused laser beam (such as a carbon dioxide laser). Parts were built up additively layer by layer. After a layer was built, the build piston lowers the build platform, and the next layer of powder is applied and to be created directly from the 3D CAD data (Exocad's Dental CAD). The specimens were sandblasted with 250mm aluminum oxide at a pressure of 3bar. All samples were cleaned with acetone in an ultrasonic cleaner for 8 minutes as per manufacturer instructions. Then according to metal manufacturer instructions, the substructure was refinished, and steam cleaned.

iv. Porcelain build-up for Group III:

Porcelain was applied to all samples, according to the manufacturer’s instructions, by layering technique using feldspathic porcelain that involved applications of opaque, dentin, and enamel layers (Ivoclar Classic IPS, Liechtenstein). A layer of opaque porcelain was first applied to the metal after mixing and fired at (960˚C) in a porcelain furnace (Automatic IvoclarVivadentProgramat P310 Porcelain Furnace).To avoid shrinkage, another layer of opaque porcelain was mixed and applied over the samples and was fired at (950˚C), followed by dentin and enamel porcelain application and firing (930˚C) then auto glazed firing (920˚C). The veneering porcelain was applied, condensed, and fired according to the manufacturer’s recommendations. Porcelain was fired on all blocks together to standardize the procedure. In order to know the amount of shrinkage during firing, a dial caliper was used to assess the dimensions of the porcelain before SBS testing.

2.Thermocycling

After the samples had been prepared, the thermocycling process was carried out in WILEYTEC THERMOCYCLER with cooling system HAAKEEK30,(Thermoelectron Corporation, Germany). All the samples underwent 500 thermocycles in a thermocycler before the pre-loading procedure with two water baths at 5°C and 55°C. Each cycle lasted for 10 s in each bath, and 10 s to complete the transfer between the baths.The thermocycling parameters were as follows;

3.Shear Bond Strength Test (Sbs Test):

Each sample was embedded in PMMA resin in the bespoke silicon mold. Self-cure acrylic resin is mixed according to the manufacturer’s instructions and poured in the fluid stage into the silicon mold. Every effort was made to keep the core-veneer interface above the mold's upper plane so that all samples were embedded along their vertical alignment to

ensure that the application of force is at the zirconia and ceramic interface. Then prepared samples were loaded on to universal testing machine (Model3345, Instron Canton MA, USA). Specimens were fixed in the testing jig in order for the load to be exerted along the direction of contact between the core and veneer. Force was applied by a stainless steeljig until fracture occurred. The universal testing machine crosshead speed was maintained at 0.5mm/min. The fracture load was measured and recorded by digital monitoring in Newtons (Bluehill Lite software Instron Canton MA, USA) for all samples. The shear bond force was calculated in Newton and the average shear bond strength (MPa) was computed by dividing the load (N) at the point of failure by the bonding area (mm2).
Shear stress (MPa)= Load (N) ÷ Area (mm2

4.Hardness Testing Of The Cores:

The sampleshardness was assessed in the following ways: a)Hardness (Vicker's translated from HIT, as acquired via nano-indentation technique using Berkovich indenter, 80 mN load) was used for Zirconia Group I and Group II, while Vicker's Hardness test was used for Co-Cr Group III.

i.Vicker's Hardness Test: It used a Vickers indenter [Wolpert Wilson Instrument, to make a hardness impression on a polished specimen surface. The indenter created a plastically-deformed region underneath the indenter as well as cracks that emanate radially outward and downward from the indentation. On the polished surface, then appeared four cracks that radiated outward from the indentation corners, and the lengths of these cracks were measured. Hardness was computed on the basis of the length of the crack, the indentation load, the hardness, the elastic modulus, the indentation diagonal size, and an empirical fitting constant.

Each group had ten specimens under each load, and each specimen had five indentations produced at random with a dwell duration of 10 seconds.TheVicker’s hardness was determined using the following formula:HV=αF/ d2 with F being the applied load (measured in kilograms-force) and d2 the area of the indentation (measured in square millimeters).

ii.Nano-indentation technique using Berkovich indenter: The nanoindentation measurements were carried out using an indenter[Anton Paar instruments fig.28] equipped with a three-sided pyramidal Berkovich diamond tip at room temperature. The load sensitivity of the instrument was 80mN. Indentation was performed under a variety of peak loads in the range of 0.05–5.0 mN. For all nanoindentation tests, the loading and unloading times were 10s, and the holding time was set as 2s at the peak indent loads. By nano-indentation technique using Berkovich indenter,hardness was calculated by converting HIT(indentation hardness), as obtained from the technique.HIT =Pmax/Ap ;where Pmax = maximum load and point ;Ap = projected contact area

5. Scanning Electron Microscopic Study:

Fractured specimens were observed under SEM (JSM7610F Plus,Japan) to classify the type of failures after shear bond testing of group I, group II and group III. Bond failures were classified as: (1) adhesive – between zirconia and metal cores with veneered porcelain,
(2) cohesive – entirely within porcelain, and (3)mixed-mode – a combination of adhesive and cohesive failure. Representative fractured surfaces of two specimens per group were selected and gold-sputtered (DII-29030SCTR Smart Coater, Japan). for further evaluation under SEM for characterization of morphology, microstructure, fractographic details on the fractured surfaces, to identify the direction of crack propagation (dcp), and failure origin to finally state the specific reasons for failure, fractographic pattern, and surface feature recognition. Images were taken at 15 kV at different magnifications and were analyzed with an image processing software (DISS 5, Point Electronic, Germany).

Results of SEM study of the three groups;

To determine the failure mode and observe the fractured surfaces, these surfaces were visually analyzed using a scanning electron microscope after measuring the shear bond strength between the core and veneer. The failure mode was classified as cohesive if the fracture occurred within the veneer or core material, adhesive if the fracture occurred between the core and veneer, and mixed failure if consisted of both adhesive and cohesive failures.
The net results of the SEM images shows, peaks and valleys, and inclusion defects in the fractured segments of the samples and these features points out that the fracture is due to the cohesive failure within the veneer portion.

RESULTS

Statistical Analysis

Statistical analysis of the data was carried out using SPSS(16.0). The means and standard deviations were calculated for the variables measured from the shear bond, hardness, and maximum load tests that were conducted in Group I, Group II, Group III samples.
One way ANOVA test was used to assess the group having higher shear bond strength. Only a slight significant difference present since $P>0.05$.
One way ANOVA test was used to assess the group having higher core hardness value. Results were considered statistically significant at $P<0.05$.
Post hoc pairwise comparison (Tukey’s Honestly Significant Difference) was done to assess the difference between each group. The shear bond strength values were calculated by obtaining the maximum load in the UTM after placing the sample.

Table.2 - Post hoc pairwise comparison (Tukey's Honestly Significant Difference) of maximum load applied at the core-veneer interface of Group I, Group II and Group III

Multiple Comparisons						
MAXIMUM LOAD(N) Tukey HSD (I) GROUPS	(J) GROUPS	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
AMANN GIRRBACH ZIRCONIA VENEERED WITH E MAX CERAM PORCELAIN	AIDITE ZIRCONIA CORE VENEERED WITH SHOFU VINTAGE PORCELAIN	8.7016	41.57389	0.976	-92.0575	109.4606
	SCHEFTNAR COBALT CHROMIUM ALLOY CORE VENEERED WITH IVOCLAR IPS CLASSIC PORCELAIN	-39.66453	41.57389	0.609	-140.4236	61.0945
AIDITE ZIRCONIA CORE VENEERED WITH SHOFU VINTAGE PORCELAIN	AMANN GIRRBACH ZIRCONIAVENEERED WITH EMAX CERAM PORCELAIN	-8.7016	41.57389	0.976	-109.4606	92.0575
	SCHEFTNAR COBALT CHROMIUM ALLOY CORE VENEERED WITH IVOCLAR IPS CLASSIC PORCELAIN	-48.36613	41.57389	0.481	-149.1252	52.3929
SCHEFTNAR COBALT CHROMIUM ALLOY CORE VENEERED WITH IVOCLAR IPS CLASSIC PORCELAIN	AMANN GIRRBACH ZIRCONIAVENEERED WITH EMAX CERAM PORCELAIN	39.66453	41.57389	0.609	-61.0945	140.4236
	AIDITE ZIRCONIA CORE VENEERED WITH SHOFU VINTAGE PORCELAIN	48.36613	41.57389	0.481	-52.3929	149.1252

Inference:

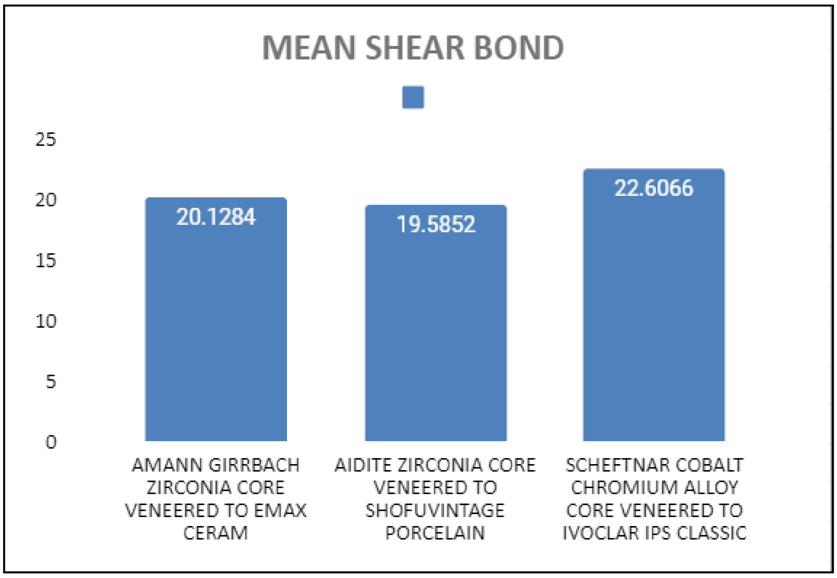
Table.2 shows that the mean of maximum load applied in newtons. Since the P value $> .05$[.976-.481], hence no statistical significance present among the groups.The mean difference of maximum load applied on the samples using Tukey HSD. For Group I the lower bound is -92.0575± -140.423,for Group II is-109.4606 $\pm$-149.125 and for Group III is-149.1252 $\pm$-61.0945.

Table.3-Post hoc pair wise comparison (Tukey's Honestly Significant Difference) of shear bond strength of Group I, Group II and Group III.

Multiple Comparisons						
SHEAR BOND STRENGTH(Mpa)						
Tukey HSD						
(I) GROUPS	(J) GROUPS	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
AMANN GIRRBACH ZIRCONIA VENEERED WITH EMAX CERAM PORCELAIN	AIDITE ZIRCONIA CORE VENEERED WITH SHOFU VINTAGE PORCELAIN	0.54321	2.59818	0.976	-5.7538	6.8402
	SCHEFTNAR COBALT CHROMIUM ALLOY CORE VENEERED WITH IVOCLAR IPS CLASSIC PORCELAIN	-2.47819	2.59818	0.609	-8.7752	3.8188
AIDITE ZIRCONIA CORE VENEERED WITH SHOFU VINTAGE PORCELAIN	AMANN GIRRBACH ZIRCONIA VENEERED WITH EMAX CERAM PORCELAIN	-0.54321	2.59818	0.976	-6.8402	5.7538
	SCHEFTNAR COBALT CHROMIUM ALLOY CORE VENEERED WITH IVOCLAR IPS CLASSIC PORCELAIN	-3.0214	2.59818	0.481	-9.3184	3.2756
SCHEFTNAR COBALT CHROMIUM ALLOY CORE VENEERED WITH IVOCLAR IPS CLASSIC PORCELAIN	AMANN GIRRBACH ZIRCONIA VENEERED WITH EMAX CERAM PORCELAIN	2.47819	2.59818	0.609	-3.8188	8.7752
	AIDITE ZIRCONIA CORE VENEERED WITH SHOFU VINTAGE PORCELAIN	3.0214	2.59818	0.481	-3.2756	9.3184

Inference:

Table.3 shows the significance in the range of 0.976-0.481 which is greater than 0.05.Since P>0.05,no statistically significant difference is present.



Graph 1: Mean shear bond strength of Group I [Amann girrbach zirconia veneered wit E max ceram porcelain],Group II [Aidite zirconia core veneered with shofu vintage porcelain] Group III [Scheftnar cobalt chromium alloy core veneered with Ivoclar IPS classic porcelain]

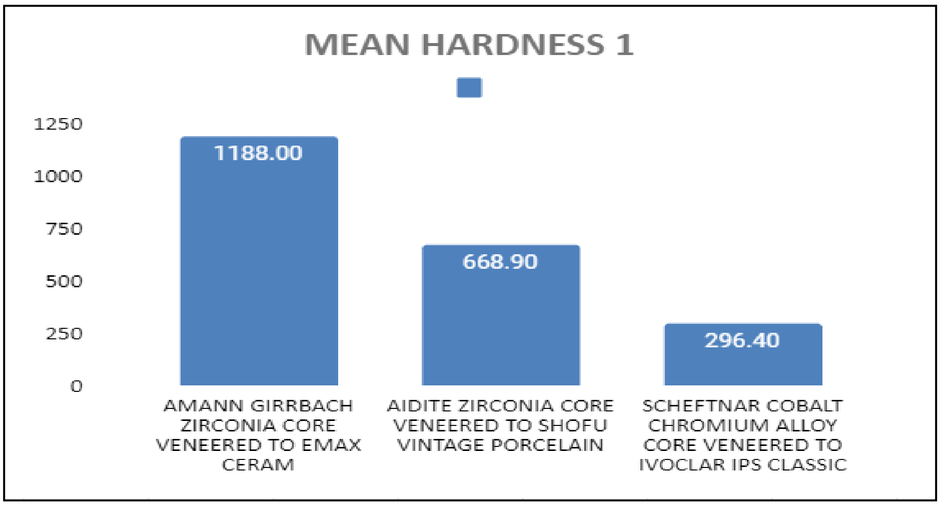
The result shows that the shear bond strength is highest for Group III (22.606), followed by Group I (20.12) and Group III (19.58)

Table 4 - Post hoc pairwise comparison (Tukey's Honestly Significant Difference) of values of Group I, Group II, and Group III at first point of indentation

Multiple Comparisons						
Hardness 1						
Tukey HSD						
(I) GROUPS	(J) GROUPS	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
AMANN GIRRBACH ZIRCONIA VENEERED WITH EMAX CERAM PORCELAIN	AIDITE ZIRCONIA CORE VENEERED WITH SHOFU VINTAGE PORCELAIN	519.1	216.94	0.06	-18.7907	1056.9907
	SCHEFTNAR COBALT CHROMIUM ALLOY CORE VENEERED WITH IVOCLAR IPS CLASSIC PORCELAIN	891.60000*	216.94	0.001	353.7093	1429.4907
AIDITE ZIRCONIA CORE VENEERED WITH SHOFU VINTAGE PORCELAIN	AMMANN GIRRBACH ZIRCONIAVENNEER ED WITH EMAX CERAM PORCELAIN	-519.1	216.94	0.06	-1056.9907	18.7907
	SCHEFTNAR COBALT CHROMIUM ALLOY CORE VENEERED WITH IVOCLAR IPS CLASSIC PORCELAIN	372.5	216.94	0.217	-165.3907	910.3907
SCHEFTNAR COBALT CHROMIUM ALLOY CORE VENEERED WITH IVOCLAR IPS CLASSIC PORCELAIN	AMANN GIRRBACH ZIRCONIA VENEERED WITH EMAX CERAM PORCELAIN	-891.60000*	216.94	0.001	-1429.4907	-353.7093
	AIDITE ZIRCONIA CORE VENEERED WITH SHOFU VINTAGE PORCELAIN	-372.5	216.94	0.217	-910.3907	165.3907
*. The mean difference is significant at the 0.05 level.						

Inference:

Table 4 - shows that for Group I the lower bound is--18.79 - 353.70 and upper bound is 1056.99 - 1429.49, for Group II the lower bound is -1056.99 - -165.390 and upper bound is 18.790 - 910.390, for Group III the lower bound is1429.490 - 910.390 and upper bound is 353.70 - 165.39.



Graph 2- Mean core hardness of Group I [Amann girrbach zirconia veneered with e max ceram porcelain],Group II [Aidite zirconia core veneered with shofu vintage porcelain] Group III [Scheftnar cobalt chromium alloy core veneered with ivoclarips classic porcelain] at first point of indentation.

The net result of the hardness values of the cores of samples after descriptive analysis and Tukey's multiple comparison analysis shows that the mean core hardness value of Group I is higher than that of Group II and Group III. The value of hardness of Group II is more than that of Group III.

DISCUSSION:

Since its conception in the early 1950s, metal-ceramic restoration has been extensively employed in clinics, integrating the natural aesthetics of porcelain veneering with the durability and marginal fit of metal casting. This restoration incorporates both precious and non-precious metal alloys. Nickel-chrome (Ni-Cr) alloy, on the other hand, is a non-precious metal alloy with superior mechanical qualities. However, clinical application of Ni-Cr alloy to dental restorations is controversial due to flaws such as inferior biocompatibility and corrosion resistance.The use of opaque porcelain in metal-ceramic restorations is recommended leads to limitations of natural color expression, and exposure of metal colors in cervical area causes esthetic defects. To overcome the demerits of the Nickel-chrome (Ni-Cr) alloy, Co-Cr is used extensively. Clinical application of all-ceramic restorations has increased to compensate for the shortcomings of metal-ceramic restorations, and as the demand for rehabilitation high aesthetic develops.[4]

Zirconia, the metal dioxide (ZrO2), was discovered as such in 1789 by the German chemist Martin Heinrich Klaproth in the reaction product obtained after heating some gems, and was used for a long time in combination with rare earth oxides as pigment for ceramics. Yttrium oxide is a stabilizing oxide that is added to pure zirconia to stabilize it at room temperature to produce partially stabilized zirconia, a multiphase material.The physical feature of partly stabilized zirconia gives Y-TZP its high initial strength and fracture toughness. Tensile forces at the fracture tip cause the meta stable tetragonal zirconium oxide form to convert into the monoclinic form. This transition is linked to a volume rise of 3% to 5% in the local area of stress distribution. [5]

The bond strength measurement of metal ceramic system was standardized by the Organization of Standardization through the Schwickerath crack investment test, and the mean debonding strength/ crack induction strength should be inferior than 25MPa to meet the ISO demand. The Schwickerath three point bending adhesion test is that the main test of the International Standard ISO 9693.1999 procedure for assessing porcelain relating to metals.

The percentage of bonding ability of ceramic to metal affects the long-term reliability of metal ceramic restorations. The core-veneer interface is related with core surface roughness, residual stress arising from the difference of thermal expansion and contraction between materials, wetting properties, presence of flaws, cooling rate systems, and viscoelastic and elastic properties. The following factors plays a significant role in the development of adherence zone:1) Alloy pre-oxidation effects, 2) Total firing time, (3) Initial relative concentrations in porcelain and metal of the principal diffusing elements (4) Oxidation-reduction behaviour between ceramic and metal oxide, (5) Extent of metal oxide dissolution by the ceramic zone, and 6) Firing chamber environment. All of the above factors may affect the characteristics of the metal oxide laser required for electronic structural continuity or chemical bonding with the adjacent ceramic structure. Adherence of ceramic to metal therefore would be promoted by the continuity of electron structure across the metal-metal oxide interface and the metal oxide-ceramic interface through metallic, ionic, and covalent bonding. The calculation of metal-ceramic bonds have been based on test standardization, interpretation, and clinical correlation of results.[6]

According to Zhang et al. to achieve the best aesthetic result, metal or zirconia core materials must be covered with feldspathic veneering ceramics, especially in terms of color and translucency.[7] Veneering ceramics are usually feldspathic porcelains that incorporate leucite in the form of crystallites to toughen the structure and provide a material that is thermally compatible with the ceramic framework. Now a days, glass ceramics are widely used as veneering ceramics. Heat-treatment crystallization of glass compositions produces glass-ceramics. The choice of constituent starting powders and heat treatments are crucial for outstanding characteristics. The most current and most durable glass veneering ceramics are lithium disilicates.

The specimens used in this investigation were made in rectangular shapes so that the cross-sectional area could be easily standardized. The core of two zirconia samples (Group I and Group II) preparation is fabricated by CAD-CAM process. The Co-Cr alloy (Group III) is fabricated under DMLS technology. These were the measurements taken to minimize the flaws and inaccuracies while constructing the all samples.

However, the methodology used in this study has some limitations. The first issue is the fixing of the test specimens using PMMA resin embedded in a bespoke silicon mould. Failures occurred within the PMMA resin when the strength of the PMMA resin was weaker than the core-veneer bond strength. As a result, a better method of specimen fixation is necessary, eg;customized metal mold. Further constraint is that the specimens had to be custom made and ground, which could have resulted in flaws or cutting defects in the specimens.

In this study, the SBS value of veneering ceramic to zirconia core in group I is 20.12± 4.0 MPa, confirming the findings of previous studies, Group II is 19.5±7.3MPa and Group III is 22.6±9.5 MPa and the results indicate a slight significant difference in the mean SBS values between the two groups of all-ceramic and base metal group. This difference in findings could be related to many factors, such as study design, methodology, skill and experience of the operator, and different physical and mechanical properties of the materials used.

In oral environment, water would be constantly present, as saliva, which would undergo repeated temperature and pH changes. In order to simulate the oral conditions, thermocycling of all samples were carried out prior to the shear bond test in the study according to ISO 11405 recommendation. Oral fluids are known to facilitate stress corrosion of ceramic materials, resulting in slow crack growth and finally leading to failure of ceramic restorations in the complex situation of the oral cavity.[8]

Guess et al.proved in their study that the application of 20,000 cycles of thermocycling had no influence on the shear bond strength of all groups investigated. The comparative studies on the bond strength of zirconia core and veneering ceramics after the process of thermocycling are not available up to now. The stable bond strength of the metal ceramic combination is in agreement with the literature. After 100,000 thermocycles, the porcelain-to-metal bond had the greatest strength. The results indicate that faults can develop over time in metal– ceramic bonding. However, the decreased bond strength after thermocycling was 29.6% for the metal–ceramic group when compared to composite – metal group.[9]

In another study by Shimoe S et al. with Y-TZP disk-shaped specimens, aging conditions such as thermal cycling (1×104,between5℃ and 55℃) and mechanical cycling(106 and 5×106 cycles)did not lead to significant changes in fracture strength and shear bond values. A considerable reduction in load-bearing capacity of all-ceramic restorations with zirconia frameworks due to combined hydrothermal and mechanical loading as observed in earlier investigations cannot be attributed to low thermal distribution(LTD), apart from the fact that the water necessary to promoting the transformation had only limited access to the zirconia.[10]

Vickers hardness test was used to evaluate the hardness of the zirconia and base metal cores in this study because it is often easier to use than other hardness test, since the required calculation are independent of the size of the indenter and the intender can be used for all materials irrespective of hardness. In this study, Tukey's multiple comparisons of the hardness of the cores of three groups shows statistically significant difference at the level of P<.05. Among these 3 groups,Group I shows higher hardness value than Group II and Group III.

Fractography has always been a puissant tool in understanding the failure mechanics of brittle materials such as dental ceramics. Identifying location, size, and types of crack initiation illustrates how cracks start, propagate, and extend to a macroscopic level, ending ultimately in fractured restoration. SEM(scanning electron microscopes) have dramatically higher magnifications (600,000X) and better resolutions (down to 1nm) than SEMs. They can compete with many transmission electron microscopes in terms of resolution and contrast. On a standard SEM, the field emission cathode substitutes tungsten cathodes. The probe beam is smaller. In many cases, accelerating voltages are lower, and conductive coatings are not utilized.

As a core ceramic material, zirconium dioxide or Zirconia (ZrO_2) ceramic has a high strength and chemical stability but lacks the translucency required for acceptable dental aesthetics. Despite the fact that zirconia framework is more aesthetically pleasing than metallic framework, it is clinically too white and opaque.To mimic the appearance of natural teeth and improve the aesthetics, it must be veneered with translucent glass ceramic. As a result, zirconia is preferred for the core or infrastructure, whereas glass or feldspathic ceramic must be chosen for the aesthetic veneering. Long-term clinical success of these all-ceramic restorations requires a strong connection between the ceramic veneer and the core substrate. Several studies have shown that one of the most prevalent failure causes of fixed dental prosthesis is veneer cracking or chipping from core ceramics, which can be very disappointing for clinicians and patients. The strength of the core-veneer bond is based upon a number of parameters, including mechanical interlocking, chemical bonding strength, wetting qualities, and thermally induced zirconia crystal rearrangement at the core-veneer interface.[11]

CONCLUSION

Within the limitations of this in vitro study, the following conclusions are drawn.

1) The mean shear bond strength value of Group I (Amann Girrbach zirconia core veneered with E max ceram) is 20.1±4.01 MPa, Group II (Aidite zirconia core veneered with Shofu vintage) is 19.58±7.38 MPa and Group III (Scheftnar Co-Cr alloy core veneered with Ivoclar) is 22.6±9.55 MPa. The results shows P value>0.05 and there is no statistically significant difference between the groups. The result shows that the shear bond strength is highest for Group III (22.606), followed by Group I (20.12) and Group II(19.58).

2) Using Tukey’s multiple comparison test, the mean value of hardness ofthe cores of three groups shows statistically significant difference ie; P value<.05 level. The net result of the hardness values of the cores of samples after descriptive analysis and Tukey’s multiple comparison analysis shows that the mean core hardness value of Group, I is higher than that of Group II and Group III. The value of hardness of Group II is more than that of Group III.
3) The Scanning Electron Microscopic study of fractured segments of samples shows cohesive failure within the veneering ceramic portion. It indicates that this intraceramic portion is weaker than core veneer interface. The net result of the SEM images shows, peaks and valleys, and inclusion defects in the fractured segments of the samples and these features points out that the fracture is due to the cohesive failure within the veneer portion.

BIBLIOGRAPHY

1. Dental Materials : a Pocket Guide.by SAUNDERS.; Kimberly G Bastin. London : Elsevier Health Sciences, 2015.
2. Craig's Restorative Dental Materials, 13thEdition.
3. GeorgeD.Quinn.Fractography of ceramics and glasses by NIST
4. De Melo RM, Travassos AC, Neisser MP. Shear bond strengths of a ceramic system to alternative metal alloys. J Prosthet Dent 2005;93:64-9.
5. Blatz MB, Sadan A, Martin J, Lang B.In vitro evaluation of shear bond strengths of resin to densely-sintered high-purity zirconium-oxide ceramic after long-term storage and thermal cycling.JProsthet Dent2004;91:356-62.
6. Choi BK, Han JS, Yang JH, Lee JB, Kim SH.Shear bond strength of veneering porcelain to zirconia and metal cores.J Adv Prosthodont. 2009;1(3):129–135.
7. .Joias RM, Tango RN, Junho de Araujo JE, Junho de Araujo MA, Ferreira Anzaloni Saavedra Gde S, Paes-Junior TJ, et al. Shear bond strength of a ceramic to Co-Cr alloys. J Prosthet Dent 2008;99:54-9 .
8. Zhang Y, Kelly JR. Dental Ceramics for Restoration and Metal Veneering. Dent Clin North Am. 2017;61(4):797-819
9. Guess PC, Kulis A, Witkowski S, Wolkewitz M, Zhang Y, Strub JR. Shear bond strengths between different zirconia cores and veneering ceramics and their susceptibility to thermocycling. Dent Mater. 2008 Nov;24(11):1556-67.
10. Shimoe S, Tanoue N, Yanagida H, et al. Comparative strength of metal-ceramic and metal-composite bonds after extended thermocycling. J Oral Rehabil 2004;31: 689–94.
11. Al-Dohan HM, Yaman P, Dennison JB, Razzoog ME, Lang BR. Shear strength of core-veneer interface in bi-layered ceramics. The Journal of Prosthetic Dentistry. 2004 Apr;91(4):349-355