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Comparative Evaluation Of Shear Bond Strength And Fracture Mode Analysis In Bi-layered Pressable And Re-pressable All Ceramics – An in vitro study

Dental Science

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ABSTRACT

PURPOSE:
The purpose of thisstudy is to compare the bond strength of layered ceramic to pressable and re pressable ceramic and the failure mode of thespecimen using universal testing machine and were analyzed using scanning electron microscope

MATERIALS AND METHOD:
The aluminum dies were fabricated according to standardized measurement of 14mm diameter and thickness of 1.3mm, internal diameter of 12mm in a disc shape. Wax patterns were fabricated for core. The wax patterns for pressable ceramicsamples (n=10) GroupI were invested followed by burnout and fresh ceramic ingots was pressed.The wax patterns for repressable ceramic samples (n=10) GroupII were invested followed by burnout and re-used ceramic ingots were collected from previously used ingots and buttons of casted restorations and they were trimmed for the excess and the removal of residues were done using 110 µm alumina particles and ultrasonic cleanse with 2%ethanol and then dried using absorbent paper and now the re-pressed ingots were prepared. layering ceramic were added with the aluminium dies fabricated according to the standardized measurement of 2mm height and 2mm of inner diameter in a cylindrical form was added to the core by conventional layering technique.Shear bond strength for each group I (n=10) and group II (n=10) were measured and compared. Sectional view of bonding interface and failure mode was observed by SEM (SCANNING ELECTRON MICROSCOPE).

RESULT:
Shear bond strength values were obtained and statistically analysed for both within the group and between the groups using ANOVA and total was interpreted with a significance P <.000. Failure mode was determined using scanning electron microscopeGroup I - 80% adhesive failure and Group II - 90% cohesive failure.

CONCLUSION:
Within the limitation of the study of layered ceramic on pressed and repressed core the following conclusion are derived. Repressing of core ceramic improved the shear bond strength (SBS) of layered ceramic than pressed core ceramic. Statistical analysis obtained for both within the group and between the groups using ANOVA and total was interpreted; a significance P <.000 was determined between the results.

KEYWORDS:

ceramics, pressable ceramics, repressable ceramics, bonding, layered ceramic

INTRODUCTION:

The focus of contemporary dentistry is not only on the prevention and treatment of disease but also on meeting thedemands for better esthetics. Thus, dentistry has evolved from a curative to a creative science in a very short span and theevolution of ceramics has hastened this shift.1Materials are said to be imperative for the fabrication of the restorations. Hi-Ceramic was developed in 1985, followed with In-Ceramic by Sadoun, based upon slip casting of alumina core, DICOR castable glass ceramic was developed by Grossman. However, DICOR had disadvantage on color which must be developed using surface glass and must be veneered with aluminous porcelain. During this process of application leucite reinforced high strength ceramic have come in to dentistry as IPS EMPRESS, OPTEC.[2,8]

All-ceramic restorations combining esthetic veneering porcelains with strong ceramic cores have become popular. Layering porcelains typically consist of a glass and a crystalline phase of fluroappatite, aluminum oxide, or leucite. Veneering a lithium disilicate, aluminum dioxide, or zirconium oxide core with the glass allows dental technicians to customize these restorations in term of form and esthetics.2 Among the various group of all ceramic core and veneering materials, pressable ceramic are popularly used. Commercially available pressable all ceramic system, e-max has a distinct place in core build up for dental restoration and have been used successfully as metal free dental restorative material. The popularity of heat-pressed ceramics relies on the ability to use the lost-wax technique to produce dental ceramic restorations. The pressed form can be made to full contour, or can be used as a substrate for conventional porcelain layering and staining procedure can be incorporated. Pressable ceramic which is subjected under pressure in vacuum has considered as advantage to minimize the failures.[3]

However, pressable ceramics have increase in their properties due to change in microcrystalline structure.3 It has not been shown much evidence on repeated pressing have any influence on the bonding mechanism of core material to thatof layering material. Hence, this study has been taken up with the aim to evaluate the bond strength of pressable and re pressable all ceramic to conventional layered ceramic using universal testing machine and fracture mode analysis using scanning electron microscope.

Material and methods:

A study was conducted to compare and evaluate the bond strength of layered ceramic to pressed and re pressed all- ceramic core. Metal dies were fabricated for fabrication of samples. 20 wax patterns were fabricated using inlay wax Kronenwachs,BEGO,Germany, (40111,580) for core. The wax patterns were invested and following burnout, ceramic was pressedIPS e.max press batch number(591384EN).Veneering ceramic IPS-e.maxCeram dentin J11470 was added to the core by conventional layering technique. The samples were subjected to shear bond strength (SBS) testing in universal testing machine (UTM), following which they were examined under scanning electron microscope (SEM) to assess the failure mode. The values obtained were subjected to statistical analysis.4

The aluminum fabricated for the core preparation with specific dimension of 12mm diameter and 1.2 mm thickness, was taken and the wax pattern fabrication was carried out fig.1.

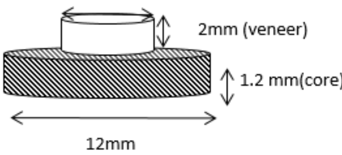

fig 1: Dimensions for die (core and veneer/layer)

Aluminum die fabricated for specified dimension of 2mm diameter and 2mm thickness as shown in fig1was used for layering procedure.

Recommended ratio of Layering powder and liquid were taken and mixed on the ceramic mixing slab. Using ceramic brush the creamy mixer of ceramic was condensed to the die and the excess liquid was removed using absorbing paper. The layered specimenwas kept in ceramic furnace for firing.fig24,5

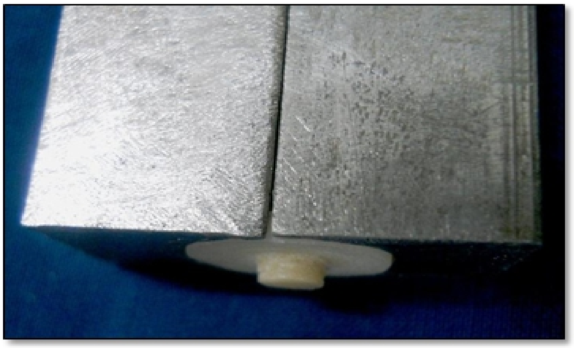

Fig 2: Prepared specimen for testing

A metal jig was made to hold the specimen during the test procedure. The thickness of the core specimen1.2 mm depth was created in the metal jig so that it can hold the sample. The specimen was mounted to the jig for testing in Universal Testing Machine (UTM).The Shear Bond Strength (SBS) was evaluated by recording the force required to fracture of veneer ceramic from the core. This was an electronic process and values were screened on the monitor. To evaluate shear bond test in the universal testing machine a load of 100kg speed 0.5mm/min of shear force was applied such that the edge of the shearing jig was in contact with core and positioned as close to core/veneer ceramic interface as possible. The specimens were loaded until fracture occurred at across lead speed of 0.5mm/min. The value obtained was divided by the cross sectional area to derive SBS value in MPa.[4,5]

$$SBS = \boxed{\text{Newton /Cross sectional area in mm}^2}$$

The values were analyzed for each specimen and noted carefully for all the twenty samples and analyzed statistically.

Evaluation of failure modes:

To evaluate the failure modes at the fracture site, the specimen obtained following the SBS testing were analyzed under scanning electron microscope (SEM) QUANTA 200 F under specific magnification of 24 XL. Ceramic being a poor conductor of electric stimuli was coated with gold i.e. gold sputtering, to improve its electron conduction prior to the analysis. The failure modes were of two type's adhesive and cohesive failure. Adhesive failure is defined as the failure between two different materials used for bonding and these failures were examined between the interface of core and layered ceramic. Adhesive were observed as visible delamination site at the core veneer interface. The cohesive failure was observed as partially delaminated surface revealing no clear crack site.4, 5, 6

Result:

The study was conducted to compare and evaluate the shear bond strength of layered ceramic to pressed and repressed all ceramics. A total of 20 samples were taken for this study and was divided into 2 groups; Group I and Group II. The shear bond strength was evaluated under universal testing machine (UTM) and the mode of failure was evaluated under Scanning Electron Microscope (SEM). The values were analyzed using student –t test and One way Analysis of variance (ANOVA).

Shear bond strength of layered ceramic to pressed ceramic values in MPa for 10 samples ranging from 20.21-25.84 MPa. Shear bond strength valuesin MPa of layered ceramic to repressed ceramic for 10 samples were ranging from 29.23 -36.3 MPa table.1.

GROUP	MEAN (MPa)	STANDARD DEVIATION	MINIMUM VALUE(MPa)	MAXIMUM VALUE(MPa)
I	23.3510	1.78833	22.82	29.14
II	32.8710	2.46288	29.23	36.3

Table 1: Mean bond strength value between layered ceramic to pressed and re pressed ceramic.

The values were analyzed between the two groups and a significant difference P<.000 was determined using ANOVA.Table2.

Source of Variance	Sum of squares	Mean sum of squares	F Ratio	P Value
Between the group(group I & group II)	270.554	1	58.410	.000

Table: 2 Statistical analysis (one way ANOVA) of shear bond strength values of layered ceramic to pressed and re-pressed ceramic

The percentage of failure mode in SBS for group I and group II were analyzed using scanning electron microscope, fig 3, 4.

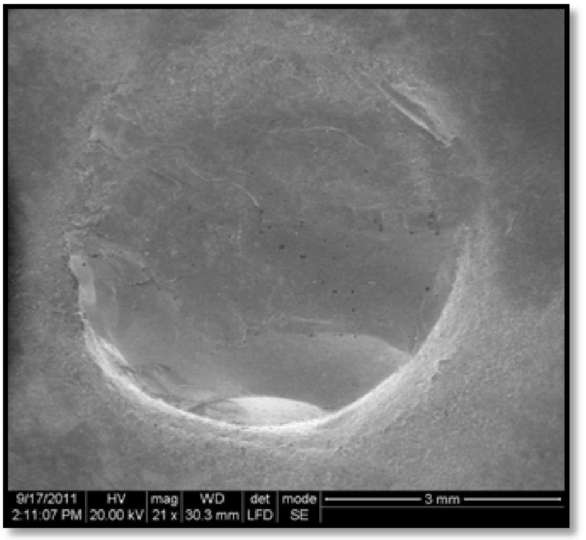

Fig 3: Adhesive failure

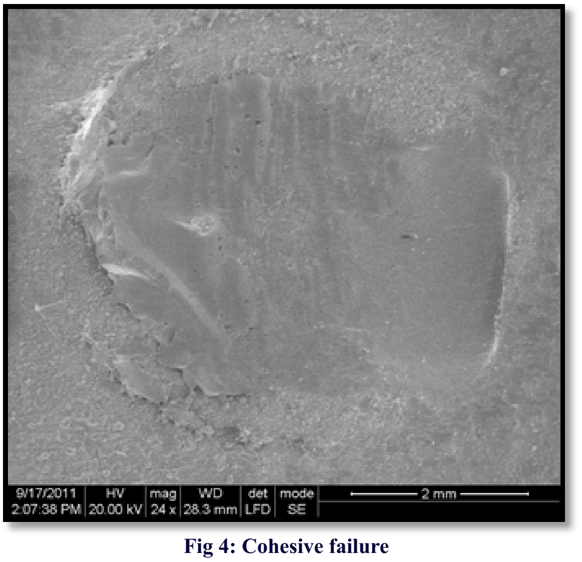

Fig 4: Cohesive failure

The failure modes were adhesive, cohesive failure or both; in group I8 samples were found to have adhesive, 2 sample of cohesive. Group II had 9 samples of cohesive failure and 1 sample adhesive failure. Finally group I had 80% adhesive failure and Group II 90% cohesive failure was analyzed. Table: 3

Mode of Failure	Group I	Group II
Adhesive failure	80%	10%
Cohesive failure	20%	90%

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Table 3: Mode of failure analysed using scanning electron microscope.

Discussion:

The materials and methods for fabrication of all-ceramic restorations are changing rapidly and significantly. Recently, several new all-ceramic crown systems which are offering good esthetics and simplified fabrications have been introduced. With these systems, it is possible to fabricate single crowns, inlays, and veneers. However, the inherent brittleness of ceramic systems may lead to premature failure especially in repeated contact loading in moist environments.[2,3,5]

Failure rates due to ceramic fractures have been reported as ranging between 2.3% and 8%.4 bilayered all-ceramic material failures were reported to be observed either as delamination of the veneering ceramic from the core ceramic or sometimes in the form of cracks on the core material itself.5Though the conventional layering improves the esthetic value of the restoration; the major disadvantage of the technique is delamination of layering ceramic.2complete debonding of the veneering ceramic from the core ceramic or adhesive failure between the two is defined as delamination.[6]

Material selection, ranking, performances and clinical recommendations on layered all-ceramics are based on routine mechanical testing methodologies. Information on the best combination of the reinforced core and veneering ceramic could assist the clinician to predict possible chippings at the core-veneering ceramic interface.4,6The purpose of evaluvating the bond strengths and failure modes of veneering ceramics to their core materials helps to estimate the durability of the all-ceramic systems in clinical applications.2,7

Studies have shown an improvement in the mechanical properties of repressed ceramic. The objectives of these studies are to compare the bond strength results obtained employing shear bond strength (SBS) tests of pressed and previously oncerepressed core and veneering ceramics, and to evaluate the failure modes microscopically.6

On microscopic analysis of the core patterns crystalline structure significant variation between the groups was evident. The study conducted by K.H.Chung et al on repressed ceramics reveals small pores observed by SEM in the microstructure of the lithium disilicate reinforced glass-ceramic were precipitates of Li_3PO_4. This crystal phase was reported as a small phase of approximately 0.1–0.3 µm in diameter, after repeated heat-pressing, an increase of lithium disilicate crystal size was disclosed, which could be related to the multiple nucleation sites found within the lithium disilicate crystals. Re-pressing leucite and lithium disilicate glass-ceramic materials did not reveal any negative effects.[3,6]

Conventional layering techniques to form the bi-layered ceramic was used in the present study for layering the core.8, 9

The shear bond test for which the test specimens were performed with universal testing machine using a load of 100 kg (speed: 0.5 mm/min). The bond strength is calculated by dividing the maximum applied force by the bonded cross sectional area. This test is relatively simple and easy to perform producing rapid results.5, 10, 11

In this study, the shear bond strength (SBS) of veneering ceramics to the pressed core ceramic (Group I) ranged between 20 MPa – 25 MPa. The SBS of veneering ceramic to the repressed ceramic (Group II) ranged 30.54-36.3 MPa.

The results of the current study are in accordance to results from previous study conducted by Al-Dohan et al on commercially available all ceramic systems who reported shear bond strength value range between 23-31 MPa.12-15 While Paula et al reported a value range lesser 19-23 MPa and Dundar et al who reported higher SBS 41 MPa, of veneering ceramic to core material than the current study.6, 7,

Data that are available in the literature regarding the bond strengths of ceramics or resins to metal substrates are said to be in a range of 54–71MPa and a sufficient bond for metal–ceramics has been accepted when the fracture stress is greater than 25MPa; however, no information is available on the bond strength values of repressed ceramic core and veneering materials.16-18 The SBS Values obtained in the study of layering porcelain to a ceramic core for pressed and repressed ceramic materials to be similar to that of the metal ceramic 30.16 ± 5.88 MPa.19-22This study demonstrated that the bond of veneering porcelain to a ceramic core for the materials tested is comparable to that of the metal ceramic. It may be expected that the clinical behavior would be similar. Hence e-max all ceramic system may be expected to have a clinical behavior similar to that of metal ceramic.23-25

The SBS value of the present study shows a significant difference between repressed and pressed groups.Repressed all ceramic samples (Group II) showed increased bond strength than pressed ceramic (Group I) (significant P Value <.000). Clinical implication of the study to evaluate the bond strength between the press able ceramic and layering ceramic, the results have revealed that the repressing or recasting of press able ceramic have improved the bond strength with the layering ceramic.3,6,12 The protocol of reusing residual materials for single time in some dental laboratories may be deemed acceptable which in addition to the reduction in cost may prove beneficial in improving the clinical performance by reducing delamination failures

Conclusion:

Within the limitation of the study of layered ceramic on pressed and repressed core the following conclusion are derived.

1. Repressing of core ceramic improved the shear bond strength (SBS) of layered ceramic than pressed core ceramic.
2. Statistical analysis obtained for both within the group and between the groups using ANOVA and total was interpreted; a significance P <.000 was determined between the results.

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