ORIGINAL RESEARCH

Comparative Analysis of Effect of Liners on Shear Bond Strength of Veneered Zirconia Block: An Institutional Based Study

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ABSTRACT

Introduction: All ceramic restorations which are comprised of porcelain veneer on a zirconia substructure are gaining more interest since it almost replaced all the metal ceramic restorations. The evaluation of bond strength of layered porcelain over zirconia substructure could be just subjected to shear bond strength test, three & four points flexure, tensile and micro-tensile bond test.

Materials and Methods: The study was designed as an in-vitro study which was conducted in Surendera Dental College & Research Institute, Sri Ganganagar, Rajasthan, India. The number of study samples were set at 80 which are fabricated from VITA zirconia discs. Samples were divided into 4 groups. Each group having 20 samples. All the 80 samples were loaded under a standard shear load at a crosshead speed of 0.5 mm/min and load was noted using universal testing machine (Asian Universal Testing Machine, LRX 2K5, Hants, UK). Sample was taken for further evaluation of the fracture mode. SEM study was done at 49 X, 350 X and 1000 X. Statistical analysis was performed.

Results: Group I is control group, group II is lithium disilicate glass–ceramic liner group, group III is silicon dioxide-based liner, and group IV is glass–ceramic interlayer group. Mean shear bond strength in group I was 22.5 MPa, in group II was 62.2 MPA, in group III was 63.4 MPa and in group IV was 34.9 MPa. The difference was significant ($P < 0.01$).

Conclusion: SBS was reported maximum after the application of lithium disilicate glass–ceramic liner at 930°C followed by glass–ceramic interlayer at the same sintering temperature which is 930°C and silicon dioxide-based liner at 930°C. The fractographic behaviour analyses that zirconia samples lined with lithium disilicate glass–ceramic liner presented with adhesive failures (failure between glass–ceramic liner) whereas the use of silicon dioxide-based liner showed cohesive failures (failure within veneering porcelain) while the control group revealed with both cohesive and combined failures.

Keywords: Adhesive Failure, Shear Bond Strength, Veneered, Ceramic.

INTRODUCTION

Earlier days, the metal ceramic fixed partial dentures (FPDs) are eventually considered to be the gold standard of all the materials and is one of the reliable materials. Therefore, the search for the aesthetic dentistry and also the ever-rising question regarding the biocompatibility of dental alloys backs the commercialization of the new products to be launched. Recently, metal-based restorations were totally replaced by all ceramic prostheses. An array of different ceramic systems isnewly developed for single crowns or fixed dental prostheses (FDPs) with visiblyimpeccableaesthetic outcomes.[1]

When compared with the all the other all-ceramic systems, the transformation-toughened zirconia is posed to be a successful alternative in various clinical situations. Their mechanical and optical properties permitted them to be used as a framework material.[2]Various in-vitro studies revealed a flexural strength of 900–1200MPa and a fracture toughness of about 9–10MPa. All the restorations are manufactured either by soft machining of pre-sintered blankswhich is followed by sintering at higher temperature or by hard machining of fully sintered blanks.[3] The adhesive fracture of layered porcelain directly represents its poor shear bond strength (SBS). Lithium disilicate with coefficient of thermal expansion (CTE 25°C – 800°C]: is a type of glass ceramic which gains thermal shock resistance, hence leads to a more stable CTE even after multiple sintering at higher temperature.[4] The SBS denotes inter-ceramic bond between zirconia core and veneering ceramics. Strong discrepancies in CTE arising between veneering porcelains and zirconia which significantly affect their bond strength.[5]

The evaluation of bond strength of layered porcelain over zirconia substructure could be just subjected to shear bond strength test, three & four points flexure, tensile and micro-tensile bond test. Shear bond tests have been observed as one of the most established bond strength tests that is available in literature. SBS measurements revealed that veneering porcelain on zirconia with lithium disilicate glass–ceramic liner which is fired at 85°C (vitali850) had the highest mean SBS when compared with others. And the failure modes have been classified as cohesive failure within veneering porcelain, adhesive failure between glass–ceramic liner and zirconia substructure and combined failure with both cohesive and adhesive failure, although the pattern of the fractographic behaviour of zirconia blocks veneered with ceramic is still hard to understand.

The present study was undertaken to assess the effectiveness of lithium disilicate glass–ceramic liner, silicon dioxide-based liner and glass–ceramic interlayer on the shear bond strength (SBS) of a commercially available veneered zirconia block.

MATERIALS AND METHODS

The study was designed as an in-vitro study which was conducted in the department.The number of study samples were set at 80 which are fabricated from VITA zirconia discs. Samples were divided into 4 groups. Each group having20 samples.

Group I - control group

Group II - lithium disilicate glass–ceramic liner group

Group III - silicon dioxide-based liner

Group IV is glass–ceramic interlayer group

All the 80 samples were loaded under a standard shear load at a crosshead speed of 0.5 mm/min and load was noted using universal testing machine (Asian Universal Testing Machine, LRX 2K5, Hants, UK) A chisel load applicator was used to point a parallel shearing force to the substructure/veneer-ceramic interface. Testing of samples for fractographic behaviour in all the 80 samples were also analysed for their fractographic behaviour (adhesive and cohesive) using scanning electron microscope (SEM) (LEO Evo 40X VP; Carl Zeiss AG, Oberkochen, Germany). Sample was taken for further evaluation of the fracture mode. SEM study was done at49 X, 350 X and 1000 X. Statistical analysis was performed.

RESULTS

Table-I, group I is control group, group II is lithium disilicate glass–ceramic liner group, group III is silicon dioxide-based liner, and group IV is glass–ceramic interlayer group.

Table II reveals that mean shear bond strength in group I was 22.5 MPa, in group II was 62.2 MPA, in group III was 63.4 MPa and in group IV was 34.9 MPa. The difference was significant ($P < 0.01$).

Table III tabulated that mode of failure was cohesive seen 8 in group I and 7 in group IV, adhesive seen 10 in group II and 8 in group III and combined seen 2 in group I, 2 in group III and 3 in group IV.

Table I: Distribution of blocks in groups

Groups	Group I	Group II	Group III	Group IV
Materials	Control	Lithium disilicate glass ceramic	Silicon dioxide	Glass-ceramic
Number	20	20	20	20

Table II: Shear bond strength of zirconia samples

Groups	Mean	P - value
Group I	22.5	0.01
Group II	62.2	
Group III	63.4	
Group IV	34.9	

Table III: Mode of failure in all groups

Groups	Cohesive	Adhesive	Combined
Group I	10 (50%)	0	4 (20%)
Group II	0	12 (60%)	0
Group III	0	10 (50%)	4 (20%)
Group IV	9 (45%)	0	6 (30%)

***p – value <0.01**

DISCUSSION

There are various factors which can influence the bond strength of zirconia with veneered ceramics such as strength of chemical bonds, mechanical interlocking, type and concentration of defects at the interface, improper framework support for the layering porcelain, wetting properties and the degree of residual compressive stress in the veneering layer because of the difference in the CTE between zirconia and the veneering ceramic. Silicate ceramics are being used for veneering zirconia.A coat of silica on zirconia is considered to enhance the bond strength effectively.[6] The purpose of present study was to assess and compare the SBS of variety of commercially available liners and to study their fractographic behaviour effectively. Many liners that are available in market were used in the study which are lithium disilicate glass– ceramic liner, silicon dioxide-based linerand glass–ceramic interlayer.

Lithium disilicate glass–ceramic liner, in particular the Li_2O-SiO_2 system, is the first material which is classified as glass ceramic discovered by *stookey*which is considered as having better mechanical properties over base glass.[7] Mean SBS between veneering porcelain and zirconia substructure was relatively improved when using lithium disilicate glass–ceramic liner. Factor which could led to enhanced SBS is good cohesion between glass–ceramic liner and veneering porcelain. *Al-Dohan* et al[8] advocated that most of the studies that

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were conducted macro shear bond test revealed most fractures occurred in the veneering layer are mostly due to cohesive failure.

The SBS of veneering ceramics was significantly greater than SBS between core and veneering ceramicsand the failure mode noted was mainly combined as adhesive at the interface and cohesive in the veneering ceramic.[2,9] SBS between zirconia core and veneering ceramics was not at all affected by the process of thermocycling.[10]Another liner which is glass–ceramic interlayer is a liquid suspension which is used between zirconia substructure and veneering porcelain to enrich their adhesion layer. Glass–ceramic interlayer could either be feldspathic porcelain or a mixture of feldspathic and leucite crystals.[11] And finally thesilicon dioxide-based liner is a VITA VM9 effect liner (VITA Zahnfabrik Bad Sackingen Germany) has been used in the study as a test group. *Aboushelib* et al proposed out that the weakest part of the all-ceramic restoration is considered as the core–veneer interface which influences and plays a major role in the success of all ceramic restorations.[2,9,13] The present study eventually compared the effectiveness of three commercially available liners which comprised of 80 samples of zirconia blocks which were further divided into 4 groups with 20 samples each. First is the control group, second is lithium disilicate glass–ceramic liner group followed by the third one is silicon dioxide-based linerand finally the fourth being glass–ceramic interlayer group.

From the results obtained, Table 2 denoted the mean SBS of each group of zirconia samples. The maximum and minimum SBS was obtained for lithium disilicate liner and control group, respectively. In the case of lithium disilicate, mismatch in CTE would be considered as a less of consequence since it has a low CTE which is also compatible with both feldspathic porcelain and zirconia. Hence, the CTE of lithium disilicate glass–ceramic liner possessed to be stable after multiple firings at high as well as in low temperatures. *Wattanasirmkit* et al[14,15]inferred that the highest SBS of vitali850 was due to the result of lithium disilicate glass–ceramic forming good adhesion to zirconia and with the two veneering porcelain layers. The mode of failure of fractured samples was recorded as adhesive, cohesive and combined failures. The values represented in table 3 represents that a significant difference was found in the distribution of the mode of failure between control group, lithium disilicate liner, glass–ceramic interlayerand silicon dioxide-based liner groups. *Fischer* et al[6]advocated that the bond strength between zirconia and the veneering ceramic was relatively greater than the cohesive strength of the veneering ceramic. In other words, the weakest link was considered as the veneering ceramic itself and not the interface.

The results of the present study predicts that SBS is enhanced by the application of a layer of liner (lithium disilicate glass–ceramic liner, glass–ceramic interlayer, and silicon dioxide-based liner). Among these, lithium disilicate glass–ceramic liner showed maximum SBS but there are authors who contradict the findings from this study theories. *Aktas* et al[16] stated that the veneering ceramic properties might get affected to the results of SBS to the zirconia core. *Choi* et al[17]quoted that the SBS test has certain disadvantages like high standard deviations, presence of non-uniform interfacial stresses and the influence from specimen geometry. Hence, the standardization of specimen preparation, cross-sectional surface area and the rate of loading application are major for improving the clinical usefulness of SBS test. *Tashkandi*[18]demonstrated that the better bond strength of zirconia is attained with air abrasion particles using an experimental primer and SEM study which ultimately revealed predominantly the cohesive failure. *Tholey* et al[19] predicted that the veneering porcelain seems to be wet and well-bonded to zirconia framework and while on HF etching, the available moisture in the wet field generates grain faceting at the surface of zirconia. *López-Mollá* et al[20] stated that the lithium disilicate porcelain and their veneer porcelain attained the highest shear strength over time.*Aalaeisha* et al[21]announced that there was no statically significant difference between the SBS of three tested veneering ceramics to the available zirconia cores. *Ozkurt* et al[21]inferred that none of the test groups revealed cohesive failure within the veneer component. Eighty percent of adhesive failure was revealed when it is veneered with Cerconceram.

CONCLUSION

To conclude,the SBS was reported maximum after the application of lithium disilicate glass–ceramic liner at 930°C followed by glass–ceramic interlayer at the same sintering temperature which is 930°C and silicon dioxide-based liner at 930°C. The fractographic behaviour analyses that zirconia samples lined with lithium disilicate glass–ceramic liner presented with adhesive failures (failure between glass–ceramic liner) whereas the use of silicon dioxide-based liner showed cohesive failures (failure within veneering porcelain) while the control group revealed with both cohesive and combined failures.

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