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ORIGINAL ARTICLE

ASSESSMENT OF SHEAR BOND STRENGTH AND FAILURE MODES BETWEEN THE BASE AND BULK RESIN RESTORATIVE MATERIALS; AN IN VITRO COMPARATIVE STUDY

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ABSTRACT:

Objective: To assess the comparative shear bond strength and failure modes between the base and bulk Resin restorative materials.

Place of Study: Dental Materials Testing Laboratory, Dr. Ishrat-ul-Ibad Khan Institute of Oral Health Sciences, Karachi.

Study Design: In Vitro, Experimental Study

Duration of Study: One week **(**August 2021)

Methodology: This experimental material research was conducted in Dental Materials Test site, Dr. Ishrat-ul-Ibad Khan Institute of Oral Health Sciences, Karachi. Using convenient sampling a total of 16 samples were prepared, eight had Z350 (Material A) while other eight used Ceram X (Material B) as bulk restorative material sandwiched with GIC as the base material. Samples were made using two sheets of polytetrafluoroethylene mold. Every single sheet contained holes which were 4×2 mm (diameter X thickness). Firstly, these samples were placed in the distilled water and later for complete polymerization in the incubator. After this they were thermo cycled and ultimately checked for shear bond strength.

Results: Material A presented the mean value of 148.522±113.928 with single mixed and all other adhesive failure mode, whereas, Material B showed single cohesive failure and rest of adhesive failures with the mean of 6062,76±2547,18.

Conclusion: Sufficient bonging strengths were observed between the base and bulk resin restorative materials using sandwich technique, however, Nano-composite "Ceram X" has demonstrated slightly better shear bond strength with in comparison to Z350. In addition, adhesive failure in both groups clearly indicated the lack of adhesive system in between the sandwich material.

Keywords: Shear strength, Dental Restoration Failure, Adhesive, Glass Ionomer Cements, Resin Cements

INTRODUCTION

Despite the common use of dental composites as restorative material, its use as posterior restoration is still questionable. (1) Even after all the modifications to overcome the polymerization shrinkage, it is still a great problem leading to marginal gaps and ultimately micro leakage. (2) Moreover, the thermal changes and masticatory forces in the oral cavity also add on to this calamity particularly in class II fillings. Micro leakage, is a vigorous untraceable clinical phenomena that occur at the inter phase of cavity wall and placed restoration, from which there is a diffusion of oral fluids along with many microorganisms and oral debris down to dentine eventually resulting in recurrent caries. (3-5) This calls a need of substitution in posterior fillings despite all advancements in adhesive dentistry.

To overcome this problem, substitute restorative techniques are under consideration in the specialty of dental materials. Among these, one of the techniques recommended by McLean was the sandwich technique. In this method, there is a replacement of dentine by Glass Ionomer Cement (GIC) and Composite Resin replaces enamel. (5-8) Two variations of this technique had also been described as open and close sandwich. In close sandwich technique both materials are within the tooth structure whereas in open sandwich technique the restorative materials are expose to the oral environment. (9,10) In this sandwich technique physical and mechanical properties of composites including reduced wear resistance and high strength are supported by the advantages of conventional GIC which have the proven advantages of physicochemical bonding to enamel and dentin along with excellent biocompatibility with the dental

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pulp. Also while using GIC there is no need to condition the tooth surface which is actually done to have proper bonding of composites to the tooth structure. Likewise, GIC have numerous other progressive features which basically include the continuous discharge of fluoride ions into the crystals of enamel, it also absorbs fluoride ions from the high fluoridated dentifrices and rinses ultimately making the tooth resistance to dental caries. (11,12)

Although Sandwich technique is globally in use, still multiple material specific variables like different bonding strengths needs to be further explored. Similarly, its technique sensitivity and reliability also require further experiments to establish this technique with more authenticity and Therefore, this study was planned with an objective to assess the comparative shear bond strength and failure modes between the base and bulk Resin restorative materials.

METHODOLOGY

This analytical, experimental, in-vitro material study was conducted over one week (in August 2021) in the laboratory of Dental Materials, Dr. Ishrat-ul-Ibad Khan Institute of Oral Health Sciences, Dow University of Health Sciences, Karachi. This research was approved by the Institution Review and Ethical Board of Advance Studies of the same institution under letter number IRB–568/DUHS/approval/2021. Because of the non-availability of one of the necessary equipment, the testing of shear strength was executed at NED University of Engineering and Technology, Karachi.

Through non-probability, convenient sampling a total of 16 samples were prepared. Among them 8 had Nano-composites Z350 (3M ESPE) as bulk restorative material sandwiched with GIC (Ketac Molar, 3M ESPE) as the base material (Material A). In the other 8 sample Nano-composites Ceram X (DENTSPLY) was used as the bulk restorative materials along with the same GIC (Ketac Molar, 3M ESPE) as the base material (Material B). Samples were made by an experienced, trained and calibrated material specialist using two sheets of polytetrafloroethylene (TEFLON) mold. Every single sheet contained holes which were 4×2 mm (diameter X thickness). Therefore, each sample was 4 mm thick and 4 mm in diameter. This was because the thickness of each material was although 2 mm, the two materials were sandwiched (GIC + Nano-Composite) giving the ultimate thickness of 4 mm. Firstly, these samples were placed in the dark bottles of distilled water to avoid unnecessary light penetration and later for complete polymerization in the incubator for 24 hours. These samples were thermo cycled for 500 cycles between 5-55 ºC/ 30s and were ultimately checked for shear bond strength using Zwicki Z5.0, 200N load cell HP, 3~4mm diameter clamping device and x-y axis mobile table Alu t-slot plate. Preload utilized for testing included 0, 1 N and the speed of test was of 1 mm/min.

The data analysis was accomplished using SPSS-21 employing descriptive statistics for the mean, standard deviation, shear bonding strength and failure modes of testing materials.

RESULTS

Over all 16 samples (in two divided groups) went through the testing of the shear bond strength and failure modes in between the base and bulk Resin restorative materials. The descriptive statistical results were given as Mean (X), Standard Deviation (S), Shear Bond Strength, Maximum Force (Fmax N in Newtons), Deformation at Maximum Force (dL at Fmax in mm), Shear Bond Strength in Kilo Pascals (kPa), Mean difference in mm (d0) and Difference in Standard Deviation in mm^2 (S0).

The results of for Material A, provided by the first set of data presented the mean value of 148.522 with standard deviation 113.928. There was only single mixed failure was noticed whereas all other samples were observed with adhesive failure mode. (Figure 1, Table I)

The second data set consisting of Material B, showed single cohesive failure and rest of adhesive failures. The mean of this group was 6062,76 with the standard deviation of 2547,18. (Figure 2, Table 2)

Material A has demonstrated slightly better bond strength in comparison to Material B, and the adhesive failure in both the groups clearly indicated the lack of adhesive material in between the sandwich material.

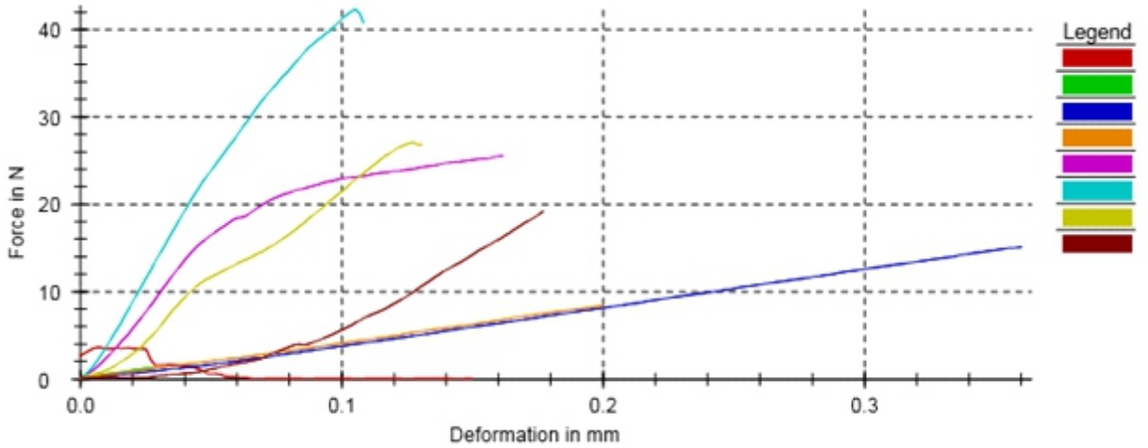

Figure 1: Failures in Material A (Z350 and Ketac Molar)

Table 1: Test results of Material A (Z350 and Ketac Molar)

Legends	Material A n=8	Fmax N	Shear Bond Strength (kPa)	dL at Fmax (mm)	d0 (mm)	S0 (mm^2)	Failure modes
1	1.1	3,639	292,49	0,007	3,98	12,44	Pretest
2	1.2	1,327	108,28	0,030	3,95	12,25	adhesive failure
3	1.3	15,14	1222,81	0,360	3,97	12,38	Mixed failure
4	1.4	8,429	680,97	0,200	3,97	12,38	adhesive failure
5	1.5	25,57	2254,94	0,162	3,8	11,34	cohesive failure
6	1.6	42,35	3404,32	0,105	3,98	12,44	mixed failure
7	1.7	27,13	2367,17	0,127	3,82	11,46	adhesive failure
8	1.8	19,17	1548,74	0,177	3,97	12,38	mixed failure

n = Samples
Fmax N = Maximum Force in Newtons (N)
Shear Bond Strength in Kilo Pascals (kPa)
dL at Fmax = Deformation at Maximum Force in millimeters (mm)
d0 = Mean difference (mm)
S0 = Difference in Standard Deviation (mm^2)

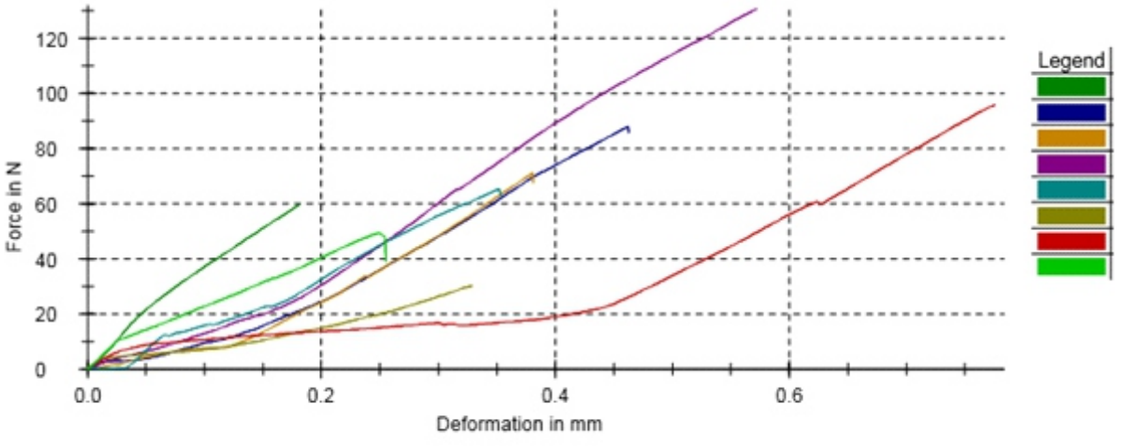

Figure 2: Failures in Material B (Ceram X and Ketac Molar)

Table 2: Descriptive statistics of the shear bond strength of Material B (Ceram X and Ketac Molar)

S. No	Material B n = 8	Fmax N	Shear Bond Strength (kPa)	dL at Fmax (mm)	d0 (mm)	S0 (mm^2)
1	X*	73,76	6062,76	0,413	3,944	12,15
2	S**	30,98	2547,39	0,190	0,04033	0,26
3	v} [%]	42,00	42,02	46,00	1,02	2,17

*X = Mean Shear Bond Strength
**S = Standard Deviation
n = Samples
dL at Fmax = Deformation at Maximum Force in millimeters (mm)
Fmax N = Maximum Force in Newtons (N)
Shear Bond Strength in Kilo Pascals (kPa)
d0 = Mean difference (mm)
S0 = Difference in Standard Deviation (mm^2)

DISCUSSION

This study was conducted to assess the comparative shear bond strength and failure modes between the base and bulk Resin restorative materials using sandwich technique and found sufficient bonding strengths between the two. However, material 'B' (Nano-composite "Ceram X") has demonstrated slightly better shear bond strength with GIC in comparison to material 'A' (Z350). The most acceptable and convenient method of evaluating bonding strength is the shear bond strength testing. This testing modality is typically implemented to evaluate the efficiency of bonding between a filling material and the dentin but in this study, it is performed to estimate the bonding between two materials using the sandwich technique with conventional GIC which have the value of shear bond strength of 3.81 MPa. (13,14) In this study, the results of Material A presented the mean value for shear bond strength of 148.522 kPa, in comparison to 6062,76 kPa which was the mean of Material B samples. These results are similar to other studies by Bilgrami et al, who studies the same in Class II Restorative Method and Tavangar et al. who researched on New Composite to Old Composites. (15,16)

The life of the composite restoration may be reduced due to leakage and weakening of bonds. To avoid such restoration failure, the restorations must be of sufficient strength to avoid cracking in presence of heavy masticatory forces. This eventually will inhibit the chance of micro leakage. In this context, the basic three sorts of failure modes were perceived in this present study, the adhesive, cohesive and mixed failures within the sandwich materials. The mode of failure of GIC with Z350 was found to be mixed and adhesive, whereas failure with Ceram X was mostly adhesive. Cohesive failure was just found in one sample. This indicates that both the groups clearly lacked the adhesive material in between the sandwich material whose presence may have increased the shear strength of the material and thus have provided a better bonding. These results are in line with the reporting of a recent study by Singh et al in 2021. (17,18)

In the adhesive system commonly 3 steps are employed including the etching, the primer and the bond to attain better bonding. In current study no adhesive system had been used because we considered the reporting of Maño and co-workers that etching may weak the matrix of cement. (19-21) Therefore, future studies are required in our part of the world to establish the fact that adhesive systems or other methods like the use of Titanium dioxide nanotubes should be used with GIC for improving the physico-mechanical properties and increasing the bond strength between two resin restorative sandwiched materials. (22)

CONCLUSION

Sufficient bonging strengths were observed between the base and bulk resin restorative materials using sandwich technique, however, Nano-composite "Ceram X" has demonstrated slightly better shear bond strength with GIC in comparison to Z350. In addition, adhesive failure in both groups clearly indicated the lack of adhesive system in

between the sandwich material. It is recommended that by improving the strength of these materials, the better bonding can be achieved.

Conflict of Interest: None

Patient Consent: Inform Consent were taken

Ethical Approval: This research was approved by the Institution Review and Ethical Board of Advance Studies of Dr. Ishrat-ul-Ibad Khan Institute of Oral Health Sciences, Dow University of Health Sciences, Karachi. under letter number IRB–568/DUHS/approval/2021

Author's Contribution:

AB, FQ & KAS: Study design, data collection and analysis
AB, OA & MS: Manuscript preparation, drafting and revising
AB, FQ & BF: Review and final approval of manuscript
All the authors have approved the final version of the manuscript to be published

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