ORIGINAL ARTICLE

COMPARISON OF SHEAR BOND STRENGTH OF PREPARED METHACRYLATE BASED COMPOSITE REPAIRED WITH SILORANE COMPOSITE

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ABSTRACT

The objective of this invitro study was to compare shear bond strength of methacrylate based composite repaired with Silorane composite using intermediate layer of silane coupling agent and Silorane adhesive bond with or without thermocycling. A total of 60 composite samples were prepared with 30 samples of silorane based and 30 samples of methacrylate based divided into control and experimental groups. Control group was processed immediately after photo-curing, while experimental group was thermal cycled (5000 cycles, 5_55°C, dwell time 20 seconds) followed by surface roughening with 400 grit silicon carbide, applied with silane coupling agent and relevant adhesive bond over the corresponding substrate and cured for 20seconds. Repair composite was placed on substrate samples of both groups and photo-cured, all samples were stored in distilled water for 24 hour at 37°C before testing with universal testing machine at crosshead speed of 0.5mm/min until debonding. Type of fracture was analyzed under light microscope at 40x magnification and was categorized as cohesive, adhesive or mixed failure. Silorane composite overall showed better shear bond strength and can be used with Methacrylate based composites in repair options using silane coupling agent and its silorane adhesive bond. Thermal cycling did not affect the shear bond strength before and after aging in both groups.

Key Words: *Shear bond strength, silorane composite resin, silane coupling agent.*

INTRODUCTION

Flowable composites (45-67% filler load) show volumetric shrinkage of 4.0-5.5% on polymerization. Hybrid composites (74-79% filler load) show a volumetric shrinkage from 1.9 to 3.5% on polymerization. Highly filled posterior composites with filler load of up to 82% shows volumetric shrinkage upto 1.7% on polymerization. This volumetric Shrinkage causes marginal gap formation resulting in post operative sensitivity, marginal discoloration, secondary caries and breakdown at tooth-restoration interface.[1] To avoid these clinical complications, modifications in resin matrix resulted in development of another monomer system, based on cationic ring opening polymerization of silorane monomers.[2] These monomers are basically a hybrid composed of siloxane and oxirane rings.[3,4] The ring opening mechanism is also responsible for reduced shrinkage and high reactivity when compared to conventional methacrylate based resin composites.[5] Silorane based resin exhibited 50% less shrinkage stress than methacrylates based resins.[6,7]

The ring opening mechanism is also responsible for better marginal integrity of silorane based composite resin as they reveal decrease sorption of water, solubility, and decrease diffusion coefficient than methacrylate based composites.[5,8,12]

Long term stability of any composite restorations might be questionable by different mechanical or chemical degradation processes. Composite restoration can fail in the form of chipping, decrease wear resistance, secondary caries formation, or discoloration. These failures in composite resin require further secondary or alternative procedures.[9] Usually complete removal of composite restoration is accompanied with the removal of tooth structure which enlarges the prepared cavity

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resulting in increase loss of sound tooth structure.[10] Therefore adhesive dentistry gives an option for the repair of already existing composite restoration instead of its complete removal and replacement.[11] Long term stability of silorane based composite resin repair needs further focus for optimization of protocol for repair process.[12,13]

Adhesion between two different restorative materials and to the same restorative material itself should be of practical attention.[10] Silorane based composite resin system as recommended by manufacturers is chemically incompatible for use with methacrylate based composites.[14] Thus most of the authors have done the repair of original composite substrate with the same composite.[7,15] As siloxanes based composite resin requires different method for activation, commonly used Bis-GMA based adhesives are not compatible for use with silorane based composite resin and the bond between methacrylate resins and silorane resins is not as strong as those with the same material. Thus to bond dimethacrylate based composite to silorane based composite, some authors have suggested that a phosphate– methacrylate-based intermediate resin can be used for bonding purpose.[9,10,16]

In resin based composites repair procedures the major problem is absence of oxygen inhibiting layer and high degree of conversion, there is also decrease in number of double bonds for bonding between old and new resin based composite. Thus Mechanical and chemical methods are traditionally employed as surface treatments. The mechanical methods aim to remove the superficial composite layer exposed to the oral environment, increasing surface roughening and exposing the filler particles.[17] Different studies used different surface treatment methodologies such as hydrofluoric acid, diamond bur, silicon carbide strips, sand blasting, silica coating.[16,18]

But the type of original composite resin at the time of repair may not be known to clinician, as whether the composite resin to be repaired is methacrylate based or silorane based, which requires its matching bonding system i.e silorane adhesive system, Thus to determine the bond strength between two different composite matrix systems was performed in this study.

METHODOLOGY

30 samples of silorane based composite (Filtek™ P90, 3M ESPE. Germany, shade A2) and 30 samples of methacrylate based composite (SwissTEC Composite, Coltene/Whaledent AG, shade Enamel A2) were prepared in Teflon moulds of dimensions (10mm depth, 5mm diameter). All prepared samples had smooth and well defined surface with 5mm to be embedded in acrylic and remaining 5mm as substrate. Composite resins were placed in small increments and cured at a distance close to the surface of composite resin with a light emitting diode (LED) photo-polymerization light (Elipar, 3M ESPE) with light intensity of 800-1000mW/cm^2 for 40 seconds.

After photo-polymerization samples from control group (A) were processed further for repair without thermal cycling while the samples in experimental groups (B) were removed from moulds and closed in PVC tubes filled with deionized water to be placed in thermal cycler (BIO-RAD, T100™) for thermal cycling (5000 cycles of 5-55°C dwell time 20seconds) before further processing for repair.

The surfaces of samples of control group (A) and samples of experimental group (B) after thermal cycling were roughened by light grinding of upper face of substrate filling composite unidirectionally with 400-grit silicon carbide paper (3MTM) then rinsed with water and air dried with triple syringe. Surface roughening was followed by application of silane coupling agent (Monobond plus, Ivoclar vivadent) on the surface of samples in both control (A) and experimental (B) groups and allowed to evaporate for 60seconds.

All the samples of both control (A) and experimental (B) groups then received an application of adhesive agent specific for silorane resin composite (P90 system adhesive, 3M ESPE. Germany) using a micro brush. It was gently air thinned to remove any excess and light cured for 20 seconds.

For repair procedure samples of both control (A) and experimental (B) groups were transferred to second Teflon moulds of dimensions (15mm depth, 5mm diameter) and placing 5mm silorane composite for repair over substrate composite by packing against the substrates in increments and light cured with LED for 40 seconds using different shade (Filtek™ P90, 3M ESPE Germany, shade A3) to identify the boundary of substrate and repaired parts.

All the samples were held in custom made self cure acrylic resin blocks and stored in distilled water for 24h at 37°C before shear bond strength testing procedure. Samples from each group (A and B) were evaluated for shear bond strength testing using universal testing machine (Testometric, Model_M500-50AT) following ISO standards for bond strength test protocols at cross head speed of 0.5mm/min (ISO standard/TR 11405).

The samples were retained in custom made polymethylmethacrylate resin and tightened in a fixture attached to the compression load cell of testing machine with 1KN load, 19 at crosshead speed of 0.5mm/min. A chisel apparatus was used to direct the Shear force parallel to resin/substrate interface until fracture or debonding occured. Shear forces were recorded in

MPa and obtained directly from computer software (Testometric, Model_M500-50AT). The type of failure was evaluated using stereo light microscope (Zoom microscope, Model SZX7, Olympus_Japan) at 40x magnification and was categorized as cohesive, adhesive and mixed failure.

Cohesive failure (C) occurred within substrate or repair material, while adhesive failure (A) if it occurred at repair interface. Mixed (M) failure if occurred at both interface and within substrate/repair composite

RESULTS

The data were entered and analyzed by using IBM SPSS Statistics version 20 (IBM Corp, Armonk, NY). The mean ± SD (standard deviation) were calculated for quantitative variables. Frequency and percentages were calculated for qualitative variables. The normality of quantitative variables was checked by Shapiro-Wilk test. Independent T-Test test was used to compare the mean difference between groups. Fisher's exact test was used to observe the association of qualitative variable with the groups. A p-value ≤ 0.05 was considered as statistical significant.

Study groups	Material For Substrate composite resin	Processing Technique
Control Group (A)	Filtek™ P90 (shade A2)	No thermal cycling
Experimental group (B)	SwissTEC composite (shade A2)	Thermal cycling (5000 cycles 5-55°C, dwell time 20 seconds.

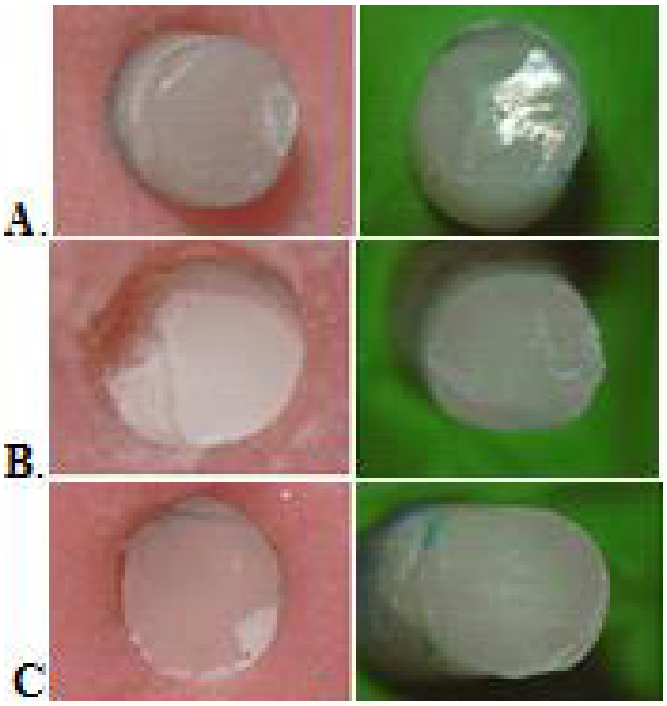

Fig 2: Substrate and repair side view of (A) Adhesive failure (B) cohesive failure (C) mixed failure.

TABLE 1: COMPARISON OF SHEAR BOND STRENGTH BETWEEN STUDY GROUPS

Shear bond strength	Study Groups	
	Control Group	Experimental Group
Mean	10.22	1.04
Std. Deviation	1.25	1.75

p-value =0.041

TABLE 2: COMPARISON OF TYPE OF FAILURES BETWEEN STUDY GROUPS

Study groups	Type of failures		
	Adhesive	Cohesive	Mixed
Control	3 10.0%	23 76.7%	4 13.3%
Experimental	5 16.7%	25 83.3%	0 0.0%
Total	8 13.3%	48 80.0%	46.7%

Table 1 displays the comparison of shear bond strength between study groups. Mean of shear bond in control group is 10.22 and standard deviation is 1.25, while mean of shear bond in experimental group is 11.04 and standard deviation is 1.75, p-value (0.041) is significant, which is less than 0.05.

The types of failures between study groups are shown in Table 2. In (control group) out of 30 samples, 3(10.0%) had adhesive failure, 23(76.7%) had cohesive failure and 4(13.3%) had mixed fracture type. While in (experimental group) out of 30 samples 5(16.7%) had adhesive failure, 25(83.3%) had cohesive failure and 0(0%) had mixed failure. Regarding comparison between repaired samples failures, majority of samples showed cohesive failure rather than adhesive failure. The adhesive, cohesive and mixed failure of samples is shown in Fig 2.

DISCUSSION

Based on difference in nature of resin matrix the use of methacrylate based and silorane based composite is of high clinical relevance because the clinician is unaware of the type of composite to be repaired at the time of fracture or chipping.[16,18]

To provide oral environment to these restorations 5000 cycles between 5 -55 ºC have been given in thermal cycler, to simulate the changes taking place in restorations during clinical service in mouth, which gave no significant difference in strength of experimental group specimens after thermal cycling. Based on the effect of aging on the strength of repair interface, Mosar in his study also concluded no significant difference in repair shear bond strength between Silorane and Methacrylate based composites before and after aging.[15]

Surface roughening with 400 grit silicon carbide strips was preferred as many clinicians may not have intra oral particulate abrasives, air abrasions devices and silica coating devices easily available with use of Silorane adhesive and Silane coupling agent for micro-mechanical and chemical interlocking.[9,10,12]

Silorane primer being hydrophilic was not used in this study instead hydrophobic 'Silorane adhesive bond' was used to get bond with its repair composite which was Silorane restorative. Luhrs et al also reported that the additional use of primer impaired and weaken the repair bond strength.[12]

Use of silane coupling agent improved the repair shear bond strength, Weigand et al and Maneenut et al also suggested the use of silane coupling agent or silane based adhesive when doing repair between composites of different matrix systems, however further research is required to confirm its performance in clinical studies.[9,16]

Repair bond strength was evaluated in terms of shear bond strength according to which the overall Filtek™ P90 with SwissTEC Composite gave better repair shear bond strength, also in bonding studies and experiments on dental materials assessment of mode of failure analysis is highly recommended.[9,12,16]

The failure analysis confirmed the shear bond strength test in a way that the samples in both groups showed more cohesive failure, thus thermal cycling did not adversely affect the strength of experimental group samples.

CONCLUSION

Within the limitation of this study it can be concluded that silorane based composite resin showed better shear bond strength with methacrylate based composite resin. Hence it can be used as repair composite with other conventionally used methacrylate based matrix systems. Thermal cycling did not affect the shear bong strength of samples in experimental group. Shear bond strength can be further enhanced if silorane based composite is used with silorane adhesive bond along with additional use of silane coupling agent.

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4	**Haider Javed:**	Helped in data collection and drafting of manuscript.