Assessment of dye penetration at composite – repair interface: Effect of application of bonding agent and comparison of two different bonding systems - An in vitro study

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ABSTRACT

Reparability of defects / fractures restricted to the bulk of the composite restoration is a highly desirable property, as being less time consuming and cost effective. This study was aimed to evaluate the microleakage at the composite repair interface following surface treatment and application of the bonding agent and compared the microleakage following application of two different bonding systems at the composite repair interface.

Material and Methods: Sixty composite resin specimens (Filtek Z350, 3M Dental Products) aged in distilled water for 1 week, were divided into four groups (n = 15) based on surface treatment and application of bonding agent. All the groups then received new resin applications using same composite resin. The samples were then thermocycled (200 cycles/50C to 550C{±2}) and immersed overnight in aqueous methylene blue dye solution. Single examiner carried out dye penetration analysis using stereomicroscope.

Results: Mann-Whitney U-Test ($p<0.05$) for group one and two showed no significant difference in repair microleakage. Group 3 and 4 showed statistically significant difference when compared with group 1 & 2. However, both group 3 and 4 did not significantly differ in microleakage scores with each other.

Conclusion: Irrespective of the type of bonding systems used, surface treatment with 50 micron size aluminum oxide particles followed by application of adhesive system are the essential steps to significantly reduce the microleakage at repair interface.

Key words: Air abrasion, Composite repair, Microleakage.

Introduction

Resin composites are most frequently used materials in direct esthetic restorations. Even after the improvement in their properties, recent composites still exhibit problems such as material fracture, discoloration[1], secondary caries and pain & sensitivity in the restored tooth.[2]

Fracture / defects of the composite restoration can be at the composite-tooth interface or within the restorative material itself. If fracture / defect lies within bulk of restorative material, complete removal of the restoration may lead to further loss of tooth structure due to difficulty in recognizing composite-tooth interface and the need for removing previously etched enamel to enable a new bonded restoration.[3, 4] It also increases the chances of pulpal trauma and the cost of the procedure.[3]

It is highly advantageous to Repair the defects / fractures restricted to the bulk of the composite restoration, as being less time consuming, cost effective or at least as being an acceptable interim procedure until further treatment.[4]

Various methods have been proposed for the preparation of the surface to be repaired like acid etching, air abrasion, roughening with diamond burs, other abrasive papers etc. Several studies have shown that surface preparation using above methods enhances repair bond strength significantly.[1, 5] Unfilled resins improve the repair strength of composites. Dissimilar composites generally bond as well as similar composites so repair strength is not improved by using materials with the same resin formulation.[1, 5]

Acid etching using hydrofluoric acid is commonly used to etch porcelain surfaces of indirect restorations or intraoral repairs. However, the use of the same for repair of composite restorations has not been found as effective as it does not produce sufficient roughness to create mechanical retention. In addition, hydrofluoric acid has been found to be less effective on microfilled composite resins.[6] Use of diamond abrasives and 50-micron size aluminum oxide particles has showed equally effective way to obtain composite surfaces for repair.[1, 5]

Various studies have demonstrated the improved bond strength of repaired surfaces using various surface treatment methods & application of bonding agents but accelerates failure. In addition, interfacial staining compromises esthetics, especially in anterior teeth that consequently require replacement of entire restoration.[3]

The study therefore incorporated a dye penetration analysis using a stereomicroscope to evaluate the microleakage at composite repair interface following surface treatment: In conjunction with or without the application of a bonding agent and comparison of two different bonding systems at the composite repair interface.

Materials & Method

A quadrangular resin mold was prepared using heat cured acrylic resin, which was used to prepare the 60 samples of composite resin. Half length of the mold was filled with ental composite (shade A2) (FiltekZ350™, 3M Dental products, India) and light cured using LED light cure unit (Litex 695™, Dentamerica, USA) for 20 seconds as per manufacturer instructions. Similar way all 60 samples were prepared. All the samples were then stored in distilled water for 1 week at room temperature. The samples were later randomly divided into four groups of 15 each, based on the method of surface treatment and the application of type of bonding system used during the repair procedure; however, one group was kept as control.

Group1: No surface treatment and no bonding agent applied during repair procedure

Group2: Surface treatment of composite repair surface with 50 micron aluminum oxide particles using micro sand blaster and no bonding agent was applied during repair procedure.

Group3: Surface treatment of composite repair surface with 50 micron aluminum oxide particles using micro sand blaster followed by application of bonding agent (Adper™ Single Bond 2™, 3M Dental Products, India) & light curing using LED light curing unit for 10 seconds during repair procedure.

Group4: Surface treatment of composite repair surface with 50 micron aluminum oxide particles using micro sand blaster followed by application of bonding agent (Prime & Bond NT™, Dentsply, India) & light curing it using LED light curing unit for 10 seconds during repair procedure.

Subsequently all the samples were placed back into the mold and the remaining half of the mold was filled using dental composite shade B2 (FiltekZ350™ 3M Dental Products, India). The samples were stored in distilled water for 24 hours at room temperature. All external surfaces of the samples were then coated with nail varnish with the exception of the side directly exposed to the curing light.

All the samples were then thermocycled for 200 cycles between 5(±2) and 55(±2) degree Celsius with 5 second dwell time at each temperature. They were then immersed overnight in 2% aqueous methylene blue dye solution. All the repaired samples were then transversely sectioned with a double faced diamond disc and the repaired surfaces were then examined under stereomicroscope (40X) for the evaluation of dye penetration at the repaired interface in different groups using dye penetration analysis. (Fig. 1) Single examiner measured the extent of microleakage according to the following scores:

0 – Absence of dye penetration

1 – Dye penetration up to ½ of the repair interface

2 – Dye penetration more than ½ of repair interface, without total involvement

3 – Complete repair interface involvement

The dye penetration scores were recorded and tabulated and statistical analysis was carried out.

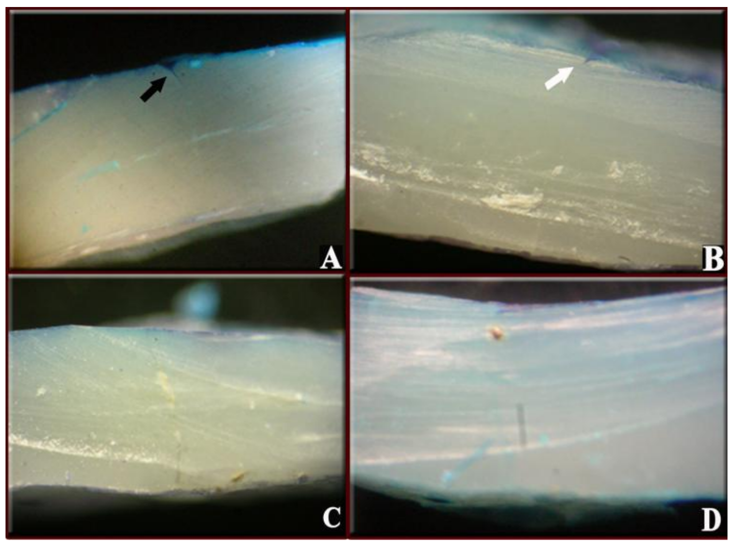

Fig 1: (A) Steromicroscopic photograph of a sample from group 1, Black arrow showing depth of dye penetration, (B) Steromicroscopic photograph of a sample from group 2, White arrow showing depth of dye penetration, (C) Steromicroscopic photograph of a sample from group 3, (D) Steromicroscopic photograph of a sample from group 4

Results

The results showed minimal or no dye penetration including the control group. (Table 1). Group 3 and group 4 were not statistically significant regarding the dye penetration and in both group 3 and group 4 only one sample showed minimal dye penetration. The mean values and standard deviation of the scores for all the groups were calculated and tabulated. (Table 2)

Comparison of all four groups using Kruskal Wallis (H) One-Way Anova test showed results to be significant with the p value of 0.0032 and H-value of 13.8016.

Pair wise comparison of all the groups by Mann-Whitney u-test showed that results were not significant (p value= 0.7557) when group 1 and group 2 were compared. Similarly group 3 and group 4 also did not show any significant difference (p value= 1.0000). Pair wise comparison of group1 and group 3 (p= 0.294), group 1 and group 4 (p= 0.294), group 2 and group 3 (p= 0.0620) and group 2 and group 4 (p= 0.0620) respectively using Mann-Whitney u-test also showed the significant difference between the respective groups. (Table 3)

GROUP	**SCORES**			
	0	1	2	3
GROUP 1	8	7	-	-
GROUP 2	9	6	-	-
GROUP 3	14	1	-	-
GROUP 4	14	1	-	-

Table1: Dye penetration scores distribution amongst various groups

Group	**Mean value**	**Standard Deviation**
1	0.5333	0.5164
2	0.4667	0.5164
3	0.0667	0.2582
4	0.0667	0.2582
Total	0.2833	0.4544

Table 2: Mean and Standard Deviation Values of Dye Penetration Scores by Groups

Group	**Ranks**	**U-value**	**Z-value**	**P-value**	**Significance**
1	240.0000	105.0000	-0.3111	0.7557	Non Significant
2	225.0000				
1	285.0000	60.0000	-2.1776	0.0294	Significant
3	180.0000				
1	285.0000	60.0000	-2.1776	0.0294	Significant
4	180.0000				
2	277.5000	67.5000	-1.8665	0.0620	Significant
3	187.5000				
2	277.5000	67.5000	-1.8665	0.0620	Significant
4	187.5000				
3	232.5000	112.5000	0.0000	1.0000	Non Significant
4	232.5000				

Table3: Pair Wise Comparison of Groups by Mann-Whitney U-Test

Discussion

Successful repair requires, adequate bonding between the existing resin restoration and the new composite filling. Repair interface must provide the bond strength similar to the cohesive strength of the substrate composite and prevent microleakage, which might lead to the further discoloration at the repair interface. Various studies have reported that repair bond strength is adequate for the clinical success of the repaired restoration.

Likelihood of achieving covalent bonding between resins appears to be inverse to the age of the substrate resin.[8] All the half length samples were aged for 1 week in distilled water which avoided the chemical bonding between methacrylate radicals from substrate resin and repair resin.

Unfilled Bis GMA resin, alone or combined with silane is the most effective procedure for enhancing the shear bond strength of the repaired composite specimens, irrespective of the surface treatments.[1] No significant difference in microleakage exists between untreated surfaces and surface treated specimens.[9] Adhesive systems (Group 3 & 4) showed decrease in the microleakage to the significant level as compared to Group 1 and Group 2.

Air abrasion is a surface treatment that causes "micro" retentive features, while a diamond stone yields "macro" and "micro" retentive features. Without a bonding system, lesser microleakage is expected from devices yielding macro retentive features. On the other hand, with bonding agents, a better surface wetting occurs as the adhesive resin infiltrates into the composite microscopic surfaces.[1, 3, 10] In our study use of aluminum oxide air abrasion created the micro retentive features and so, significant difference was found between groups with and without the application of bonding system.

Dye penetration analysis was carried out using buffered aqueous solution of methylene blue. To calculate the depth of penetration the dye penetration scoring criteria similar to the previous studies was utilized.[9] The use of colored agents to demonstrate microleakage continues to be the most popular of techniques, which are currently available. This method allows the production of sections showing leakage in contrasting colors to both tooth and restoration without the need for further chemical reaction or exposure to potentially hazardous radiation.[11]

Placing a specimen in vacuum before immersing in a dye solution significantly increases dye penetration along marginal defects. This is due to the removal of entrapped air from within the system.[12] The present study did not involve the storage of repaired samples under vacuum hence; differences in the results can be anticipated. Size of dye particle might limit the dye penetration into the submicron spaces, which may also give the false positive results.

The use of repeated thermal and mechanical loading of the restorations plays an important role in demonstrating marginal adaptation and microleakage.[11] Temperature cycles used in thermal stressing vary between workers, with few studies on the normal temperature variation in the mouth.[13] The present study utilized the 200 thermal cycles at 5^0C (±5) & 55^0C (±5) with a dwell time of 5 seconds at each temperature.

Surface roughness has a greater influence on repair strength & microleakage than using a bonding system[5, 9] also microleakage values of composite repair are lower when using a bonding agent, than from only surface treated surfaces.[14] Thus, it seems reasonable to suggest that efficient bonding agents and a surface treatment should be used to optimize the repair procedure.

The results seem to be favorable within the limits of in vitro conditions of the present study however; the in vivo conditions are the best for clinically relevant findings.

Within the confines of this in vitro study, it can be concluded that irrespective of the type of bonding systems used, surface treatment with 50 micron size aluminum oxide particles followed by application of adhesive system are the essential steps to significantly reduce the microleakage at repair interface.

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