ORIGINAL RESEARCH

# Influence of Adhesive Systems on Bond Strength of Restorative Material to Bleached Enamel and Dentin

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## ABSTRACT

**Aim**: To assess the influence of two adhesive systems on the bond strength of the restorative material to enamel and dentin after bleaching. **Materials and method**: 60 non-carious extracted premolar teeth after bleaching with 40% Hydrogen peroxide were divided into four groups based on type of adhesive system used and the tooth surface i.e. enamel and dentin used for bonding. G1ET and G3DT were restored using total etch adhesive system whereas G2ES and G4DS with self etch adhesive system. Similarly 60 teeth were used as control group which were not bleached and restored using the different adhesive systems. The samples were subsequently submitted to shear bond strength test in a Universal machine and the fracture patterns were assessed under a stereoscopic microscope. **Results**: All the bleached groups showed decrease in mean shear bond strength. Enamel showed greater bond strength on using total etch adhesive system. Bleached dentin showed significantly higher bond strength when self etched. **Conclusion**: Shear bond strength of composite to enamel and dentin decreases after bleaching treatment. Self-etching adhesive and Total-etching adhesive should be the first choice when performing restoration of teeth involving dentin and enamel respectively after bleaching.

**KEYWORDS:** Bleaching, Dentin, Enamel, Self Etch, Total Etch

## INTRODUCTION

Discoloration of anterior teeth is a serious aesthetic problem in restorative dentistry and it requires effective treatment.[1] Tooth bleaching is a conservative option for the treatment of dark teeth when compared to veneers and indirect crowns. Bleaching is achieved from an oxidation-reduction reaction in which oxygen free radicals released from bleaching agent degradation attack the dark-coloured chromophore molecules with long chains present in the dental tissues and break them down into less coloured, smaller and more diffusible molecules, producing the whitening effect.[2,3] Peroxides are the main active chemical component of most agents used in tooth bleaching therapies due to their reactive properties.[4]

Hydrogen peroxide ($H_2O_2$) is a strong caustic oxidizer at high concentrations (> 30%).[2,4] Although a high concentration agent is efficient for bleaching the tooth, it has unwanted complication in hard tooth tissues, including alterations in the adhesive capacity of the restorative materials. The reduction in bond strength is attributed to morphological and chemical alterations of the substrate; remnants of the bleaching gel inside the dentinal tubules and the collagen matrix or to the presence of residual oxygen in the enamel, which may be responsible for the inadequate polymerization of the adhesive systems.[5,6]

Despite of the possibility of side effects of bleaching treatment, there would be the need for restoring bleached teeth by using different adhesive systems.[6] Modern adhesive systems can be grouped into two categories according to their etching technique: total-etch and self-etch products. The first category utilizes the total-etch (etch and-rinse) technique which relies on the removal of the smear layer and exposure of the collagen matrix by acid etching, following which the self-priming agent is applied that combines the primer and the adhesive resin into one solution.[7] The second category utilizes the self-etching adhesive system, which combines the acid and primer agents in one single step, enabling a smaller chair time.[6] This also eliminates the risk of promoting the collapse of collagen fibers, because of omission of washing and drying step after the etchant agent application.[8,9]

Enamel is more mineralized than dentin and dentin has a considerable amount of organic material and water, when compared to enamel which can lead to difference in bonding strengths of different adhesive systems to enamel and dentin. Hence, the objective of this study is to assess the influence of two different adhesive systems on the bond strength of the restorative material to enamel and

*How to cite this article:*
Kumar NK, Das S. Influence of Adhesive Systems on Bond Strength of Restorative Material to Bleached Enamel and Dentin. Int J Dent Med Res 2015;1(5):65-68.

dentin after bleaching.

## MATERIALS AND METHOD

A total of 120 intact, non-carious, single rooted human mandibular premolar teeth that were planned for orthodontic extraction within six month period of start of the study constituted the total sample size. The sample was collected from the Department of Oral and Maxillofacial Surgery, Government Dental College and Research Institute, Bengaluru after obtaining ethical clearance. Teeth with caries, restoration or fluorosis were considered under exclusion criteria. The selected teeth were randomly divided into four control and four experimental groups. The groups were subjected to different treatments as follows:

***EXPERIMENTAL GROUPS:*** 60 premolar teeth were bleached with 40% hydrogen peroxide gel (Opalescence Boost, Ultradent, USA). Before bleaching, a prophylaxis was performed with a rubber cup and pumice. Two bleaching treatment sessions will be carried out with an interval of one week between them. At each session, the teeth will be given 3 applications of the bleaching agent lasting eight minutes (a total of 48 minutes of treatment). After two weeks of final bleaching session the teeth were randomly divided as follows.

***G1ET:*** The buccal surfaces of 20 premolar teeth were flattened with silicone carbide sandpaper with decreasing granulations (#120, #240, #400, #600) under abundant irrigation for 10 seconds with each sandpaper. The purpose was to standardize the smear layer and obtain flat enamel surfaces. The samples were then immersed in distilled water and stored at room temperature for 24hrs before using total-etch adhesive system. 37% phosphoric acid (3M ESPE Scotchbond™ Multipurpose) as an etchant was applied for 20 seconds and washed thoroughly with water for 10 seconds. The tooth surface was then air dried for 2 seconds followed by the application of the bonding agent (One Coat Bond SL, Coltene). The bonding agent was applied in two coats and was spread evenly on the etched surface with a gentle air blow from the three-way syringe. After 30 seconds the bonding agent was cured with LED unit for 20 seconds.

***G2ES:*** 20 premolar teeth were treated same as in G1ET except for the use of self-etch adhesive system (One Coat Self-Etching Bond, Coltene) instead of total etch adhesive system.

***G3DT:*** 10 premolar teeth were properly embedded in dental utility wax and were cut longitudinally at buccal-lingual direction, with the aid of a double-faced diamond disc. 20 fragments of vestibular face of crown were embedded in dental utility wax with the intracoronary dentin faced up. The dentin surface was ground with #280 and #400-grit silicon carbide sandpaper under water cooling to flat the surface. Complementary grinding was performed with #1200-grit silicon carbide paper for 1 min to produce a standardized smear layer. The specimens were stored in distilled water at room temperature for 24hrs before using total-etch adhesive system. The method of use of the adhesive system was same as described in G1ET.

***G4DS:*** 10 premolar teeth were treated same as in G3 except for the use of self-etch adhesive system instead of total-etch adhesive system.

***CONTROL GROUPS:*** 60 premolar teeth were cleaned prophylactically with a rubber cup and pumice. The samples were then randomly divided into four groups as follows:
G1CET: 20 premolar teeth were treated same as G1ET
G2CES: 20 premolar teeth were treated same as G2ES.
G3CDT: 10 premolar teeth were treated same as G3DT
G4CDS: 10 premolar teeth were treated same as G4DS

***COMPOSITE BUILD UP***: To build the restoration, a round stainless steel mould with a longitudinal cut central hole 5mm in height and 3mm in diameter was positioned over the specimens so that the central hole coincided with the delimited areas of enamel and dentin. Filtek P$^{60}$ composite (3M ESPE Filtek™ P60) was inserted in 2 increments, and each was photopolymerized with LED light for 20 seconds.

After the resin composite cylinders had been prepared, the specimens were stored in distilled water for 24hrs, and subsequently submitted to shear bond strength test in a Universal machine.

The fracture patterns of the specimen were assessed under a stereoscopic microscope and were classified as follows: Type1- Adhesive Fracture (occurring at the bond interface, with adhesive system displacement from the enamel or dentinal surface); Type 2- Cohesive fracture in the resin composite (fracture that occurred in the resin composite structure); Type 3- Cohesive fracture in enamel or dentin (enamel or dentinal substrate fracture); and Type 4- Mixed fracture (fracture with features of adhesive fracture and/or cohesive fracture of adhesive and/or cohesive resin fracture).

## RESULTS

The data analysis showed decrease in mean shear bond strength in all the experimental groups, i.e. groups submitted to bleaching treatment when compared to their respective control groups which were not subjected to bleaching treatment. The decrease was significant in all the experimental groups compared to their control groups except for comparison between G4DS and G4CDS (Table 1)

Table 2 shows the comparison of the bond strength of total etch and self etch adhesive systems on enamel and dentin separately. It was found that enamel showed greater shear bond strength in case of use of total etch adhesive than self etch adhesive for both unbleached and bleached samples. The difference was significant in both the control and experimental groups. Bleached dentin showed significantly higher shear bond strength when self etched rather than total etch. Unbleached dentin also showed higher shear bond strength when self etched but the difference was not significant.

| Adhesive System | Enamel/ Dentin | Group | Bond Strength | 't' value# | P value |
|---|---|---|---|---|---|
| Total Etch | Enamel | Control | 11.315 ± 1.168 | 11.498 | <0.001 ** |
| | | Experiment | 6.394 ± 1.517 | | |
| | Dentin | Control | 4.749 ± 1.322 | 3.212 | 0.003* |
| | | Experiment | 3.397 ± 1.339 | | |
| Self Etch | Enamel | Control | 8.214 ± 1.774 | 5.550 | <0.001 ** |
| | | Experiment | 4.943 ± 1.949 | | |
| | Dentin | Control | 5.429 ± 1.546 | 1.541 | 0.132$^{NS}$ |
| | | Experiment | 4.691 ± 1.485 | | |

TABLE 1: Comparison of mean shear bond strength (MPa) between control and experimental groups, #Unpaired 't' test; NS: p > 0.05; Not Significant; *p < 0.05; Significant; ** p < 0.001; Highly significant

| Group | Enamel / Dentin | Adhesive | Bond Strength | 't' value# | P value |
|---|---|---|---|---|---|
| Control | Enamel | Total Etch | 11.315 ± 1.168 | 6.530 | <0.001** |
| | | Self Etch | 8.214 ± 1.774 | | |
| | Dentin | Total Etch | 4.749 ± 1.322 | 1.497 | 0.143$^{NS}$ |
| | | Self Etch | 5.429 ± 1.546 | | |
| Experiment | Enamel | Total Etch | 6.394 ± 1.517 | 2.626 | 0.012* |
| | | Self Etch | 4.943 ± 1.949 | | |
| | Dentin | Total Etch | 3.397 ± 1.339 | 2.895 | 0.006* |
| | | Self Etch | 4.691 ± 1.485 | | |

TABLE 2: Comparison of the shear bond strength (MPa) of total etch and self etch adhesive systems on enamel and dentin separately. #Unpaired 't' test; NS: p > 0.05; Not Significant; *p < 0.05; Significant; ** p < 0.001; Highly significant

| Adhesive System | Group | Enamel / Dentin | Bond Strength | 't' value# | P value |
|---|---|---|---|---|---|
| Total Etch | Control | Enamel | 11.315 ± 1.168 | 16.646 | <0.001** |
| | | Dentin | 4.749 ± 1.322 | | |
| | Experiment | Enamel | 6.394 ± 1.517 | 6.623 | <0.001** |
| | | Dentin | 3.397 ± 1.339 | | |
| Self Etch | Control | Enamel | 8.214 ± 1.774 | 5.292 | <0.001** |
| | | Dentin | 5.429 ± 1.546 | | |
| | Experiment | Enamel | 4.943 ± 1.949 | 0.460 | 0.648$^{NS}$ |
| | | Dentin | 4.691 ± 1.485 | | |

TABLE 3: Comparison of the shear bond strength (MPa) of enamel and dentin when treated with total etch and self etch adhesive systems separately. #Unpaired 't' test; NS: p > 0.05; Not Significant; *p < 0.05; Significant; ** p < 0.001; Highly significant

Table 3 shows the comparison of the bond strength of enamel and dentin when treated with total etch and self etch adhesive systems separately. For all the samples that were treated with total etch adhesive, it was found that enamel had significantly greater shear bond strength than dentin in both bleached and unbleached cases. For the groups where self etch adhesive was used, enamel showed significantly higher shear bond strength than dentin in case of unbleached specimens but for the bleached specimens, the values were almost similar.

Table 4 shows percentage of failure modes in each group after shear bond strength test. All the experimental groups showed prevelance of adhesive failures.

| Adhesive System | Enamel / Dentin | Group | Bond Strength | 'T' Value# | P Value |
|---|---|---|---|---|---|
| Total Etch | Enamel | Control | 11.315 ± 1.168 | 11.498 | <0.001** |
| | | Experiment | 6.394 ± 1.517 | | |
| | Dentin | Control | 4.749 ± 1.322 | 3.212 | 0.003* |
| | | Experiment | 3.397 ± 1.339 | | |
| Self Etch | Enamel | Control | 8.214 ± 1.774 | 5.550 | <0.001** |
| | | Experiment | 4.943 ± 1.949 | | |
| | Dentin | Control | 5.429 ± 1.546 | 1.541 | 0.132$^{ns}$ |
| | | Experiment | 4.691 ± 1.485 | | |

TABLE 4: Percentage of failure modes in each group after shear bond strength test.

## DISCUSSION

Hydrogen peroxide is one of the commonly used agent for bleaching teeth. Following bleaching, restoration of fractured teeth or replacement of earlier aesthetic restorations form an integral part of the treatment protocol. Bond strength of composite used with different etching and adhesive systems to natural enamel and dentin surface show various results. Moreover, enamel and dentin have different physical and chemical properties. Hence, the influence of the different adhesive systems on the bond strength of composite to bleached enamel and dentin separately has to be evaluated.

In this study, 40% hydrogen peroxide was used as bleaching agent. This was followed by the use of adhesive systems- total etch and self etch systems. The results of this study showed lower mean bond strength values in the bleached groups when compared with the unbleached group, regardless the adhesive system used. Except for G4DS, all the other experimental groups showed significant difference in the shear bond strength values in comparison to their respective control groups. This decrease in the bond strength can be attributed to the morphological and chemical alterations of the substrate; remnants of the bleaching gel inside the dentinal tubules and the collagen matrix or to the presence of residual oxygen in the enamel, which may be responsible for the inadequate polymerization of the adhesive systems.[5,6] To minimize the effect of the residual oxygen in the dentinal tubules, an interval of 15 days were left before the

composite build up. A study by Vieira et al showed similar result regarding the decrease in the bond strength of restorative material to dentin after the use of high-concentration bleaching agents.[10] Also, study by Mortazavi et al showed reduced bond strength of the composite to the enamel bonded with a three step total etch and two simplified one step all-in-one dental bonding agents.[11]

The present study showed that the bond strength of the composite restoration on enamel was higher in G1ET where total etch adhesive was used, than G2ES where self etch adhesive was used. Similar result was shown in a study performed by Lopes et al where the total etch system showed greater shear bond strength than the five different self etch systems used. However, only one self etch system among them showed similar shear bond strength to the total etch system used in the study.[12] The reason behind this may be the greater demineralization effect of the total etch adhesive on enamel than the self etch adhesive.

On comparison of total etch adhesive system to the self etch adhesive system on bonding of composite material to the dentin, the present study showed greater shear bond strength in case of self etch adhesive than the total etch adhesive. This result was in accordance with the result obtained in a study by Bruniera et al.[6] The lower results in case of total etching system can be attributed to the solvents and alcohol present in its composition which rapidly evaporates leaving behind collapsed dentinal collagen fibers.[13] Whereas, the self etching adhesive system eliminates the risk of collapse of the collagen fibers due to the omission of the washing and drying of the substrate after application of the adhesive agent.[8,9] Moreover, the solution of the self-etching adhesive system containing water, organic solvents and diluents, is fluid enough to easily penetrate into the tooth tissue.[14]

For all the samples that were treated with total etch adhesive, it was found that enamel had significantly greater shear bond strength than dentin in both bleached and unbleached cases. The reason behind this may be the difference in chemical composition between enamel and dentin. Enamel has more mineral content when compared to dentin. Moreover, enamel is composed of 96% inorganic component. Total etch system helps in greater demineralisation in case of enamel whereas in case of dentin, there is greater collapse of the collagen fibers after washing and drying. For all the samples that were treated with self etch adhesive, the shear bond strength of composite to enamel was significantly higher than that to dentin in the control groups but the bleached teeth showed similar shear bond strength of composite to both enamel and dentin.

In this study, it was observed the prevalence of greater adhesive failures for the all the experimental groups, i.e. bleached samples when compared to their control groups except for g4dentin and g4control where the percentages of adhesive failure were the same. Similar result was obtained in the study by Vieira et al which showed prevalence of adhesive failures in all the bleached groups, regardless the bleaching agent used.[6,10]

## CONCLUSION

Under our study conditions, it was found that shear bond strength of composite to enamel and dentin decreases after bleaching treatment. Bonding of composite to enamel was found to be better when total etch adhesive system was used. Also, self-etching adhesive should be the first choice when performing the restoration of teeth involving dentin after bleaching.

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Source of Support: Nil
Conflict of Interest: Nil