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The Impact of an Antioxidizing Agent on Shear Bond Strength of Bleached Teeth: A Comparative Study

Dr. Danish Zahoor[1], Dr. Ashish Gupta[2], Dr. Aashee Verma[3], Dr. Ashwani Dahiya BDS[4]

[1]MDS, Department of Orthodontics and Dentofacial Orthopaedics
Email: *zahoordanish16[at]gmail.com*

[2]Professor, Swami Devi Dyal Hopital and Dental College, Barwala Panchkula
MDS, Department of Orthodontics and Dentofacial Orthopaedics

[3]PG Student, Swami Devi Dyal Hopital and Dental College, Barwala Panchkula,
Department of Orthodontics and Dentofacial Orthopaedics
Email: *aashee_verma[at]yahoo.co.in*

[4]Email: drashwanidahiya[at]gmail.com

Abstract: ***Aim: This study was performed to evaluate the effect of an antioxidizing agent on the shear bond strength of bleached teeth. Materials and Methods: A total of 60 non carious, sound premolar, extracted for routine orthodontic treatment (Fig.1) were used in this study. The samples were divided randomly into three groups of 20 each as Group A, B and C. The acrylic blocks in which the teeth were embedded were color coded. Group A was the control group, whereas Group B and C were the study groups. Results: Maximum Shear bond strength was observed in Group A - (Control group, ethched and bonded, white coloured), which was 10.86 ± 2.05 Mpa, followed by Group C (treated with antioxidizing agent, bleached and bonded, pink coloured) which had the Shear bond strength of 6.38 ± 2.65 Mpa. Whereas Group B (bleached and bonded, purple coloured) had the Shear bond strength of 3.19 ± 0.68 Mpa. Conclusion: Bleaching with 35% hydrogen peroxide reduced the Shear bond strength.***

Keywords: Shear bond strength, Antioxidizing agent, Bleached and Bonded

1. Introduction

Dental bleaching is a conservative treatment that promotes colour change through a redox reaction caused by the presence of hydrogen peroxide in the composition of bleaching agents. Ions resulting from the degradation of hydrogen peroxide as free radicals and reactive oxygen penetrate the enamel to reach dentin by diffusion and the complex molecules of pigments are transformed into smaller molecules[1]. High concentrations of oxidizing agents such as 35 - 37% carbamide peroxide and 30 - 35% hydrogen peroxide for use in the office, and low concentration such as 3 - 7% hydrogen peroxide and 10 - 20% carbamide peroxide for use at home by the patient are available, with advantage and disadvantage for each agent. Some of the advantages of the in office technique are that everything is under the control of the practitioner, soft tissues are properly protected, and the procedure will yield good results in a short period of time. Despite the fact of above mentioned factors on tooth bleaching, complications such as pulp irritation, tooth structure alterations, microleakage of restorations, and reduced bond strength of composite resin to tooth structure might arise. One of the most important complications of the use of bleaching agents is decreased composite resin bond strength to enamel immediately after bleaching procedure. It has been recommended a waiting period from 24 hours to 3 weeks after bleaching to perform adhesive restorative procedures. This period is important to eliminate the residual oxygen from dental structure and reestablish the enamel bond strength. However, not always this waiting time is possible, because the search for immediate results and urgency for aesthetic rehabilitation. Other methods have been proposed for the restorative procedure can be done immediately after bleaching, as the application of adhesives containing organic solvents, organic compounds and antioxidants agents. Many studies have shown that the bleaching of teeth with various concentrations of bleaching agents such as hydrogen peroxide reduces the bond strength of orthodontic brackets to the enamel surface[2].

2. Aim and Objectives

Aim of the study

The aim of the study was to evaluate the effect of an antioxidizing agent on the shear bond strength of bleached teeth.

Objectives of the study

The objectives of the study were:

1) To evaluate the effect of bleaching on shear bond strength of orthodontic brackets.
2) To evaluate the effect of an antioxidizing agent on the shear bond strength of orthodontic brackets.
3) To compare the effect of bleaching and antioxidizing agent on the shear bond strength of orthodontic brackets.
4) To evaluate and compare the Adhesive Remnant Index (ARI) on bonded teeth.

3. Materials and Methods

This in - vitro study was conducted in the Department of Orthodontics and Dentofacial Orthopaedics, Swami Devi Dyal Hospital and Dental College, Golpura, Panchkula, Haryana.60 premolar teeth extracted for orthodontic purpose were collected from the Department of Oral and Maxillofacial Surgery, Swami Devi Dyal Hospital and Dental college, Barwala, Panchkula.

The Inclusion criteria for teeth selection were

- eHealthy and Intact buccal enamel, no restorations, attrition and structural defects, no hypoplastic, caries or demineralization areas and teeth had not undergone any chemical treatment such as bleaching, alcohol or acid treatment.

Figure 1: 60 extracted premolars

Sample Preparation

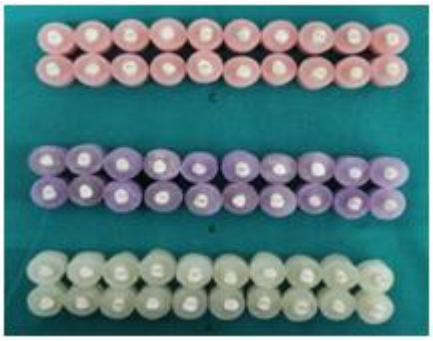

Figure 2: Group A (white), Group B (purple), Group C (pink)

Collection of extracted teeth:
The extracted teeth were cleared of debris and residual tissues. These teeth were visually inspected for the following criteria and then stored in normal saline.

Inclusion criteria were as follows:
a) Healthy and Intact buccal enamel.
b) No pretreatment with chemical agents such as peroxide, acids, alcohol or any other form of bleaching agents.
c) No restorations, attrition and structural defects.
d) No hypoplastic, caries or demineralization areas.
e) The tooth should not have undergone any chemical treatment such as bleaching, alcohol or acid treatment.

Sample preparation: Each extracted premolar tooth was mounted vertically in the self cure acrylic blocks so that the crown of the teeth were exposed above the cervical area and the buccal surface of the tooth was exposed for the purpose of bonding of bracket, and fabricated for mounting onto an Instron Universal Testing machine.

Grouping of the samples: (Fig.2)
All the samples were divided randomly into three groups of twenty each as group A, B and C, and the acrylic block in which teeth are embedded were colour coded as follows:
Group A: control group (white)
Group B: bleached and bonded (purple)
Group C: treat with 10% sodium ascorbate, then bleached and bond (pink)

Bonding Procedure

1) Group A (control group, white coloured):
Each teeth were individually etched with 37% phosphoric acid for 30 seconds and then rinsed with water and dried till the enamel surface of the teeth showed frosty white appearance, then the preadjusted edgewise appliance bracket (0.022 Slot) of a surface area 10mm2 were bonded on to the etched surface using light cure composite resin and then cured by light emitting diode (LED) light source for 30 seconds, care should be taken to remove the excess composite by using sharp probe around the bracket before curing. This group is known as control group.

2) Group B (bleached and bonded, purple coloured):
In this group, initially teeth were individually bleached with 35% hydrogen peroxide (POLA OFFICE), which was mixed according to the manufacturer recommendation approximately 2mm in thickness ensuring no enamel was visible. It was then cured using a LED curing light for 30 seconds and kept in place for 3 min before it was washed away. Immediately after this, the bonding area was etched with 37% phosphoric acid gel for 30 s then washed and dried till white frosty appearance was seen. The pre - adjusted edgewise brackets were bonded as mentioned earlier for Group A.

3) Group C (antioxidizing agent, bleached and bonded, pink coloured):
In this group, initially teeth were bleached with 35% hydrogen peroxide as mentioned in group B and after washing away the bleaching agent, 10% sodium ascorbate solution was applied to the enamel surface of the embedded teeth as an irrigation solution for 10 min with the flow rate of 1 ml/min. During this period the enamel surface was continuously agitated using a sterile brush and after the antioxidant (10% sodium ascorbate) treatment the enamel surface was thoroughly rinsed with distilled water for 30 seconds, then acid etching is done with 35% phosphoric acid and rinsed with water. After drying the enamel surface till the frosty appearance comes, and the bracket bonded using LED light cure unit were carried out as mentioned previously for two other groups.

Storage
The teeth from all the three groups were stored in saline water at room temperature for 24 hours before subjecting them for shear bond strength testing.

Testing of shear bond strength (Fig.3 - Fig.5):

- The teeth in all the groups were mounted individually on to the universal testing machine (UTM) for the debonding procedure. The shear bond strength was tested in the laboratory at Mechanical Engineering Department, Punjab Engineering College (PEC), Sector - 12, Chandigarh.
- For debonding procedure, each specimen will be loaded into the universal testing mechine with the long axis of the specimen perpendicular to the direction of the applied force. The standard knife edge of the Universal Testing Mechine (UTM) positioned vertically in such a way that the knife edge of the UTM touches the bracket superiorly to debond the bracket from the buccal surface of the tooth. Bond strength will be determined in the shear mode at a crosshead speed of 0.5 mm/min until fracture occurred.

Figure 3: Testing of Shear Bond Strength of a specimen of group A (white)

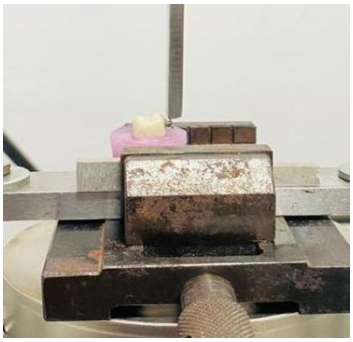

Figure 4: Testing of Shear Bond Strength of a specimen of group B (purple)

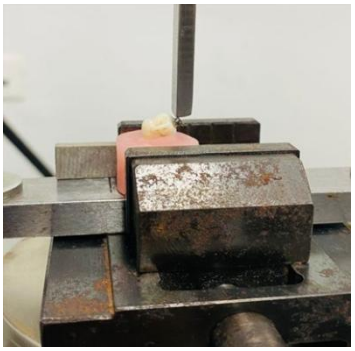

Figure 5: Testing of Shear Bond Strength of a specimen of group C (pink)

Measurement of Adhesive Remnant Index

The amount of residual index was classified according to Modified Adhesive Remnant index[3]

Score	Definition
0	No adhesive left on the tooth
1	1% - 25% of adhesive left on the tooth
2	26% - 50% of adhesive left on the tooth
3	51% - 75% of adhesive left on the tooth
4	76% - 99% of adhesive left on the tooth
5	All adhesive left on the tooth with distinct impression of bracket mesh

Statistical Analysis

Data was analyzed using the statistical package SPSS 22.0 (SPSS Inc., Chicago, IL) and level of significance was set at $p<0.05$.

4. Results

Table I: Comparison of Shear Bond Strength between the groups

Groups	Minimum	Maximum	Mean	SD	Anova Test	p value
Group A (White)	7.30	16.50	10.86	2.05	78.35	<0.01*
Group B (Purple)	2.00	4.40	3.19	0.68		
Group C (Pink)	2.90	13.20	6.38	2.65		
Tukey HSD Post – hoc Test. . . Group A vs Group B: Diff= - 7.6700, 95%CI= - 9.1514 to - 6.1886, p=<0.01* Group A vs Group C: Diff= - 4.4800, 95% CI= - 5.9614 to - 2.9986, p=<0.01* Group B vs Group C: Diff=3.1900, 95% CI=1.7086 to 4.6714, p=<0.01*						

*statistically significant

Table II: Adhesive remnants index score between the groups

Groups	Minimum	Maximum	Mean	SD	Anova Test	p value
Group A	0	4	1.45	1.19	8.16	0.0008*
Group B	0	3	1.15	0.93		
Group C	0	5.00	2.50	1.19		
Tukey HSD Post- hoc Test. . Group B vs Group C: Diff=1.35, 95% CI=0.51 to 2.19, p=0.0009*						

Group B vs Group A: Diff=0.30, 95% CI= - 0.55 to 1.15, p=0.67 Group C vs Group A: Diff= - 1.05, 95% CI= - 1.89to - 0.21, p=0.0113*

*statistically significant

5. Discussion

The bleaching procedure provides the enamel surface with a more universally whiter shade. . Concentrated solution of hydrogen peroxide are the most commonly agents used to bleach discoloured teeth. According to McGuckin et al[4], the void areas present at the interface decrease in bonds formed at longer time intervals after bleaching cessation, indicating a gradual elimination of hydrogen peroxide and its byproducts with consequently increase of the bond strength. According to Titley et al[5], the dentin and dentinal fluid can act as a peroxide and oxygen reservoir. The reservoirs of gaseous or dissolved oxygen products could persist until removed by pulpal microcirculation and diffusion from the external surface. Alterations in bond strength might be significant with regard to clinical operative procedures that involve composite resin bonding, such as bonding orthodontic brackets, porcelain veneers, composite veneers or future composite restorations[6]. It has also been reported that the weakening of the bond occurred both superficially and internally. This could be attributed to the presence of residual peroxide, which interferes with the resin tag formation and inhibits the resin polymerization. Removal of the superficial layer of enamel, treating the bleached enamel with alcohol before restoration and the use of adhesives containing organic solvents are some of the techniques that have been suggested to solve the clinical problems related to the post bleached compromised bond strength. However, the general approach is to postpone any bonding procedure for a period varying from 24 h to 4 weeks after bleaching since the reduction of bond strength has been shown to be temporary[7].

Some studies report that the time application of 5 minutes, 10 minutes, 15 minutes or 30 minutes is not enough to reverse adhesion strength[8]. But Alencar et al[9], suggest that although the results are immediate and satisfactory statistically similar to the uncontrolled group, these values are reduced in comparison with the force of adhesion found in groups with a waiting time of 7 days, thus being safer for 7 days after bleaching to perform the adhesive restorative procedure. Good results with 10% sodium ascorbate in a short period of time has been possible when it is applied 24 hours after bleaching or when the bleaching agent is used in a shorter time than recommended clinically.

According to Lai et al[10], 10% sodium ascorbate should be used for at least one third of the time of the bleaching to be effective. The application of antioxidant agents for a brief period and immediately after bleaching is essential for being clinically feasible. Studies have shown that 10% ascorbic acid when used for 1 or 10 minutes over can create micromechanical retention on bleached enamel due to its low pH, which consequently increases the bond strength[11]. Freire et al[12] demonstrated that the reaction between the oxide residuals and antioxidants usually reaches its summit in about a minute, which highlights the importance of the number of sodium ascorbate applications rather than the duration of application. Thus, only increasing the contact time of the sodium ascorbate solution may not be sufficient to eliminate residual oxide. Repeated short applications of sodium ascorbate is an effective approach to reverse the weakening effects of bleaching agents, such as hydrogen peroxide. Sodium ascorbate is available as an over the counter vitamin supplement. While it can cause gastrointestinal symptoms when ingested in very high doses, it is entirely safe to be utilized topically.

In this study, 10% sodium ascorbate solution was used as an antioxidizing agent, whereas 35% hydrogen peroxide was used as an bleaching agent. This approach usually require one to two visits to the dental office. In terms of ARI index group C had the maximum ARI score followed by group A and least in group B. Previous studies conducted by Adanir et al[13] in 2007 and Dishman[14] in 1994 showed similar results where they found reduced bond strength when the teeth was treated with 35% hydrogen peroxide and was immediately bonded with light cure composite for bonding procedure. Several authors have reported significant reduction in the bond strength of brackets bonded to enamel, immediately after bleaching. One of the reasons suggested for the reduced bond strength is because of the release of free oxygen radical of the bleaching agents on the tooth surface.

Studies conducted by Machado et al[15] 2007, Bishara et al[16] and Bulut, et al[17] 2006, the results showed that if the bonding procedure on the bleached teeth is delayed for 1 week the bond strength will be reversed. Study by Turkun et al[18] in 2009 found that the concentration of 10% sodium ascorbate will be effective in reversing the bond strength of the bleached teeth to the normal. Study conducted by Muraguchi[19] showed that the antioxidant treatment immediately after office bleaching was effective in reversing the bond strength of both adhesive systems. Kunjappan et al[20] in 2013 concluded that in office bleaching with 35% hydrogen peroxide though reduced the bond strength, it did not significantly reduced the shear bond strength below the required level of 7 MPa which was not in concordance to our results where the bond strength after bleaching was reduced even below the required level of 7 MPa. Emaan H Ismail et al[21] in 2017 found that application of a high concentration of sodium ascorbate for a shorter time reversed the negative effect of 35% hydrogen peroxide bleaching on composite bonding strength to debtine. Nari Ratih D and Widyastuti A[22] in 2019 reported that application of antioxidants increased the shear bond strength of composite resin to enamel following extra coronal bleaching using 40% hydrogen peroxide.10% sodium ascorbate, 10% alpha tocopherol, 10% green tea and 10% Aloe vera extracts produced the same effect on the shear bond strength of composite resin to enamel following extra coronal bleaching using 40% hydrogen peroxide. When standard bleaching protocols are considered, it is wise to wait before esthetic restoring of teeth until the colour change has been stabilized. Besides delaying bonding of restorations, application of an antioxidant might also be recommended to restore the compromised bond strength of the luting resin to bleached enamel.

6. Summary and Conclusion

Based on the result of this study the following conclusion were produced

1) Out of the three groups, maximum Shear bond strength (SBS) was found in group A (Table 1) (control group, white coloured), which was 10.86 ± 2.05 Mpa, followed by group C (treated with antioxidizing agent, bleached and bonded, pink coloured) which had the Shear bond strength of 6.38 ± 2.65 Mpa. Whereas group B (bleached and bonded, purple coloured) had the Shear bond strength of 3.19 ± 0.68 Mpa.
2) Bleaching with 35% hydrogen peroxide in group B (bleached and bonded, purple coloured) reduced the Shear bond strength (3.19 ± 0.68 Mpa) when compared to group A (control group, white coloured, 10.86 ± 2.05 Mpa).
3) However using the Antioxidizing agent (10% sodium ascorbate) in group C (treated with antioxidizing agent and then bleached and bond), increased the Shear bond strength when compared to group B (bleached and bond, purple coloured)
4) ARI score were significantly different in all the groups (Table 2). The unbleached group (group A, control group), failure was primarily at the bracket/adhesive interface. Whereas the group C (treated with antioxidizing agent, and then bleached and bonded) showed cohesive failure within the adhesive or failed at the adhesive/enamel interface.
5) It can be concluded that in office bleaching 35% hydrogen peroxide reduced the bond strength (6.38 ± 2.65 MPa) below the required level of 7 Mpa. It was also found that the sodium ascorbate treatment increased the bond strength when compared to bonding with bleached only group.

Conflict of Interest: The authors declare that they have no conflict of interest.

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