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"Orthodontic brackets bonded to bleached enamel: a comparative study of the effects of two antioxidants on the shear bond strength"

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ABSTRACT:

Advancements in dentistry require better management of teeth whitening and orthodontic procedures. Hydrogen peroxide whitening can reduce adhesive strength due to enamel changes and residual oxygen. This investigation in-vitro compared the effects of two antioxidant mediums regarding the strength of the bond between orthodontic brackets applied to teeth bleached 24 hours prior. The goal was to develop guidelines for optimizing bracket bond strength in cases where bleaching precedes orthodontic bonding. It evaluated how in-office teeth whitening with 35% hydrogen peroxide affects orthodontic bracket bond strength and tested the efficacy of antioxidants in reversing this effect. Sixty sound human premolars were separated into four groups: a control group with standard bonding, a bleaching group, and two antioxidant groups treated with 7% sodium bicarbonate or 10% sodium ascorbate following bleaching. Using a universal testing apparatus, the shear bond strength was determined after 24 hours. The study showed that bleaching with 35% hydrogen peroxide significantly reduced orthodontic bracket bond strength (6.60 MPa) compared to the control group (12.98 MPa). However, applying 10% sodium ascorbate or 7% sodium bicarbonate restored bond strength to levels similar to the control group.

KEYWORDS:

Enamel bleaching, Bond strength, Antioxidants, Orthodontic brackets, Orthodontics

INTRODUCTION:

In this era of interdisciplinary collaboration, orthodontics can no longer operate in isolation from other specialties. Since 1861, teeth whitening has been accepted as a legitimate dental procedure.[1] Hydrogen peroxide solutions are the most widely used type of peroxide-based tooth whitening agent. It is known that cohesive strength decreases subsequent to teeth whitening because of loss of prismatic structure,[15] calcium depletion,[3] micro hardness reduction[3] or change in the subsurface basic substance by oxidizing effect of hydrogen peroxide.[3] Residual oxygen (absorbed during bleaching) may compete with free radicals formed during polymerization of resins resulting in premature chain termination causing resin polymerization inhibition and affecting bond strength to enamel.[2,12] Numerous procedures have been advised to address cohesive strength issues following whitening, including removing superficial enamel layers,[19] using adhesives that include organic solvents and pre-treating bleached enamel with alcohol.[4-20] Popular proposal is to delay bonding right after whitening, as the decreased bond strength to freshly treated enamel is typically temporary. Research suggests waiting between 72 hours and 4 weeks before proceeding with bonding,[12,21-24] and hence, it may be confusing for the clinician to decide the optimal waiting period for bonding post bleaching. Certain studies suggest applying antioxidants immediately after bleaching to neutralize its effects. This approach decreases local oxygen levels, removes catalytic metal ions, reclaims the redox capacity of the oxidized material and facilitates proper adhesive's polymerization by free radicals thereby reversing compromised bonding. This study was conceptualized considering prevailing lifestyle changes leading to many patients seeking dental treatment and wanting several dental procedures carried out in a short time. Significance of changes occurring in shear cohesive strength of composites on teeth treated with 35% hydrogen peroxide has been studied and optimizing effect of two different antioxidant agents, i.e. sodium bicarbonate and sodium ascorbate on the cohesive strength after bleaching has been evaluated and compared.

AIMS AND OBJECTIVES:

1. To compare the outcome of two antioxidant medium on bleached teeth before orthodontic bonding, this in-vitro study assessed cohesive strength of orthodontic brackets using extracted teeth of humans that were bleached a day prior.
2. To form guidelines for selection of a clinical regimen to optimize bond strength of brackets in those cases where bleaching process has preceded orthodontic bonding.

MATERIALS AND METHOD:

This research was conducted at Orthodontics and Dentofacial Orthopedics Department, Padmashree Dr. D.Y. Patil, Dental Hospital, Navi Mumbai, sought to assess the impact, with regard to in-office teeth-whitening using hydrogen peroxide on the orthodontic bracket adhesive bond strength and evaluate the effectiveness of antioxidants in reversing this effect.

Materials (Fig. 1)

Teeth:

The study used sixty sound human premolars extracted from adolescents undergoing orthodontic treatment.

Inclusion criteria were:

- Intact, non-restored, and non-carious buccal surfaces or enamel defects
- Adequate root length for stable embedding in acrylic resin
- No prior chemical treatments or bleaching

- Following tooth removal, teeth were made free of blood and tissue remnants and placed in distilled water.

Bonding agent:
Bonding agent employed was Transbond XT, a light cured orthodontic bonding system made by Unitek.
Transbond XT primer comprises

- *Triethylene glycol dimethacrylate* (TEGDMA) at 45–55 weight percent.
- 45–55 wt % bis-GMA.

Transbond XT adhesive comprises

- Silane-treated quartz which makes up 70–80% of the weight.
- Bis-GMA 10–20% weight.
- 5–10 weight percent of *bisphenol A bis-dimethacrylate.*
- <2% silane-treated silica.

Bleaching agent:
Observing the guidelines provided by the manufacturer, the powder and solution were mixed to create a 35% hydrogen peroxide gel (Pola Office Tooth Whitening System, SDI). After that, a brush was used to apply the gel to the tooth's buccal surface.

Antioxidants:
7% sodium bicarbonate and 10% sodium ascorbate solutions.

Brackets:
60 Ormco Mini 2000 Series stainless steel pre-adjusted edgewise bicuspid brackets with a 0.022 bracket and a micro-etched base (mean surface area 9.63 mm^2) were used. The brackets were kept in the original pack until bonding and operated with tweezers to avoid contamination.

Testing apparatus:
A universal testing apparatus (Fig. 2) with a 1 kN load cell and a crosshead speed of 1 mm/min was used for shear testing.

Fig 1. Materials employed

Fig 2. Instron Testing apparatus

Method:

After being cleansed and disinfected with 0.5% chloramine-T for a week at ambient temperature, the distilled water was used to store teeth that was replaced every two weeks to prevent the formation of bacteria. Using a diamond bur, each root was grooved in the apical third. It was then covered with self-curing acrylic, its long axis vertical till cementoenamel junction, and let to settle. After using pumice slurry devoid of fluoride to remove any debris, distilled water was used to rinse the face, and compressed air was used to dry it. After that the teeth were split up into four groups of fifteen at random.

Group A (Control):

The tooth's facial surface was polished, then cleaned, dried, and etched with 37% phosphoric acid. Following that, *Transbond XT* primer was used and given a 10-second light cure. The bracket base was coated with adhesive, then it was applied, adjusted, and firmly pressed on the tooth. After removing any excess adhesive, the resin underwent a 10-second light cure on either side.

Group B (Bleached):

Each facial surface of the tooth was polished, rinsed, and dried. A whitening solution containing 35% hydrogen peroxide was blended and applied in a 1 mm layer on the enamel. It was twice subjected to halogen light for ten seconds each, and it was left on for sixteen minutes before being cleaned off. As in control group A, brackets were bonded after a 24-hour period.

Group C (Sodium bicarbonate):

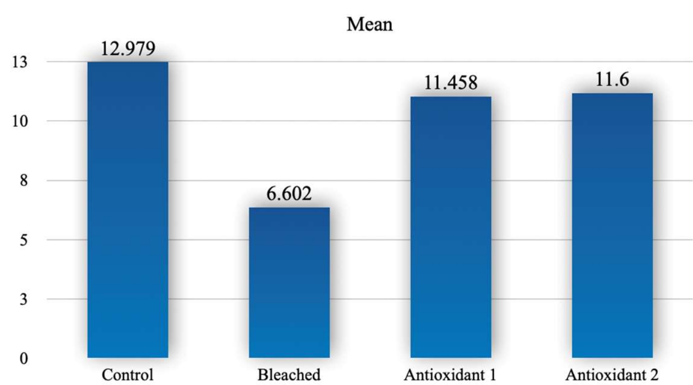
This group's teeth were treated similarly to those in Group B, except 1 millilitre of a 7% sodium bicarbonate solution was administered to the facial area right away following bleaching. After two applications over a ten-minute period, this was given a water rinse for thirty seconds and allowed to air dry for twenty seconds. The same as with control group A, brackets were bonded after 24 hours.

Group D (Sodium ascorbate):
This group's teeth were treated similarly to those in Group B, but after bleaching, the facial surface was treated with 1 millilitre of 10% sodium ascorbate solution. After two applications over a 10 minute period, this was given a water rinse for thirty seconds and allowed to air dry for 20 seconds. The same as with control group A, brackets were bonded after 24 hours.

Debonding
Distilled water was used to store teeth for a full day after bonding. A universal testing machine was then employed to test the entire specimen, with the bracket base orientated parallel to the shear force's direction. Up until debonding, the shear cohesive strength was assessed at a crosshead speed of 1 mm/min. Megapascals (MPa) were obtained by dividing the measured failure loads (in Newtons) by the bracket base surface area (9.63 mm^2).
Under a stereomicroscope, the de-bonded brackets were examined, and sum of resin still on the tooth was evaluated using the Adhesive Remnant Index.

STATISTICAL ANALYSIS
A research statistician conducted the statistical analysis, which involved determining the descriptive statistics for each test group. The mean difference using a one-way ANOVA, shear bond strengths were calculated, and any significant differences were then examined using the Bonferroni test. P-values less than 0.05 were deemed to be of statistical significance.

OBSERVATIONS AND RESULTS:
Mean shear cohesive strength of individual groups is found to be:
Group 1 (Control) - 12.9793 MPa (SD ± 4.5552)
Group 2 (Bleached) - 6.6022 MPa (SD ± 2.3919)
Group 3 (Antioxidant 1) - 11.4578 MPa (SD ± 4.4647)
Group 4 (Antioxidant 2) - 11.6000 MPa (SD ± 5.4668)
Mean strength of each group's shear bond are represented graphically in (Graph 1):



Graph 1. Mean shear bond strength

A clinically effective orthodontic bonding would require a minimum bond strength of 5.9 MPa to 7.8 Ma, according to Reynolds (1975).[37] All groups have mean shear bond strengths within Reynolds' acceptable range, but Group 2 (bleached) has a minimum value significantly below this threshold.

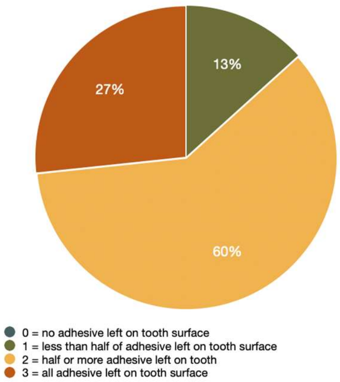
The results show that Group 1 (control) has the greatest shear bond strength at 12.9793 MPa, while Group 2 (bleached) has the lowest at 6.6022 MPa. This suggests that brackets in Group 2 are more likely to be dislodged with less force, leading to frequent breakages and potentially increasing the overall treatment time due to the need for more frequent re-bonding.

Comparison of mean shear bond strengths:
To compare mean shear cohesive strengths, one-way ANOVA and Bonferroni several comparison analyses were employed.

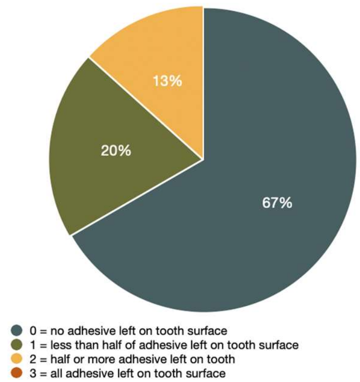
Interpretation:
The means of the four groups differ significantly, as indicated by the ANOVA p-value of less than 0.05. A multiple comparison test called Bonferroni was employed to pinpoint the precise differences.
Bonferroni tests results indicate that:

- Group 2 (bleached) and Group 1 (control) showed a substantial difference in bond strength (p=0.001), suggesting that whitening had a significant impact on bind strength.
- Group 1 (control) and Group 3 (7% sodium bicarbonate) did not significantly vary in bond strength (p=1.000), suggesting that 10% sodium ascorbate brought bond strength back to control levels.
- Group 4 (10% sodium ascorbate) and Group 1 (control) did not vary significantly in shear bond strength (p=1.000), indicating that bond strength was also restored to figures akin to those of the control group by the 10% sodium ascorbate therapy.
- Group 2 (bleached) and Group 3 (7% sodium bicarbonate) revealed a notable variation in binding strength. (p=0.021), indicating a considerable improvement in bond strength from 7% sodium bicarbonate.
- Group 2 (bleached) and Group 4 (10% sodium ascorbate) showed a significant difference in binding strength (p=0.016), suggesting that the 10% sodium ascorbate treatment greatly increased bond strength.
- Group 3 (7% sodium bicarbonate) and Group 4 (10% sodium ascorbate) did not significantly differ in binding strength (p=1.000), indicating that the two treatments' impacts on bond strength are similar.
- Group 2 (bleached) demonstrated a quite notable distinction from every other group, suggesting that whitening has a negative and noteworthy impact on the shear binding strength of composite resin.
- Groups 3 (7% sodium bicarbonate) and 4 (10% sodium ascorbate) showed no discernible variation from Group 1 (control), suggesting that both treatments were successful in counteracting the detrimental effects of whitening on shear cohesive strength.

Adhesive Remnant Index
Adhesive Remnant Indices for all groups and all samples were made.
ARI SCORES are as follows (Graph 2- 5)

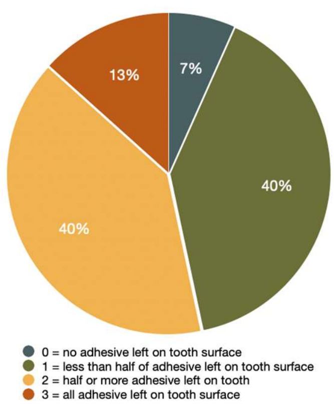


Graph 2: Control Group 1

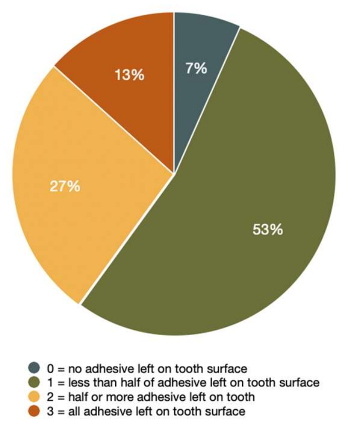


Graph 3: Bleached Group 2

Graph 4 : Antioxidant 1 Group 3



Graph 5: Antioxidant 2 Group 4



Group 2 had significantly different ARI scores compared to the others, with no differences among the remaining groups. No enamel damage was observed after debonding, and in cases with an ARI score of 0, enamel was not visible on the bracket surface even at 40x magnification.

DISCUSSION:

Nowadays, research has demonstrated that compared to unbleached enamel, the binding strength of composite to bleached enamel is substantially lower. [4,8,15,33,34,35,36] Conversely, Certain investigations have reported no discernible variation in the binding strength between enamel that has been bleached and that that has not.[15-18] The study's conclusions showed that, in comparison to the control group, the composite resin's shear bond strength to enamel significantly decreased immediately following 35% hydrogen peroxide bleaching.

This is in line with the outcomes found by Titly et al (1988)[8], Torneck et al (1990)[11], Cvitko et al (1991)[19], Strokes et al (1992), Titley et al (1992)[35], Garcia et al (1993)[36], Dishman et al (1994)[12], Barghi and Godwin (1994)[20], Miles et al (1994)[21], Cavalli et al(2001)[23], Lai et al (2002)[26], Turkun et al (2004)[27], El Din et al (2006)[13], Cacciafesta et al (2006)[22] and Turkkahrahman et al (2007).[9]

One of the factors that reduces the binding strength of composite resins after whitening is increased enamel porosity,[15] deficient calcium,[3,32] reduction in microhardness [3,25,32] and change in the organic matter.[3,25,32] Remaining oxygen from bleaching treatments is thought by many writers to prevent composite resins from polymerising, which lowers bond strength.[2,11,12,26,27,31]

According to Torneck et al. (1990) [11], oxygen and hydrogen peroxide are water soluble and can readily pass through enamel to reach dentinal fluid, where they are subsequently released through diffusion. According to Lai et al. (2001)[29], it is likely that the antioxidants allow the adhesive resin to polymerise without prematurely terminating it by re-establishing the oxidised bonding material's changed redox potential. Later findings indicated that sodium ascorbate counteracts the whitening effect on composite bond strength.[14,25,30] The composite resin's shear binding strength to whitened teeth was found to be enhanced by sodium ascorbate, according to studies carried out by Lai et al (2002)[26], Turkun et al (2004)[27], Bulut et al (2005)[14], Bulut et al (2006)[25], and Kimyai et al 2006)[28]. However, these studies utilised either 10% hydrogen peroxide or 10% carbamide peroxide.

The current study's findings contradict those of Torres et al. (2006)[31], who discovered that after bleaching bovine enamel with 35% hydrogen peroxide, 10% sodium ascorbate had no discernible influence on the potency of the composite bond. This difference may be due to Torres et al. using bovine enamel, which differs in porosity and density from human enamel used in this study.

The results of this investigation demonstrate that composite adhesive shear bond strength was considerably lowered by 35% hydrogen peroxide whitening; however, this impact may be effectively counteracted by immediately applying 10% sodium ascorbate or 7% sodium bicarbonate. Since Group 2 (bleached) showed significantly reduced and variable shear bond strength compared to Group 1 (control), and this change was credited to altered enamel, further investigation was conducted to determine if bleaching weakened the enamel, potentially making it more susceptible to damage during accidental debonding.

ARI score of 0 indicating absence of adhesive on tooth surface comprised almost 20% of total sample but almost 2/3rd of group 2 sample. This suggests a higher risk of enamel damage if orthodontic bonding is done instantly after bleaching. This study observed no enamel damage under a stereomicroscope at 40x magnification, but this observation was indirect, as only the adhesive surface was examined, not the enamel itself. ARI scores of 1 and 2 wherein adhesive failure occurs partially on adhesive-enamel interface and partially on adhesive-bracket base interface comprised the bulk incidence of total sample (2/3rd) in this study. Similar results have been found in another ARI study by Titley et al.[38]

CONCLUSION:

Sample was divided into 4 groups:

Group 1: Brackets with Transbond XT enamel bonding.

Group 2: Transbond XT was used to bond the brackets right away after the enamel was bleached with 35% hydrogen peroxide.

Group 3: After treating the enamel for ten minutes with 7% sodium bicarbonate and bleaching it with 35% hydrogen peroxide then with Transbond XT, the brackets were bonded after a 24-hour period.

Group 4: After treating the enamel for ten minutes with 10% sodium ascorbate and whitening it with 35% hydrogen peroxide, brackets were placed with Transbond XT after a 24-hour period.

Brackets were debonded from one another using a universal testing machine with a shear stress and a crosshead speed of 1 mm per minute after bonding for 24 hours.
An ANOVA was used to identify Statistically noteworthy variations in the group's mean shear bond strength.
The conclusions of the present study are as follows:

- Under ideal bonding conditions, the light-cured orthodontic bonding method Transbond XT in Group 1 (control) shows a clinically satisfactory shear bond strength.
- In comparison to Group 1 (unbleached), Group 2 (bleached) showed a notably reduced shear binding strength, demonstrating that bond strength is significantly decreased by bleaching with 35% hydrogen peroxide.
- Binding strength was much higher in group 3 (teeth treated with 7% sodium bicarbonate) than in group 2 (teeth bleached). It was discovered that group 3's binding strength was nearly identical to that of group 1 (control). This demonstrates that after bleaching, the diminished bond strength is greatly increased by 7% sodium bicarbonate.
- After bleaching, treating the teeth with 10% sodium ascorbate (group 4) improved the bond strength even more than group 2 (bleached), reaching values that were nearly identical to those of groups 1 (control) and 3 (7% sodium bicarbonate).

Research have indicated that whitening dramatically diminishes the composite resin's shear binding strength. Finding strategies to mitigate the adverse effects of bleaching is crucial to achieving clinically appropriate bond strength for brackets on bleached enamel.
Antioxidants, according to some experts, may be able to successfully undo the consequences of bleaching on binding strength.
This study's objective was to assess the impacts of 35% hydrogen peroxide bleaching on the shear binding strength of Transbond XT, a light-cured bonding agent, and to determine how well 7% sodium bicarbonate and 10% sodium ascorbate might counteract these effects.

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