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Comparative Evaluation of The Shear Bond Strength of Composite Resin to Bleached Enamel with and Without Application of Herbal Antioxidants at Two Different Time Intervals: An in Vitro Study

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Abstract

Tooth bleaching is a widely accepted esthetic procedure for the management of discolored teeth. However, residual oxygen free radicals generated during bleaching adversely affect the polymerization of adhesive resins, resulting in reduced bond strength between composite resin and enamel. The application of antioxidants has been proposed to reverse the compromised bonding and facilitate immediate restorative procedures. The present study aimed to evaluate and compare the shear bond strength of composite resin to bleached enamel with and without application of herbal antioxidants at two different time intervals.

Thirty extracted human maxillary incisors were selected and randomly divided into five groups comprising six specimens each. Group I served as the bleached control,

while Groups II and III received 10% grape seed extract for 10 and 20 minutes respectively. Groups IV and V received 10% green tea extract for 10 and 20 minutes respectively. Bleaching was performed using 35% carbamide peroxide bleaching gel (Ammdent UltraWhite). Following antioxidant treatment, the enamel surfaces were etched with 37% phosphoric acid and bonded using Fusion Bond adhesive. Composite build-up was carried out using Waldent nanofilled composite resin with the aid of a standardized mould measuring 4 mm in diameter and 3 mm in height. All specimens were stored in distilled water for 24 hours and subjected to shear bond strength testing using a universal testing machine. Statistical analysis was performed using one-way analysis of variance followed by Tukey's post hoc test.

Group III exhibited the highest mean shear bond strength (10.41 ± 0.099 MPa), whereas Group I demonstrated the lowest value (7.42 ± 0.07 MPa). Both antioxidants significantly improved the bond strength when compared with the bleached control group. Within the limitations of this in vitro study, application of 10% grape seed extract for 20 minutes produced the highest shear bond strength and effectively reversed the reduction in bond strength associated with bleaching procedures.

Keywords: Bleaching, Shear bond strength, Grape seed extract, Green tea extract, Antioxidants, Composite resin, Bleached enamel.

Introduction

Tooth discoloration is one of the most common esthetic concerns encountered in contemporary dental practice. With increasing patient awareness and demand for esthetic treatment, tooth bleaching has become a popular and conservative approach for the management of intrinsic and extrinsic stains. [1]

Among the various bleaching agents available, carbamide peroxide is widely used because of its efficacy and favorable safety profile. It decomposes into hydrogen peroxide and urea, releasing reactive oxygen species that oxidize chromogenic molecules present within enamel and dentin, thereby producing a whitening effect. [2]

Despite the advantages associated with bleaching procedures, several studies have reported a reduction in the bond strength of resin-based restorative materials to bleached enamel. Residual oxygen and peroxide radicals retained within the enamel interfere with resin infiltration and inhibit polymerization of adhesive systems, resulting in compromised bonding and reduced shear bond strength. [3, 4]

Conventionally, postponing adhesive procedures for one to three weeks following bleaching has been recommended to allow dissipation of residual oxygen species and restoration of bond strength. However, this delay may not always be clinically feasible when immediate restorative treatment is required.[5]

Antioxidant therapy has emerged as an effective approach for neutralizing residual free radicals and restoring the altered redox potential of bleached enamel. Various synthetic and naturally occurring antioxidants have been investigated for their ability to reverse the compromised bond strength associated with bleaching procedures. [6]

Recently, naturally derived antioxidants have gained considerable attention because of their biocompatibility and potent free radical scavenging activity. Grape seed extract contains oligomeric proanthocyanidin complexes, whereas green tea extract is rich in catechins and polyphenolic compounds, both of which exhibit significant antioxidant properties. [7]

Although previous studies have demonstrated the beneficial effects of these herbal antioxidants in improving the bond strength of composite resin to bleached enamel, limited information is available

regarding their comparative efficacy when applied for different durations. [8] Therefore, the present in vitro study was undertaken to evaluate and compare the shear bond strength of composite resin to bleached enamel with and without application of herbal antioxidants at two different time intervals.

Materials And Methods

Study Design

The present in vitro study was conducted to evaluate and compare the shear bond strength of composite resin to bleached enamel with and without application of herbal antioxidants at two different time intervals.

Sample Selection

Thirty freshly extracted human maxillary incisors free from caries, restorations, cracks, and developmental defects were selected for the study. Soft tissue remnants and calculus deposits were removed using an ultrasonic scaler, and the teeth were stored in distilled water until use.

Sample Preparation

The roots of the selected teeth were sectioned at the cementoenamel junction using a diamond disc under continuous water coolant. The crowns were embedded in self-cure acrylic resin blocks with the labial surfaces facing upward and parallel to the horizontal plane. The labial enamel surfaces were polished with pumice slurry and thoroughly rinsed with distilled water. The specimens were randomly divided into five groups comprising six samples each (n=6).

Group I

Bleaching only (Control)

Group II

Bleaching + 10% Grape Seed Extract for 10 minutes

Group III

Bleaching + 10% Grape Seed Extract for 20 minutes

Group IV

Bleaching + 10% Green Tea Extract for 10 minutes

Group V

Bleaching + 10% Green Tea Extract for 20 minutes

Bleaching Procedure

All specimens were subjected to bleaching using 35% carbamide peroxide bleaching gel (Ammdent UltraWhite; Ammdent Dental Products Pvt. Ltd., Mohali, India). A uniform layer of the bleaching gel was applied to the labial enamel surfaces and allowed to remain undisturbed for 30 minutes. Following bleaching, the specimens were rinsed thoroughly with distilled water and gently air dried before antioxidant application.

Preparation of Antioxidant Solutions

Ten percent grape seed extract solution was prepared by dissolving 10 g of grape seed extract powder in 100 mL of distilled water. Similarly, 10% green tea extract solution was prepared by dissolving 10 g of green tea extract powder in 100 mL of distilled water.

Antioxidant Application

Following bleaching, the antioxidant solutions were applied to the enamel surfaces using a microbrush according to their respective groups. Group II and Group III received 10% grape seed extract for 10 and 20 minutes, respectively, whereas Group IV and Group V received 10% green tea extract for 10 and 20 minutes, respectively. Following antioxidant application, the specimens were rinsed thoroughly with distilled water and gently air dried.

Figure 1: Antioxidant application

Bonding Procedure

The enamel surfaces were etched with 37% phosphoric acid for 15 seconds, rinsed with water, and gently air dried. Fusion Bond adhesive was applied uniformly to the etched enamel surface and light cured for 20 seconds.

Figure 2: Etching and bonding agent application

Composite Build-up

Composite build-up was performed using Nano filled composite resin (Waldent Innovations Pvt. Ltd., India). A standardized mould measuring 4 mm × 3 mm was used to obtain composite specimens of uniform dimensions. The composite resin was packed into the mould and light cured for 20 seconds.

Storage of Specimens

Following restoration, all specimens were stored in distilled water at room temperature for 24 hours prior to shear bond strength testing.

Shear Bond Strength Testing

Figure 3: Shear bond strength test using universal testing machine

The specimens were mounted on a universal testing machine, and shear force was applied at the enamel-composite interface until bond failure occurred. The maximum load required to debond the composite was recorded in Newtons (N), and the corresponding shear bond strength values were calculated in megapascals (MPa).

Statistical Analysis

The obtained data were tabulated and subjected to statistical analysis using Statistical Package for Social Sciences (SPSS) software version 20.0 (IBM Corp., Armonk, NY, USA).. One-way analysis of variance (ANOVA) was used to compare the mean values among the groups, followed by Tukey's post hoc test for pairwise comparison. A p-value less than 0.05 was considered statistically significant.

Results

One-way analysis of variance (ANOVA) revealed a statistically significant difference among the groups for both maximum force and shear bond strength ($p<0.001$). Group III (Bleaching + 10% Grape Seed Extract for 20 minutes) exhibited the highest mean maximum force (126.20 ± 2.25 N) and shear bond strength (10.41 ± 0.099 MPa). Group I (Bleaching only) demonstrated the lowest mean maximum force (93.59 ± 1.73 N) and shear bond strength (7.42 ± 0.07 MPa). Group II (Bleaching + 10% Grape Seed Extract for 10 minutes) showed a mean maximum force of 102.30 ± 1.07 N and a mean shear bond strength of 8.23 ± 0.12 MPa. Group IV (Bleaching + 10% Green Tea Extract for 10 minutes) exhibited a mean maximum force of 97.15 ± 1.30 N and a mean shear bond strength of 7.60 ± 0.089 MPa, whereas Group V (Bleaching + 10% Green Tea Extract for 20 minutes) demonstrated a mean maximum force of 103.04 ± 0.57 N and a mean shear bond strength of 8.21 ± 0.073 MPa. The mean maximum force and shear bond strength values of all experimental groups are presented in Table 1.

Table 1: Comparison of compressive stress and maximum load among all the groups

Groups	Mean ±SD	
	Maximum force	Shear stress
Group1	93.59± 1.73	7.42±0.07
Group 2	102.30±1.07	8.23± 0.12
Group 3	126.20±2.25	10.41± 0.099
Group 4	97.15± 1.30	7.6±0.089
Group 5	103.04± 0.57	8.21±0.073
Oneway anova	P=<0.001*	P=<0.001*

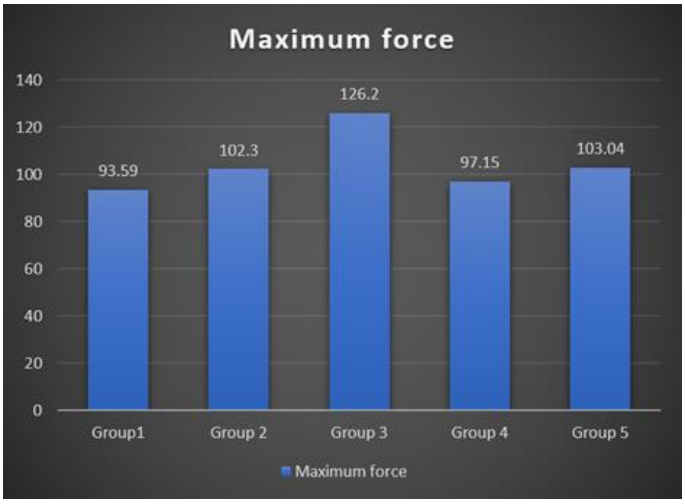
Intergroup comparison using Tukey's post hoc test revealed statistically significant differences between Group I and Group II (p=0.000), Group I and Group III (p=0.000), Group I and Group IV (p=0.016), and Group I and Group V (p=0.000). Similarly, statistically significant differences were observed between Group II and Group III (p=0.000), Group II and Group IV (p=0.000), Group III and Group IV (p=0.000), Group III and Group V (p=0.000), and Group IV and Group V (p=0.000).

Table 2: Comparison of mean difference of compressive stress in between different groups

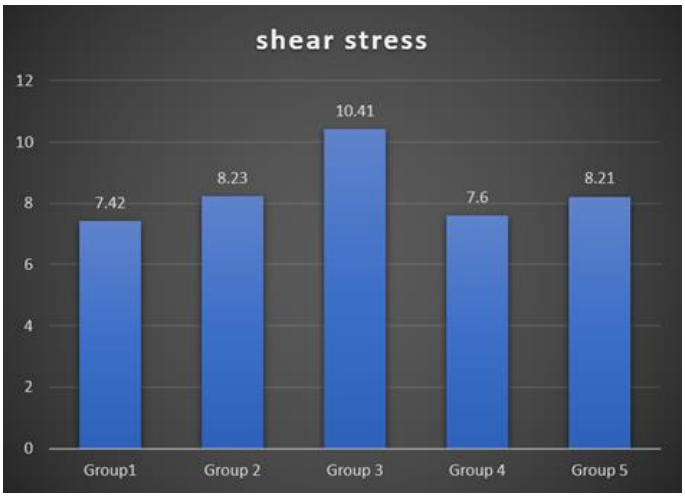
Groups	Mean difference	Pvalue
Group 1 versus Group 2	-0.81667	0.000*
Group 1 versus Group 3	-3.00167	0.000*
Group 1 versus Group 4	-0.18333	0.016*
Group 1 versus Group 5	-0.79167	0.000*
Group 2 versus group 3	-2.18500	0.000*
Group 2 versus group 4	0.63333	0.000*
Group 2 versus group 5	0.02500	0.989(NS)
Group 3 versus group 4	2.81833	0.000*
Group 3 versus group 5	2.21000	0.000*
Group 4 versus group 5	-0.60833	0.000*

However, no statistically significant difference was observed between Group II and Group V (p=0.989), indicating that both groups exhibited comparable shear bond strength values.

The highest mean difference was observed between Group I and Group III (-3.00167), followed by Group III and Group IV (2.81833), indicating superior bond strength in specimens treated with 10% grape seed extract for 20 minutes. The results suggest that increasing the duration of antioxidant application enhanced the shear bond strength values, with grape seed extract exhibiting greater efficacy than green tea extract.



Graph 1: Mean maximum force values among the experimental groups



Graph 2: Mean shear bond strength values.

Graph 1 illustrates the mean maximum force values among the experimental groups, whereas Graph 2 depicts the mean shear bond strength values. Both graphical representations demonstrated that Group III exhibited the highest values, while the bleached control group showed the lowest values.

Discussion

The present in vitro study evaluated the effect of two herbal antioxidants, grape seed extract and green tea extract, applied at different time intervals on the shear bond strength of composite resin to bleached enamel. The results demonstrated statistically significant differences among the experimental groups. Group III, in which 10% grape seed extract was applied for 20 minutes, exhibited the highest shear bond strength, whereas the bleached control group demonstrated the lowest bond strength values.

The reduced bond strength observed in the control group may be attributed to the presence of residual oxygen and peroxide radicals entrapped within the enamel following bleaching. These residual free radicals interfere with resin infiltration and inhibit polymerization of adhesive systems, thereby compromising adhesion and reducing bond strength. Similar findings were reported by Titley et al. and Dishman et al., who demonstrated a significant reduction in bond strength immediately following bleaching procedures. [3,4]

In the present study, application of both grape seed extract and green tea extract significantly improved the shear bond strength when compared with the bleached control group. This increase in bond strength may be attributed to the ability of antioxidants to neutralize residual oxygen species and restore the altered redox potential of enamel, thereby promoting complete polymerization of resin-based restorative materials. Lai et al. reported that antioxidant treatment effectively reversed compromised bonding in bleached enamel and facilitated immediate restorative procedures.[5]

Among all the experimental groups, Group III demonstrated the highest shear bond strength values. Grape seed extract contains oligomeric proanthocyanidin complexes, which possess potent antioxidant activity and exhibit remarkable free radical scavenging properties. These compounds effectively neutralize residual oxygen species and improve the polymerization efficiency of adhesive resins. Similar observations were reported by Vidhya et al., who demonstrated that grape seed extract significantly improved the bond strength of composite resin to bleached enamel. [7]

The duration of antioxidant application also influenced the bond strength values. In the present study, increasing the application time from 10 minutes to 20 minutes resulted in higher shear bond strength values. This may be attributed to prolonged interaction between antioxidant molecules and residual oxygen radicals, allowing more complete neutralization of free radicals and thereby improving resin-enamel adhesion. Similar findings were reported by Sasaki et al. and Bulut et al., who observed that antioxidant treatment significantly restored bond strength after bleaching. [9, 10]

Green tea extract also demonstrated a beneficial effect on shear bond strength when compared with the control group. Green tea contains catechins and polyphenolic compounds, particularly epigallocatechin gallate, which possess strong antioxidant properties. These compounds are capable of scavenging free radicals and restoring the bonding potential of bleached enamel. Sharafeddin et al. and Berger et al. reported comparable findings and concluded that green tea extract effectively improved the bond strength of composite restorations to bleached enamel. [8, 12]

Although both antioxidants were effective in improving bond strength, grape seed extract demonstrated comparatively higher values than green tea extract. This superior performance may be attributed to the high concentration of oligomeric proanthocyanidins present in grape seed extract, which possess antioxidant activity greater than vitamins C and E. Garcia et al. demonstrated the potent antioxidant activity of natural antioxidants and highlighted their ability to neutralize free radicals effectively.[11] Similar observations were reported by Khamverdi et al. and Ghaleb et al., who demonstrated superior bond strength values with natural antioxidant agents following bleaching procedures. [13,14]

From a clinical perspective, the use of herbal antioxidants may facilitate immediate restorative procedures following bleaching without the need for prolonged waiting periods. Their biocompatibility, availability, and cost-effectiveness make them attractive alternatives to synthetic antioxidants.

The present study was conducted under in vitro conditions and, therefore, certain limitations should be considered. Factors such as thermal fluctuations, saliva, masticatory stresses, and oral environmental conditions could not be simulated. Furthermore, the relatively small sample size limits direct extrapolation of the findings to clinical situations. Elawsya et al. also emphasized the need for long-term in vivo studies to validate the effectiveness of natural antioxidants under clinical conditions. [15]

Further clinical studies with larger sample sizes and long-term follow-up are recommended to substantiate the findings of the present investigation.

Conclusion

Within the limitations of this in vitro study, it can be concluded that bleaching with 35% carbamide peroxide reduced the shear bond strength of composite resin to enamel. Application of herbal antioxidants improved the bond strength, with 10% grape seed extract applied for 20 minutes showing the highest shear bond strength. Thus, natural antioxidants, particularly grape seed extract, may be effective in reversing the adverse effects of bleaching and facilitating immediate adhesive restorative procedures.

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