Original Article

In vitro comparative evaluation of antioxidative effect of selenium alone and in combination with green tea and alpha-tocopherol on the shear bond strength of universal composite resin to enamel after in-office bleaching

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Abstract

Background: Antioxidant application soon after bleaching process increases the shear bond strength (SBS) of composite resin to enamel.

Aims: The aim of the study was to evaluate the antioxidant effects of selenium alone and in combination with alpha-tocopherol (αT) and green tea (GT) on SBS of composite resin to enamel following in-office bleaching with 38% hydrogen peroxide (HP).

Methods: Sixty extracted human single -rooted premolar teeth were cleaned and embedded in acrylic resin blocks at the level of cementoenamel junction(CEJ) followed by bleaching with 38% hydrogen peroxide (HP) and arbitrarily divided into seven groups (n=10) for antioxidant application: Group I (negative control): intact teeth, Group II (positive control): only bleaching, Group III:10% selenium (Se), Group IV: 10% alpha tocopherol (αT), Group V:10% αT +10% Se, Group VI:10% Green tea (GT), Group VII: 10%GT+10% Se. In all groups, self-etch adhesive was applied and composite restoration was done, and specimens were stored in distilled water for 24h followed by SBS evaluation.

Statistical Analysis: One-way analysis of variance and *post hoc* Tukey's tests were used ($P < 0.05$).

Results: The highest SBS was found in negative control Group I (intact teeth) and least in positive control Group II (bleached teeth), whereas in experimental groups, Group VII (GT + Se) showed highest followed by Groups V (αT + Se), III (Se), and VI (GT) and least in Group IV (αT).

Conclusion: Combination of selenium with green tea and alpha tocopherol enhanced the SBS of composite resin following in-office bleaching.

Keywords: Alpha-tocopherol; antioxidants; composite resin; green tea; in-office bleaching; selenium; shear bond strength

INTRODUCTION

In modern times, esthetics is of utmost importance. Bleaching of the discolored teeth is a simple, noninvasive, and affordable method that enhances esthetics. Hydrogen peroxide (HP) and carbamide peroxide are frequently

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Date of submission : 23.08.2023
Review completed : 26.10.2023
Date of acceptance : 31.10.2023
Published : 13.01.2024

Access this article online

Quick Response Code:

Website: https://journals.lww.com/jcde

DOI: 10.4103/JCDE.JCDE_146_23

How to cite this article: Halkai RS, Halkai KR, Aneesha YA, Naaz S. *In vitro* comparative evaluation of antioxidative effect of selenium alone and in combination with green tea and alpha-tocopherol on the shear bond strength of universal composite resin to enamel after in-office bleaching. J Conserv Dent Endod 2024;27:57-61.

employed for tooth bleaching. In comparison to carbamide peroxide, HP has a higher oxidative capacity and releases more residual oxygen molecules.[1] Tooth sensitivity, soft-tissue irritability, permanent and irreversible enamel damage, and inadequate esthetic results are some of the unfavorable effects of tooth whitening. In addition, bleaching alters the mechanical properties of enamel and dentin by increasing enamel porosity, which results in surface roughness.[2]

Due to the increased demand for esthetics, bleaching is occasionally immediately followed by composite restoration if the results are unsatisfactory, or in case of chipped off teeth, or broken teeth that need to be restored.[3] The bond strength of composite resin to enamel has been observed to be reduced by the interaction of bleaching chemicals with tooth substrate.[4,5] This is because the bleaching process releases free radicals that prevent the formation of resin tags and interfere with polymerization.[6] Removal of superficial enamel surface and adhesive application containing alcohol, organic solutions, and antioxidants are few methods to prevent this.[7] Otherwise, composite restoration following bleaching is delayed for 1–3 weeks so that residual molecules release gradually.[8] To shorten this time, various antioxidants are used that scavenge free radicals, thereby increasing the bond strength.[3] Natural antioxidants such as ascorbic acid, green tea (GT), alpha-tocopherol (αT), and Vitamins E and C have been found to strengthen the binding between composite resin and bleached teeth and therefore enhance the bond strength. The antioxidants absorb free oxygen radical and therefore modulate the redox reactions.[9]

A fat-soluble vitamin having antioxidant properties, Vitamin E, serves as second-line defense antioxidants. It is the combined name for a set of eight related tocopherols and tocotrienols. Vitamin E is more stable and oxidizing in nature due to its hydrophobic nature. Sources include green leafy vegetables, sunflower oil, seeds, and nuts.[10] αT is an effective and active form of nonenzymatic antioxidants. Because of its high biological availability, it is easily absorbed by the body. It neutralizes the free radicals by passive detoxification and prevents the spread of free radical through chain-breaking action; on the other hand, GT has antioxidants in abundance. Polyphenols present in GT are responsible for its antioxidative action and neutralization of the free radicals.[11]

Selenium is an essential component of the human body present in smaller amount. It is a component of selenoproteins and enzymes that protect against cell damage and infections. It has strong antioxidant properties.[12] It is a more potent antioxidant than Vitamins E, C, and A and beta-carotene.[11] According to Sentkowska and Pyrzyńska, selenium incorporated with GT has the highest antioxidative property compared to selenium or GT alone; therefore, the combination of antioxidative agents results in synergistic effect.[13]

Selenium has not yet been studied alone or in combination with other antioxidants as a potential antioxidative agent for bleached teeth. Therefore, the purpose of this study aims to investigate the antioxidative effect of selenium and the combination of selenium with αT and GT on shear bond strength (SBS) of universal nanohybrid composite resin to enamel surface after in-office bleaching with 38% HP.

METHODS

The study (ref no.: IEC/2022-2023/26) obtained clearance from the institutional ethical committee and was performed accordingly.

The experimental materials were prepared as follows. About 10 g of selenium (HealthyHey LLP, Maharashtra, India) powder was dissolved in 100 mL of deionized distilled water (ZVEE Chem Trading Co., Ahmedabad, Gujarat) to obtain 10% selenium (Se) solution. Similarly, 10 g of αT (Procter and Gamble Health Ltd., Goa, India) gel was dissolved in 100 mL of ethanol (Changshu Hongsheng Fine Chemical Co. Ltd., China) to obtain 10% αT. To obtain a 10% GT solution, 10 g of GT (Tata Consumer Products Ltd., Greenford, UK) powder was dissolved in 100 mL of distilled water. The freshly prepared solutions as mentioned above were combined in a beaker in a 1:1 ratio and agitated vigorously in a magnetic stirrer (Borosil, Mumbai, India) to obtain the combination of 10% selenium with 10% αT and 10% GT solutions, respectively.

Around seventy human single-rooted premolars extracted for orthodontic reasons were collected and were cleaned using ultrasonic tips (Guilin Woodpecker, Medical Instrument Co. Ltd., Guilin, China) to remove soft and hard debris. The teeth were then embedded in 2 cm × 2 cm acrylic resin blocks at the level of cementoenamel junction.

In all the specimens except ten to serve as a control group, bleaching was done using 38% HP gel (Pola Office, SDI Limited, USA) with four times application for 10 min using a microbrush. The specimens were rinsed with water thoroughly and were subsequently divided into seven groups ($n = 10$):

- Group I: Intact teeth (negative control)
- Group II: Bleaching only (38% HP) (positive control)
- Group III: 10% selenium (Se)
- Group IV: 10% αT
- Group V: 10% selenium and 10% αT (Se + αT)
- Group VI: 10% GT
- Group VII: 10% selenium and 10% GT (Se + GT).

Except in the specimens of groups I and II, antioxidant solutions as mentioned in above groups were applied for 10 min using micro brush, followed by rinsing with sterile water for 30 seconds. Soon after the antioxidant application in all groups except in group I (intact teeth), self-etch adhesive (Tetric N-Bond Universal, US) was applied on the buccal

surface of teeth and light cured using LED light curing unit (Monitex Blue LEX, Xianyang Holy Medical Co., Ltd. China) for 20 seconds with a light intensity of 1200 mW/cm2, followed by placement of a universal nanohybrid composite resin (Fusion, Prevest Denpro, Jammu, India) in 1 mm increments using a plastic mould with dimensions of 3 mm in diameter, 2 mm in height and light cured for 20 seconds. All the specimens were then kept in distilled water at 37°C for 24 h.

For evaluating the SBS, the samples were loaded in a universal testing device (Instron Universal Testing System, Hyderabad, India), and a metal bar of standard square cross section of 1.94 mm diameter was applied on the buccal surface of each sample at 1 mm/min of crosshead speed [Figure 1]. The force required to fail the bonding was obtained in Newton (N) and converted into MPa using the following formula: SBS = Force (N)/Area (m^2).

Statistical analysis

The data were analyzed using the Statistical Package for the Social Sciences version 22 software (IBM Statistics, Chicago, IL, USA). Mean and standard deviation for each group were calculated and analyzed using one-way analysis of variance (ANOVA), and multiple comparisons between groups were done using the *post hoc* Tukey's test ($P \leq 0.05$).

RESULTS

Analysis by one-way ANOVA showed that the highest SBS was found in Group I (intact teeth) and least in positive control group (bleached teeth), whereas in experimental groups, Group VII (GT + Se) showed highest followed by Groups VI (αT + Se), III (Se), and VI (GT) and least in Group IV (αT) [Table 1].

Multiple comparison by *post hoc* Tukey's test showed no significant difference found between Groups II and IV, II and VI, III and V, III and VI, and between V and VII, whereas a significant difference was found between all other groups ($P \leq 0.05$) [Table 2].

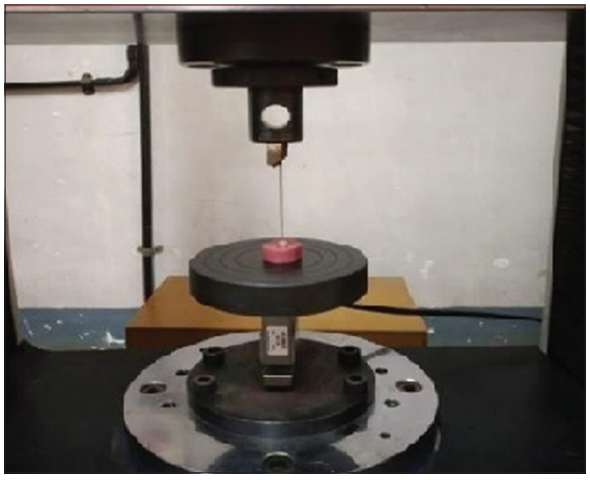

Figure 1: Specimen loaded under universal testing machine to determine shear bond strength

DISCUSSION

In-office vital tooth bleaching is a noninvasive procedure for the management of teeth discoloration. It is performed with HP of concentration ranges from 35% to 38%.[1] Since the bleaching process affects the bonding, it is pivotal to evaluate SBS of composite resin to surface of enamel. Application of antioxidants soon after bleaching enhanced the SBS of composite to enamel surface of bleached teeth.[3] Since no studies were reported till now, regarding the use of selenium and the combination of different antioxidants for bleached teeth hence this study was undertaken to fill the gap of existing literature.

It has been reported that neutralization of residual oxygen species occurs when GT, sodium ascorbic acid, pomegranate peel, and grape-seed extracts were applied on tooth surface after bleaching using 38% HP and thereby enhanced the SBS.[14] The results of the present study showed that GT was found to enhance the bond strength of composite resin to enamel than αT comparatively. In the present study, αT was not statistically significant although it slightly enhanced the SBS when compared to positive control (only bleaching). The antioxidative effect of GT is evident, especially by their role to scavenge free radicals and metal ion (d-block elements) sequestration and to enhance the enzyme activities. Bansal *et al*. reported that GT produced the highest bond strength of bleached enamel when compared with αT and sodium ascorbic acid.[15] GT inhibits the production of residual oxygen and enhances the degree of polymerization through its polyphenolic content. As well as the presence of proanthocyanidin has oxygen scavenging ability. According to Rababah *et al*., higher antioxidative activity was seen in GT extracts than Vitamin E. Although GT has comparatively lower phenolic content than Vitamin E, higher antioxidative property signifies that phenolic content type is responsible than the amount.[16] Application of GT solution after home bleaching using 15% carbamide peroxide did not enhance the SBS of resin composite to the surface of the enamel compared to in-office bleached enamel using 38% HP. This is due to the difference in application time, concentration, and composition of the bleaching material. Fifteen percent carbamide peroxide produces fewer residual molecules than 38% HP as it is a weaker agent comparatively. Hence, this is the reason for the effectiveness of the antioxidants on in-office bleaching agent.[17] According to Kavitha *et al*., 10% αT did not improve SBS notably.[18] This is due to the impairment in the polymerization because of its nonaqueous nature.[19]

In the present study, selenium (Se) significantly enhanced the bond strength compared to GT and αT alone. However, the combination of selenium with green tea showed highest SBS compared to other groups followed by selenium with alpha

Table 1: Shear bond strength of all groups by one-way ANOVA

Groups	Number of samples	Minimum	Maximum	Mean	SD
Group I (negative control): Intact teeth	10	21.89	22.85	22.33	0.33
Group II (positive control): Only bleaching	10	12.01	12.45	12.23	0.13
Group III: Se	10	14.78	15.65	15.28	0.29
Group IV: αT	10	12.34	12.71	12.54	0.12
Group V: αT + Se	10	15.90	16.38	16.17	0.16
Group VI: GT	10	13.72	14.23	14.01	0.17
Group VII: GT + Se	10	16.49	17.45	17.02	0.31
ANOVA test value and *P* value		$F=118.318$, $P=0.000$, significant ($P<0.001$)*			

Se: Selenium, αT: Alpha-tocopherol, GT: Green tea, SD: Standard deviation

Table 2: Multiple comparison by *post hoc* Tukey's test of shear bond strength between the groups

Groups	Comparison group	Difference	*P*
Group I (negative control): Intact teeth	Group II	10.10	0.027 (significant)
	Group III	7.04	0.000 (significant)
	Group IV	9.79	0.000 (significant)
	Group V	6.16	0.000 (significant)
	Group VI	8.32	0.000 (significant)
	Group VII	5.32	0.000 (significant)
Group II (positive control): Bleaching	Group III	−3.05	0.000 (significant)
	Group IV	−0.3080	0.154 (NS)
	Group V	−3.942	0.000 (significant)
	Group VI	−0.401	0.081 (NS)
	Group VII	−4.778	0.000 (significant)
Group III: Se	Group IV	2.745	0.000 (significant)
	Group V	−0.432	0.078 (NS)
	Group VI	0.512	0.097 (NS)
	Group VII	−1.784	0.000 (significant)
Group IV: αT	Group V	−3.634	0.000 (significant)
	Group VI	−1.563	0.000 (significant)
	Group VII	−4.470	0.000 (significant)
Group V: αT + Se	Group VI	2.187	0.000 (significant)
	Group VII	−0.502	0.103 (NS)
Group VI: GT	Group VII	−3.004	0.000 (significant)
Group VII: GT + Se	-	-	-

NS: Not significant, Se: Selenium, αT: Alpha-tocopherol, GT: Green tea

tocopherol group. Studies suggest that supplementation of tea in distinct forms with Se exhibited significantly higher antioxidative property compared to regular tea.[20,21] The main polyphenols present in the green tea are monomeric catechins, when these polyphenols combine with selenium it forms complex molecules exhibiting antioxidative property distinct from individual elements. The antioxidant process of these chemicals and different proportions of bioactive constituents in the combinations are responsible for this effect.[13] According to Molan *et al*., water extracts prepared from selenium-containing GT (SGT) have higher antioxidative property than GT. The higher phenolic content (TPC) and organic selenium concentration in SGT or the combination of both may determine this supremacy of SGT over GT.[20] The results of the present study are in line with the above studies.

In the present study, 10% concentration was used for all the antioxidants for 10 min, whereas Thapa *et al*. reported that 10% αT applied for 60 min was more effective than at 10 min. Hence, the antioxidant effectiveness is dependent on time.[22]

Certain limitations of the present study are since it is an *invitro* study, it is difficult to exactly mimic the oral environment and the outcome of this study cannot be generalized, as the sample size is smaller. The outcome of this study cannot be generalized, as the sample size is smaller. Only 10% concentration of experimental materials was used for 10-min application time; there might be changes in the results with different concentrations and time. Type of composite resin and adhesive resins used for restoration of bleached teeth might also effect the shear bond strength, hence other composite resins and adhesive systems need to be considered in future. This study evaluated the SBS; apart from this, microhardness and cytotoxicity are the other parameters to be considered. Therefore, further studies are needed in future considering the above shortcomings for confidently using selenium alone and in combination with other antioxidants.

CONCLUSION

Combination of selenium with GT and αT enhanced the SBS of composite resin to enamel following in-office bleaching using 38% HP. Therefore, it emerges as a new promising agent during bleaching procedure.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

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