An in-vitro evaluation of the effectiveness of 10% Alpha-Tocopherol solution, 10% Sodium ascorbate solution, 10% Sodium ascorbate gel, 10% Green tea extract solution and 10% Grape seed extract solution as antioxidants on the shear bond strength of bleached enamel to dental composite resin.

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Abstract:

140 extracted human permanent maxillary central incisor teeth were included. All specimens were decoronated 2mm apical to cemento-enamel junction and were embedded in self-cure acrylic resin blocks with only the labial surfaces of the crown portion of teeth visible and circular windows were made on the labial surfaces of all teeth using acrylic resin in dimensions of 5mm diameterx 3mm height. The 140 specimens were then randomly divided into 7groups (5 Experimental groups & 2 Control groups) with 20 specimens per group. The exposed labial surfaces of enamel in all the specimens were then bleached with 37.5% Hydrogen peroxide gel, except in Negative control group in which the specimens were not bleached.In Group A:10% Alpha-Tocopherol solution, Group B:10% Sodium ascorbate solution,Group C:10% Sodium ascorbate gel, Group D:10% Green tea extract solution, Group E:10% Grape seed extract solutions were used as antioxidants. Immediately after tooth bleaching, by using applicator tips the freshly prepared antioxidant solutions were applied on bleached enamel as per group for 10minutes followed by fresh application of it once in every 2 minutes. Group F (Positive control):No antioxidants were used on bleached enamel, Group G (Negative control): Specimens were neither bleached nor any antioxidants used. All specimens were rinsed with deionized water and were then acid etched with 37% Phosphoric acid for 15 seconds,

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rinsed with water, gently air dried and dentin bonding agent was applied on etched enamel and light cured. Dental composite restorations were done corresponding to the dimensions of circular windows on the labial surfaces of teeth in incremental layering technique and light cured. The shear bond strength of bleached enamel to composite restorations were then measured for each specimen at the interface of tooth-composite restoration until fracture in the Universal testing machine. The shear bond strength values were recorded in Megapascal (Mpa). 10% Sodium ascorbate gel as antioxidant showed the maximum effectiveness in the shear bond strength of bleached enamel to dental composites compared to all the other antioxidants used. However, no significant difference was seen in its antioxidant efficiency with 10%bGrape seed extract solution. 10%Sodium ascorbate solution was found as the least effective antioxidant.

Key words: Antioxidants; Bleaching; Dental composites; Shear bond strength; Universal testing machine

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Introduction:

Discoloured teeth affect people of various age groups and are multifactorial in nature. With the evolution of Esthetic dentistry, both In-office & Home tooth bleaching procedures have become very popular.[1]Tooth bleaching is a conservative esthetic treatment approach to remove both intrinsic and extrinsic stains on teeth. Hydrogen peroxide and Carbamide peroxide are the most commonly used agents for home bleaching and in-office whitening of teeth.[2]However, these bleaching agents have certain adverse effects such as tooth hypersensitivity, gingival irritation, reduced enamel micro-hardness and they also affect the bonding of restorative materials to tooth structure immediately after bleaching. This problem is more notable when the desired results after tooth bleaching were not achieved and the patient wishes for additional esthetic options such as Dental composite restorations.[1]

The shear bond strength of dental composites bonded to tooth structure immediately after bleaching was significantly lower compared on the unbleached tooth surface due to the presence of residual oxygen layer and removal of this layer was found to increase the shear bond strength of composite resin to bleached enamel. The general approach of overcoming this post-bleaching compromised bond strength was to delay the bonding procedure required for composite restorations by a period varying from 24 hours to 3 weeks.[3] However, not always this waiting time is possible, because of the growing concern for the immediate aesthetic rehabilitation of teeth from both patient's and clinicians perspective.[2]

Several methods were proposed to reverse the compromised bond strength of tooth structure following bleaching such as; subjecting the bleached enamel to alcohol treatment prior to composite resin restorations, removal of outermost layer of enamel, by the application of water, saline, artificial saliva or antioxidants on the bleached enamel.[4] In our study, freshly prepared 10% Alpha-Tocopherol solution, 10% Sodium ascorbate solution, 10% Sodium ascorbate gel, 10% Green tea extract and 10% Grape seed extract solutions were used as antioxidants on the bleached enamel.

Vitamin E is the collective name for a group of potent, lipid soluble, chain-breaking antioxidants and its antioxidant activity is structurally attributed to Tocopherols (α, β, γ, and δ).[6] Alpha-Tocopherol achieves reversal of bond strength by scavenging free radicals and molecular oxygen on the bleached enamel and enhancing its bond strength to composite resin.[5]Vitamin C in the form of Sodium ascorbate is a neutral, biocompatible, water soluble, non-enzymatic agent used both in solution or gel forms without any change in their antioxidant efficiency in the removal of

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active free radicals in the biological systems.[6]Sodium ascorbate with its potent antioxidant property effectively neutralizes the accumulation of oxygen and its by-products on the tooth surface, thus reversing the compromised bond strength of bleached enamel to composite resin.[7]

Grape seed extract is a natural antioxidant containing 98% Oligomeric-Proantho Cyanidin complexes (OPC's).[8] OPC contains multiple electron donor sites (hydroxyl sites) that allows it to bind to free radicals on the bleached enamel by donating its hydrogen atoms and the presence of gallic acid also increases the free radical scavenging activity. Proanthocyanidinsare high molecular weight polymers in the form of monomeric phenolic compounds such as catechin, epicatechin and epicatechin-3-0-gallate, having free radical scavenging and potent antioxidant activities.[4,9]

Green tea extract is manufactured from newly picked leaves of Camelliasinensis plant and are exposed to heat and then pan-fried or steamed prior to rolling or shaping and were then dried. The strong antioxidant properties of green tea extract is attributed to catechins of EpiGallo Catechin Gallate (EGCG) and Epi Gallo Catechin (EGC).The catechins donates hydrogen from the hydroxyl groups in their structure showing excellent antioxidant activity and free-radical scavenging ability.[10]The powdered form of green tea revealed greater scavenging effect on the production of Reactive Oxygen Species (ROS).[11]

The shear bond strength of bleached enamel to dental composite resin was measured at the interface of tooth-composite restoration using Universal testing machine.

Materials and Methods:

One-hundred forty freshly extracted human permanent maxillary central incisor teeth were collected in Triveni Institute of Dental Sciences, Hospital and Research centre, Bilaspur. India. Inclusion criteria: Teeth without any previous; Carious lesions, non-carious lesions, fractured, restored, endodontically treated, cracked, hypoplasia and teeth which were not subjected to pre-treatment with any chemicals. Exclusion criteria: Teeth with any previous carious lesions, non-carious lesions, endodontically treated, fractured, restored, cracked, hypoplasia and any developmental defects or anomalies associated with the crown and also teeth which were subjected to pre-treatment with any chemical agents. All the teeth were cleaned of superficial debris, calculus, residual tissue tags with ultrasonic instruments and were stored in deionized water at room temperature until used.

All the specimens were decoronated 2mm apical to cemento-enamel junction by means of a diamond disc (DFS Germany). Each tooth was then embedded in cylindrical self-cure acrylic resin (DPI-RR Cold cure, Dental products of India, Mumbai)blocks with only the labial surfaces of the crown portion of teeth visible, facing upwards and palatal, incisal, proximal surfaces of teeth totally embedded in acrylic resin with circular windows made on the labial surfaces of all teeth using acrylic resin in dimensions of 5mmX3mm (diameter of 5mm and height of 3mm) (Figure 1).

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Figure 1

Teeth mounted in acrylic resin block with window preparation

The 140 specimens were then randomly divided into 07 groups (05 Experimental groups & 02 Control groups) with 20 specimens per group. The exposed labial surfaces of enamel in all the specimens were then bleached with 37.5% Hydrogen peroxide available in gel form (Pola Office-Tooth whitening system, SDI Limited, Bays water, Victoria, Australia)with four applications of 8 minutes each; the bleaching agent was placed on the exposed surfaces of enamel using micro-brush, except in Negative control group in which the specimens were not bleached. Post-bleaching, all the specimens were thoroughly rinsed with deionized water for 2 minutes (Figure 2).

Figure 2

Pola Office-Tooth whitening system

Group A: Sample size: 20:- 10% freshly prepared Alpha-Tocopherol solution was used as antioxidant; 10 grams of Alpha-Tocopherol powder (Charco Chemicals, Hoshiarpur, Punjab, India) was taken into a glass beaker and mixed with 100ml of ethyl alcohol (Changshu Hangsheng Fine chemical, Mumbai, India), stirred for 2 minutes and passed through filter paper (Whatman No.1) to obtain 100ml of 10% Alpha-Tocopherol solution, the strained solution was collected and used as test antioxidant (Figure 3).

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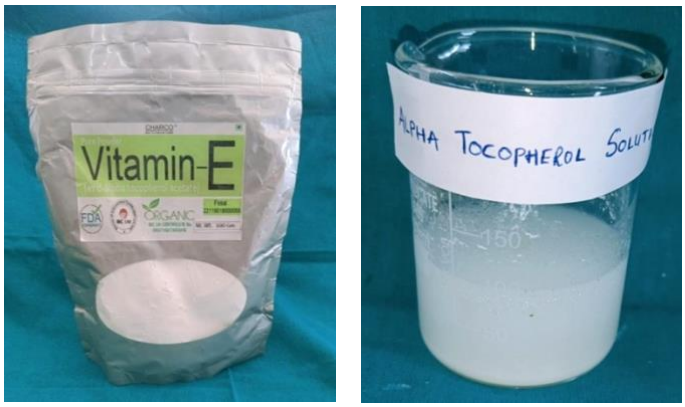
Figure 3

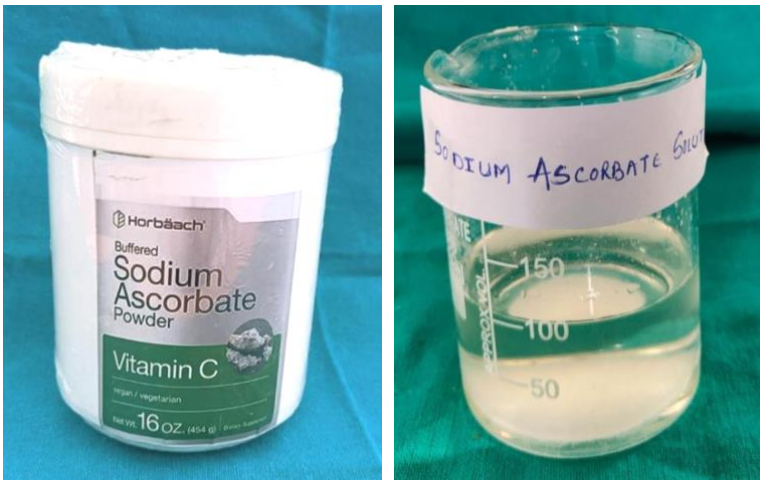
Vitamin E – Alpha-Tocopherol powder with 10% Alpha-Tocopherol solution



Group B: Sample size: 20:- 10% freshly prepared Sodium ascorbate solution was used as antioxidant; 10grams of Sodium ascorbate powder (Horbaach Manufacturers, Hanover, Niedersachsen, Germany)was taken into a glass beaker and mixed with100ml of distilled water (Vitszee chemicals fertilizers, Gujarat, India), stirred for 2minutes and passed through filter paper (Whatman No.1) to obtain 100ml of 10% Sodium ascorbate solution, the strained solution was collected and used as test antioxidant (Figure 4).

Figure 4

Sodium ascorbate powder with 10% Sodium ascorbate solution



Group C: Sample size: 20:- 10% freshly prepared Sodium ascorbate gel was used as antioxidant; 5grams of Sodium ascorbate powder (Horbaach Manufacturers, Hanover, Niedersachsen, Germany) was taken into a glass beaker and mixed with 50ml of Triethanolamine liquid (Ases Chemical Works, Jodhpur, Rajasthan, India)(Figure 5) stirred for 2 minutes to obtain 50ml of 10% Sodium ascorbate gel and used as test antioxidant (Figure 6).

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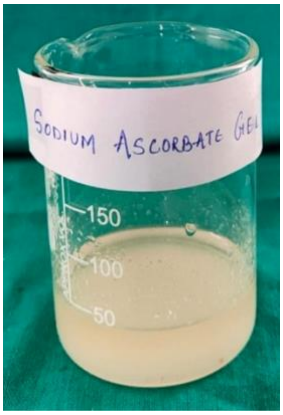
Figure 5

Triethanolamine liquid

Figure 6

10% Sodium ascorbate gel



Group D: Sample size: 20:- 10% freshly prepared Green tea extract solution was used as antioxidant; 10grams of Green tea powder (Hindustan Unilever LTD., Delhi, India)was taken into a glass beaker and mixed with 100ml of distilled water (Vitszee chemicals fertilizers, Gujarat, India), stirred for 2minutes and passed through filter paper (Whatman No.1) to obtain100ml of 10% Green tea extract solution, the strained solution was collected and used as test antioxidant (Figure 7).

Figure 7

Green tea powder with 10% Green tea extract solution

Group E: Sample size: 20:- 10% freshly prepared Grape seed extract solution was used as antioxidant;10 grams of Grape seed powder (Herbal Engine, Zirakpur, Punjab, India) was taken into a glass beaker and mixed with 100ml of distilled water (Vitszee chemicals fertilizers, Gujarat, India), stirred for 2minutes and passed through filter paper (Whatman No.1) to obtain100ml of 10% Grape seed extract solution, the strained solution was collected and used as test antioxidant (Figure 8).

Figure 8

Grape seed powder with 10% Grape seed extract solution

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In all the experimental groups, 2mlofthe test antioxidant solutions as per the group or gel(Group C)were used per specimen. Immediately after tooth bleaching, by using an applicator tip (Reach Global India PVT Ltd., Pune, Maharashtra, India) the freshly prepared antioxidant agents were applied on the bleached enamel for 10minutes followed by fresh application of it once in every 2minutes.Group F(Positive control): After tooth bleaching, no antioxidants were used to treat the bleached enamel. Group G(Negative control):Specimens were neither bleached nor any antioxidants were used. All specimens were then rinsed with deionized water for 1minute and air dried.

All the teeth were then acid etched with 37% Phosphoric acid (Actino Gel, PrevestDenPro, Jammu, India) for 15 seconds, rinsed with water for 10 seconds to completely remove the etchant and were gently air dried. Dentin bonding agent (Fusion Bond5, PrevestDenPro,Jammu,India) was then applied on the etched enamel as a thin layer using a microbrush (3MESPE,USA), gently air dried & light cured with LED (Light Emitting Diode)dental composite curing light (SAAB, China) for 20seconds. Dental composite restorations [NanoHybrid Universal Restorative composite resin] (3M ESPE FILTEK Z250XT, USA) (Figure 9) were done in incremental layering technique, with each increment of 1mm in thickness using a Teflon coated composite carrier instrument (Hu-friedy, Chicago, USA) and light cured for 20seconds per increment with the dimensions of composite restorations corresponding to the dimensions of circular windows previously made on labial surfaces of teeth. After the completion of composite restorations, all the teeth were removed from acrylic resin blocks and composite restorations were then additionally light-cured for 20seconds to ensure complete polymerization of the composite resin. The specimens were placed in incubator (Zeal International, New Delhi, India) at 37^0C until subjected to shear bond forces.

Figure 9

NanoHybrid Universal Restorative composite resin

The knife edge of indent of Universal testing machine (Acme Engineers, India)(Figure 10) was loaded at the interface of tooth-composite restoration. The shear bond strength was then measured for all specimens at a cross head speed of 0.5mm/minute until fracture and shear bond strength values of each specimen were recorded in Newton (N) and converted into Megapascal (Mpa) using the formula:-Shear bond strength (Mpa)=F(N)/m^2.

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Figure 10

Universal testing machine

Results:

The recorded readings of shear bond strength values in Megapascal(Mpa) of all specimens were tabulated and statistically analysed with computer software; Statistical Package for Social Sciences(SPSS) version 24, Using Analysis of variance(One Way ANOVA) and Tukey's post-hoc test. Analysis of Variance tests the equality of three or more means at one time by using variances. One way ANOVA

Showed statistically significant difference in the mean shear bond strength values in Megapascals between the groups as P(Probability) value is < 0.05 (Table 1).

According to One-way ANOVA, Group C; 10% Sodium ascorbate gel as antioxidant showed the maximum shear bond strength of composite resin to the bleached enamel with the Mean value of 5.64 followed by Group E;10%Grape seed extract solution as antioxidant with the Mean value of 4.89. Minimal or lowest shear bond strength of composite resin to the bleached enamel was seen in Group B; 10% Sodium ascorbate solution as antioxidant with the Mean value of only1.10.

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Table 1
Analysis of Variance(One Way ANOVA)

Groups	No.of Specimens per group	Shear bond strength(Mean ±SD)	*P value
GroupA:10%Alpha-Tocopherolsolution	20	2.19± 0.93	**<0.05***
Group B: 10% Sodium ascorbate solution	20	1.10± 0.34	
GroupC:10%Sodiumascorbate gel	20	5.64± 0.95	
Group D: 10% Green tea extract solution	20	3.69± 0.56	
GroupE:10%Grape seed extract solution	20	4.89± 0.43	
GroupF:Positive control	20	0.64± 0.36	
GroupG:Negative control	20	7.12± 0.56	

*Statistically significant difference exists(P<0.05)
*P: Probability. *SD: Standard Deviation

To find exactly which group differs from the other. Tukey's post-hoc test was done for Inter-group comparison between the seven groups.Tukey's post-hoc test showed that all the Inter-group comparisons were statistically significant as P value < 0.05, except in the Inter-group comparison between Group B; 10%Sodium ascorbate solution and Group F; Positive control, Group C; 10% Sodium ascorbate gel and Group E; 10% Grape seed extract solution used as antioxidants on the bleached enamel; there was no statistically significant difference, as the P value was>0.05 (Table 2).

The obtained results showed, in the specimens with application of antioxidants on the bleached enamel significantly increased its shear bond strength to dental composite resin compared to the specimens in which the bleached enamel was immediately bonded with composite restorations without any pre-treatment with antioxidants (Graph 1).

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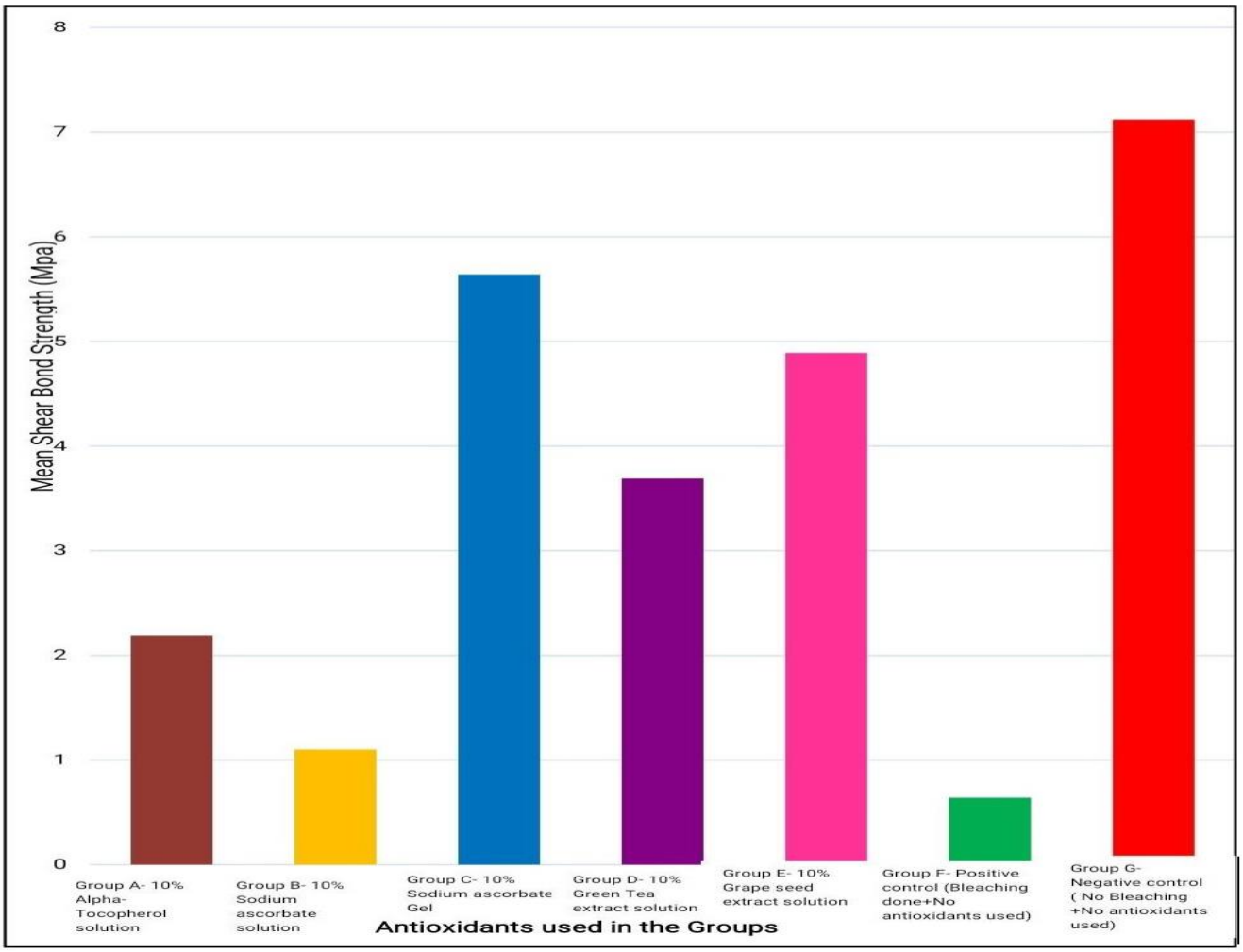
Table 2

Inter-group comparison	Comparative difference in the Mean values	P value
GroupA&GroupB	1.09	<0.001
GroupA&GroupC	3.45	<0.001
GroupA&GroupD	1.50	<0.001
GroupA&GroupE	2.70	<0.001
GroupA&GroupF	1.55	<0.001
GroupA&GroupG	4.93	<0.001
GroupB&GroupC	4.54	<0.001
GroupB&GroupD	2.59	<0.001
GroupB&GroupE	3.79	<0.001
GroupB&GroupF	0.46	**0.263**
GroupB&GroupG	6.02	<0.001
GroupC& GroupD	1.95	<0.001
GroupC&GroupE	0.75	**0.004**
GroupC&GroupF	5.00	<0.001
GroupC&GroupG	1.48	<0.001
GroupD&GroupE	1.20	<0.001
GroupD&GroupF	3.05	<0.001
GroupD&GroupG	3.43	<0.001
GroupE &GroupF	4.25	<0.001
GroupE & GroupG	2.23	<0.001
GroupF&GroupG	6.48	<0.001

Tukey's post-hoc test for Inter-group comparison

Graph 1

Vertical Bar Graph– Experimental groups & Control groups



Discussion:

With the growing awareness of dental esthetics, there is a great demand for various treatment modalities in treatment of discolored teeth. In the present world, patients are winding-up esthetically more cognizant as any discoloured teeth in the oral cavity becomes a state of concern and the interest towards minimally invasive treatment modalities has increased patient's inclination towards tooth bleaching.[12]In this era of Conservative dentistry, the concept now is the conservation of the tooth structure and it has become very common to combine direct composite restorations and tooth whitening procedures to achieve better dental esthetics clinically.[13]

Peroxide containing bleaching agents (Hydrogen peroxide) removes tooth discolorations through oxidation. Hydrogen peroxide is a low molecular weight agent decomposes into oxygen and perhydroxyl free radicals and is associated with high permeability and high diffusibility into tooth structure.

Free radicals released from the hydrogen peroxide permeate into the enamel through inter prismatic regions and reacts not only with the pigmented organic molecules, but also with the organic enamel.[4]

After tooth bleaching, there is decrease in the

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micro-hardness of enamel and also its shear bond strength to dental composites and this is attributed to the chemical changes in the tooth enamel which interferes with the acid-etching technique, decrease in the relative concentrations of calcium and phosphorus of bleached enamel.[14]The compromised bond strength following tooth bleachingis due to the fact that the bleaching agent leaves behind a residual oxygen layer which interferes with the resin infiltration into etched enamel and inhibits the polymerization of composite resin. During bleaching with hydrogen peroxide, peroxide apatite is formed as a result of the substitution of hydrogen radicals by peroxideions.[4]

Antioxidants re-establishes the altered redox potential of the oxidized bonding substrate of the bleached enamel and allows the free radical polymerization of adhesive resin without its premature termination. Free radicals are deficient electrons and the neutralization process results in the oxidation of neutralizer agent. They are classified into three categories; Full-time prevention, Active detoxication and Passive detoxication. The role of the full-time prevention is to prevent the over-production of free radicals by inactivating molecules responsible for their generation. The active detoxication is based on three enzymes that compose the basic system of antioxidant defense system; super-oxyde dismutase, catalase and glutathione peroxidase. Passive detoxication allows the reduction of free radicals which could have survived the two other lines of defense.[15]The most frequently ignored guideline in the test protocol is to follow the ISO/TS 11405 specification (2003); “A limitation of the bonding area is important.”[15] Hence to fulfill this criteria; in our study, Circular windows were made on the labial surfaces of all teeth using self cure acrylic resin to limit the flow and effect of bleaching agent and antioxidants beyond the limitations of the bonding area.

Hydrogen peroxide, being a low-molecular-weight substance, permeates into the dental hard tissues and breaks down into free radicals, so surface treatment done with any antioxidant to remove these free radicals should have low molecular weight for efficient scavenging action. According to Lipinski’s rule, molecular weight of the drug should be less than 500g/mol for its bioavailability.[16]Sodium ascorbate is a derivative of ascorbic acid with neutral pH and neutralizes the effect of residual oxygen layer, allows free radical polymerization of resin base materials to proceed without premature termination by restoring the altered redox potential of the oxidized bonding substrate, thus reversing the compromised bonding. Sodium ascorbate has a molecular weight of 198.11 g/mol, included in passive detoxification that can neutralize free radicals and it belongs to non-enzyme antioxidants.[17]

In our study, 10% Sodium ascorbate gel used as antioxidant on bleached enamel showed maximum shear bond strength to dental composites compared to all the other antioxidants used. The results of our study corroborates with a previous study of TurkunM et al[18] concluded that application of 10%Sodium ascorbate gel on bleached enamel was effective In reversing the compromised bonding of oxidized enamel to dental composites. Murad CG et al[19] in their comparative study stated that when 10% Sodium ascorbate gel was applied on enamel surface immediately after bleaching, most of the antioxidant effect occurred within the first few minutes of its application and that leaving the gel for longer periods of time (30 and minutes) did not bring much contribution to the final shear bond strength of dental composites to the bleached enamel.

In our study, 10% Sodium ascorbate solution

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used as antioxidant on bleached enamel showed minimal or lowest shear bond strength among all the other antioxidants. However the results of our study in this regard contradicts to the previous studies of Paul et al,[20]Thapa et al[21] and Subramonian et al[4] reported that application of 10% Sodium ascorbate solution as antioxidant on the bleached enamel is effective in reversing its compromised shear bond strength to dental composites.

Whereas, in our study 10% Sodium ascorbate gel was found to be more effective antioxidant compared to 10% Sodium ascorbate solution. Osth K etal[22] stated that when chemical agents are converted into gel form, their drug release rates are much slower than when they are in solution form, thus extending their effectiveness over-time. 10% Sodium ascorbate gel showed more acceptability for its use as antioxidant in clinical scenario, as inthe dental chair-side, manipulation of solution becomes more difficult compared to gel and as the gel is in less fluid form, it provides a more adequate control over its flow during application. The gel also stays in position on the enamel surface for the defined time period of the antioxidant.[17,23]

In our study, 10% Alpha-Tocopherol solution used as antioxidant on bleached enamel showed minimal shear bond strength to composite resin. However, its antioxidant efficiency was more effective compared to 10% Sodium ascorbate solution.α-Tocopherol functions as achain-breaking antioxidant that prevents propagation of free radical reactions.[24]Sasaki RTet al[25]reported, application of 10%α-Tocopherol solution on bleached enamel was found to be more effective compared to 10% Sodium ascorbate solution in reversing the compromised bonding of oxidized enamel to dental composites and concluded that the presence of alcohol in the composition of 10% α-Tocopherol solution may have contributed to the good response in reversing the compromised bond strength of bleached enamel, since 10% α-Tocopherol was not miscible in water solutions. Thus, the phenomenon observed may be system-specific, not only due to the antioxidant agent α-Tocopherol, but also due to the presence of alcohol.[25]

The utilization of plant extracts as a viable alternative to chemical and synthetic antioxidants have been encouraging.[26] Hence in our study, emphasis was placed on the use of 10% freshly prepared Grape seed and Green tea extract solutions as antioxidants to reverse the compromised bond strength of bleached enamel to dental composites. In our study, 10% Grape seed extract solution used as antioxidant on bleached enamel showed maximum shear bond strength to composite resin with no significant difference in its antioxidant efficiency compared to10% Sodium ascorbate gel. The antioxidant efficiency of Grapeseed extract solution is attributed to the following: 1) The specificity of OPC's for hydroxyl free radicals. 2) The presence of multiple donor sites on OPC's that trap superoxide radicals. 3)Presence of free flavanol monomers, catechin,epicatechin,epicatechin-3-0-gallateindimeric and trimericforms.[26]

VidhyaSetal[27]concluded 10% Grape seed extract solution showed higher antioxidant efficiency in reversing the compromised bond strength of bleached enamel to dental composites compared to 10% Sodium ascorbate and 10% Alpha-Tocopherol solutions. Proanthocyanidins were found to have specificity for hydroxyl free radicals and possess multiple donor sites, which enables it to trap superoxide radicals. However,in a previous study Arumugam MT et al[9] concluded that 10% Sodium ascorbate solution as antioxidant showed significantly higher bond strength to bleached enamel compared to 6.5% Proanthocyanidins (Grape

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seed extract solution) and stated that the low molecular weight of Sodium ascorbate solution as antioxidant could have enabled it to penetrate better into bleached enamel compared to the high molecular weight of Proanthocyanidins. Butthe difference in the findings of their study and our study is; in their study 6.5% Grape seed extract solution was compared to 10% Sodium ascorbate solution and in our study we used 10% Grape seed extract and 10% Sodium ascorbate solutions. The findings of our study also corroborates with a previous study of Fine AM[26] reporting the free radical scavenging ability and antioxidant potential of Grape seed extract solution (OPC's) is 50 times greater than Sodium ascorbate solution and 20 times greater than Alpha-Tocopherol solution.

In our study, 10% Green tea extract solution used as antioxidant on bleached enamel showed moderate shear bond strength to dental composites, however it was found to be superior compared to 10% Alpha-Tocopherol and 10% Sodium ascorbate solutions. The findings of our study corroborates with previous studies of Cavalli V et al[28] and Dishman MV et al[29] stating that Green tea extract solution through the release of free radicals helps in the removal of the residual oxygen contained in the bleached enamel which interferes with resin bonding and inhibiting resin polymerization, thus enabling the adhesive procedure (Composite restorations) to be performed immediately post-enamel bleaching. Green tea extract solution contains EGCG (Catechin); a safe, water soluble, active with the ability to destroy free radicals.[30]

Sharafeddin F et al[8] and Ozelin AA et al[31] in their studies stated that the efficiency ofGreen tea extract solution isdue to the presence of polyphenolsand potent antioxidant activity of Green tea catechins decreases dentin demineralization by inhibiting MMP's(Matrix Metallo Proteinases) thereby, stabilizing the composite resin-tooth bonding interface.

According to the material safety analysis, the level of health hazards of Sodium ascorbateis higher than Grape seed and Green tea extract solutions. Moreover, Sodium ascorbate was found to be mutagenic for mammalian somatic cells, while the Green tea and Grape seed extract solutions have nomutagenic effects when their material safety data's were examined.[32] The natural antioxidants;10% Grape seed and 10% Green tea extract solutions used in this study showed optimal effectiveness in reversing the compromised bond strength of bleached enamel to dental composites, especially the10% Grape seed extract solution showed superior antioxidant efficiency and can beused as a viable option to avoid the waiting time-period of patients and to directly go for immediate esthetic rehabilitation post-tooth bleaching with composite resin restorations making it clinically significant.

However this being an in-vitro study, it cannot mimic the in-vivo conditions. In the oral cavity, the interface of composite restoration and tooth surface are subjected to cyclic loading; each load is sufficient to provoke failure and in the long-term, it can possibly lead to marginal deterioration and loss of restoration.[4] Therefore in our study, fatigue testing using Universal testing machine was done to measure the shear bond strength of composite resin restoration to the tooth structure and is better expected to predict their in-vivo performance.

Conclusion:

Within the limitations of this study it was found that; 10% Sodium ascorbate gel as antioxidant on bleached enamel showed the maximum effectiveness in its shear bond strength to dental composite resin compared to all the other antioxidants used. However, there was no

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significant difference in its antioxidant efficiency compared to natural antioxidant;10% Grape seed extract solution.10% Sodium ascorbate solution was found to be the least effective antioxidant. The use of antioxidants on bleached enamel significantly improved its shear bond strength to dental composites compared to directly bonding of composite resin to the bleached enamel without the intermediate use of antioxidants. However, further in-vivo studies are recommended to confirm and correlate the findings of this in-vitro study to a clinical scenario.

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References:

1. Gogia H, Taneja S, Kumar M**,** Soi S. Effect of different antioxidants on reversing compromised resin bond strength after enamel bleaching: An in vitro study. J Conserv Dent;2018:21:1:100–104.

2. Ferraz LN, Oliveira ALBM, Grigoletto M, Botta AC**.** Methods for reversing the bond strength to bleached enamel: A Literature Review.JSMDent;2018:6;1:1-5.

3. Tabatabaei MH, Arami S, Nojoumian A, Mirzaei M**.** Antioxidant effect on the shear bond strength of composite to bleached bovine dentin.BrazJOralSci; 2011:10:1:33-36.

4. Subramonian R,Mathai V,Christaine AngeloJ B, Ravi J. Effect of three different antioxidants on the shear bond strength of composite resin to bleached enamel: An in vitro study.J ConservDent;2015:18:144-148.

5. Sasaki RT, Florio FM, Basting RT. Effect of 10% sodium ascorbate and 10% alpha-tocopherol in different formulations on the shear bond strength of enamel and dentin submitted to a home-use bleaching treatment. J. OperDent; 2009:34:746-752.

6. Silva JMGS, Botta AC, Barcellos DC, Pagani C, Torres CRG. Effect of antioxidant agents on bond strength of composite to bleached enamel with 38% hydrogen peroxide. J. Mat Res; 2011:14:235-238.

7. Sharafeddin F, Farshad F**.** The effect of aloe vera, pomegranate peel, grape seed extract, green tea and sodium ascorbate as antioxidants on the shear bond strength of composite resin to home-bleached enamel. J.Dent Shiraz Univ Med Sci; 2015:16:296-301.

8. SharafeddinF,MotamediM,ModiriS.Effectofimmediateapplicationofpomegranate peel, grape seed and green tea extracts on composite shear bond strength of in-office bleached.Res J BiolSci;2013:8:83-87.

9. Arumugam MT, Nesamani R, Kittappa K,Sanjeev K, Sekar M.Effect of various antioxidants on theshear bond strength of composite resin to bleached enamel: An in vitro study. JConservDent;2014:17:22-26.

10. Berger SB, De Souza Carreira RP, Guiraldo RD, Lopes MB, Pavan S, Giannini M et al**.** Can green tea used to reverse compromised bond strength after bleaching.EurJOralSci;2013:121:377–381.

11. Farooq S, Sehgal A**.** Antioxidant activity of different forms of green tea: Loose leaf, bagged and matcha. Curr.Res.Nutr Food Sci Journal;2018:6:1:35-40.

eISSN 1303-5150

12. Sharafeddin F, Jamalipour G. Effect of 35%carbamide peroxide gel on surface roughness and hardness of composite resins.JDent;2010:7:6-12.
13. Nair R, Bandhe S, Onkar Ganorkar, Saha S, Sial S, Nair A. A comparative evaluation of the three different antioxidant treatments on the bond strength of composite resin to bleached enamel: An in vitro study.JConservDent;2019:22:82-86.
14. Ferreira R, Nunes TV, Luiz BK, Garcia RN. Effects of catalase, 2% chlorhexidine gel and1% sodium hypochlorite on the micro-tensile bond strength of teeth bleached with 35%hydrogen peroxide. South Brazilian Dentistry Journal (RSBO);2011:8:266-270.
15. ISO. Dental materials – Testing of adhesion to tooth structure. Technical specificationno.11405;2003.
16. Chikhi A, Bensegueni A. In silico study of the selective inhibition of bacterial peptide deformylases by several drugs. J.Proteomics Bioinform;2010:3:61-65.
17. Garcia EJ, Oldoni TL, Alencar SM, Reis A, Loguercio AD, Grande RH. Antioxidant activity by DPPH assay of potential solutions to be applied on bleached teeth. Braz Dent J; 2012:23:1:22–27.
18. Turkun M, Kaya AD. Effect of 10% sodium ascorbate on the shear bond strength of composite resin to bleached bovine enamel.J Oral Rehabil;2004:31:12:1184-1191.
19. Murad CG, Andrade SN, Disconzi L., Munchow EA, Piva E, Pascotto RC et al. Influence of 10% sodium ascorbate gel application time on composite bond strength to bleached enamel.Acta Biomaterialia Odontologica Scandinavica;2016:2:1:49-54.
20. Paul P, Rosaline H, Balagopal S. The effect of hydrogel and solution of sodium ascorbate on the bond strength of bleached enamel.JConservDent;2007:10:43-47.
21. Thapa A, Vivekananda PA, Manuel S Thomas. Evaluation and comparison of bond strength to 10% carbamide peroxide bleached enamel following the application of10% and 25% sodium ascorbate and alpha-tocopherol solutions: An in vitro study. J Conserv Dent; 2013:16:2:111-115.
22. Osth K, Paulsson M, Bjork E, Edsman K. Evaluation of drug release from gels on pig nasal mucosa in a horizontal using chamber. Journal of Controlled Release; 2002:83:3:377-388.
23. Hansen JR, Frick KJ, Walker MP. Effect of 35% sodium ascorbate treatment on micro tensile bond strength after non vital bleaching. J Endod; 2014: 40:10:1668–1670.
24. Al Awdah AS, AlHabdan AHA, Al Muhaisen N, Al Halifa R. The effect of different forms ofantioxidant surface treatment on the shear bond strength of composite restorations to bonded to office bleached enamel. Int Journal of Research and Review;2016:4:5-11.
25. Sasaki RT, Florio FM, Basting RT. Effect of 10% sodium ascorbate and 10% alpha-tocopherol in different formulations on the shear bond strength of enamel and dentin submitted to a home-use bleaching treatment.J.OperDent;2009:34:746-752.
26. Fine AM. Oligomeric proanthocyanidin complexes: history, structure,and phytopharmaceutical applications Alternative Medicine Review: A Journal of Clinical Therapeutics;2000:5:2:144-151.
27. Vidhya S, Srinivasulu M, Sujatha M, Mahalaxmi S. Effect of grape seed

extract on the bond strength of bleached enamel.J.OperDent;2011:36:433-438.

28. Cavalli V, Carvalho RM, Giannini M. Influence of carbamideperoxide-based bleaching agents on the bond strength of resin-enamel/dentin interfaces. Braz OralRes; 2005:19:23-29.
29. Dishman MV, Covey DA, Baughan LW. The effects of peroxide bleaching on composite to enamel bond strength. Dent Mater; 1994:10:33–36.
30. Bornhoeft J, Castaneda D, Nemoseck T, Wang P, Henning SM, Hong MY. The protective effects of green tea polyphenols: Lipid profile, inflammation, and antioxidant capacity in rats fedanatherogenic diet and dextran sodium sulfate. J MedFood;2012:15:726-732.
31. Ozelin AA, Guiraldo RD, Carvalho RV, Lopes MB, Berger SB. Effects of Green tea application time on bond strength after enamel bleaching. Braz DentJ;2014:25:5:399-403.
32. Perumalla AV, Hettiarachchy NS. Green tea and grape seed extracts-Potential applications in food safety and quality. Food ResInt;2011:44:827-839.