Comparative evaluation of the effect of different surface treatment techniques on shear bond strength of orthodontic brackets bonded to teeth following bleaching: An In-vitro study.

Dr. Amey Terse, Dr. Nitin Gulve, Dr. Amit Nehete, Dr. Shivpriya Aher, Dr. Mukul Tambe Patil, Dr. Digvijay Patil

Second year post graduate[1] , Head of Department[2] , Professor[3] , Professor[4] , Professor[5] , Professor[6] .

Department of Orthodontics and Dentofacial Orthopaedics, MGV's KBH Dental College and Hospital, Nashik - 422003, Maharashtra, India

Address for Correspondence:

MGV's KBH Dental College and Hospital

Mumbai Agra Road, Panchavati, Nashik, Maharashtra- 422003

E-mail: nasa.terse@gmail.com[1], nashikdentist@gmail.com[2], dramit0202@gmail.com[3], drshivpriyaaher@gmail.com[4], drmukultambe@gmail.com[5] , patildk1983@gmail.com[6]

Scientific motivation-

From an Orthodontic point of view, it is important for brackets to remain bonded to teeth throughout the treatment, frequent debonding leads to prolongation of overall of treatment time, bonding of brackets to the tooth surface is a factor of shear bond strength. One of the reasons for reduction in shear bond strength is bleaching of teeth, which is a popular option for management of discolouration. Various methods were advocated to restore the bond strength following bleaching to overcome this.

The general significance of obtained results-

Out of all the surface treatment methods, there was hierarchical evidence observed ranging from the most effective to the least effective treatment to restore the reduced bond strength.

ABSTRACT

Aim: This In-Vitro study investigated the effect of different surface treatment techniques on SBS of orthodontic brackets bonded to teeth following bleaching.

Material and Method:
Fifty extracted human premolars teeth were embedded into self- cure acrylic resin exposing the coronal portion. The embedded specimens were categorized into five groups of 10 teeth each, and the groups were as follows:
Group I: No bleaching + orthodontic bracket bonding.
Group II: bleaching + orthodontic bracket bonding.
Group III: bleaching + sandblasting + orthodontic bracket bonding.
Group IV: bleaching + 70 % ethyl alcohol + orthodontic bracket bonding.
Group V: bleaching + 10% sodium ascorbate + orthodontic bracket bonding.
Orthodontic premolar brackets were bonded to the buccal surface of embedded teeth using composite and cured for 40 seconds and SBS was measured.
The SBS analysis was performed with the help of the universal testing machine.

Results:
1. The differences in SBS among the five tested groups were highly significant ($p < 0.001$).
2. Comparison of the five groups using Tukey's post hoc test revealed lower SBS ($p < 0.001$) in test groups II, III, IV, and V than in group I.
3. The order of SBS in descending order found was Group I > Group III > Group V > Group IV > Group II.

Conclusion:
1. Bleaching of human teeth with 35% Hydrogen-peroxide reduced the SBS of orthodontic brackets bonded to enamel.
2. Surface treatment of bleached enamel using various techniques can reverse the reduced SBS to a certain level.
3. Among the various surface treatment measures used it was found that sandblasting was most effective in reversing the reduced SBS followed by 10% sodium ascorbate and lastly 70% ethyl alcohol.

Keywords:
Alcohol, Bleaching, Orthodontic bonding, Sandblasting, Shear bond strength, Sodium ascorbate.

INTRODUCTION

Tooth discoloration is a common aesthetic issue these days seen in patients seeking orthodontic treatment, and orthodontists occasionally encounter patients who report issues with the placement and colour of their teeth.[1] With the rising concern and evolving demand for aesthetic dentistry, the management of discoloured teeth has become one of the most frequently performed treatments in clinical practice. The treatment options available for correcting tooth discoloration include veneering, bleaching, micro/macro-abrasion, and placement of porcelain crowns.

Amongst the multiple available options, the bleaching technique has become the most preferred treatment lately as it is simple, relatively safe, effective, economical, and a conservative approach to treating discoloration.[2] The bleaching agents generally used for performing the procedure include hydrogen peroxide, carbamide peroxide, and sodium perborate. Vital tooth bleaching using peroxide compounds of various concentrations is a well-accepted and safe method for treating tooth discoloration.[3]

Even though tooth bleaching is a minimally invasive and conservative approach in comparison to other restorative procedures, several studies have demonstrated the adverse effects of bleaching on the tooth surface. The increase in surface roughness[4], as well as the decrease in surface microhardness[5], mineral content[5-6], resistance[7], and bond strength[8] of the bleached enamel, have been reported. Various techniques are used to reverse the reduced bond strength postbleaching, including the elimination of the superficial outermost layer of enamel, exposing the bleached tooth surface to alcohol before restoration, treating the bleached surface specimens with artificial saliva/saline/water, incorporating adhesives containing organic solvents, and usage of antioxidants.[9,10]

Among the wide variety of formerly-mentioned practices, the utilization of antioxidants has been suggested to be an effective and relatively safe modality of increasing the bond strength during the postbleaching period.

Sandblasting is a process that alters the tooth surface. Following the sandblasting procedure there is an elimination of the superficial enamel layer and roughening of the tooth surface. Sandblasting when carried out following the bleaching procedure is capable of eliminating the superficial enamel layer containing residual oxygen, this could help in the reversal of reduced SBS caused by bleaching. The reversal of reduced SBS depends on the extent of superficial enamel layer removal.

Although several studies done in the past have evaluated the effect of the use of the above-mentioned techniques on the shear bond strength of orthodontic brackets to bleached enamel, none have compared the effect of the reversal of shear bond strength using both physical and chemical methods.

Thus, the present study is aimed to compare the effect of the use of sandblasting, alcohol, and antioxidant (10% Sodium Ascorbate) application on shear bond strength of the orthodontic brackets bonded bleached enamel with 35%Hydrogen peroxide.

MATERIALS AND METHODS

The study was approved by Institutional Review Board. 50 extracted premolars were obtained from private clinics and the oral and maxillofacial surgery department of the college. The examination of the teeth was carried out and the teeth were excluded if any of the following findings were seen: caries, fracture, restoration, cracks, gross irregularities, hypoplasia, or hypo calcification. Only intact teeth and teeth with sufficient root length were included in our study to allow mounting of these teeth in acrylic resin. The teeth were cleaned to remove blood and debris and stored in 0.025% thymol solution until all the teeth were collected. The sampling technique used was simple random sampling. Sample power analysis designated that 10 teeth per group would result in an 80% chance of obtaining significance at the 0.84 level.

Specimen preparation

A total of 50 teeth were vertically mounted in self-cure acrylic molds with their crowns exposed. Following this they were randomly divided with 10 teeth in each group as presented in Table 1 and Figure 1.

Experimental groups:
The specimens will be randomly divided into five groups (n= 10) :

- Group I (Control Group): This group will receive direct bonding of orthodontic brackets to the labial surface of the extracted premolars without any bleaching procedure.
- Group II: This group will receive bleaching treatment followed by immediate bonding of orthodontic brackets to the labial surface of the extracted premolars.
- Group III: This group will receive bleaching treatment followed by surface treatment with sandblasting and bonding of orthodontic brackets to the labial surface of the extracted premolars.
- Group IV: This group will receive bleaching treatment followed by surface treatment with alcohol and bonding of orthodontic brackets to the labial surface of the extracted premolars.
- Group V: This group will receive bleaching treatment followed by the application of 10% Sodium Ascorbate for 10 mins. This will be followed by the bonding of orthodontic brackets to the labial surface of the extracted premolars.

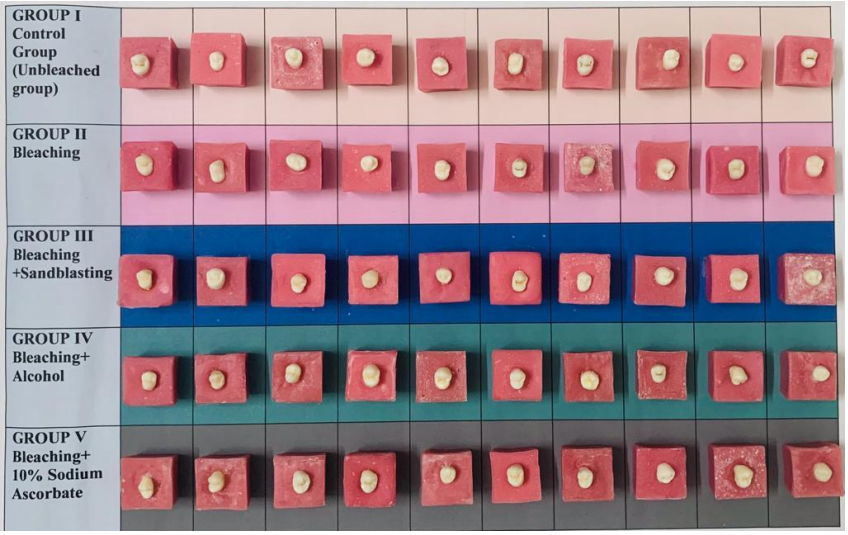

Figure 1. Prepared Sample

Bleaching

Tooth bleaching was carried out using 35% hydrogen peroxide (Pola office, SDI Limited) according to the manufacturer's instructions. The collected teeth were first washed with water and then air-dried for 15 seconds. Then specimens were treated with the bleaching gel with three applications of 8 min each. Following the application of the bleaching agent, the specimens were rigorously rinsed with water from a three- way syringe for 1 min and air- dried.

Figure 2. Bleaching Armamentarium

Postbleaching Surface Treatment:

The surface treatment procedures used to reverse the reduction in SBS were sandblasting alcohol and 10% sodium ascorbate.

Sandblasting Procedure

The buccal surface of the bleached teeth was treated with a sandblasting method using 50 um aluminum oxide particles for 10 seconds with 40-lb pressure.

Figure 3. Sandblasting Machine

Alcohol

The buccal surface of the bleached teeth was treated with 70% ethanol application for 3 mins.

Figure 4. Ethyl Alcohol

Preparation of Sodium Ascorbate

10% Sodium Ascorbate was prepared by mixing 10gms of sodium ascorbate with 100mL distilled water in a 100mL glass beaker. The prepared solution was applied on the buccal surface of bleached teeth for 10 mins.

Figure 5. Sodium Ascorbate

Bracket Bonding

Following bleaching and surface treatment procedures (sandblasting/alcohol/sodium ascorbate) buccal surfaces of the teeth were etched with 37% phosphoric acid for 15-20 seconds, after which the teeth were rinsed for 10 seconds and air-dried for 10 seconds. Further, a layer of bonding agent was applied on the buccal surface with an applicator tip and light cured for 20 seconds, and the adhesive was applied at the bracket base. Following this, the brackets were placed on the tooth surface and pressed firmly until they adhered to the tooth. Subsequently, the extra resin pressed out was removed from around the bracket. The specimens were then light-cured for 40 seconds.

Figure 6. Bracket bonded to prepared sample

Testing of SBS

A universal testing machine with a load cell of 25KN and a cross-head speed of 1 mm/minute was used for SBS testing. Every specimen was positioned in the universal testing machine, with a bracket base aligned parallel to the direction of the shear force. The chisel-shaped blade positioned in an occluso-gingival direction in contact with the bonded area of the specimen was loaded on the upper section of the machine. The values of SBS were recorded and converted into megapascal (MPa) by dividing the failure loads (Newton) by the surface area of the bracket base(mm^2).

Figure 7. Universal Testing Machine

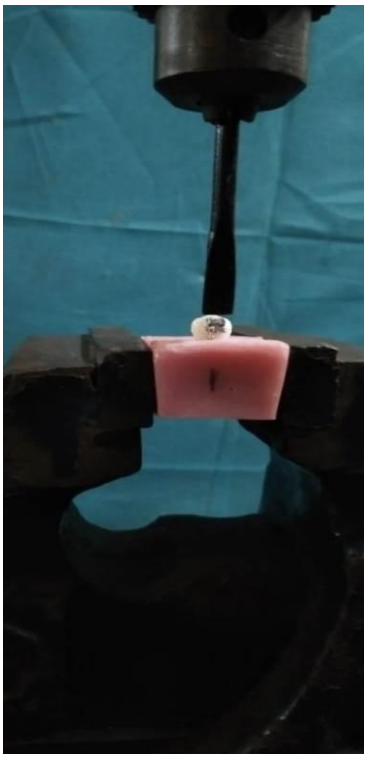

Figure 8. Sample testing

STATISTICAL ANALYSIS

Statistical analysis of the obtained data for the five experimental groups was measured using a statistical package for social science software (SPSS), version 24.0 (SPSS Inc., Chicago, IL, USA) was used, and statistical significance was seen at $p < 0.05$. Significant differences among the mean SBS values of the five groups were determined using a one-way analysis of variance. Where significant differences were observed, Tukey's post hoc comparison test was used to evaluate which of the mean values were significantly different from each other.

Table 1: Descriptive statistics of shear bond strength values of each group

	Mean	SD	SE	Minimum	Maximum
Group I (Control)	19.39	1.14	0.361	17.6	21.2
Group II (Bleached)	8.44	0.83	0.263	7.4	9.8
Group III (Sandblasting)	15.75	1.51	0.479	14.11	18.4
Group IV (Alcohol)	11.71	1.12	0.355	10.2	13.5
Group V (Na Ascorbic)	13.73	1.32	0.419	11.2	15.9

RESULTS

Shear bond strength values were highest in group 1 (control) followed by group 3(sandblasting), group 5 (sodium ascorbic), group 4 (alcohol), and least in group 2 (bleached).

On overall comparison using the one-way ANOVA f test, it was observed that a highly statistically significant difference ($p<0.001$) exists among the five groups. (Table 1)

Sample	Mean	SD	One-way Anova F test	P value, Significance
Group I (Control)	19.39	1.14	**F = 116.33**	**p < 0.001****
Group II (Bleached)	8.44	0.83		
Group III (Sandblasting)	15.75	1.51		
Group IV (Alcohol)	11.71	1.12		
Group V (Na Ascorbic)	13.73	1.32		

Tukey's post hoc test for pairwise comparison			
Group	**Comparison Group**	**Mean Difference**	**P value, Significance**
Group I (Control) vs	**Group II (Bleached)**	**10.95**	**p < 0.001****
	Group III (Sandblasting)	**3.64**	**p<0.001****
	Group IV (Alcohol)	**7.68**	**p<0.001****
	Group V (Na Ascorbic)	**5.66**	**P<0.001****

Group II (Bleached) vs	**Group III (Sandblasting)**	**7.31**	**p<0.001****
	Group IV (Alcohol)	**3.27**	**p<0.001****
	Group V (Na Ascorbic)	**5.29**	**p<0.001****
Group III (Sandblasting) vs	**Group IV (Alcohol)**	**4.04**	**p<0.001****
	Group V (Na Ascorbic)	**2.02**	**p = 0.005***
Group IV (Alcohol) vs	**Group V (Na Ascorbic)**	**2.02**	**P =0.005***

Table 2: Overall Comparative statistics of shear bond strength values using One-way Anova F test

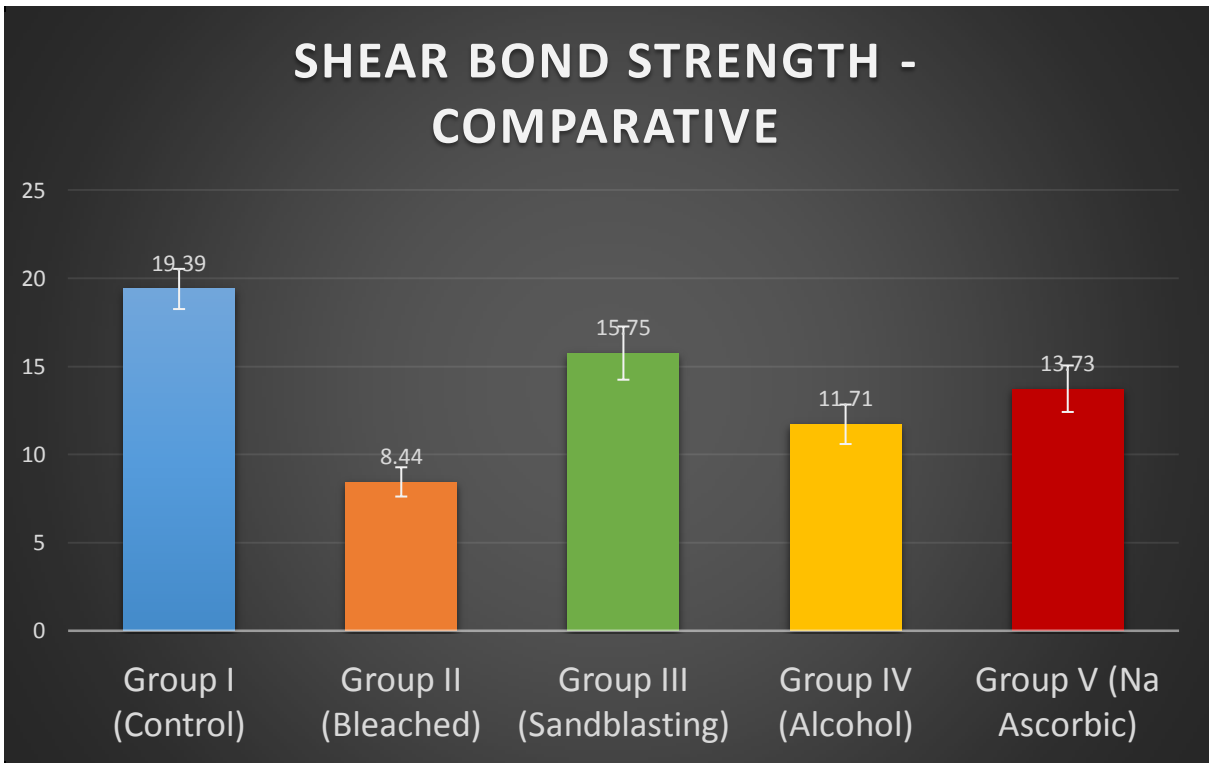

Chart 1: Comparison of Shear bond strength

Group I (control) had higher statistically significant shear bond strength as compared to groups 2,3,4 and 5.

Group 2 (bleached) had highly statistically significantly lower shear bond strength as compared to groups 3,4 and 5.

p>0.05 – no significant difference *p<0.05 – significant **p<0.001 – highly significant

Table 3: Pairwise Comparative statistics of shear bond strength values using Tukey's post hoc test

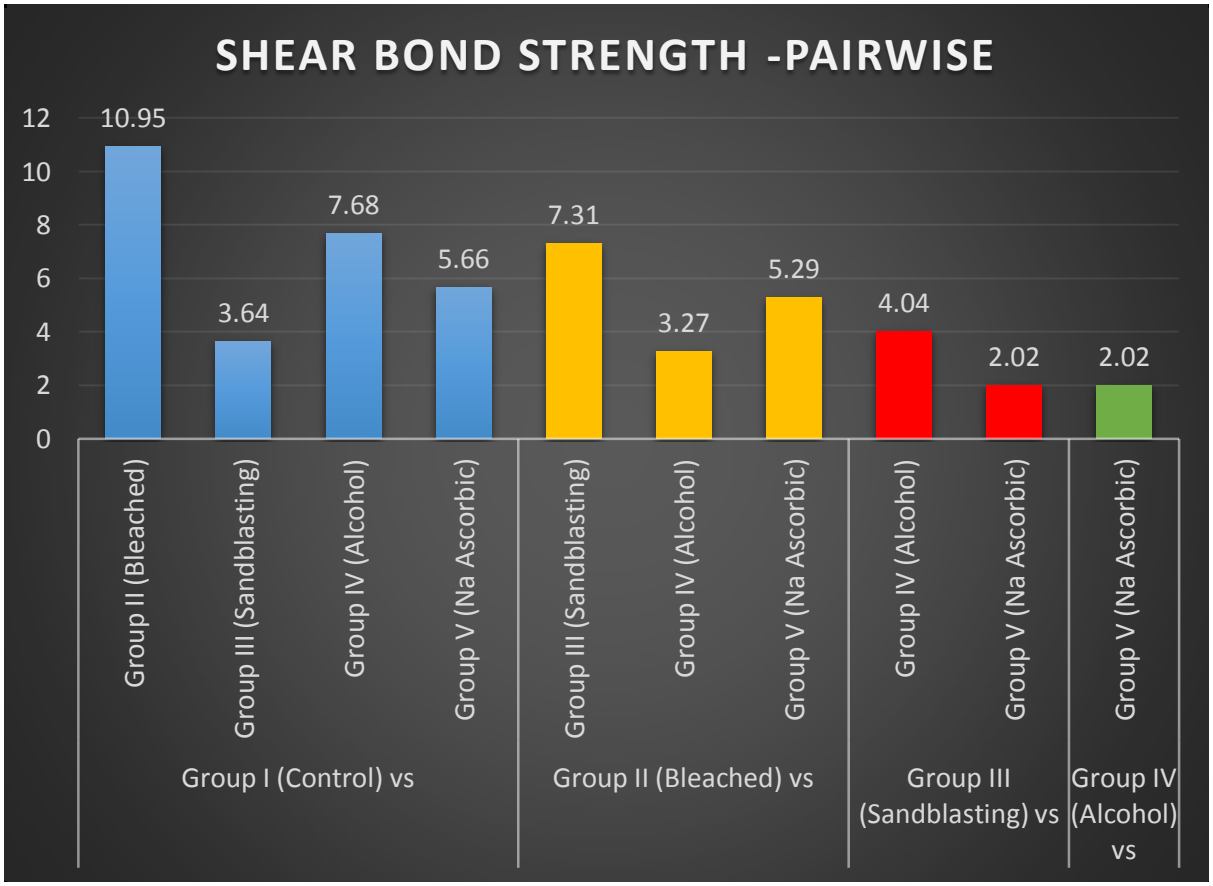

Chart 2: Pairwise comparison of Shear bond strength

Group 3 (sandblasting) had highly statistically significantly greater shear bond strength as compared to Group 4

Group 3 (sandblasting) had statistically significantly greater shear bond strength as compared to Group 5

Group 4 (alcohol) had statistically significantly lower shear bond strength as compared to Group 5

DISCUSSION

The present study aimed to assess the effect of various surface treatment procedures on the SBS of metal orthodontic brackets bonded to teeth bleached with 35% Hydrogen peroxide. The results showed that all three surface treatment techniques were capable of restoring the

reduced SBS of bleached enamel bonded to metallic brackets immediately after bleaching with 35% hydrogen peroxide but to different levels. Hence, the null hypothesis was rejected.

Various studies have examined the interaction between bleached enamel and SBS of metal brackets. It has been documented that SBS decreases when the brackets are bonded immediately to enamel following bleaching with 35% hydrogen peroxide. In the present study, there was a pronounced decrease in SBS of specimens that were treated with 35% hydrogen peroxide and immediately subjected to bracket bonding. However, the adverse effect of bleaching materials on the SBS of brackets seen in the study has been contradicted in studies performed by Bishara et al.[11] and Uysal and Sisman[12]. These investigators found that bleaching with 35% hydrogen peroxide or 10% hydrogen carbamide had no effect and showed no reduction of the SBS of an orthodontic bracket to the enamel. Reduction in SBS following bleaching with 35% hydrogen peroxide could be related to changes in the roughness of the enamel surface and changes in structure caused by the loss of prismatic formation or changes in the organic content, loss of calcium, and reduction in microhardness. Moreover, leaching of the residual oxygen from the bleaching agent causes inhibition of resin infiltration into the bleached enamel or impedes with polymerization of the resin. However, the use of various surface treatment methods eliminates either the superficial layer of enamel that contains residual oxygen and causes roughening or residual oxygen in the enamel structures right after bleaching, allowing the brackets to be bonded to the bleached enamel instantly.

This In-vitro study showed that SBS was highest with Group I (control group), which was the unbleached group, and lowest with Group II (bleached group). Amongst the various surface treatment techniques used Group III (sandblasting group) showed the highest reversal of reduced SBS followed by Group V (10% Na Ascorbate group) and lastly Group IV (Alcohol group).

The reversal of reduced SBS seen following sandblasting of the bleached enamel seen in our study was consistent with the results of the study performed by Hooman Zarif Najafi et al.[13] The possible reason for the reversal of reduced SBS following sandblasting of the bleached enamel surface could be the elimination in of superficial enamel layer and roughening of the enamel surface.

Sodium ascorbate is a sodium salt of ascorbic acid that shows a good antioxidant ability and is capable of causing neutralization and reversal of the oxidant effect of bleaching agents used in dentistry. Many studies have shown that 10% Na ascorbate treatment of bleached teeth for 10 minutes before bonding of brackets causes reversal of the reduction in SBS. The effect seen on SBS following surface treatment with 10% Na ascorbate in our study was identical to that of the study performed by Laila Baidas et al.[14] The antioxidant property of SA is due to its property of scavenging free oxygen left in the layers of enamel.

The results obtained in this study were by the study performed by Kalili et al.[15] which showed that treatment of bleached enamel with alcohol causes a decrease in the residual water and oxygen and an increase in the bond strength of orthodontic bracket to the bleached enamel. However, when compared to other methods alcohol group showed the lowest values indicating that it was less effective as compared to sandblasting and 10 % SA in reversing the reduced bond strength.

Bleaching has various adverse effects on the enamel caused by oxygen inhibition of bleaching agents, this has become a matter of concern among orthodontists. Many studies have shown that delayed bonding can help the reversal of the reduced shear bond strength. Although various methods can be used for the reversal of reduced SBS, none of them were able to completely reverse the reduced SBS. The results of this study show that bleaching deteriorates the surface properties of enamel, of which bonding to orthodontic brackets is a matter of concern. Thus, bonding of brackets to the enamel following bleaching can be reversed by using physical methods like surface roughening using bur, sandblasting, etc. as well as by using chemical methods like treatment with 10% sodium ascorbate, alcohol, alpha-tocopherol, hesperidin, etc.

CONCLUSION

1. Bleaching of human teeth with 35% Hydrogen-peroxide reduced the SBS of orthodontic brackets bonded to enamel.
2. Surface treatment of bleached enamel using various techniques can reverse the reduced SBS to a certain level.
3. Among the various surface treatment measures used it was found that sandblasting was most effective in reversing the reduced SBS followed by 10 % sodium ascorbate and lastly 70% ethyl alcohol.

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