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# An In Vitro Study of the Effect of the Different Bleaching Types and Antioxidant Treatment on Shear Bond Strength of Orthodontic Brackets

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***Abstract:*** *In present days, the society is striving to have straight white perfect teeth with attractive smile resembling famous actors and actresses that is called "Hollywood smile". Nowadays, due to the increase in demand for a bright smile, many whitening techniques were developed. (1) Tooth whitening has become increasingly popular, even with adolescent patients. (2) Esthetic problems such as teeth crowding, rotations and spacing are related to more susceptibility to teeth staining and discoloration Many orthodontic patients may have bleaching done at home or may be interested in having their teeth bleached at the time of orthodontic treatment. (2)In spite of the vast amount of information presented in hundreds of articles during the last decade there is a remarkable lack of consent regarding brackets bond strength values after bleaching. The goal of this study was directed to investigate the effect of time elapsed after bleaching and before bracket bonding and the application of antioxidant agent to the previously bleached teeth using different dental bleaching systems on bracket bond strength.A sample of seventy premolars was divided randomly into seven groups of ten specimens each.Regarding the results of shear bond strength of orthodontic brackets of this study revealed a significant increase of shear bond strength after 5 weeks with both types of bleaching. A significant decrease of shear bracket bond strength was obtained after antioxidant treatment*

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## I. Introduction

In present days, the society is striving to have straight white perfect teeth resembling famous actors and actresses that is called "Hollywood smile". Nowadays, due to the increase in demand for a bright smile, many whitening techniques were developed. (1) Tooth whitening has become increasingly popular, even with adolescent patients. (2) Esthetic problems such as teeth crowding, rotations and spacing are related to more susceptibility to teeth staining and discoloration. Many orthodontic patients may have bleaching done at home or may be interested in having their teeth bleached at the time of orthodontic treatment. The need to measure the bond strength of orthodontic brackets on the bleached teeth became anecessity. (2) Most studies did not recommend immediate bonding procedures after bleaching. The recommended post-bleaching period for bonding procedures varies from 24 hours to 4 weeks. (3, 4&5) However, there is no agreement on how long the orthodontist should wait before bonding brackets to teeth that have been exposed to bleaching agents. (6)

In spite of the vast amount of information presented in hundreds of articles during the last decade there is a remarkable lack of consent regarding brackets bond strength values after bleaching. The goal of this study was directed to investigate the effect of time elapsed after bleaching and before bracket bonding and the application of antioxidant agent to the previously bleached teeth using different dental bleaching systems on bracket bond strength.

## II. Material And Methods

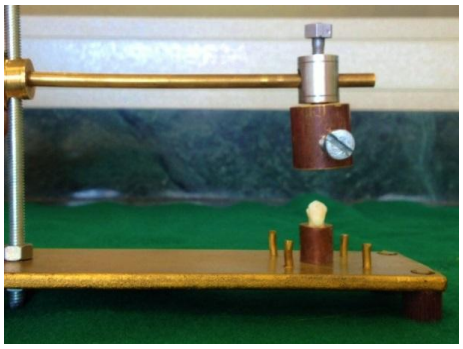
This in-vitro study was carried out on orthodontic department at Cairo University Hospital, from November 2013 to November 2014. A total Seventy freshly extracted upper human premolars were collected over a period of 6 months

**Study Design:**An In -Vitro study
**Study Location**: This was teaching hospital based study done in Department of orthodontics.
**Study Duration:** November 2014 to November 2015.
**Sample size:** Seventy freshly extracted upper human premolars.
**Experimental Groups:** The sample was randomly divided into seven groups of ten each :**( n=10)**

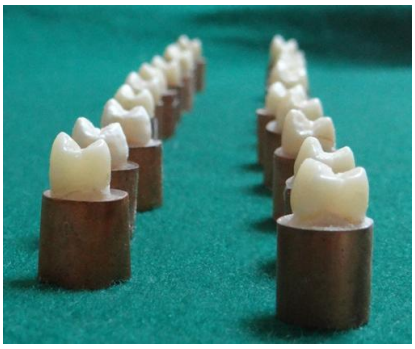
**Group I: Control group(Ct)** –included ten premolars which were mounted then held in artificial saliva for one week without bleaching before bracket bonding.
**Group II orHB (1w);** included ten premolarswhich wereexposedtoNiteWhite at-home bleaching gel with a waiting period of 1 week before bracket bonding.
**Group III or OB (1w);** included ten premolars which were exposed to zoom in-office bleaching gel with a waiting period of 1 week before bracket bonding.
**Group IV or HB (5w);** included ten premolars which were exposed to NiteWhite at-home bleaching gel with a waiting period of 5 weeks.
**Group V or OB (5w);** included ten premolars which were exposed to zoom in-office bleaching gel with a waiting period of 5 weeks.
**Group VIor** (**HA);** included ten premolars which were bleached using NiteWhite at-home bleaching gel then antioxidant application immediately before bracket bonding.
**Group VII or (OA);** included ten premolars which were bleached using zoom in-office bleaching gel with antioxidant application immediately before bracket bonding.
**Inclusion criteria:**
All premolars were freshly extracted for orthodontic purpose and had undamaged intact buccal enamel,
**Exclusion criteria:**
caries, enamel defects or cracks due to the pressure of the extraction forceps.
No pre-treatment with any chemicals such as alcohol, formalin, peroxides or any other form of bleaching.

**Procedure methodology**

All teeth were cleaned of debris, soft tissues and polished with non-fluoridated pumice by rubber cups on a slow-speed hand-piece for 10 seconds before storage and just before bonding. The teeth were stored in artificial saliva to prevent dehydration that was changed every week to avoid bacterial growth. (7) One week before the experiment, the teeth were embedded in the mold containing self-cure resin with exposed crowns using a parallelometer. Teeth embedded into acrylic resin by the vertical arm (FIGURE 1,2).Subsequently, the procedure specified for each experimental group was followed the manufacturer's directions according to the group for The Zoom In-Office Light-Activated Whitening system25% hydrogen peroxides or 22% carbamide peroxide home whitening gel for 3 hours for 3 days( FIGURE 3). A solution containing 10% sodium ascorbate was used as antioxidant treatment(FIGURE 4). The teeth were polished with non-fluoridated pumice by polishing brushes on low-speed hand-piece for 10 seconds just before bonding.Surface enamel etching was done for 30 seconds using gel. They were rinsed with abundant water for 20 seconds to stop etching process and remove demineralized particle and dried with an air syringe until the frosty white appearance of etched enamel was seen. After the previous surface preparation, a thin layer of liquid primer was applied to the etched surfaces and bracket bases. Sufficient bonding paste was applied to cover the bracket bases. For standardization all brackets were then seated firmly on the enamel surface at 4 mm from buccal cusp tip by bracket positioner and pressed on the tooth surface until they were fully seated (FIGURE 5).Finally, the excess resin was removed from the periphery of the bracket base with a dental explorer. After bonding, the specimens in all groups were stored in distilled water at room temperature for 24 hours to allow complete resin polymerization before debonding. Twenty four hours after bonding, each sample was mounted on the lower fixed compartment of a computer controlled materials of a universal testing machine*with a load cell of 5 kilo Newton and data was recorded using computer software**. The long axis of the specimen was kept perpendicular to the direction of the applied force and subjected to a compressive shear loading in occluso-gingival direction to ensure only shearing force application at a crosshead speed of 0.5 mm/min via mono- beveled chisel edge rod attached to the upper movable compartment of testing machine. The chisel tip was positioned to touch only the base of the bracket. The maximum failure load was recorded in Newton. The load at failure was divided by bonding area (the surface area of the bracket base). Area of the bracket base was measured with a light optical stereomicroscope at 16 X magnificationsto express the bond strength in megapascals (N/mm2). Failure was manifested by displacement of the bracket and confirmed by sudden drop along load-deflection curve recorded by computer software.(FIGURE 6,7).

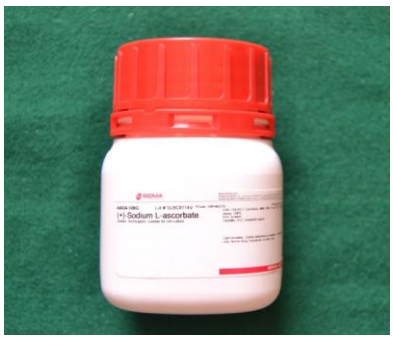


**(Figure 1):** Parallelometer



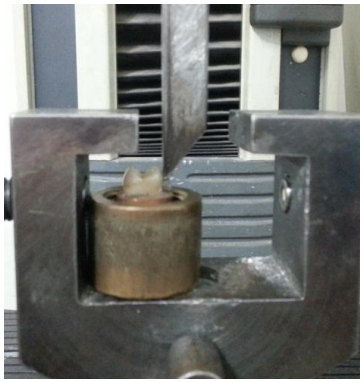
**(Figure 2):** all specimens were embedded up to the CEJ


**(Fig. 3):** Proper positioning of the light guide & brush mixing.

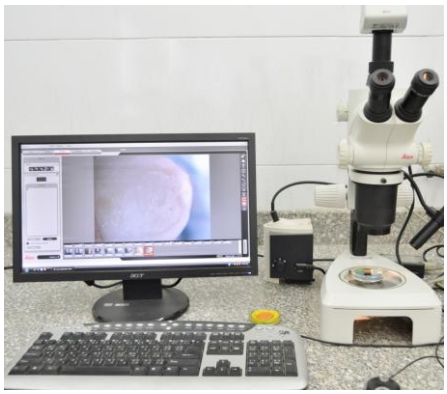



**(Fig. 4):** Sodium ascorbate powder

**(Figure 5):** proper bracket positioning A-occlusal view



**(Figure 6):** Measuring the shear bond strength of the bonded bracket sample in the universal testing machine



**(Fig.7):** stereomicroscope

**Statistical Analysis**

1-**Descriptive statistics**: including the mean and standard deviation were calculated for each of the groups tested.

**2- One-way Analysis of Variance (ANOVA)** was used to compare between all groups. Tukey's post-hoc test was used for pair-wise comparisons between the groups when ANOVA test is significant. Student's t-test was used to compare between the two time periods as well as to compare between bleaching without and with the addition of Anti-oxidant. The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM SPSS Statistics Version 20.

**3- Adhesive Remnant Index (ARI) scores** were compared using non-parametric tests. Kruskal-Wallis test was used to compare between (ARI) of all groups. Mann-Whitney U test was used for pair-wise comparisons between the groups when Kruskal-Wallis test is significant. Mann-Whitney U test was also used to compare between the two time periods as well as to compare between bleaching without and with the addition of Anti-oxidant.

**4-Inter-observer reliability (agreement)** regarding ARI was measured using Cronbach's alpha reliability coefficient. Cronbach's alpha reliability coefficient normally ranges between 0 and 1. Values of Cronbach's alpha which are larger than 0.7 indicate very good agreement.

The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBMSPSS Statistics Version 20.

## III. Results

**Comparison between all groups**: (Table 1, Fig. 8) There was no statistically significant difference between the mean shear bond strengths of both home bleaching and zoom office bleaching after 5 weeks; both showed the highest mean shear bond strength values of all groups.There was no statistically significant difference between mean shear bond strengths of control group, home and zoom bleaching after 1 week, all showed a lower mean shear bond strength values than that found after 5weeks.There was no statistically significant difference between mean shear bond strengths of the antioxidant group after zoom (5.8MPa ±1.4) and home bleaching (6MPa ±1.4); both showed the lowest mean shear bond strength values of all groups.

**Table (1):** *Mean, standard deviation (SD) values and results of one-way ANOVA and Tukey's tests for comparison between shear bond strength of all groups:*Significant at P ≤ 0.05, Different letters are statistically significantly different*

***: MPa MEGAPASCAL*

| Group | Mean (MPa)** | SD | *P*-value |
|---|---|---|---|
| Control | 10.3 [b] | ± 2.8 | <0.001* |
| Zoom (1 week) | 8.8 [b] | ± 2 | |
| Home (1 week) | 10.5 [b] | ± 3.4 | |
| Zoom + Anti-oxidant | 5.8 [c] | ± 1.4 | |
| Home + Anti-oxidant | 6 [c] | ± 1.4 | |
| Home (5 weeks) | 17.8 [a] | ± 4.9 | |
| Zoom (5 weeks) | 14.1 [a] | ± 4.3 | |

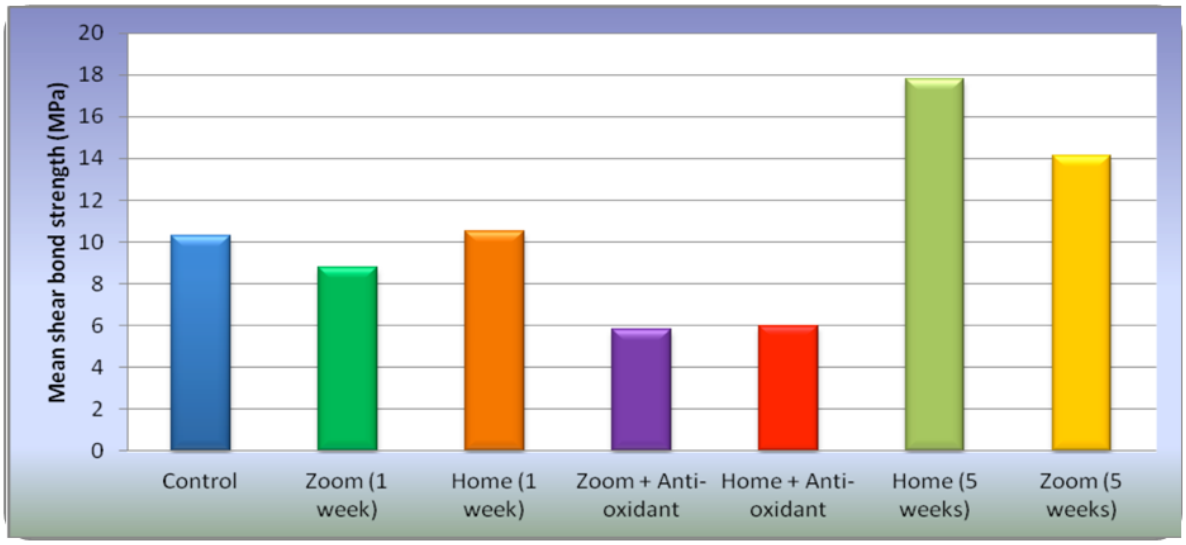



**Figure (8):** Bar chart representing mean values for comparison between shear bond strengths of all groups

**Inter-observer agreement (Reliability) of ARI scores**

There was a statistically significant inter-observer agreement in all groups. Cronbach's alpha values were above 0.7 in all groups indicating very good agreement. The highest agreement (Cronbach's alpha = 0.929) was found in Antioxidant after home bleaching group while the lowest agreement (Cronbach's alpha = 0.704) was found in the control group **Table (2)** FIGURE 9

**Table (2):** Results of Cronbach's alpha reliability coefficient for inter-observer agreement regarding ARI scores

| Group | Cronbach's alpha | *P*-value |
|---|---|---|
| Control | 0.704 | 0.037[1]* |
| Zoom (1 week) | 0.759 | 0.005* |
| Home (1 week) | 0.841 | <0.001* |
| Zoom + Anti-oxidant | 0.809 | 0.001* |
| Home + Anti-oxidant | 0.929 | <0.001* |
| Home (5 weeks) | 0.804 | 0.002* |
| Zoom (5 weeks) | 0.727 | 0.009* |

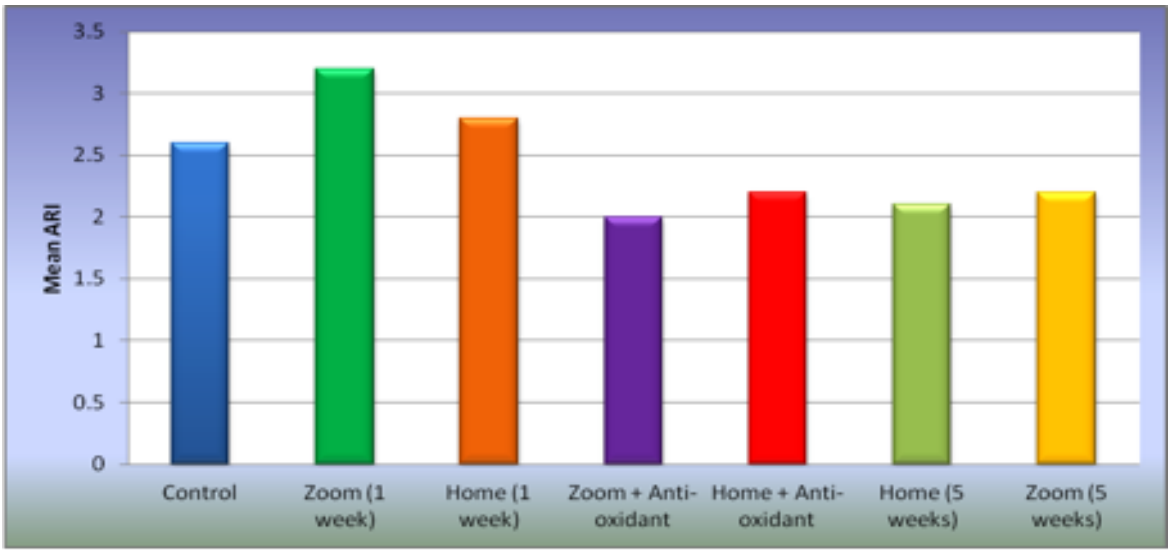



**Figure (9):** Bar chart representing mean values for comparison between (ARI) of all groups

*: *Significant at P ≤ 0.05*

## IV. Discussion

As bleaching procedures are now considered a popular routine dental procedure; combination of both orthodontic treatment and teeth bleaching has become a current clinical procedure in dentistry. The widespread of bleaching procedures with different concentrations and protocols among people made it necessary to investigate the effect of different bleaching agents on the bond strength of orthodontic brackets to enamel surface. There are no conclusive studies in the literature and many authors agree that more researches on this topic are needed. So this study was carried out to investigate the effect of different types of dental bleaching agents on orthodontic brackets bond strength, in addition to determining the effect of using an antioxidant agent immediately after bleaching versus measuring the effect of two waiting periods after the bleaching procedures used on the bracket bond strength.

Different methods of bleaching techniques (in-office and at home bleaching) were carried out in the present study to allow comprehensive evaluation of their effect on shear bracket bond strength. Home bleaching using 22% carbamide peroxides was selected due to its simplicity, low cost and safety. [8, 9, 10, and 11] Most studies concerned with the effect of in–office bleaching on SBS used high concentrations of hydrogen peroxides35%-38%.[12, 13&14] On the other hand, few studies evaluated the effect of in office bleaching by using 25% hydrogen peroxides.

Several methods have been proposed to avoid clinical problems related to compromised bond strength after bleaching, such as removal of the superficial layer of enamel [7], pretreatment of bleached enamel with alcohol[15] , use of adhesives containing organic solvents [16]and usage of reducing (antioxidant) agents such as sodium ascorbate, catalase, sodium bicarbonate and glutathione. However, some other studies recommended delay bonding after bleaching, because the reduction of bond strength to freshly bleached enamel has been shown to be transient. The recommended post bleaching period for bonding procedures varied from 24 hours to 4 weeks. [8, 17, 6 &18] Consequently the purpose of the present study was to compare the effect of antioxidant treatment versus delaying bonding after in-office and home bleaching on SBS of metal brackets bonded with chemical cure composite resin to human enamel.

Vitamin c (ascorbic acid AA) and its salts (sodium ascorbate SA) are non-toxic, commonly used in the food industry and haven't adverse biological effects or clinical hazards**.** Therefore sodium ascorbate for the antioxidant treatment was chosen in this study. The use of the SA, instead of the AA is recommended to avoid the potential double –etching effect of this mild acid on the etched teeth. [19]

There was no significant reduction in the mean shear bond strength at least one week following home bleaching and the control group (10.5 MPa and 10.3 MPa) respectively. The results for the shear bond strength of the bleached groups in this study were in accordance with previous studies **Cacciafesta et al. [13], Turkkahraman et al. [20], Mullins et al. [21], Abe et al [22], Oztas et al [23], AL-Jumaili and Thiab et al**.[24], **Phan et al** [25], **and Martins et al. [26]**, **Khan et al. [27]**. This may be owing to the fact that the bonding procedure was delayed for a week after the bleaching protocol had finished, thus allowing enough time for the elimination of the residual oxygen that normally interferes with the polymerization of the resin tags. On other hand,**Uysal et al [14], Agha et al [18]**found that time lapse should be more than 3 weeks to improve the bracket bonding strength**.** Regarding the effect of one week waiting time after zoom in-office bleaching, there was no significant difference compared with the control group(8.8 MPa and 10.3 MPa) respectively. This was in concurrence with **Agha et al [18] Bulut [11] Cacciafesta [13]**. Whereas, other studies performed by **Josey et al [17], Cavalli et al. [6]** suggested a waiting period more than 1 week to reverse the SBS.

It was interesting to note that the highest mean of shear bracket bond strength was with delaying bonding for 5 weeks after NiteWhite home and zoom in-office bleaching (17.8MP) and (14.1MP) respectively. Both were significantly higher than control group (10.3 MP). A possible explanation for this may be the fact that the bonding procedure was delayed for 5 weeks after the bleaching protocol had finished, thus allowing enough time for the elimination of the residual oxygen that normally interferes with the polymerization of the resin tags. **[13]** Early bonding following bleaching could result in polymerization inhibition of the composite due to the delayed release of oxygen. **[29]** Moreover, the use of artificial saliva as the storage medium may have promoted remineralization due to the calcium and phosphate ion content in the artificial saliva which allows faster by-products release.**[24, 26&25]** It is also important to emphasize that the bleached enamel surface might have become more porous or over etched than regular etched enamel after being treated with phosphoric acid. [17, 15] A combination of these overall effects might have consequently increased the number of resin tags which was translated into higher shear bond strength. Both values were much more than the recommended clinically acceptable range suggested by **Khosravanifard et al. [33]**

High SBS indicated a risk of enamel fracture during debonding. Retief (32), reported that enamel fracture might occur with SBS as low as 9.7MP. Although enamel fracture during bracket debonding didn't occur during this study, precaution should be taken.

Unfortunately, there was an obvious decrease in SBS of NiteWhite and zoom in-office groups subjected to antioxidant treatment before bonding (6-5.8MP) respectively. Moreover, these values were

significantly less than the control group (10.3 MP) and the least among other experimental groups. Furthermore, they were less than the recommended clinically accepted range (33). This was in conflict withBulut et al (11) Torres et al (30)Khosravanifard et. al. (33)

A possible explanation for the obvious decrease in the SBS with antioxidant use before bracket bonding might be insufficient immersion time for donating two high energy electrons to scavenge the free radicals and neutralize the residual oxygen. Lai et al (2002) (19)suggested that antioxidant sodium ascorbate should be applied for 3 hours or at least one-third of the bleaching time which is not clinically accepted. Another possible reason leading to the reduction of the shear bond strength could be due to insufficient rinsing after antioxidant treatment.

Similar results, but with the use of light cure adhesive were recorded by Kimyai et al.(34) Torres et al (30)whoalso found no significant difference in SBS after (20 minutes) application of SA solution. Khosravanifard et. al. (33)found that 10% SA sol. could reverse SBS of resin modified glass ionomer. On the contrary, this was in conflict with Bulut et al (11) who found an increase of SBS after (20 minutes) application of sodium ascorbate solution. This might be attributed to the time of application, different commercial materials of antioxidant used in the previous study.

This study demonstrated that there was a slight increase in SBS of at- home bleaching compared with in-office. However, this difference was statistically insignificant. This maybe explained as the lower concentration and larger molecules of carbamide peroxides of at-home bleaching than hydrogen peroxides with subsequently slower diffusion to enamel surface would produce which came in agreement with Agha et al.(18)Some studies found that in-office bleaching significantly reduced the SBS as Aksakalli et al (12), Ray et al.(35) On the contrary, other studies revealed that home bleaching had a much decrease in Shear bond strength than in-office bleaching such as Gungor et al (10), Scougall-vilchis et al. (36)

In this study, data of bond failures (ARI) showed that there were statistically significant differences among the seven groups. The comparison of ARI scores of all experimental groups demonstrated that the control group, home bleaching and in-office groups after one week were significantly higher compared with bleaching after 5 week and antioxidant treatment. However, the results of ARI in this study among the seven groups mainly indicated cohesive failures (score2-3). The higher ARI scores (score3) means that the mode of failure is closer to the enamel /adhesive interface. Bond failures within the adhesive (cohesive failure) or at bracket adhesive interface are preferred because they decrease stresses at enamel surface and the risk of enamel fracture is decreased. (8, 37)

These results were in agreement with Pithon et al. (38) and Uysal et al. (14) Aksakalli et al. (12) An attempt to explain the failure site was that the oxygen release from the tooth structure after bleaching may interfere with the resin polymerization producing cohesive failure during debonding. However, this result revealed that antioxidant treatment could affect the ARI and reduce SBS of orthodontic brackets after bleaching by both types. This disagreed with Kimyai et al (34) Who wasfound that three hours of sodium ascorbate immersion could partially reverse SBS but could not affect ARI.

## V. Conclusion

1- Shear bond strength of orthodontic brackets after one week following NiteWhite home bleaching or zoom in-office bleaching is within the clinically acceptable range. Thus dental bleaching is not contraindicated before orthodontic treatment.

2-Delaying bracket bonding for 5weeks after bleaching significantly increased the bond strength above the accepted range regardless of the bleaching type.

3-Application of antioxidant solution to bleached teeth prior to metal bracket bonding did not reverse the reduced SBS after bleaching.

4-There was no difference between at-home and in-office bleaching in shear bond strength and site of bond failures.

5-Bond failures in the bleached groups mostly showed cohesive failures as is preferred.

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