

Impact of Antioxidant Irrigation on the Shear Bond Strength of Orthodontic Brackets Post-dental Bleaching – An *In vitro* Study

K. Lakshmi Bhavya¹, CH. Sumalatha², Sri Harsha Yelchuru^{3*}, E. Srikanth⁴, T. Prasanna⁵, T. Srikanth⁶

¹Department of Conservative Dentistry and Endodontics, Drs. Sudha and Nageshwar Rao Siddhartha Institute of Dental Sciences, Vijayawada, Andhra Pradesh, India.

²Department of Conservative Dentistry and Endodontics, Singareni Institute of Medical Sciences, Ramagundam, Telangana, India.

³Department of Orthodontics and Dentofacial Orthopedics, Drs. Sudha and Nageshwar Rao Siddhartha Institute of Dental Sciences, Vijayawada, Andhra Pradesh, India.

⁴Department of Orthodontics and Dentofacial Orthopedics, Meghna Dental College, Nizamabad, Telangana, India.

⁵Department of Conservative Dentistry and Endodontics, KIMS Dental College and Hospital, Amalapuram, Andhra Pradesh, India.

⁶Department of Restorative and Prosthetic Dentistry, School of Dentistry, University of Rwanda, Kigali, Rwanda.

Abstract

Background: To evaluate the shear bond strength (SBS) and adhesive remnant index (ARI) of brackets bonded to enamel surfaces bleached with various agents, and to assess the effect of antioxidant application on SBS and ARI scores following bleaching. **Materials and Methods:** One hundred five teeth were divided into four groups: Group 1 (control), Group 2 (hydrogen peroxide [HP], Xtra Boost, Ultradent), Group 3 (light-activated HP, Pola Office, SDI), and Group 4 (carbamide peroxide [CP], Opalescence, Ultradent). In all bleaching groups, 15 teeth were bonded immediately after bleaching, whereas the remaining 15 teeth were treated with 10% sodium ascorbate before bonding. Following enamel pre-treatment with transbond plus self-etching primer, brackets were bonded using transbond plus color changing adhesive (TPCC) adhesive. After 24 h, SBS was tested using a universal testing machine and ARI scores were recorded under a stereomicroscope. One-way analysis of variance (ANOVA) and Dunnett's *post hoc* test compared SBS, whereas Kruskal–Wallis ANOVA and Chi-square tests compared ARI. **Results:** SBS of brackets decreased in all bleaching groups. No significant difference in SBS was found between antioxidant-treated groups and the control. The control and CP groups had the highest ARI scores, whereas the 40% HP and 35% light-activated HP groups had the lowest ARI scores. **Conclusion:** All groups showed reduced SBS for brackets bonded immediately after bleaching. Antioxidant treatment can increase SBS and restore bond strength, making it a viable alternative to delayed bonding.

Keywords: Antioxidant, Bleaching, Shear bond strength, Self-etching primer.

INTRODUCTION

With rising demand for adult orthodontics, many patients are dissatisfied not just with alignment but also with tooth color. As dental bleaching becomes more common, many seeking orthodontic treatment also opt for teeth whitening.^[1]

Previous studies on the effect of bleaching gels with different concentrations on orthodontic bracket bond strength have shown mixed results. While some research found no significant changes to enamel beyond normal variations, other studies reported increased enamel porosity, mineral loss, altered prismatic form, and reduced bond strength.^[2]

To address reduced bond strength after bleaching, delayed bonding is commonly recommended, ranging from 24 h to 4 weeks. Other suggestions include removing the enamel's superficial layer, pre-treating with alcohol, and using adhesives with organic solvents.^[3] Lai *et al.*^[4] showed that

applying sodium ascorbate before bonding reversed the reduced dentin bond strength after hydrogen peroxide (HP) bleaching.

If the antioxidant treatment of bleached enamel restores composite resin bond strength, it could replace waiting and avoid postponing bonding. This study aimed to compare the effects of three bleaching protocols and antioxidant treatments on the shear bond strength (SBS) of orthodontic brackets.

Address for correspondence: Dr. Sri Harsha Yelchuru,

Department of Orthodontics and Dentofacial Orthopedics, Drs. Sudha and Nageshwar Rao Siddhartha Institute of Dental Sciences, Gannavaram,

Vijayawada, Andhra Pradesh, India.

Email: drharshayelchuru86@gmail.com

Received: Aug. 25, 2024; **Accepted:** Sep. 28, 2024; **Published:** Oct. 15, 2024

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

Access this article online

Website:
www.jrad.co.in

DOI:
<https://doi.org/10.53064/jrad.2024.16.1.617>

How to cite this article: Bhavya KL, Latha CS, Yelchuru SH, Srikanth E, Prasanna T, Srikanth T. Impact of Antioxidant Irrigation on the Shear Bond Strength of Orthodontic Brackets Post-dental Bleaching – An *In vitro* Study. J Res Adv Dent 2025;16(1):1-4.

MATERIALS AND METHODS

One hundred five freshly extracted human maxillary premolars with intact, untreated buccal enamel, free of cracks, caries, or restorations, were stored in normal saline at room temperature. The saline was changed weekly to prevent bacterial growth, ensuring no physical or chemical damage to the enamel before testing.

Fifteen teeth were assigned to the first group, whereas the remaining three groups had 30 teeth each, divided into subgroups of 15. All teeth were mounted in colored autopolymerizing resin for differentiation (Table 1). Before enamel pre-treatment with bleaching agents, the buccal surfaces were cleaned and polished with pumice slurry and a rubber cup, then rinsed with water and dried with compressed air for 30 s. Except for Group 1, all teeth were treated with three different bleaching agents according to the manufacturer's instructions.

In Group 2, all teeth were bleached with 40% HP (Opalescence Xtra Boost, Ultradent). A 1 mm thick layer of gel was applied to the buccal surfaces for 15 min, then rinsed with water and dried with air. This process was repeated twice daily for 3 days.

In Group 3, teeth were bleached with light-activated 35% HP (Polo Office, SDI). After mixing the powder and liquid to form a gel, it was applied in a 1 mm layer for 2 min. The gel was then activated with blue light emitting diodes (420–440 nm) for 3 min, cleaned with a compressed air-water syringe, and the process was repeated immediately.

In Group 4, teeth were bleached with 10% carbamide peroxide (CP) gel (Opalescence, Ultradent). A 1 mm thick layer was applied to the buccal surfaces with a brush and left on for 6 h daily over 1 week. After each bleaching cycle, teeth were thoroughly rinsed, dried with clean air, and stored in normal saline until bonding.

In subgroups 2B, 3B, and 4B, after bleaching pre-treatment, teeth were irrigated with 10% sodium ascorbate solution (Loba Chemie Pvt Ltd) for 10 min at 1 mL/min under agitation. They were then rinsed with distilled water for 30 s, dried, and bonded. Stainless steel premolar brackets (MBT 0.022 inch slot, Gemini series, 3M Unitek) were bonded using transbond plus self-etching primer (TSEP, 3M Unitek). TSEP was applied to the enamel for 5 s, distributed with slight air pressure, and photopolymerized for 10 s. Transbond plus color changing

adhesive was applied to the bracket base, seated on the tooth, excess flash removed, and polymerized for 20 s.

After bonding, specimens were stored in distilled water at 37°C for 24 h before SBS testing. A steel rod attached to a universal testing machine (Autograph, Shimadzu®) applied an occluso-gingival load to create shear force at the bracket-tooth interface. Bond strength was measured at a crosshead speed of 0.5 mm/min, and fracture load was recorded in megapascal (MPa).

After debonding, the buccal surfaces were examined under a stereomicroscope at ×10 magnification to assess residual adhesive using the adhesive remnant index (ARI) scores developed by Artun and Bergland.

0 – No adhesive remains on the tooth

1 – Less than half of the adhesive remains on the tooth

2 – More than half of the adhesive remains on the tooth

3 – All adhesive remains on the tooth, with a clear impression of the bracket mesh.

Statistical Packages for the Social Sciences 17 software was used to analyze SBS means with one-way analysis of variance (ANOVA) and perform inter-group comparisons using Dunnett's *post hoc* test. The Chi-square test analyzed ARI scores, whereas Kruskal–Wallis ANOVA with Bonferroni correction assessed inter-group differences.

RESULTS

Table 2 shows the descriptive statistics (minimum, maximum, mean, and standard deviation) for all study groups. Despite visible differences, one-way ANOVA with a $P = 0.05$ revealed no statistical significance. *Post hoc* Dunnett test indicated a significant difference only between the control group and the in-office HP bleach group, with no significance found in other bleached or antioxidant-treated groups.

Table 3 presents ARI descriptive statistics. Kruskal–Wallis ANOVA with Bonferroni correction ($P = 0.016$) showed a significant difference between the control group and groups 2A and 3A. The Chi-square test also indicated significant differences among the groups ($P = 0.05$) (Table 4).

DISCUSSION

As adult orthodontic treatment demand rises, many patients use HP-based bleaching agents to enhance tooth color.

Table 1: Treatment regimens before bonding

Group	Color	Treatment regimen
1	Clear	Control
2A	Dark blue	HP bleach
2B	Light blue	HP bleach followed by anti-oxidant treatment
3A	Dark green	Light-activated HP bleach
3B	Light green	Light-activated bleach followed by anti-oxidant treatment
4A	Dark orange	CP bleach
4B	Light orange	CP bleach followed by anti-oxidant treatment

HP: Hydrogen peroxide, CP: Carbamide peroxide

Table 2: Descriptive statistics of SBS, $P=0.085$

Group	n	Min	Max	Means	Standard deviation	Dunnett
Group 1	15	6.63	18.61	9.39	3.70	A
Group 2A	15	3.83	10.66	6.63	1.85	B
Group 2B	15	6.59	17.84	9.03	3.40	A
Group 3A	15	2.19	9.95	6.73	2.17	B
Group 3B	15	4.64	18.34	9.03	4.90	A
Group 4A	15	4.56	14.08	7.72	2.25	A
Group 4B	15	5.55	17.56	9.01	3.61	A

SBS: Shear bond strength

Table 3: Descriptive statistics of ARI scores and comparison with Kruskal–Wallis ANOVA with Bonferroni correction at 0.007

Groups	n	Mean	SD	P-value
Group 1	15	2.47	0.64	0.016 sig
Group 2A*	15	1.13	1.19	
Group 2B	15	1.93	0.80	
Group 3A*	15	1.33	1.11	
Group 3B	15	1.87	0.99	
Group 4A	15	1.73	1.03	
Group 4B	15	2.00	0.76	

ARI: Adhesive remnant index, ANOVA: Analysis of variance, SD: Standard deviation

Table 4: Frequency distribution of ARI scores using Chi-square test

Group	ARI			
	0 (%)	1 (%)	2 (%)	3 (%)
Group 1	0	1	6	8
	0.0	6.7	40.0	53.3
Group 2A	6	4	2	3
	40.0	26.7	13.3	20.0
Group 2B	0	5	6	4
	0.0	33.3	40.0	26.7
Group 3A	4	5	3	3
	26.7	33.3	20.0	20.0
Group 3B	1	5	4	5
	6.7	33.3	26.7	33.3
Group 4A	2	4	5	4
	13.3	26.7	33.3	26.7
Group 4B	0	4	7	4
	0.0	26.7	46.7	26.7

ARI: Adhesive remnant index

HP generates free radicals that break down dark-colored molecules into lighter ones. External activation (light or heat) speeds up this oxidation process, rapidly removing stains.^[2] CP, a common ingredient in both professional and at-home bleaching products, includes Carbopol to improve adhesion and extend peroxide release in at home bleaching products.^[5] Bleaching before or after orthodontics may alter enamel surface topography, potentially affecting adhesive bond strength.^[6]

Scougall-Vilchis *et al.*^[7] found that SBS in HP and CP groups was lower compared to the control group after bleaching. Their results were higher than in the present study, likely due to their use of 10% CP instead of 15% and bovine incisors. Bishara *et al.*^[8] noted that 10% CP bleaching did not significantly impact immediate bond strength over a week, despite reduced SBS. In contrast, Miles *et al.*^[9] reported a significant bond strength reduction in ceramic brackets 72 h after using the same bleaching agent and the debonding occurred at the bracket-resin interface, attributing this to residual bleaching agent effects on enamel.

Spyrides *et al.*^[10] found that 35% HP, 35% CP, and 10% CP bleaching reduced dentin bond strength, with the reduction

depending on the bleaching agent's concentration. Similarly, in the present study, 40% HP, 35% light-activated HP, and 15% CP bleaches reduced bond strength to 6.63 MPa, 6.73 MPa, and 7.72 MPa, respectively.

Since the minimum bond strength needed for orthodontic forces is 6–8 MPa,^[11] all groups in this study showed clinically acceptable bond strengths. In contrast, Bishara *et al.*^[8] reported bond strengths below 6 MPa, likely due to using adhesive pre-coated ceramic incisor brackets on molars and debonding within 30 min of bonding.

Studies^[2,12,13] have linked physical changes after bleaching such as mineral loss, increased porosity, and loss of prismatic form to altered bond strength. Only two studies^[6,12] suggested that these changes might affect adhesive retention due to residual peroxide or related substances inhibiting composite resin polymerization and reducing resin tags. They have demonstrated that the reduction in SBS is transient and within 7 days to 6 weeks, peroxide ions get leached from enamel when immersed in water.

Sung *et al.*^[14] found no significant bond strength decreases with ethanol-based bonding agents, as the alcohol reduces bleaching process inhibition. Similarly, ascorbic acid and its salts are effective antioxidants against oxidative compounds.^[15] This study showed that treating bleached enamel with 10% sodium ascorbate before bonding restored bond strength to metal brackets, consistent with Lai *et al.*^[4]

In the control group, most bond failures occurred at the bracket/adhesive interface, leaving adhesive on the tooth surface. After bleaching, failures shifted to the adhesive/enamel interface, with little or no adhesive remaining on the tooth. Titley *et al.*^[6] observed through a scanning electron microscope that enamel surfaces often lacked resin, and any tags present were fragmented, poorly defined, and less deeply penetrated, which likely caused the shift in the failure site.

Consistent with these studies, SBS values were significantly lower in all bleached groups compared to the control. Thus, bleaching should be postponed until orthodontic treatment is complete, or antioxidants such as ascorbate salts should be used to neutralize bleaching agents and restore bond strength. Given the limited literature, further research into factory-made antioxidant agents is needed.

CONCLUSION

1. Bleaching with different agents decreased the mean SBS of orthodontic brackets to enamel, with the reduction directly related to the concentration of HP used
2. A 10% sodium ascorbate antioxidant treatment restored the lost SBS in bleached groups and can be a viable alternative to delayed bonding
3. The control group showed the highest ARI scores with more adhesive remaining on the tooth, whereas the 40% HP and 35% light-activated HP groups had the lowest ARI scores, with minimal or no adhesive left.

REFERENCES

1. Gungor AY, Ozcan E, Alkis H, Turkkahraman H. Effects of intracoronal bleaching methods on shear bond strengths of orthodontic brackets. *Angle Orthod* 2012;82:942-6.
2. Patusco VC, Montenegro G, Lenza MA, De Carvalho AA. Bond strength of metallic brackets after dental bleaching. *Angle Orthod* 2009;79:122-6.
3. Bulut H, Turkun M, Kaya AD. Effect of anti-oxidizing agent on the shear bond strength of brackets of brackets bonded to bleached human enamel. *Am J Orthod Dentofacial Orthop* 2006;129:266-72.
4. Lai SC, Mak YF, Cheung GS, Osorio R, Toledano M, Carvalho RM, *et al.* Reversal of compromised bonding to oxidized etched dentin. *J Dent Res* 2001;80:1919-24.
5. Oztas E, Bagdelen G, Kilicoglu H, Ulukapi H, Aydin I. The effect of enamel bleaching on the shear bond strengths of metal and ceramic brackets. *Eur J Orthod* 2012;34:232-7.
6. Titley KC, Torneck CD, Smith DC. Effect of concentrated hydrogen peroxide solution on the surface morphology of cut human dentin. *J Endod Trauma* 1988;4:32-6.
7. Scougall-Vilchis RJ, Gonzalez-Lopez BS, Contreras-Bulnes R, Rodriguez-Vilchis LM, Garcia-Niño de Rivera MW, Kubodera-Ito T. Influence of four systems of dental bleaching on the bond strength of orthodontic brackets. *Angle Orthod* 2011;81:700-6.
8. Bishara SE, Sulleman AH, Olson M. Effect of enamel bleaching on the bonding strength of orthodontic brackets. *Am J Orthod Dentofacial Orthop* 1993;104:444-7.
9. Miles PG, Pontier JP, Bahiraei D, Close J. The effect of carbamide peroxide bleach on the tensile bond strength of ceramic brackets: An *in vitro* study. *Am J Orthod Dentofacial Orthop* 1994;106:371-5.
10. Spyrides GM, Perdigao J, Pagani C, Araujo MA, Spyrides SM. Effect of whitening agents on dentin bonding. *J Esthet Dent* 2000;12:264-70.
11. Reynolds IR. A review of direct orthodontic bonding Bracket. *J Orthod* 1975;4:171-8.
12. Josey AL, Meyers IA, Romaniuk K, Symons AL. The effect of a vital bleaching technique on enamel surface morphology and the bonding of composite resin to enamel. *J Oral Rehabil* 1996;23:244-50.
13. Dishman MV, Covey DA, Baughan LW. The effects of peroxide bleaching on composite to enamel bond strength. *Dent Mater* 1994;10:33-6.
14. Sung EC, Chan SM, Mito R, Caputo AA. Effect of carbamide peroxide bleaching on the shear bond strength of composite to dental bonding agent enhanced enamel. *J Prosthet Dent* 1999;82:595-8.
15. Cacciafesta V, Sfondrini MF, Stifanelli P, Scribante A, Klersy C. The effect of bleaching on shear bond strength of brackets bonded with a resin-modified glass ionomer. *Am J Orthod Dentofacial Orthop* 2006;130:83-7.