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DOI:
10.4103/jos.JOS_149_16

Effect of different intracoronal bleaching methods on shear bond strength of ceramic brackets bonded to bleached enamel: An *in-vitro* study

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Abstract:

OBJECTIVE: To investigate the effect of different intracoronal bleaching methods on the shear bond strength and site of failure of ceramic brackets.

MATERIALS AND METHODS: Sixty freshly extracted human maxillary incisors were randomly divided into four groups (n = 15). Endodontic access cavity was prepared and root canals were filled, root fillings were removed 2mm apical to the cementoenamel junction, and a 2-mmthick layer of glass ionomer cement base was applied. Group 1 served as the control. Intracoronal bleaching was performed with 35% carbamide peroxide in group 2, sodium perborate in group 3, and 37.5% hydrogen peroxide in group 4. The teeth were immersed in artificial saliva for 4 weeks before bracket bonding. Ceramic brackets were bonded with composite resin and cured with LED light. After bonding, the shear bond strength of the brackets was tested with a universal testing machine. The site of bond failure was determined by modified ARI (Adhesive Remnant Index).

RESULTS: The highest value of shear bond strength was measured in control group (18.67 ± 1.59 MPa), which was statistically significant from groups 2,3, and 4. There was no significant difference between groups 2 and 4. The lowest shear bond strength was measured in group 3. ARI scores were not significant from each other.

CONCLUSIONS: Intracoronal bleaching significantly affected the shear bond strength of ceramic brackets even after 4 weeks of bleaching. Bleaching with sodium perborate affects shear bond strength more adversely than does bleaching with other agents like hydrogen peroxide and carbamide peroxide.

Keywords:

Ceramic brackets, enamel bonding, intracoronal bleaching, shear bond strength

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Introduction

Facial esthetics plays a major role in our life not only for enhancing our social skills but also in creating job opportunities. Discoloration of teeth is one of the major aesthetic concerns of dental patients.[1] Discoloredteeth, especiallyinthe anterior region, can cause considerable cosmetic impairment.[2]

Tooth discoloration may be classified as intrinsic or extrinsic. The main intrinsic factors for discoloration are pulp hemorrhage, decomposition of pulp, bacteria and its products, tetracycline, pulp necrosis, intracanal medicaments, some endodontic filling materials, metallic restorations, and also by incorporation of chromatogenic material into dentin and enamel during odotogenesis or after eruption.[3]

Intracoronal bleaching is a conservative alternative to more invasive non-vital aesthetic treatments such as crowning or the placement of veneers on discolored teeth.[3]

How to cite this article: Chauhan V, Kumar P, Sharma P, Shetty D. Effect of different intracoronal bleaching methods on shear bond strength of ceramic brackets bonded to bleached enamel: An *in-vitro* study. J Orthodont Sci 2017;6:86-90.

The bleaching agents most commonly used for internal tooth bleaching are carbamide peroxide, hydrogen peroxide, and sodium perborate.[4] Over the years, various authors have demonstrated that intracoronal bleaching agents produce changes in enamel structure and composition, which may affect the shear bond strength of orthodontic brackets.[1] Hydrogen peroxide is the active component for various bleaching agents used in dentistry. It may be applied directly or produced by a chemical reaction from sodium perborate or carbamide peroxide. Hydrogen peroxide acts as a strong oxidizing agent through the formation of reactive oxygen molecules. These reactive molecules attack long-chained, dark coloredchromophore molecule, and split them into smaller, less colored, and more diffusible molecules.[5] The compromised bonding after bleaching has been attributed to the inhibition of polymerization as a result of this residual oxygen.[1]

Carbamide peroxide gel provides 25% to 35% hydrogen peroxide equivalent and its effect on human enamel composition and topography has been studied by Covington *et al*., and their results suggested a controlled oxidation process in which the organic phase of the enamel is mobilized without producing grossly unacceptable enamel surface topography.[6]

Sodium perborate is an oxidizing agent available as a powder. In the presence of water, it breaks down to form sodium metaborate, hydrogen peroxide, and nascent oxygen. Water-based sodium perborate paste has been reported to be less harmful to dental tissues.[7]

Ceramic orthodontic brackets were introduced in 1987 as a more aesthetic alternative to stainless steel brackets. Ceramic brackets demonstrate superior aesthetics, biocompatibility, and resistance to physical and chemical factors and are reported to have greater or equal bond strength as stainless steel brackets.[8] These brackets allow the curing light to transmit through them and thus there may be a better polymerization.

Therefore, the aim of this study was to investigate the effect of different intracoronal bleaching methods on shear bond strength of ceramic brackets bonded to bleached enamel. The null hypothesis considered was that there was no difference between the bond strength of ceramic brackets bonded before and after bleaching with different intracoronal bleaching methods.

Materials and Methods

Sixty freshly extracted non-carious human maxillary incisors with intact labial surface and no pre-treatment with any chemical agent were used for the study. After extraction, maxillary incisor teeth were washed under running tap water and stored in a solution of 0.1% (weight/volume) thymol till use. Each tooth was embedded in an auto-polymerizing acrylic resin.

Endodontic access cavity was prepared and biomechanical preparation was done for all the teeth. Thorough irrigation was performed using 2.5% sodium hypochloride and root canal was dried with sterile paper points. The canal was obturated with root canal sealer and gutta-percha points. After obturation, the root canal filling was removed 2mm apical to the cementoenamel junction and a 2-mm thick layer of glass ionomer cement was applied.

All the samples were randomly assigned to four groups (n = 15 in each group), as follows:

- Group 1: The access cavity was rinsed with distilled water and dried and the final composite restoration was placed
- Group 2: Intracoronal bleaching was performed with 35% carbamide peroxide
- Group 3: Intracoronal bleaching was performed with sodium perborate
- Group 4: Intracoronal bleaching was performed with 37.5% hydrogen peroxide.

Bleaching agent was placed into the cavity and the cavity was closed by temporary filling material. This procedure was repeated a further two times (once every four days). After 12 days, the temporary filling was removed and the access cavity was rinsed with distilled water and restored with composite.The teeth were immersed in artificial saliva for 4 weeks before bracket bonding.

The teeth were cleaned with non-fluoridated pumice, rinsed thoroughly with water, and dried with oil and moisture-free compressed air. After that 37% of phosphoric acid gel was applied to the labial surface of each tooth for 15 seconds and the tooth was thoroughly rinsed and dried. A frosted appearance was taken as obvious proof of success in etching. A thin uniform layer of Transbond XT primer was applied to the etched enamel and was lightly blown with oil and moisture free compressed air and then cured for 5 seconds. The Ortho Organizer illusion plus ceramic bracket was used. After that, Transbond XT plus adhesive was applied to the bracket base and placed onto the labial enamel surface and pressed firmly into place to express adhesive from the margins of the bracket base. The excess adhesive was removed. Light curing was done for 10 seconds from all sides.

Each specimen was loaded onto a Computerised Instron Universal Testing Machine (Asian Group Inc;

Model no. 6578) with the long axis of the specimen kept perpendicular to the direction of the applied force. The standard knife edge was positioned in the occluso-gingival direction and in contact with the bonded specimen. Bond strength was determined in the shear mode at a crosshead speed of 1 mm/min until fractured occurred. The values of failure load (N) were recorded and converted into megapascal (MPa) by dividing the failure load (N) by the surface area of by the bracket base which was 9.03 mm^2 according to manufacturer.

After debonding, the teeth were examined under a stereomicroscope (10×). Adhesive remaining after bracket removal was assessed according to the modified adhesive remnant index.[9] The data recorded was subjected to statistical analysis. One-way analysis of variance (ANOVA) and Tukey HSD multiple comparison tests were used to compare shear bond strength among the groups. The Chi-square test was used to determine differences inARI (Adhesive Remnant Index) scores among groups. Significance for all statistical tests was predetermined at $P < 0.05$. All statistics were performed with SPSS version 20.0.

Results

Descriptive statistics of various groups are presented in Table 1 and Figure 1.

On comparison of the mean shear bond strength of four groups, group 1 had maximum bond strength (18.67 ± 1.59MPa), followed by group 2 (15.85 ± 1.84 MPa), group 4 (15.26 ± 1.21 MPa);group 3 (12.65 ± 1.29 MPa) had the minimum bond strength.

ANOVA suggested a significant difference between the groups. The P value was found to be <0.001 so the difference of means between four groups was statistically highly significant, [Table 2].

On multiple comparisons by Tukey HSD test, group 1showed highest values of bond strength and the bond strength was significantly higher when compared with groups 2, 3, and 4. The lowest shear bond strength was observed in group 3. There was no statistically significant difference between groups 2 and 4, [Table 2].

Chi-square analysis showed that the ARI scores for the various test groups were not significant from each other;χ^2 df = 3 = 1.796, $P = 0.616$ [Table 3].

Discussion

In our study, the lowest bond strength was observed when bleaching was done with sodium perborate. The bond strength of groups bleached with hydrogen peroxide and carbamide peroxide was higher than the sodium perborate group. The control group showed the highest bond strength. These results are in accordance with a study by Gungor *et al*. who found that sodium perborate had more effect in reducing the bond strength, while carbamide peroxide and hydrogen peroxideboth showed similar effects.[3] They had also reported that the control group had the highest bond strength.[3] Abdulkareem *et al*. in their study reported similar findings with stainless steel brackets but in case of ceramic brackets they found no significant difference in the bond strength between bleached and unbleached enamel.[10] Cakmak *et al*. and Amaral *et al*. have also reported no significant difference in bond strength between bleached and unbleached enamel after 7 days and 30 days of bleaching.[8,11] The probable reason for this might be that those two studies had used sodium perborate mixed with distilled water as compared to our study where sodium perborate was mixed with

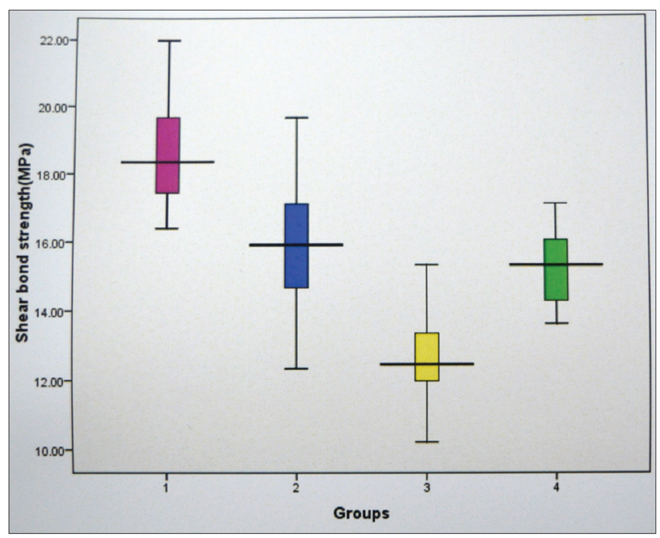

Figure 1: Shear bond strength (MPa) of various groups

Table 1: Descriptive statistics for shear bond strength of various groups

Groups	*n*	Mean	Standard deviation	Standard error	95% Confidence interval for mean		Minimum	Maximum
					Lower bound	Upper bound		
Group 1	15	18.67	1.59563	0.41199	17.7904	19.5576	16.39	22.00
Group 2	15	15.85	1.84404	0.47613	14.8375	16.8799	12.33	19.66
Group 3	15	12.65	1.29192	0.33357	11.9386	13.3694	10.22	15.32
Group 4	15	15.26	1.20642	0.31150	14.5972	15.9334	13.62	17.12

Table 2: ANOVA and multiple comparison of various groups

Groups	Mean difference	Standard error	*P* (Tukey HSD)	95% Confidence interval	
				Lower bound	Upper bound
Group 1 vs. Group 2	2.81533	0.54988	<0.001	1.3593	4.2714
Group 1 vs. Group 3	6.02000	0.54988	<0.001	4.5640	7.4760
Group 1 vs. Group 4	3.40867	0.54988	<0.001	1.9526	4.8647
Group 2 vs. Group 3	3.20467	0.54988	<0.001	1.7486	4.6607
Group 2 vs. Group 4	0.59333	0.54988	0.704	−0.8627	2.0494
Group 3 vs. Group 4	−2.61133	0.54988	<0.001	−4.0674	−1.1553
Between groups ANOVA			<0.001		

Table 3: ARI Scores for various groups

ARI Scores	Group 1	Group 2	Group 3	Group 4
1	1 (6.7%)	0 (0%)	0 (0%)	0 (0%)
2	2 (13.3%)	1 (6.7%)	2 (13.3%)	2 (13.3%)
3	7 (46.7%)	6 (40%)	5 (33.3%)	5 (33.3%)
4	3 (20%)	5 (33.3%)	5 (33.3%)	6 (40%)
5	2 (13.3%)	3 (20%)	3 (20%)	2 (13.3%)

hydrogen peroxide for bleaching. Abdulkareem *et al.*, explained that the insignificant effect of bleaching on the bond strength of ceramic brackets could be due to the following: (1) the presence of zirconia particles coating the bracket base creates millions of undercuts that secure the bracket in place, by micromechanical retention means, (2) due to the translucency that monocrystalline bracketsprovides, itgives a better chance for complete polymerization of the adhesive with light curing, (3) monocrystalline brackets are hard and offer great strength that prevents or reduces the peeling effects that may occur during brackets debonding, thus gives them high shear bond strength values.[10]

Most authors concluded that bleaching adversely affects the shear bond strength of orthodontic brackets when the bonding procedure is performed immediately or even if it is delayed by upto 1 month.[1,5–7,12,13]

Toko *et al*. have given a hypothesis according to which the adverse effect of hydrogen peroxide may be attributed to the removal of non-fibres organic content within the tooth substance.[14] Hydrogen peroxide has also been suspected to cause denaturation of proteins in the organic component of dentin and enamel, thus altering the organic–inorganic ratio with an increase in organic component.[14]

In contrast, Bishara *et al*. and Uysal *et al*. contraindicated the effect of bleaching on bond strength and reported no significant difference in bond strength of bleached and unbleached enamel when 10% carbamide peroxide or 35% hydrogen peroxide was used.[15-17] Mishima *et al*. and Oltu *et al*. in their studies have corroborated these findings.[18,19] Oztaş *et al*. also reported that bleaching agents that contain 20% carbamide peroxide did not affect the shear bond strength of metal and ceramic brackets when bonding was performed 24 hours or 14 days after bleaching.[20]

These variations in the results of various studies have been explained due to the difference in the post-bleaching period before the samples were tested for bond strength. Studies that reported no adverse effect of bleaching on bond strength evaluated bond strength after 24 hours to 30 days post-bleaching, which may have reversed any change due to bleaching.[15,17,20] Also, these studies have showed varying concentration of bleaching agents, which have resulted in difference in the results.Bishara *et al*. reported that a delay of at least 2 weeks is needed after bleaching for the tooth structure to regain its pre-bleaching adhesive properties.[16]

Bulut *et al*., Uysal *et al*., and Mishima *et al* reported that the bond strength that had been reduced post-bleaching was restored 30 days after the immersion of specimens in artificial saliva.[13,21,18] The recovery of reduced bond strength may have been caused by the removal of residual oxygen and residual peroxide or peroxide-related substances released from the bleached enamel during the immersion process. Firoozmand *et al*. reported a reduction in bond strength of polycrystalline ceramic brackets even after 14 days of bleaching.[22]

Although numerous studies have investigated extracoronal bleaching, we have found only few studies that investigated the effect of intracoronal bleaching treatment on the shear bond strength of metallic brackets bonded with orthodontic composites to enamel.[2–4,10,23] There are only a couple of studies that investigated the effect of intracoronal bleaching treatment on the shear bond strength of ceramic brackets bonded to enamel. One of these studies was done by Abdulkareem *et al*. who did their study on sapphire brackets and another study was done by Cakmak *et al*.[10,8]

ARI scores are used to define the site of bond failure between the enamel, adhesive, and bracket base. Bond failures within the adhesive or at the bracket-adhesive interface are preferred because they decrease shear force stress at the enamel surface and increase the probability of maintaining an undamaged enamel surface.[9] ARI scores of our study indicated that the most common site of bond failure was at the bracket/adhesive interface or within the adhesive in all the groups except hydrogen peroxide group, which showed bond failure closer to the enamel/adhesive interface and the difference was not statistically significant. Bond failure at the bracket/adhesive interface and within the adhesive found in this study is similar to other studies evaluating bond strength to bleached enamel.[3]

Conclusions

Intracoronal bleaching significantly affected the shear bond strength of ceramic brackets even after 30 days of bleaching.Bleaching with sodium perborate affects shear bond strength more adversely than does other bleaching agents.Hydrogen peroxide and carbamide peroxide are the preferable agents where bleaching has to be followed by orthodontic bonding.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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