Dental Journal
Majalah Kedokteran Gigi

Dental Journal
(Majalah Kedokteran Gigi)
2024 March; 57(1): 45–49

Original article

Desensitizing agents' post-bleaching effect on orthodontic bracket bond strength

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ABSTRACT

Background: *Nowadays, many patients wanting to bleach and do orthodontic treatment simultaneously, in-office bleaching is more favorable because of the instant results. However, in-office bleaching procedures result in severe enamel surface demineralization and decreasing the attachment of the orthodontic bracket. Applying a desensitizing agent after in-office bleaching can remineralize the enamel surface. There are two types of desensitizing agents: Fluoride-based and non-fluoride-based.* ***Purpose:*** *This study aims to analyze the effect of applying fluoride-based and non-fluoride-based desensitizing agents after in-office bleaching on orthodontic brackets.* ***Methods:*** *Twenty-seven post-extraction upper premolars were divided into three groups (n=9): Control group, fluoride-based group, and non-fluoride-based group. The samples were subjected to an in-office bleaching procedure before a fluoride desensitizing agent was applied to the fluoride group and a non-fluoride desensitizing agent was applied to the non-fluoride group. Then, a brackets bonding procedure was performed on all samples. The samples were tested for shear bond strength (SBS), and the adhesive remnant index (ARI) was measured. The data was analyzed by a one-way analysis of variance on the SBS test, while the ARI scores were analyzed by the Kruskal–Wallis test.* ***Results:*** *The fluoride and non-fluoride groups showed a significantly increased SBS of the brackets after in-office bleaching ($P < 0.05$), with the fluoride-based desensitizing agent having the highest SBS score, while the ARI scores had an insignificant difference between all groups ($P > 0.05$).* ***Conclusion:*** *The application of desensitizing agents after in-office bleaching increased the metal brackets' SBS but could not change the ARI scores.*

Keywords: *adhesive remnant index; desensitizing agent; in-office bleaching; orthodontic bracket; shear bond strength*
Article history: *Received 9 February 2023; Revised 5 May 2023; Accepted 9 June 2023; Published 1 March 2024*

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INTRODUCTION

The high demand for dental aesthetics in society makes many people come to the dental clinic to get neat, white teeth.[1] This could create a situation where patients interested in bleaching treatment are also interested in orthodontic treatment.[2] Bleaching treatment and orthodontic treatment, carried out simultaneously, can reduce the bracket bond to the tooth enamel surface,[3] especially with in-office bleaching procedures because of the high concentration of hydrogen peroxide (35–40%).[4] Higher levels of hydrogen peroxide in bleaching gel whiten teeth faster, meaning that in-office bleaching is preferred by the public over home bleaching, which uses a lower concentration of hydrogen peroxide.[5]

Hydrogen peroxide as a bleaching agent can demineralize the morphology of tooth enamel because of changes in the mineral content and protein of the enamel.[1] Demineralized tooth enamel makes the enamel surface brittle, weakening its ability to withstand the forces between the bracket and tooth enamel.[3] Brackets that are easily detached during orthodontic treatment can prolong treatment time and reduce the quality of treatment.[6]

Desensitizing agents work through a remineralization mechanism. Using desensitizing agents after in-office bleaching can strengthen the surface structure of tooth enamel and potentially increase bracket bond strength to tooth enamel.[1] Based on the content of the desensitizing agent, it can be divided into two categories, namely, fluoride-based and non-fluoride-based. Fluoride-based

DOI: 10.20473/j.djmkg.v57.i1.p45–49

desensitizing agents contain casein phosphopeptide-amorphous calcium fluoride phosphate (CPP-ACFP), while non-fluoride-based desensitizing agent contains casein phosphopeptide-amorphous calcium phosphate (CPP-ACP).[7] Both types of desensitizing agents have the same function, which is to restore the lost mineral composition of teeth.[8]

Using a non-fluoride-based desensitizing agent after in-office bleaching will reform hydroxyapatite (Ca5(PO4)3OH) in the enamel prism lost due to the in-office bleaching procedure. In contrast, using a fluoride-based desensitizing agent after in-office bleaching will convert hydroxyapatite into fluorapatite (Ca5(PO4)3F) by substituting OH ions with F ions. Fluorapatite has a harder nature than hydroxyapatite, increasing resistance to acid dissolution.[9] Fluorapatite's stronger structure provides the advantage of potentially reducing the risk of enamel fracture, making orthodontic brackets more easily detached.

The light-activated glass ionomer cement (GIC) has good adhesion as a cementation material after the desensitization procedure because of its ability to bond to teeth through mechanical and chemical bonds.[11] Chemical bonding of GIC occurs due to the bonding of carboxylic ion (COO^-) from polyacrylic acid powder with Ca^{2+} ions from hydroxyapatite crystals on tooth enamel.[12] GIC provides a slow release of fluoride that helps increase the remineralization process after bleaching, and it does not require etching material that would make tooth enamel more demineralized. Therefore, it is recommended to use GIC to cement brackets post-bleaching.[13]

Along with the development of materials in dentistry, it is necessary for these materials to be evaluated. The shear bond strength (SBS) test is one of the tests that is often used to analyze the attachment of dental materials to teeth.[14] Bracket bond strength can also be evaluated by measuring the adhesive remnant index (ARI) to determine the attachment failure between the bracket and a tooth.[15] The bracket separating from the enamel surface causes morphological changes when compared to the enamel's condition before the bracket was placed. The morphology of the enamel can be observed with a scanning electron microscope (SEM).[16, 17]

Based on this description, the researcher intends to test the effect of fluoride and non-fluoride-based desensitizing agents after in-office bleaching on the bond strength of metal brackets with light-activated GIC cementation. The tests carried out are the SBS test, measurement of ARI scores, and observation of enamel morphology after the bracket SBS test using SEM.

MATERIALS AND METHODS

This type of research is laboratory experimental. The research design and materials were reviewed and approved by the ethics committee of the Faculty of Dentistry—Prof. Soedomo Dental Hospital, Universitas Gadjah Mada No.144/KE/FKG-UGM/EC/2022. The samples used for this study were 27 post-extraction upper premolar teeth. The samples were trimmed using a dental micromotor (Strong, Korea) on the dental root tip with the length of the cementoenamel junction to the bottom of the tooth along 7 mm; then, samples were fixed with self-cured acrylic (Hilon, England) with a size of 25 mm x 25 mm x 6 mm. All samples underwent a bleaching procedure (SDI, Australia) and were divided into three groups, with nine samples in each group.

The first group is the control group, which went without a desensitizing agent after the in-office bleaching procedure; the second group is the fluoride group, which was given a fluoride-based desensitizing agent (GC, Japan) after the in-office bleaching procedure; and the third group is non-fluoride group, which was given a non-fluoride based desensitizing agent (GC, Japan) after the in-office bleaching procedure. In the final stage, all samples were attached with orthodontic metal brackets (Orto Technology, USA) with light-activated GIC cementation (GC, Japan).

The first test is the SBS test, and the test value was obtained with the universal testing machine (UTM) (Pearson Panke Equipment, England). All samples were placed in a fixation table with the blade's position right on the bracket gap and perpendicular to the bracket surface with a machine loading speed of 1 mm/minute (Figure 1). The machine was operated until the bracket separated from the teeth, and the amount of force used (newtons) was recorded. The magnitude of the force obtained (newtons) is divided by the surface area of the bracket base (in square millimeters) so that the magnitude of the SBS will be measured in megapascals (MPa).

The second test is the ARI measurement. The measurement score was obtained through observation with a 10x magnification stereomicroscope (Olympus, Japan). The ARI score was measured using a scale of 1–5 (modified ARI) with a detailed score as follows: 1: All

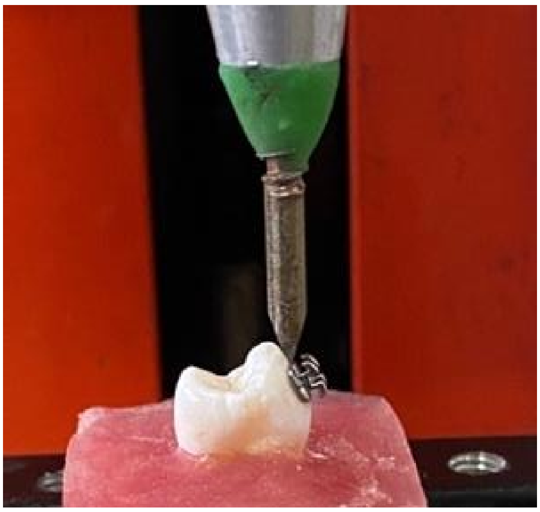

Figure 1. SBS test with a UTM.

DOI: 10.20473/j.djmkg.v57.i1.p45–49

adhesive material remaining on the teeth; score 2: > 90% adhesive material remaining on teeth; score 3: 10–90% adhesive remaining on the teeth; score 4: < 10% adhesive remaining on the teeth; score 5: There is no adhesive remaining on the teeth.[18] The last test was the observation of enamel morphology on one sample from each group using an SEM (Phenom, Netherlands) with a magnification of 10.000x.

RESULTS

The results of the SBS test obtained using a UTM for the three groups are displayed in Figure 2. The results of the SBS test between all groups showed significant differences ($P < 0.05$), which means the use of desensitizing agents after in-office bleaching affects the SBS, with the highest score found in the fluoride-based group.

The ARI scores were observed using a stereomicroscope (Figure 3 and Table 1). A higher ARI score indicates less adhesive material remaining on the teeth. The highest ARI score was found in the control group, with a mean score of 3.56, followed by the non-fluoride group, with a mean score of 3.33, and the lowest ARI score was found in the fluoride group, with a mean score of 3.11. However, no significant difference was found between the groups, meaning that the use of desensitizing agents after in-office bleaching does not affect the ARI score.

After performing the SBS test and separating the brackets, one sample from each group was observed for the enamel morphology structure. A representative sample from each group was taken to be observed using SEM

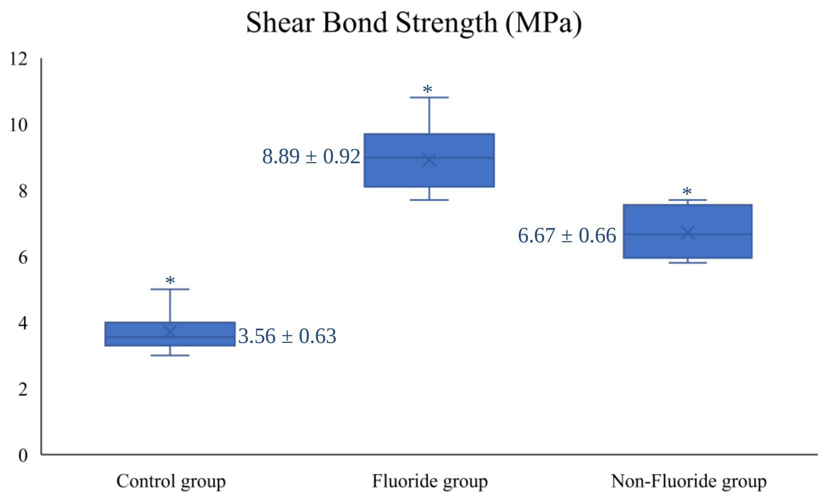

Figure 2. The average value of the samples SBS test (*: statistically significant difference, with $P < 0.05$).

Figure 3. Appearance of the tooth enamel surface after removing the bracket with a stereomicroscope (A: Control group; B: Fluoride group; C: Non-fluoride group).

Table 1. Percentage of ARI score analyzed by the Kruskal-Wallis test

Group	Adhesive Remnant Index (ARI)					
	Score 1	Score 2	Score 3	Score 4	Score 5	*P* value
Control group	0%	11.11%	22.22%	66.66%	0%	
Fluoride group	0%	22.22%	44.44%	33.33%	0%	0.435
Non-fluoride group	0%	22.22%	22.22%	55.55%	0%	

DOI: 10.20473/j.djmkg.v57.i1.p45–49

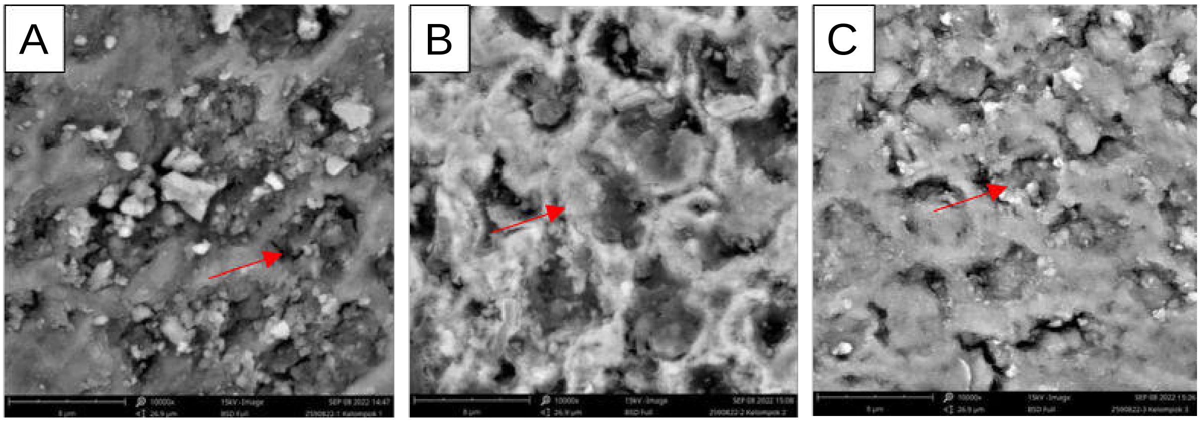

Figure 4. The results of observations on the morphology of tooth enamel after the SBS test of metal brackets were carried out using SEM with a magnification of 10.000x; red arrows indicate the porosity formed (A: Control group; B: Fluoride group; C: Non-fluoride group).

(Figure 4). Figure 4A shows the enamel morphology in the control group with the widest and deepest enamel porosity compared to the fluoride and non-fluoride-based groups. Figure 4B shows the morphology of tooth enamel with the application of a fluoride-based desensitizing agent, which causes remineralization in the form of fluorapatite; therefore, the outer layer looks whiter compared to Figure 4A. Additionally, Figure 4C showed the remineralization of hydroxyapatite in the non-fluoride-based group, resulting in smaller and shallower porosity than the other groups.

DISCUSSION

This study tested the efficacy of fluoride and non-fluoride desensitizing agents after in-office bleaching to increase the bond strength of metal orthodontic brackets to the enamel surface. This will allow better treatment for patients who choose simultaneous bleaching and orthodontic treatment. The SBS test was used to verify the attachment of brackets to the tooth enamel surface. The ideal bracket bond strength value for orthodontic treatment is 6–10 MPa.[19] Alterations of the enamel surface were observed after in-office bleaching, such as erosion, craters, and porosity,[20] which caused the decrease of SBS post-in-office bleaching.[21]

The results of the control group showed a significantly decreased SBS, consistent with previous findings.[3] Additionally, the control group viewed through SEM (Figure 4A) showed that the enamel surface had a darker surface and a wider, deeper porousness. The darker color of the enamel surface indicates the demineralization process that makes the enamel surface brittle, and the size of the porosity indicates the severity of demineralization. The brittle enamel surface made the SBS value low because the enamel surface could not hold the brackets when shear force was exerted.

Desensitizing agents work by strengthening the enamel surface through a remineralization process.[20] The results of the fluoride and non-fluoride-based groups showed a significant increase in SBS values. Figures 4B and 4C show a whiter enamel surface, indicating that the remineralization process has occurred, making the enamel prism stronger. The fluoride-based group had a higher SBS value than the non-fluoride group; based on the SEM views, the fluoride group (Figure 4B) showed a deeper porosity than the non-fluoride group (Figure 4C).

The cementation material used in this study worked through a physicochemical mechanism that required porosity to physically bond through the infiltration of organic components into the porous enamel surface, creating micro-mechanical retention.[22] Our results showing higher SBS values in the fluoride-based group than the non-fluoride-based group is relevant in this study because the porosity of the fluoride group on SEM view is more tangible than in the non-fluoride group. Therefore, less enamel porosity would result in less SBS.[23] Another reason for this result was the higher concentration of calcium ions on the enamel surface after applying CPP-ACFP than CPP-ACP.[24] The cementation material used was GIC, which bonded to enamel through a chemical mechanism with the calcium ions. Therefore, the fluoride-based group was capable of bonding with more ion calcium on the enamel surface, resulting in higher SBS values.

The ARI scores in this study were not significantly different, with most groups having an ARI score of 4, which means less than 10% of adhesive material remained on the enamel surface. This is because the base of the bracket has greater surface strength than the strength of the enamel surface after in-office bleaching, even after applying a desensitizing agent. Our results are similar to those of previous studies. The ARI scores only indicate adhesive and cohesive failures at the enamel-bracket interface and are not related to SBS scores; therefore, the strength of the tooth enamel surface is not the only factor that determines which adhesive will adhere better to the enamel surface, but the surface strength of the bracket base is also decisive.[25,26] ARI scores of 4 and 5 are clinically advantageous in the debonding process because this means less adhesive

DOI: 10.20473/j.djmkg.v57.i1.p45–49

adhering to the tooth, resulting in easier and faster removal and minimum destruction.[27, 28]

This study can conclude that desensitizing agents were able to increase the SBS of the orthodontic metal bracket post-in-office bleaching, with fluoride-based desensitizing agents having better SBS than non-fluoride-based desensitizing agents. The ARI scores were similar for all groups, meaning that adhesive materials adhere more to the bracket than the enamel surface. Based on this study, we recommend that clinicians should choose and apply a fluoride-based desensitizing agent post-in-office bleaching to optimize bracket bond strength in orthodontic treatment.

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DOI: 10.20473/j.djmkg.v57.i1.p45–49