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Website:
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DOI:
10.4103/jos.JOS_5_19

Effect of different bleaching treatment protocols on shear bond strength of bonded orthodontic brackets with no-primer adhesive resin

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Abstract:

BACKGROUNDS: Bleaching procedure can be companied before, during, or after orthodontic treatments. However, the risk of compromised bond strength of brackets to bleached enamels is in debate. This study tried to evaluate the shear bond strength (SBS) of bonded metal brackets to the previously bleached enamels.

MATERIALS AND METHODS: In this *in vitro* study, 60 extracted, sound, human premolars were mounted vertically in cylindrical molds. The samples were randomly divided into four groups ($n = 15$): Control (C); at-home bleached by 20% carbamide peroxide (HB); in-office bleached by 45% carbamide peroxide (OB); and in-office bleached by 40% hydrogen peroxide activated with diode laser (L-OB). Sixty stainless steel brackets were bonded by no-primer adhesive resin (OrthoCem). Then SBS of bonded brackets was measured after 5000 thermal cycles at 5°C and 55°C. Finally, the collected data were analyzed by one-way ANOVA, and Tukey HSD tests by using SPPS software at a significant level of 0.05 ($\alpha = 0.05$).

RESULTS: Group C showed significantly higher SBS values (all $P < 0.001$); however, there were no significant differences in SBS compared to other tests' groups with each other (all $P > 0.05$).

CONCLUSION: The SBS of bonded orthodontic brackets were compromised after bleaching with 20% and 40% of carbamide peroxide. Diode laser activation may not eliminate the negative effect of bleaching agents on SBS of bonded orthodontic brackets, neither.

Keywords:

Bleaching, carbamide peroxide, hydrogen peroxide, orthodontics, shear bond strength

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Submitted: 05-Feb-2019
Revised: 24-Mar-2019
Accepted: 25-Feb-2021
Published: 09-Jul-2021

Introduction

Irreversible and unaesthetic iatrogenic side effects of orthodontic treatments are some major issues that many clinicians are concerned about.[1] Plaque accumulation around brackets and tooth color changes are also some of these side effects that some patients complained usually.[2] Therefore, tooth bleaching is suggested by many clinicians to overcome or solve these problems as much as possible.[3] Up to now, several contemporary materials and techniques are proposed to bring about impressive and predictable esthetic outcomes. Hydrogen peroxide (HP), sodium perborate, and carbamide peroxide (CP) are some of these reliable bleaching agents that can be administered for both at-home and in-office bleaching procedures.[4-6] The basic difference between these materials used for in-office or at-home bleaching is that the CP in the latter contains carbopal that acts as an additive that thickens the bleaching material, improves adhesion, and prolongs the oxygen release of the peroxide.[6] Moreover, the bleaching agents used for in-office bleaching are in higher concentrations that are activated by either heat or light.[7]

How to cite this article: Sadeghian S, Garavand S, Davoudi A. Effect of different bleaching treatment protocols on shear bond strength of bonded orthodontic brackets with no-primer adhesive resin. J Orthodont Sci 2021;10:11.

Having this background in mind, the bleaching procedure can be administered before, during. or after orthodontic treatments. Lunardi *et al*.[8] evaluated the effect of applying bleaching agents on color changes during orthodontic treatments. They found significant color changes between enamel surfaces subjected to bleaching with that of untreated samples (control groups).[8] One good point is that, as soon as the esthetic properties of a patient's teeth are elevated, their enthusiasm for following orthodontic treatments and overall oral health care are increased, too.[4] Despite mentioned advantages, the risk of compromised bond strength of adhesively bonded brackets to bleached enamels is reported by some studies.[5,9,10] However, controversial reports are either available.[11,12] Bulut *et al*.[13] measured the shear bond strength (SBS) of metal brackets bonded to previously bleached enamel with 10% CP and they found a significant SBS decrease in bleached samples compared to the control groups.[13] In contrast, Oztas *et al*.[11] tried 20% CP for bleaching intervention and revealed no significant differences in SBS of metal and ceramic orthodontic brackets that were bonded to enamel after 24 hours or 14 days of bleaching.[11]

As controversial results are remaining, and the available researches seems to be spar with lack of novelty, the present study tried to evaluate the SBS of bonded metal brackets to the enamel that were bleached with conventional or laser-activated methods, then bonded with self-adhesive resin system. The null hypothesis is that different bleaching regimens do not have any effect on the SBS of bonded orthodontic brackets.

Materials and Methods

In this *in vitro* study, 60 extracted, sound, human premolars (maxillary and mandibular) were collected and stored in a 0.1% thymol solution. All of the teeth were observed to have intact buccal enamel; no pretreatment with any chemical agents; no cracks from forceps; no caries; and no restorations.

All the teeth were debrided, washed with distilled water, and mounted vertically in standardized, cylindrical molds filled with self-curing acrylic resin (HeraeusKulzer GmbH, Hanau, Germany) with exposed crowns; then they were stored in distilled water at 4°C for 3 days. Before any intervention, the enamel surfaces were polished with fluoride-free fine pumice (Glove Club Ltd, Greenford, UK) and water by using a slow-speed handpiece for 10 s.[14] The samples were randomly divided into four groups (n = 15) as follows:

Group C: Control group without any intervention that stored in artificial saliva (Hypozalix, Biocodex, France)

Group HB: At-home bleached samples by using 20% CP (Opalescence; Ultradent Product, Utah, USA) for 4 h each day for 7 days.

Group OB: In-office bleached samples by using 45% CP (Opalescence; Ultradent Product, Utah, USA) for 30 min.

Group L-OB: In-office bleached samples using 40% HP (Opalescence; Ultradent Product, Utah, USA) activated by diode laser irradiation (810 nm wavelength, 2.5 W) for 60 s from 1-mm distance.

All the bleaching procedures were in accordance with the manufacturer's instructions. To provide a situation that resembles the oral environment, all the specimens were stored in artificial saliva (Hypozalix, Biocodex, France) for 2 weeks before bracket bonding.[14]

Sixty stainless steel brackets (0.022 × 0.028; Roth, CA, USA), appropriate for premolar tooth, were used in this study. The enamel surfaces of each sample were polished again with fluoride-free fine pumice and water. Then the buccal surface of each tooth was etched with 37% phosphoric acid for 20 s, then rinsed and dried for 20 s until the enamel frosty pattern was emerged.[14,15] Each bracket was placed on the enamel surface and bonded by OrthoCem cement (FGM, Joinvile, Brazil) under light curing (Good Doctors Co, Incheon, Korea). After the bonding procedure, all samples were stored in an incubator (Dorsa, Tehran, Iran) at 37°C for 24 hours.[14] To mimic the daily biomechanical stress induced in oral environment, all samples were subjected to 500 thermal cycles (Dlta Tpo2, Mashhad, Iran) in two separate thermally controlled baths of streaming tap water maintained at 5°C and 55°C, respectively, with a dwell time of 10 s in each temperature.[14,16]

All the procedures, from sample preparing to end of bonding phase, was done by one researcher. Then all specimens were coded and the deboning procedure was done by another researcher in a complete blindness manner. The SBS measurement was accomplished using a universal testing machine (Walter + Bai, Lohningen, Switzerland) with crosshead speed of 1 mm/min with an applied load of 250 g. To avoid misalignment of the testing apparatus, a custom made, knife-edge shearing rod was used [Figure 1]. The specimens were secured and positioned precisely aligned toward the shearing blade by using the movable platform. The long axis of the bracket was positioned parallel to the plunger of the testing machine. The load was applied until complete debonding of the brackets was recognized and the force-to-failure value was calculated regarding the area of the bracket base and recorded in megapascals (MPa).

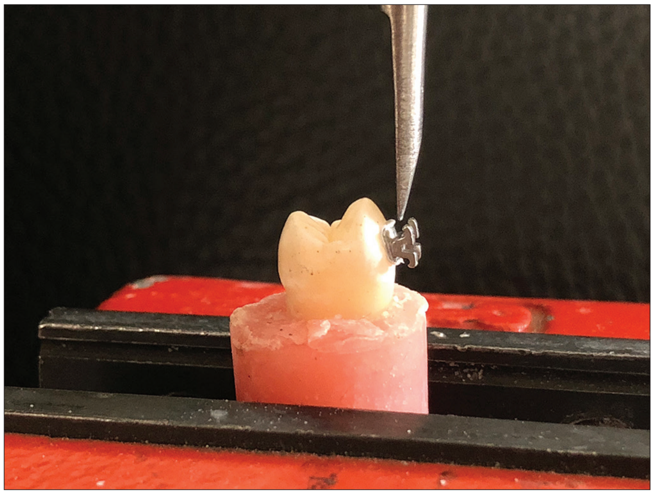

Figure 1: Mounted sample in the universal testing machine with a knife-edge rod

Finally, the collected data were analyzed by Kolmogorov Smirnov, One-way ANOVA, and Tukey HSD tests by using SPPS software version 21 at a significant level of 0.05 ($\alpha = 0.05$).

Results

As the normality of collected data, analyzed by Kolmogorov–Smirnov test, were insignificant ($P > 0.05$), one-way ANOVA was used that showed significant differences in SBS values of study groups ($P < 0.001$).

Descriptive data analysis of each group is shown in Figure 2. The highest and lowest mean SBSs were observed in groups C (12.40 ± 2.00 MPa) and OB (6.62 ± 1.12 MPa), respectively. The maximum and minimum reported SBSs were observed in groups C and L-OB with 15.04 and 4.01 MPa, respectively.

Pair-wise comparison of study groups was done with Tukey HSD [Table 1]. According to the analyzed data, group C showed a significant difference in SBS values with other three groups (for all, $P < 0.001$), however, there were no significant differences in SBSs of three tests' groups with each other exclusively (for all, $P > 0.05$). To be more precise, although no significant differences were reported by statistical tests, HB (7.45 ± 1.80 MPa) and L-OB (7.39 ± 2.16 MPa) groups showed higher SBS values than OB (6.62 ± 1.12 MPa). Despite no significant difference ($P = 1.00$), the HB group (7.45 ± 1.80 MPa) showed slightly higher SBS values than L-OB group (7.39 ± 2.16 MPa).

Discussion

Bonding of orthodontic brackets is so critical because of biomechanical importance of a stable bracket during orthodontic treatments. Nowadays, many bleaching

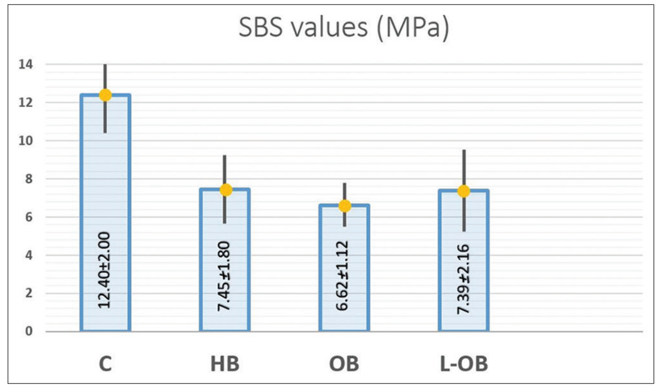

Figure 2: Mean and standard deviation SBS values of study groups

Table 1: Pair-wise comparison of study groups by means of *P* reports

Groups	HB	OB	L-OB
C	0.001	0.001	0.001
HB	-	0.59	1.00
OB	-	-	0.65

products are available and bracket bonding to bleached enamel have become to a hot topic among researchers, lately. Present study tried to evaluate different bleaching regimens, especially laser activated ones, on SBS of orthodontic brackets. Also, a new no-primer adhesive resin cement (OrthoCem) was used to make advantage of simple and reliable bonding procedure with low risk of contaminated bonding. Besides that, it contains sodium fluoride which can eliminate enamel decalcification and prevents white spot formation.[17] According to the available results, this new cement did not show any significant differences with other conventional resin cements in providing adequate SBS for orthodontic brackets.[17]

Relying on analyzed data, the defined null hypothesis was rejected as all of the bleaching protocols decreased the SBS of brackets significantly. Titley *et al*.[18] observed significant differences in the interface of resin-bleached and resin-unbleached enamels. Extensive areas of denuded enamel and segmented resin tags with undefined borders were found in bleached samples.[18] These resin tags with shallow penetration into roughened enamel might be the reason for lower SBS compared to unbleached samples. They also found existence of some bubbles and granules in bleached enamel–resin interface during their SEM observation.[19] They claimed a reverse correlation between the number of bubbles and final bond strength values. They believed trapped bubbles are originated from oxygen molecules from the oxidation of peroxide agents in the subsurface of bleached enamel.[18] Besides these findings, reduction in the amount of calcium ion, and organic composition change of the enamel are other contributing factors in the reduction of SBS of bleached enamel.[20] In the present study, CP was used in HB and OB groups. Relying on available articles, CP releases oxygen-free radicals responsible for breaking the complex molecules into smaller byproducts and finally whitening the tooth color.[21] The existence of these byproducts in the surface and subsurface of enamel may act as a retarded for resin polymerization of resin components and reduced final bond strength value.[21] Moreover, it is believed that CP causes some morphological changes on the enamel surface that may compromise the final bonding strength of polymerized resin.[22]

The minimum acceptable SBS of bonded brackets to teeth is recommended to be 6–8 MPa,[21] and the optimum SBS to prevent deboning is reported as 14 MPa.[23] In the present study, the lowest (6.62 MPa) and highest (12.42 MPa) SBS values were in the standard range. Also, the present study revealed that HB caused higher SBS values compared to OB and L-OB groups but with no significant differences. These results are in accordance with some studies that reported higher SBS of HB samples compared to OB ones,[24,25] but it is different in another aspect as they stated no significant differences between HB group with that of the control group.[24] Most of these studies that compared both HB and OB on SBS of orthodontic brackets used 10% CP for HB and >30% CP or HP for OB.[24,25] However, 20% and 45% CP were applied for HB and OB in this study, respectively. That might be the main reason for the differences between the present study and mentioned researches as they found 10% CP did not influence the SBS negatively.[24] To comprehend more, Soares *et al*.[26] compared the effect of a 16% and 10% CP on mineralized content and morphological change of enamel surface. Their final results from energy-dispersive x-ray spectroscopy and atomic force microscopy analyses showed an intense adverse effect of 16% CP on enamel surfaces.[26]

One of the novelties in the present study was applying laser irradiation for bleaching as this contemporary technology is getting more widespread days and days. It is hypothesized that bleaching regiments activated with laser irradiation would not negatively affect the enamel properties.[27] Most of the recent studies on SBS of bonded orthodontic brackets used Nd; YAG[27] or Er; YAG[28] for bleaching, however, diode laser was applied in the present study, which is less invasive than other laser irradiants. Akin *et al*.[27] evaluated the effect of 35% HP, non-activated and activated by Nd: YAG laser, on SBS of orthodontic brackets and they found HP decreased the SBS values, with and without Nd: YAG laser activation.[27] Similar results were stated by Ozdemir *et al.* that irradiating Er; YAG laser on 38% HP is not preferable before orthodontic bracket bonding.[28] Nevertheless, the results of diode laser, obtained from the current study, on SBS of bonded brackets is not different from mentioned previous studies.

This study has some limitations such as applying only two concentrations of CP, applying only one laser irradiation devise for activation, and using only metal orthodontic brackets for bonding. Overall, the following findings can be concluded:

Bleaching with 20% and 40% CP reduced the SBS of bonded orthodontic brackets. Diode laser activation may not eliminate the negative effect of bleaching procedure on SBS of bonded orthodontic brackets.

At last, this study recommends researchers to applying different concentrations of CP with different activation protocols. Also, conducting a systematic review or meta-analysis is encouraged at this time.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

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