Original Article

Comparison of Shear Bond Strengths of Ceramic Brackets Using Either Self-etching Primer or Conventional Method After Intracoronal Bleaching

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ABSTRACT

Objective: To evaluate initial shear bond strengths (SBSs) of ceramic brackets using either a self-etching primer (SEP) or the conventional method (CM) after intracoronal bleaching with sodium perborate and distilled water.

Materials and Method: Eighty human incisors were divided into 4 groups according to bleaching and bonding procedures: group 1, bleaching was not applied and brackets were bonded with SEP; group 2, bleaching was not applied and brackets were bonded with the CM; group 3, intracoronal bleaching with sodium perborate was applied for 3 weeks and brackets were bonded with SEP; group 4, intracoronal bleaching with sodium perborate was applied for 3 weeks and brackets were bonded with the CM. The SEP (Transbond Plus) was applied as recommended by the manufacturer. After SEP application, ceramic brackets were bonded with light cure adhesive (Transbond XT). For the CM, the teeth were etched with 37% phosphoric acid. After etching, a thin uniform coat of primer (Transbond XT Primer) was applied and ceramic brackets were bonded with light cure adhesive (Transbond XT). The SBSs were measured after water storage for 30 days, after 1000 cycles of thermocycling between 5°C and 55°C. Bond failure location was determined with the adhesive remnant index (ARI).

Results: For the SEP method, there was no significant difference between the SBS values of the bleaching and nonbleaching groups. Furthermore, for the CM, the SBS value of the nonbleaching group was not significantly different from that of the bleaching group. The SBS values of the SEP method presented significant differences from the SBS values of the CM ($p < 0.001$). The SBS values of the SEP application decreased with and without bleaching. ARI scores did not show any significant difference between the groups ($p = 0.174$).

Conclusion: Intracoronal bleaching with sodium perborate and distilled water did not affect the SBS values of ceramic brackets. (*Turkish J Orthod* 2015;28:48–54)

KEY WORDS: Bond Strength, Ceramic Brackets, Intracoronal Bleaching, Self-Etching Primer

INTRODUCTION

The contamination of the pulp cavity, irrigants, root canal, and other restorative materials as well as pulpal injury may cause discoloration of endodontically treated teeth.[1] Intracoronal bleaching of the discolorized tooth is an option. Hydrogen peroxide, sodium perborate, and carbamide peroxide are agents that are widely used for intracoronal bleaching. 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.[2] Water-based sodium perborate paste has been reported to be less harmful to dental tissues.[3]

The data on the effect of bleaching agents on shear bond strengths (SBS) of orthodontic brackets are contradictory. Uysal *et al.*[4] reported that bleaching did not adversely influence the bond strengths of brackets bonded immediately after bleaching or 30

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days after bleaching. Conversely, Teixeira *et al.*[5] reported that nonvital tooth bleaching affected the resin/enamel SBS values when sodium perborate mixed with 30% hydrogen peroxide was used.

Recently, acid-etch primers have gained significant attention. A self-etching primer (SEP) combines the etching and priming steps, eliminating the need for distributing, etching, rinsing, and drying. In addition, an SEP can be actively used to bond orthodontic brackets and can work as a practical alternative to the conventional 2-stage bonding system.[6] Several *in vivo* studies were published concerning the rates of bond failure with the conventional method (CM) and SEP.[7–12] Asgari *et al.*[8] and dos Santos *et al.*[11] reported significantly lower bond failure rates with SEP than with CM. Conversely, Ireland *et al.*[9] and Murfitt *et al.*[12] found significantly higher failure rates with SEP than with CM. On the other hand, Cal-Neto and Miguel[10] and Aljubouri *et al.*[7] did not observe any significant differences between the failure rates of SEP and CM bonds at the end of a 6-month and a 12-month observation period.

Ceramic orthodontic brackets were introduced in 1987 as a more esthetic alternative to stainless steel brackets.[13] Ceramic brackets demonstrate superior esthetics, biocompatibility, and resistance to physical and chemical factors and are reported to have greater or equal bond strength as stainless steel brackets.[14,15] A review of the literature found no studies on the effect of intracoronal bleaching treatments on the bond strength of ceramic brackets bonded with composites to enamel.

The aim of this *in vitro* study was to evaluate the initial SBSs of ceramic brackets using either SEP or CM after intracoronal bleaching with sodium perborate/distilled water and to determine the adhesive remnant index (ARI) scores of ceramic brackets bonded with SEP and CM.

MATERIALS AND METHOD

Eighty noncarious, freshly removed single-rooted mandibular incisors were used. The buccal surfaces were intact. Teeth with cracks, gross irregularities of the enamel structure, and histories of pretreatment with a chemical agent such as alcohol, formalin, or hydrogen peroxide were not included.

After extraction, the teeth were kept in distilled water until they were used. The water was changed weekly to avoid bacterial growth. The buccal surfaces were polished with a rubber cup and slurry of pumice and water, rinsed with water spray, and dried with compressed air.

Bleaching Procedures

The samples were randomly divided into 4 groups with 20 teeth in each group. The specimens in groups 1 and 2 did not receive any bleaching agent. Specimens in groups 3 and 4 received intracoronal bleaching with sodium perborate and distilled water. The bleaching procedure was as follows.

An endodontic access cavity was prepared with a round diamond bur (Diatech, Coltene Whaledent, Altstatten, Switzerland) and a high-speed hand piece under water cooling. The root canal was prepared by using ProTaper (Dentsply-Maillefer, Ballaigues, Switzerland) nickel-titanium rotary instruments up to a size F3; an irrigation of 2.5% sodium hypochloride was provided between each file. Final irrigation was applied with saline solution, and the root canal was dried with sterile paper points. The canal was filled with AH26 (Dentsply, DeTrey, Konstanz, Germany) sealer and ProTaper F3 gutta-percha by using a single-matched cone. The cervical third of the canal was prepared with Gates-Glidden drills (Dentsply Maillefer, Ballaigues, Switzerland). Approximately 2 mm of light-cured glass ionomer base (Ionoseal, Voco GmbH, Cuxhaven, Germany) was placed coronal to the gutta-percha in the canal before the bleaching agent was inserted into the pulp chamber to prevent apical leakage of the agent.

The intracoronal bleaching agent was then inserted to fill the pulp chamber, and a coronal seal was provided with light-curing glass ionomer cement. The bleaching agent was changed every 7 days for 3 weeks. When the bleaching was completed, the access cavity was permanently sealed with composite resin restoration (Filtek Z250, 3M ESPE, St Paul, MN, USA).

Brackets

Eighty identical ceramic mandibular incisor brackets (Clarity, 3M Unitek, Monrovia, CA, USA) were used for all of the experimental groups. The mean area of each bracket's base was 8.65 mm^2, according to the manufacturer.

In groups 1 and 3, SEP was applied to the enamel surface and rubbed for 3 seconds. Then, a gentle burst of dry air was delivered to thin the primer. The adhesive resin (Transbond XT, 3M Unitek) was placed onto the bracket base, and the bracket was positioned on the enamel surface. Excess adhesive resin was removed with an explorer. Polymerization

Table 1. Shear bond strength values (MPa) and comparison of these values between 4 groups with Kruskal-Wallis test[a]

	Minimum	Maximum	Median	Mean	SD	Mean Rank	*df*	χ^2	*p*
Group 1 (nonbleaching.SEP)	8.92	31.83	15.80	17.6058	6.77195	26.83	3	30.191	0.00000126
Group 2 (non-bleaching.CM)	14.72	32.72	25.65	25.3919	4.66709	56.33			
Group 3 (bleaching.SEP)	11.91	22.61	16.82	17.1503	3.43217	25.73			
Group 4 (bleaching.CM)	15.70	30.59	20.94	24.5954	4.89264	53.13			

[a] CM, conventional method; SEP, self-etching primer.

for a total of 20 seconds from 2 directions using a visible light-curing unit having an output power of 600 mW/cm^2 was performed.

In groups 2 and 4, bonding was performed with the CM, the teeth were etched with 37% phosphoric etchant liquid gel (3M ESPE) for 30 seconds, rinsed, and dried. After etching, a thin uniform coat of primer (Transbond XT Primer, 3M Unitek) was applied. The adhesive resin (Transbond XT Light Cure Adhesive Paste, 3M Unitek) was placed onto the bracket base, and the bracket was positioned on the enamel surface. Bonding with Transbond XT adhesive resin was performed as for SEP.

Debonding Procedure

Thirty days after the bracket bonding, thermocycling was performed between 5°C and 55°C, with a dwell of 30 seconds, as recommended by the International Organization for Standardization.[16] After 1000 thermal cycles, the samples were debonded.

The samples were embedded into cold-cure acrylic resin (Orthocryl, Dentaurum, Ispringen, Germany) cylindrical blocks (31 $\times$ 15 mm) before the shear bond test.

The shear bond test was performed with a universal testing device (Lloyd LRX; Lloyd Instruments, Fareham, UK). Each specimen was secured in the lower part of the machine so that the bracket base paralleled the direction of the shear force. The specimens were stressed in an occlusogingival direction with a cross-head speed of 1 mm/min.

Residual Adhesive

The enamel surfaces were examined with a stereomicroscope (Stemi 2000-C; Carl Zeiss, Göttingen, Germany) at a magnification of 10$\times$ to determine the amount of composite resin remaining according to the ARI.[17] The ARI scale has a range from 0 to 3: 0 indicates that no composite remains on the enamel; 1, less than half of the composite remaining; 2, more than half of the composite remaining; and 3, all composite remaining on the tooth surface.

Statistical Analysis

Statistical analyses were performed with SPSS 18.0 software (SPSS Inc, Chicago, IL, USA). Variables were expressed as median, minimum, and maximum. The ARI scores were compared using Pearson's chi-square test for groups. Kruskal-Wallis test was used to determine differences between the 4 groups for MPa variables. Bonferroni-adjusted Mann-Whitney *U* test was used for a post hoc test after the Kruskal-Wallis test. A *p* value of less than 0.05 was considered statistically significant for all tests.

RESULTS

Descriptive statistics for each group are presented in Table 1 and Figure 1. The Kruskal-Wallis analysis showed a significant difference among the groups ($p < .001$). Pairwise comparison with the Mann-Whitney *U* test showed that there was no significant difference between groups 1 and 3 (Table 2). Furthermore, group 2 was not significantly different from group 4. The SBS values of SEP presented significant differences from the SBS values of the CM ($p < .0083$). The SBS values of the SEP application decreased with and without bleaching.

Distributions of the ARI scores are given in Table 3 and Figure 2. A chi-square analysis indicated that there was no significant difference among the groups ($p = 0.174$).

DISCUSSION

Intracoronal bleaching of a discolored nonvital tooth is a widely used method in dental practice. Conservation of tooth structure and achievement of good esthetics are the most important aspects of internal bleaching; the procedure itself is cheap and easy to perform.[18] Particularly, adult patients demand a higher quality of esthetics and consider

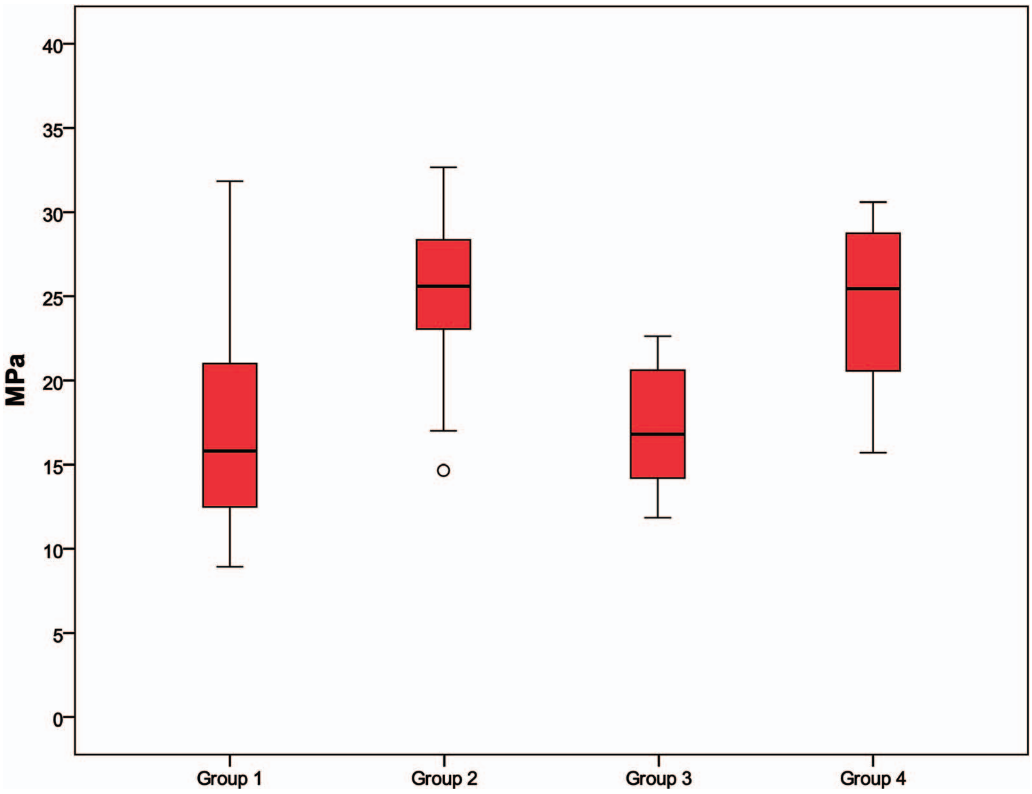

Figure 1. Box plot of the distribution of shear bond strength values for the 4 groups.

orthodontic treatment as a solution. Therefore, during the orthodontic treatment of adults, the possibility of experiencing an intracoronally bleached tooth is high.

The diffusion of an intracoronal bleaching agent into the dentin tubules directly affects the accomplishment of bleaching treatment. Although penetration of the bleaching agent into tubules is expected, Palo *et al.*[19] showed that sodium perborate in distilled water penetrated outward from the pulp chamber to the external root surface. Lewinstein *et al.*[20] indicated that intracoronal bleaching lowers the microhardness of dentin and enamel by the loss of calcium and alterations in the organic substance; these factors might be significant causes of the reduced strength of enamel bonds.

To our knowledge, the effect of sodium perborate on the SBS value of porcelain brackets has not been

Table 2. Pairwise comparison with the Mann-Whitney *U* test[a]

Group	N	Mean Rank	Sum of Ranks	U	P
Group 1 (Non-bleaching.SEP)	20	14.03	280.50	70.50	0.000460**
Group 2 (Non-bleaching.CM)	20	26.98	539.50		
Group 1 (Non-bleaching.SEP)	20	19.23	384.50	174.50	0.490314
Group 3 (Bleaching.SEP)	20	21.78	435.50		
Group 1 (Non-bleaching.SEP)	20	14.58	291.50	81.50	0.001348**
Group 4 (Bleaching.CM)	20	26.43	528.50		
Group 2 (Non-bleaching.CM)	20	28.95	579.00	31.00	0.000005***
Group 3 (Bleaching.SEP)	20	12.05	241.00		
Group 2 (Non-bleaching.CM)	20	21.40	428.00	182.0	0.626328
Group 4 (Bleaching.CM)	20	19.60	392.00		
Group 3 (Bleaching.SEP)	20	12.90	258.00	48.00	0.000039***
Group 4 (Bleaching.CM)	20	28.10	562.00		

[a] CM, conventional method; SEP, self-etching primer.
**$p < 0.001666$; ***$p < 0.0001666$.

Table 3. Frequency distribution and the results of the χ^2 analysis of the adhesive remnant index (ARI).[a]

	ARI Scores[b]			
	0	1	2	3
Group 1 (nonbleaching,SEP)	0	3	1	16
Group 2 (nonbleaching,CM)	0	0	3	17
Group 3 (bleaching,SEP)	2	4	4	10
Group 4 (bleaching,CM)	1	1	2	16

[a] $\chi^2 = 12.751$, $p = 0.174$. CM, conventional method; SEP, self-etching primer.
[b] Adhesive remnant index scores: 0 indicates no composite left on enamel surface; 1, less than half of composite left; 2, more than half of composite left; and 3, all composite left.

assessed. The effect of sodium perborate was evaluated during intracoronal bleaching on the SBS values of metallic brackets.[21] Nonvital bleaching with sodium perborate mixed with 30% hydrogen peroxide affected the resin/enamel SBS values.[22] Similarly, Shinohara *et al.*[23] reported that nonvital bleaching treatment with sodium perborate and distilled water adversely affected the SBS of composite resin for both enamel and dentin. On the contrary, Amaral *et al.*[24] reported that none of the bleaching techniques tested, including sodium perborate and distilled water, reduced the SBS of enamel. According to Uysal *et al.*,[25] a 30-day delay in bonding procedures after bleaching slightly improved the bond strength of orthodontic brackets, but not up to the levels of the unbleached group. In our study, the brackets were bonded 30 days after bleaching.

The effect of the intracoronal bleaching agent on the enamel surface is still unknown. Ari and Ungör[26] reported that sodium perborate should be mixed with water rather than with hydrogen peroxide in order to prevent or minimize the occurrence of bleaching-related surface alterations. According to our results, bleaching with sodium perborate and distilled water did not significantly affect the SBS. However, Gungor *et al.*[21] concluded that intracoronal bleaching significantly affected the SBS of orthodontic brackets on human enamel. Contradicting our results, they stated that bleaching with sodium perborate affected SBS more adversely than bleaching with hydrogen peroxide and carbamide peroxide agents. Nevertheless, the liquid mixed with sodium

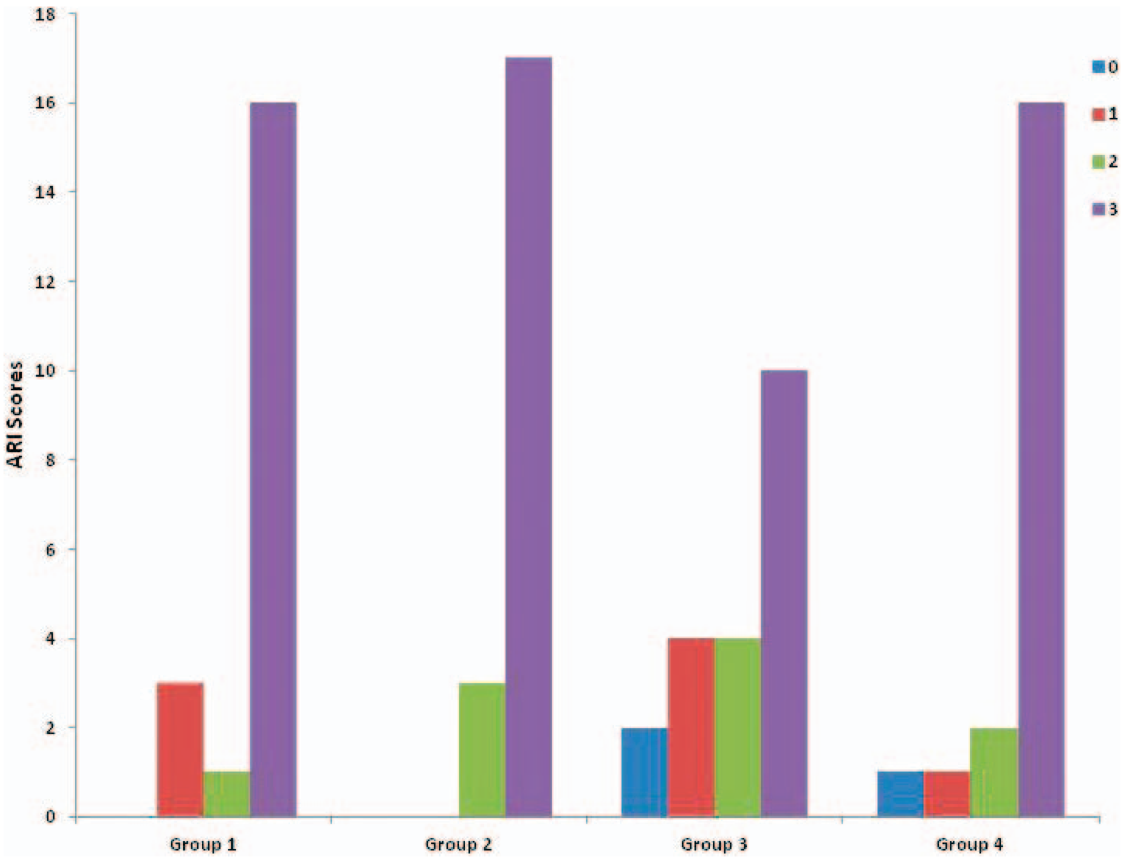

Figure 2. Column chart of adhesive remnant index scores for the 4 groups.

perborate was not stated in their study. The difference between the results of the 2 studies may be related to the liquid mixed with sodium perborate (ie, whether they mixed it with hydrogen peroxide instead of distilled water). Similar to our results, Teixeira *et al*.[5] observed no alteration in bond strength after bleaching with sodium perborate combined with distilled water. On the other hand, a reduction in SBS was reported only for the group bleached with a mixture of sodium perborate and hydrogen peroxide.

The bond strength of bracket can be effected by surface preparation techniques,[27] bonding technique,[28] and the type of bonding materials.[29] Similarly, our results demonstrated that the type of bonding agent is important for SBS. The only significant difference was recorded between the groups regarding the type of bonding.

CONCLUSION

- The results of this study showed that intracoronal bleaching with sodium perborate and distilled water did not affect the SBS values of ceramic brackets that were bonded 30 days after bleaching.
- Thus, the aforesaid mixture can be safely used before and/or during orthodontic treatment, if intracoronal bleaching is required.

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