TURKISH JOURNAL of ORTHODONTICS

DOI: 10.5152/TurkJOrthod.2016.15-00006R2

ORIGINAL ARTICLE

Comparison of the Shear Bond Strengths of Ceramic Brackets Using Either a Self-Etching Primer or the Conventional Method after Intracoronal Bleaching

Fethiye Çakmak Özlü[1], Sibel Koçak[2], Mustafa Murat Koçak[2], Selma Elekdağ-Türk[3], Tamer Türk[3]

[1]Department of Orthodontics, Bülent Ecevit University School of Dentistry, Zonguldak, Turkey
[2]Department of Endodontics, Bülent Ecevit University School of Dentistry, Zonguldak, Turkey
[3]Department of Orthodontics, Ondokuz Mayıs University School of Dentistry, Samsun, Turkey

ABSTRACT

Objective: To evaluate the 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.

Methods: Eighty human incisors were divided into four groups according to bleaching and bonding procedures: Group 1, bleaching was not applied and the brackets were bonded with a self-etching primer; Group 2, bleaching was not applied and the brackets were bonded with the conventional method; Group 3, intracoronal bleaching with sodium perborate was applied for three weeks and the brackets were bonded with a self-etching primer; and Group 4, intracoronal bleaching with sodium perborate was applied for three weeks and the brackets were bonded with the conventional method. A self-etching primer (Transbond Plus) was applied as recommended by the manufacturer. After SEP application, the ceramic brackets were bonded with a light-curing adhesive (Transbond XT). For the conventional method, the teeth were etched with 37% phosphoric acid. After etching, a thin uniform coat of primer (Transbond XT Primer) was applied and the ceramic brackets were bonded with a light-curing adhesive (Transbond XT). 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 SBS values of the bleaching and non-bleaching groups. Furthermore, for the conventional method, the SBS value of the non-bleaching group was not significantly different from that of the bleaching group. SBS values of the SEP method presented significant differences from those of the conventional method ($p<0.001$). SBS values of SEP application decreased with and without bleaching. The ARI scores did not show any significant difference among the groups ($p=0.174$).

Conclusion: Intracoronal bleaching with sodium perborate and distilled water did not affect the SBS values of ceramic brackets.

Keywords: Self-etching primer, intracoronal bleaching, ceramic brackets, bond strength

INTRODUCTION

The contamination of the pulp cavity, irrigants, root canal, and other restorative materials as well as pulpal injury may cause the discoloration of endodontically treated teeth.[1] Intracoronal bleaching of the discolorized tooth is an option to overcome this. 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 about the effect of bleaching agents on the shear bond strengths (SBS) of orthodontic brackets is contradictory. Uysal et al.[4] reported that bleaching did not adversely influence the bond strengths of brackets bonded

Corresponding Author: Dr. Fethiye Çakmak Özlü, Department of Orthodontics, Bülent Ecevit University School of Dentistry, Zonguldak, Turkey E-mail: ckfethiye@hotmail.com

Received: 15.01.2015
Accepted: 04.07.2015

immediately after bleaching or at 30 days after bleaching. Conversely, Teixeira et al.[5] reported that non-vital tooth bleaching affected the resin/enamel shear bond strength 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, SEP can be actively utilized to bond orthodontic brackets and can work as a practical alternative to the conventional two-stage bonding system.[6] Several *in vivo* studies have been 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 6-month and 12-month observation periods.

Ceramic orthodontics 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 bond strength greater than or equal to that of 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.

METHODS

Eighty non-carious, 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 four groups with 20 teeth in each group. The specimens in Groups 1 and 2 did not receive any bleaching agent, while 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. The 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 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 seven days for three 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, California, USA) were used for all the experimental groups. The mean area of each bracket's base was 8.65 mm^2, according to the manufacturer.

In Group 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, CA, USA) was placed onto the bracket base and the bracket was positioned on the enamel surface. Excess adhesive resin was removed with an explorer. Polymerization for a total of 20 seconds from two directions using a visible light-curing unit having an output power of 600 mW/cm^2 was performed.

In Group 2 and 4, bonding was performed with the conventional method (CM): the teeth were etched with 37% phosphoric etchant liquid-gel (3M ESPE, St Paul, MN, USA) for 30 seconds, rinsed, and dried. After etching, a thin uniform coat of primer (Transbond XT Primer, 3M Unitek, CA, USA) was applied. The adhesive resin (Transbond XT Light Cure Adhesive Paste, 3M Unitek, CA, USA) 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 x 15 mm) before the shear bond test.

Table 1. Shear bond strength values (MPa) and comparison of these values between four groups with the Kruskal–Wallis test

	Minimum	Maximum	Median	Mean	SD	Mean Rank	df	χ^2	p
Group 1 (Non-bleaching, 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			

SEP: self-etching primer; CM: convertional method; SD: standard devitaion

Table 2. Pairwise comparison with the Mann–Whitney U test

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		

p<0.008333; p<0.001666; p<0.0001666
SEP: self-etching primer; CM: convertional method

Table 3. Frequency distribution and the results of the χ2 analysis of the Adhesive Remnant Index (ARI)[a]

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

[a]χ^2=12.751, P=0.174
[b]ARI 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.
SEP: self-etching primer; CM: convertional method

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 was parallel to the direction of the shear force. The specimens were stressed in an occlusogingival direction with a crosshead 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 10x to determine the amount of composite resin remaining according to the adhesive remnant index (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 remains; 2, more than half of the composite remains; and 3, all the composite remains on the tooth surface.

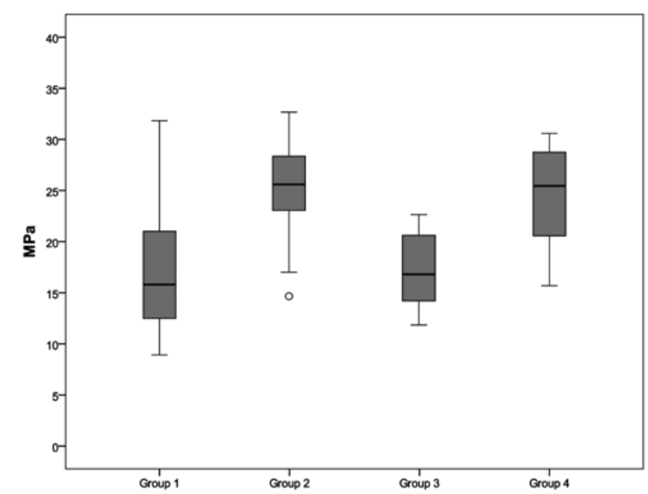

Figure 1. Box plot of the distribution of SBS values for the four groups

Statistical Analysis

Statistical analyses were performed with Statistical Packages for the Social Sciences 18.0 software (IBM SPSS Statistics; Armonk, NY, USA). Variables were expressed as the median, minimum, and maximum. ARI scores were compared using Pearson's chi-square test for the groups. Kruskal Wallis test was used to determine for differences between the four groups for MPa variables. Bonferroni adjusted Mann–Whitney U test was used for the post-hoc test after the Kruskal–Wallis test. A p value of less than 0.05 was considered statistically significant for all the 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 ($p<0.001$). 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. SBS values of SEP presented significant differences from the SBS values of the CM ($p<0.0083$). The SBS values of the SEP application decreased with and without bleaching.

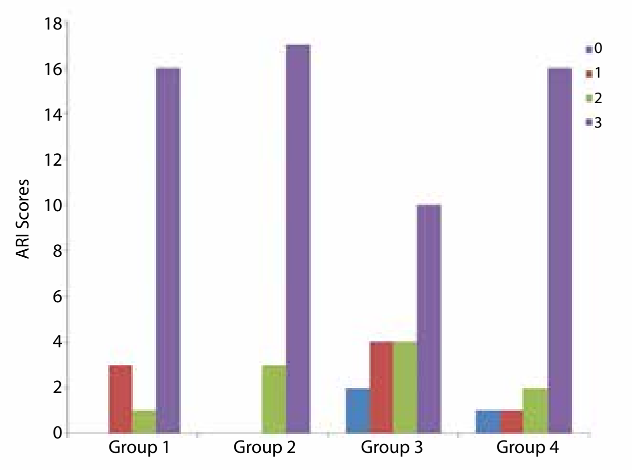

Figure 2. Column chart of ARI scores for the four groups
ARI: Adhesive Remnant Index

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 non-vital tooth is a widely used method in dental practice. Conservation of the 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] In particular, adult patients demand a higher quality of esthetics and consider 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 the best of our knowledge, the effect of sodium perborate on the SBS value of porcelain brackets has not yet been assessed. The effect of sodium perborate was evaluated during intracoronal bleaching on the SBS values of metallic brackets.[21] Non-vital bleaching with sodium perborate mixed with 30% hydrogen peroxide affected the resin/enamel SBS values.[22] Similarly, Shinohara et al.[23] reported that non-vital bleaching treatment with sodium perborate and distilled water adversely affected the SBS of composite resin for both enamel and dentin. Conversely, 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 Üngor[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. Contradictory to 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 perborate was not stated in their study. The difference between the results of the two studies may be related to the liquid mixed with sodium perborate (i.e., 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 brackets can be effected by the 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 the shear bond strength. 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.

Acknowledgement: The authors would like to thank to 3M Company for material support.

REFERENCES

1. Attin T, Paqué F, Ajam F, Lennon AM. Review of the current status of tooth whitening with the walking bleach technique. Int Endod J 2003; 36: 313-29. [CrossRef]
2. Plotino G, Buono L, Grande NM, Pameijer CH, Somma F. Nonvital tooth bleaching: a review of the literature and clinical procedures. J Endod 2008; 34: 394-407. [CrossRef]
3. Weiger R, Kuhn A, Löst C. In vitro comparison of various types of sodium perborate used for intracoronal bleaching of discolored teeth. J Endod 1994; 20: 338-41. [CrossRef]
4. Uysal T, Basciftci FA, Usumez S, Sari Z, Buyukerkmen A. Can previously bleached teeth be bonded safely? Am J Orthod Dentofacial Orthop 2003; 123: 628-32. [CrossRef]

5. Teixeira EC, Hara AT, Turssi CP, Serra MC. Effect of nonvital tooth bleaching on resin/enamel shear bond strength. J Adhes Dent 2002; 4: 317-22.
6. Elekdag-Turk S, Cakmak F, Isci D, Turk T. 12-Month Self-Ligating Bracket Failure Rate with a Self-Etching Primer. Angle Orthod 2008; 78: 1095-100. [CrossRef]
7. Aljubouri YD, Millett DT, Gilmour WH. Six and 12 months' evaluation of a self-etching primer versus two-stage etch and prime for orthodontic bonding: a randomized clinical trial. Eur J Orthod 2004; 26: 565-71. [CrossRef]
8. Asgari S, Salas A, English J, Powers J. Clinical evaluation of bond failure rates with a new self-etching primer. J Clin Orthod 2002; 36: 687-9.
9. Ireland AJ, Knight H, Sherriff M. An in vivo investigation into bond failure rates with a new self-etching primer system. Am J Orthod Dentofacial Orthop 2003; 124: 323-6. [CrossRef]
10. Cal-Neto JP, Miguel JA. An in vivo evaluation of bond failure rates with hydrophilic and self-etching primer systems. J Clin Orthod 2005; 39: 701-2.
11. dos Santos JE, Quioca J, Loguercio AD, Reis A. Six-month bracket survival with a self-etch adhesive. Angle Orthod 2006; 76: 863-8.
12. Murfitt PG, Quick AN, Swain MV, Herbison GP. A randomised clinical trial to investigate bond failure rates using a self-etching primer. Eur J Orthod 2006; 28: 444-9. [CrossRef]
13. Birnie D. Ceramic brackets. Br J Orthod 1990; 17: 71-4. [CrossRef]
14. Odegaard J, Segner D. Shear bond strength of metal brackets compared with a new ceramic bracket. Am J Orthod Dentofacial Orthop 1988; 94: 201-6. [CrossRef]
15. Joseph VP, Rossouw E. The shear bond strengths of stainless steel and ceramic brackets used with chemically and light-activated composite resins. Am J Orthod Dentofacial Orthop 1990; 97: 121-5. [CrossRef]
16. Dental Materials-Testing of Adhesion to Tooth Structure. Geneva, Switzer-land: International Organization for Standardization; 2003. ISO/TS 11405.
17. Artun J, Bergland S. Clinical trials with crystal growth conditioning as an alternative to acid-etch enamel pretreatment. Am J Orthod 1984; 85: 333-40. [CrossRef]
18. Abbott P, Heah SY. Internal bleaching of teeth: an analysis of 255 teeth. Aust Dent J 2009; 54: 326-33. [CrossRef]
19. Palo RM, Valera MC, Camargo SE, Camargo CH, Cardoso PE, Mancini MN, et al. Peroxide penetration from the pulp chamber to the external root surface after internal bleaching. Am J Dent 2010; 23: 171-4.
20. Lewinstein I, Hirschfeld Z, Stabholz A, Rotstein I. Effect of hydrogen peroxide and sodium perborate on the microhardness of human enamel and dentin. J Endod 1994; 20: 61-3. [CrossRef]
21. Gungor AY, Ozcan E, Alkis H, Turkkahraman H. Effects of different intracoronal bleaching methods on shear bond strengths of orthodontic brackets. Angle Orthod 2012; 82: 942-6. [CrossRef]
22. Teixeira EC, Hara AT, Turssi CP, Serra MC. Effect of nonvital tooth bleaching on resin/enamel shear bond strength. J Adhes Dent 2002; 4: 317-22.
23. Shinohara MS, Peris AR, Rodrigues JA, Pimenta LA, Ambrosano GM. The effect of nonvital bleaching on the shear bond strength of composite resin using three adhesive systems. J Adhes Dent 2004; 6: 205-9.
24. Amaral C, Jorge A, Veloso K, Erhardt M, Arias V, Rodrigues JA. The effect of in-office in combination with intracoronal bleaching on enamel and dentin bond strength and dentin morphology. J Contemp Dent Pract 2008; 9: 17-24.
25. Uysal T, Er O, Sagsen B, Ustdal A, Akdogan G. Can intracoronally bleached teeth be bonded safely? Am J Orthod Dentofacial Orthop 2009; 136: 689-94. [CrossRef]
26. Ari H, Ungör M. In vitro comparison of different types of sodium perborate used for intracoronal bleaching of discolored teeth. Int Endod J 2002; 35: 433-6. [CrossRef]
27. Demirtas HK, Akin M, Ileri Z, Basciftci FA. Shear-bond-strength of orthodontic brackets to aged nano-hybrid compositeresin surfaces using different surface preparation. Dent Mater J 2015; 34: 86-90. [CrossRef]
28. Flores T, Mayoral JR, Giner L, Puigdollers A. Comparison of enamel-bracket bond strength using direct- and indirect-bonding techniques with a self-etching ion releasing S-PRG filler. Dent Mater J 2015; 34: 41-7. [CrossRef]
29. Turk T, Elekdag-Turk S, Isci D, Cakmak F, Ozkalayci N. Saliva contamination effect on shear bond strength of self-etching primer with different debond times. Angle Orthod 2007; 77: 901-6. [CrossRef]