

Tooth Whitening Effects on Bracket Bond Strength In Vivo

Joseph M. Mullins^a; Elizabeth C. Kao^b; Chris A. Martin^c; Erdogan Gunel^d; Peter Ngan^e

ABSTRACT

Objective: To test the hypothesis that there is no difference between the bracket survival rate of brackets bonded to bleached and unbleached teeth.

Materials and Methods: Thirty-eight patients who required comprehensive orthodontic treatment were included in the study. A split mouth technique was used with one arch exposed to in-office whitening gel containing 38% hydrogen peroxide for 30 minutes, while the unbleached arch served as the control. Patients were divided into two groups: Brackets bonded within 24 hours after bleaching and brackets bonded 2–3 weeks after bleaching. The bracket survival rate was computed using the log-rank test (Kaplan-Meier Analysis).

Results: A significantly higher rate of bracket failure was found with bleached teeth (16.6%) compared with unbleached teeth (1.8%) after 180 days. Brackets bonded within 24 hours of bleaching resulted in significantly higher clinical failure (14.5%) compared with those bonded after 3 weeks (2.1%). Adhesive Remnant Index scores of failed brackets revealed that the majority of failure in bleached teeth occurred in the enamel/resin interface.

Conclusions: The hypothesis was rejected. Brackets bonded within 24 hours after bleaching have a significantly higher risk for bond failure. Orthodontic bonding should be delayed for 2–3 weeks if patients have a history of in-office bleaching with 38% hydrogen peroxide. (*Angle Orthod.* 2009; 79:777–783.)

KEY WORDS: Bleaching; Bond strength; Bracket survival rate

INTRODUCTION

Bleaching has been one of the most popular patient-requested procedures in dentistry. Teeth bleaching tends to improve self-image of both the younger and the older populations.^{1,2} Many orthodontic patients may have bleaching done at home or may be interested in having their teeth bleached at the time of orthodontic treatment. Few studies have reported on bleaching and its effects on orthodontic bonding.^{3–5}

However, no clinical study on bracket survival rate with bleaching has been documented in the literature to date. Most studies in restorative dentistry recommend a waiting period anywhere from 24 hours to 4 weeks after bleaching to complete any bonding procedure.⁴ However, there is no consensus on how long orthodontists should wait before bonding brackets to teeth that have been exposed to whitening agents.^{5,6}

Bleaching systems that are used at home commonly contain carbamide peroxide, which breaks down into hydrogen peroxide and urea in aqueous solution; with hydrogen peroxide being the active ingredient.⁷ For patients who value efficiency and instant results, a 35% to 38% carbamide peroxide or hydrogen peroxide preparation has also been available for in-office initiation, followed by an at-home bleaching regimen, with gels containing 10% to 20% carbamide peroxide. However, the rapid process of bleaching has been shown to increase the side effects of tooth sensitivity, gingival irritation, throat irritation, and nausea.^{8,9}

There are controversies surrounding the exact nature of how bleaching products work and how the morphology and structure of the bleached enamel surface may affect bond strength of orthodontic brackets.^{10–19} Several studies have found diminished tensile bond

^a Private practice, San Diego, Calif.

^b Professor, WVU School of Dentistry, Department of Restorative Dentistry, Morgantown, WV.

^c Associate Professor, WVU School of Dentistry, Department of Orthodontics, Morgantown, WV.

^d Professor, WVU Department of Statistics, Morgantown, Morgantown, WV.

^e Professor and Chair, WVU School of Dentistry, Department of Orthodontics, Morgantown, WV.

Corresponding author: Dr Peter Ngan, Department of Orthodontics, West Virginia University School of Dentistry, Health Science Center North, PO Box 9480, Morgantown, WV 26506 (e-mail: pngan@hsc.wvu.edu)

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strength with 30% hydrogen peroxide,^{20,21} whereas others have reported no reduction in bond strength.^{6,22-26} Cavalli et al²⁷ suggested that a period of up to 3 weeks is required between bleaching and bonding before resin-enamel bond strengths return to values obtained for unbleached enamel. The objectives of this study were to determine if enamel bleaching affects the in vivo survival rate of orthodontic brackets and if a waiting period before bonding improves the bracket survival rate for patients receiving enamel bleaching. We hypothesized that there is no difference in bracket survival rate between bleached and unbleached teeth; there is no difference in bracket survival rate between teeth that were bonded 24 hours after bleaching and those that were bonded 2-3 weeks after bleaching.

MATERIALS AND METHODS

Forty patients who received comprehensive orthodontic treatment in the Department of Orthodontics at the West Virginia University School of Dentistry were recruited for the study. Two subjects could not afford the orthodontic treatment and were eliminated from the study. The final sample consisted of 38 subjects. Criteria for selection include (1) a permanent maxillary and mandibular dentition; (2) treatment requiring comprehensive orthodontics; (3) no prior history of using tooth whitening agents; and (4) teeth without caries or large existing restorations. Informed consent and child assent were obtained. The age of the patients ranged from 12 to 17 years (mean age = 15.1 ± 1.8 years). A split mouth technique was used where one arch was used as treatment and the other arch with no treatment served as the patient's own control. Patients were randomly assigned to one of the four treatment groups:

Group 1: Ten patients had their maxillary arch bleached with Opalescence Xtra Boost (Ultradent, South Jordan, Utah) in-office tooth whitening gel (38% hydrogen peroxide) within 24 hours before bonding brackets with Transbond XT adhesive (3M Unitek, Monrovia, CA) or APC brackets precoated with Transbond XT using the conventional visual light cure (VLC) unit (Ortholux XT, 3M Unitek, Monrovia, CA).

Group 2: Eleven patients had their mandibular arch bleached 24 hours before bonding brackets.

Group 3: Seven patients had their maxillary arch bleached, but there was a time lapse of 3 weeks between the enamel bleaching and bonding of orthodontic brackets.

Group 4: Ten patients had their mandibular arch bleached, but there was a time lapse of 3 weeks

Table 1. Categorization of In Vivo Experimental Groups^a

Location	Time Before Bonding	Bleach	Group Name
Maxillary	24	Yes	U24
Mandibular	24	Yes	L24
Maxillary	2-3 weeks	Yes	U3W
Mandibular	2-3 weeks	Yes	L3W
Maxillary (control)	NA	No	UNB
Mandibular (control)	NA	No	LNB

^a U24 indicates maxillary arch bleached within 24 hours before bonding; L24, mandibular arch bleached within 24 hours before bonding; U3W, maxillary arch bleached 2-3 weeks before bonding; L3W, mandibular arch bleached 2-3 weeks before bonding; UNB, unbleached maxillary arch; LNB, unbleached mandibular arch; NA, not applicable.

between the enamel bleaching and bonding of orthodontic brackets.

All patients were given the same oral hygiene and diet instructions. Patients were followed up for bracket survival for a total of 6 months or approximately 180 days. The survived teeth were categorized into six groups for data analysis (Table 1). For example, patients assigned to Group 1 will have the survived teeth categorized in Group U24 for the maxillary arch and Group LNB for the mandibular arch.

Before the bleaching, all patients' teeth were compared to a VitaValue (Vita Lumin, Bad Sackingen, Germany) shade guide arranged according to its value to get a baseline shade. The VitaValue arrangement was as follows: B1, A1, B2, D2, A2, C1, C2, D4, A3, D3, B3, A3.5, B4, C3, A4, and C4. Bleaching was completed according the manufacturer's directions for Ultradent's Opalescence Xtra Boost gel. An Opal Dam or reflective resin barrier (Ultradent) was applied to protect the oral soft tissues. After the gel was applied it was light-cured with a VLC unit. The study arch was bleached for two 15-minute cycles. The Vita shade guide was again used to compare the postbleaching shade.

Teeth were pumiced, etched, and bonded with Transbond XT adhesive from the prepackaged syringe or with prepasted APC brackets. Etching was accomplished with Transbond plus soft etching primer. A premolar bracket was placed on the tooth surface with cotton forceps. An explorer was used to deliver a constant force to completely set the bracket. A 20-second exposure time (10 seconds mesial and 10 seconds distal) was used with the curing light (Ortholux XT). Any bracket failures were noted in the patient chart. The failed brackets were not rebonded but placed in separate envelopes and labeled to indicate the group in which the patient was included. The debonded brackets were later examined to determine where the failure occurred and analyzed for significant differences.

Table 2. Modified Adhesive Remnant Index (ARI) Scores

Score	Definition
0	No adhesive left on bracket
1	Less than 25% of adhesive left on bracket
2	25% of adhesive left on bracket
3	50% of adhesive left on bracket
4	75% of adhesive left on bracket
5	100% of adhesive left on bracket

es in Adhesive Remnant Index (ARI) scores (Table 2). The bracket survival rate was studied for a period of 6 months or 180 days and computed using Kaplan-Meier analysis. A log-rank test was applied to distinguish any significant differences in bracket survival rates according to the tooth, arch, location of bracket, bleaching, and bonding regimen.

RESULTS

A total of 760 teeth were followed up for 180 days. Of the 380 teeth that were not bleached, 98.2% of the brackets on the unbleached teeth survived (7 failures). Of the 380 teeth that were bleached, 83.4% of the brackets on the bleached teeth survived (63 failures, Figure 1). Significant differences were found between the survival rate of bonding to bleached and unbleached teeth ($P < .0001$). Bonding to unbleached

teeth yielded a significantly higher survival rate (Figure 2). A total of 56 bracket failures occurred in the mandibular arches and 14 occurred in the maxillary arches. Significant differences were found in the survival rate between the maxillary and mandibular arch ($P < .0001$). Bonding brackets to the maxillary arch had significantly higher survival rate than bonding to the mandibular arch. (Figure 3). A total of 8 bracket failures occurred in the bleached groups that had a time lapse of 2–3 weeks before bonding, and 55 brackets were lost in the bleached groups that were bonded within 24 hours of bonding (Figure 4).

Significant differences were found between the survival rate of bleaching 2–3 weeks after bleaching and 24 hours after bleaching ($P < .005$). Bonding brackets to teeth that are bleached 24 hours before bonding had significantly higher chance of bracket failure (Figure 5).

Significant differences were found in maxillary arches with bleaching done 24 hours before bonding compared with the control with no bleaching ($P < .001$). No significant differences were found between maxillary arches with bleaching done 2–3 weeks before bonding compared with the control ($P < .24$). No significant differences were found between maxillary arches with bleaching done 24 hours before bonding and those with bleaching done 2–3 weeks before

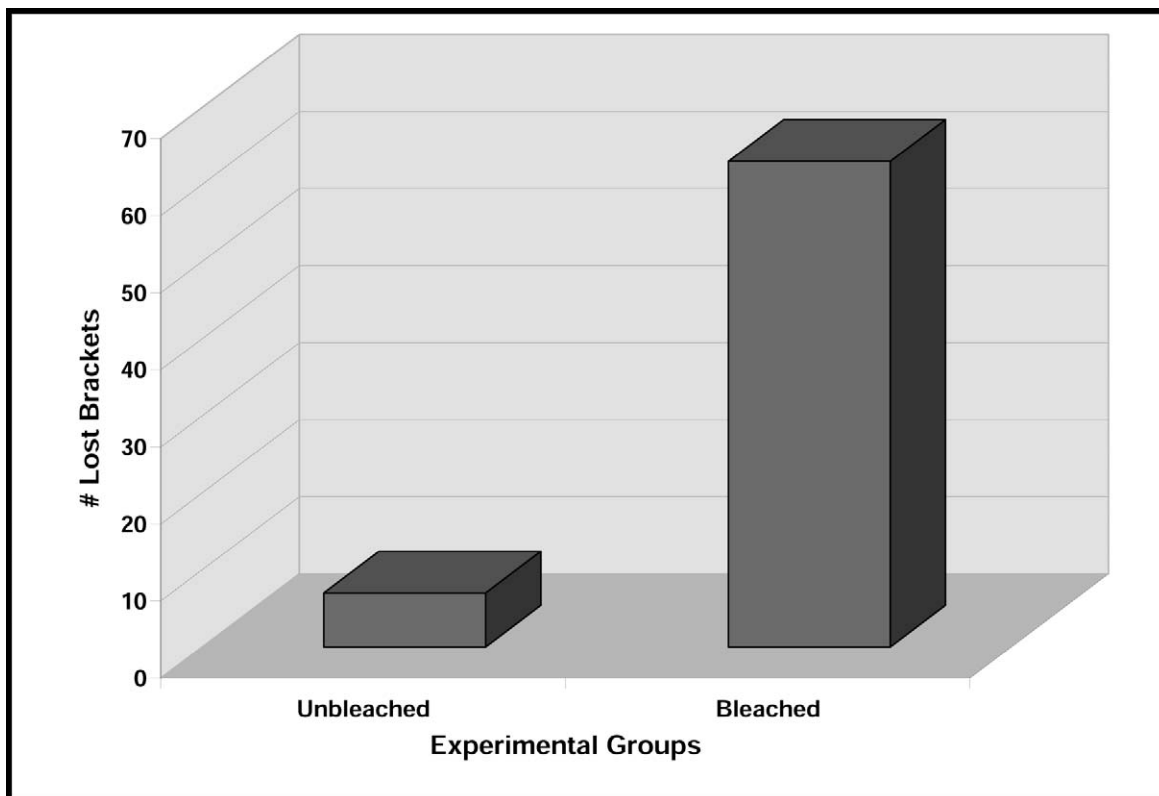


Figure 1. Comparison of bracket failures between bleached and nonbleached teeth.

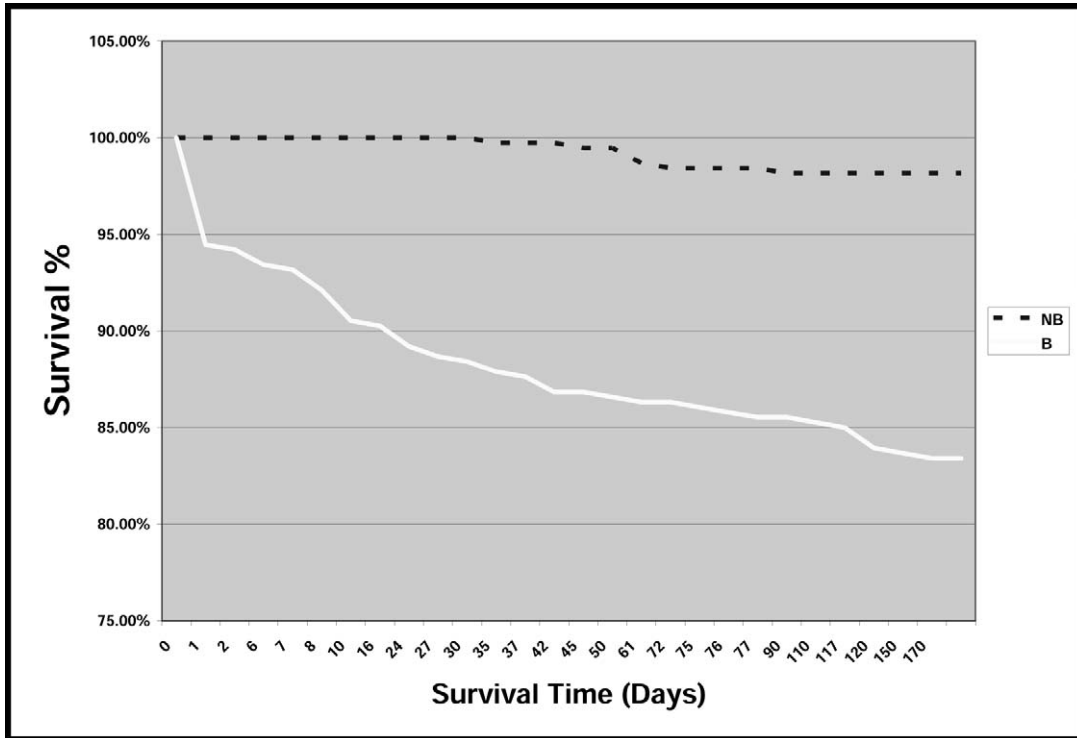


Figure 2. Survival plot comparing bracket failures of bleached and nonbleached teeth.

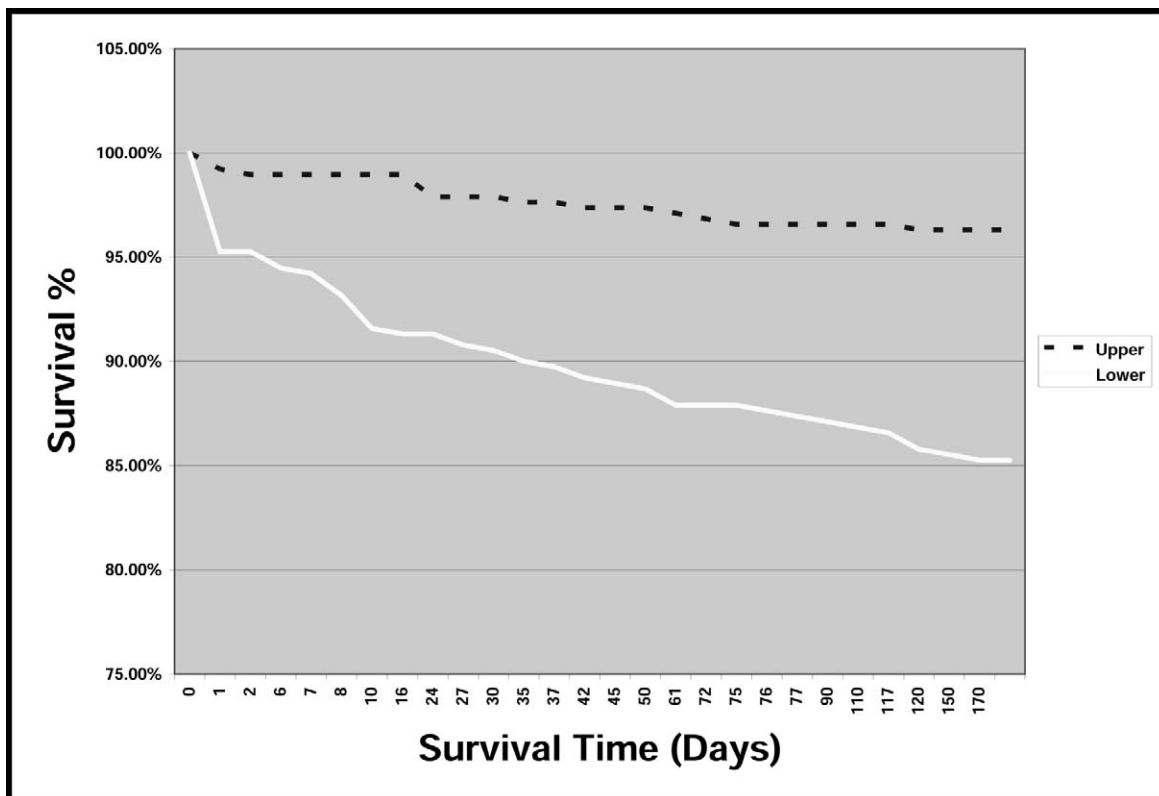


Figure 3. Comparison of bracket failures between teeth that were bleached 2–3 weeks and teeth that were bleached 24 hours before bonding.

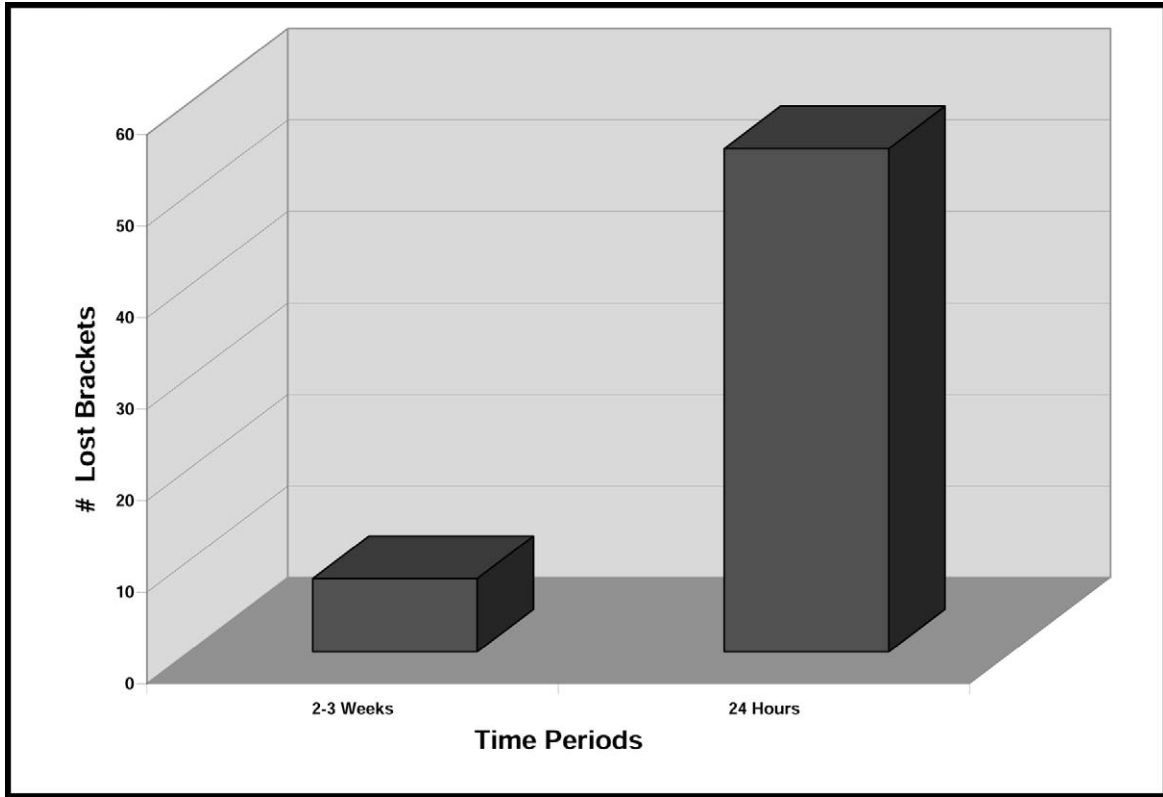


Figure 4. Survival plot comparing bracket failures in the maxillary and mandibular arches.

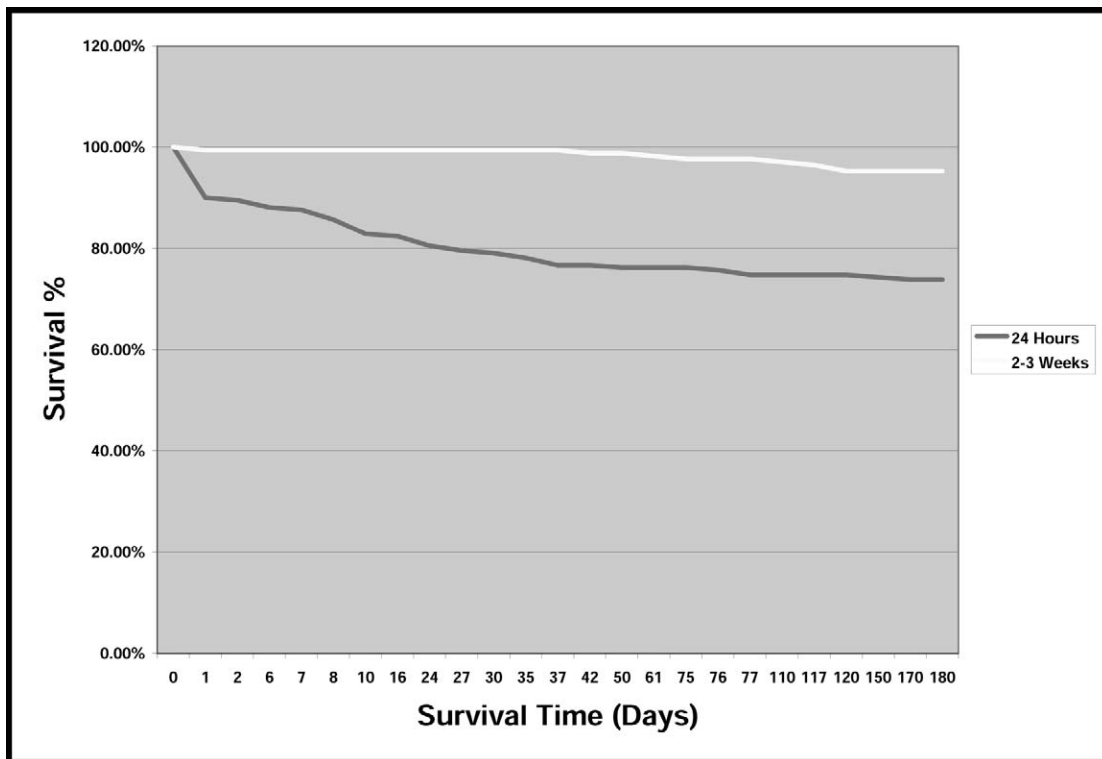


Figure 5. Survival plot comparing bracket failures of teeth that were bleached 2–3 weeks and teeth that were bleached 24 hours before bonding.

bonding ($P < .07$). Bonding brackets to maxillary teeth 24 hours before had higher chance of bracket failure but the difference was not statistically significant.

Significant differences were found between mandibular arches with bleaching done 24 hours before bonding compared with the control group with no bleaching before bonding ($P < .001$). A significantly lower survival rate was found with mandibular brackets bonded 24 hours after bleaching than with no bleaching. Significant differences were also found between mandibular arches with bleaching done 24 hours before bonding and those with bleaching done 2–3 weeks before bonding ($P < .001$). A significantly lower survival rate was found with mandibular brackets bonded 24 hours after bleaching compared with those bonded 2–3 weeks after bleaching. No significant differences were found between mandibular arches with bleaching done 2–3 weeks before bonding compared with the control group with no bleaching ($P = .22$).

No significant differences were found between maxillary arches with bleaching done 2–3 weeks before bonding and mandibular arches with bleaching done 2–3 weeks before bonding ($P = .33$).

Significant differences were found between maxillary arches with bleaching done 24 hours before bonding and mandibular arches with bleaching done 24 hours before bonding ($P < .001$). A significantly lower survival rate was found with mandibular brackets bonded 24 hours before bonding compared with rates for the upper arch. No significant differences were found between maxillary arches with no bleaching before bonding and mandibular arches with no bleaching before bonding ($P = .15$).

Brackets collected from the bleached teeth had a mean ARI score of 5.0 ± 0 , indicating that most of the bracket failure occurred at the enamel/resin interface. The sample size of the failed brackets collected was too small to justify a statistical analysis.

DISCUSSION

All teeth that were bleached with 38% hydrogen peroxide had an average change in shade guide of 2 to 3 shades in one office visit. The survival rate seemed to be dependent on the time lapse between bleaching and bonding and dependent on the location in the mouth. The unbleached arches had significantly higher survival rates than bleached arches within 24 hours before bonding. All unbleached arches and those bleached 2–3 weeks before bonding had a significantly higher survival rate than those bleached within 24 hours before bonding. This is in agreement with the *in vitro* study that reported a recovery of bond strength after a waiting period of up to 3 weeks.²⁷ Uysal et al^{24,28} compared the bond strength of bleaching treatment

performed immediately before bonding and 30 days before bonding and found significant reduction in bond strength with immediate bonding.

Clinically, most of the bracket loss occurred in the mandibular arches that were bleached within 24 hours. Teeth in the mandibular arch were subjected to more occlusal forces and functional demands, such as mastication. As evidenced from the survival plot, most of the brackets are lost within 24 hours. The ARI score from the few samples collected on the bleached teeth showed that the bond failure occurred at the resin/enamel interface. This is in agreement with those reported by Uysal et al²³ and Torneck et al.²⁴ Recent studies have shown that changes in enamel morphology or continual release of oxygen from the tooth structure may interfere with the resin polymerization and adherence.²⁹

CONCLUSIONS

- Brackets bonded with self-etching primer system to previously bleached teeth have an increased chance of bond failure. Mandibular teeth have a higher incidence of bond failure after bleaching.
- Bonding brackets to recently bleached enamel has a higher chance of bond failure due to reduced bond strength or higher variation in bond strength. We recommend a waiting period of 2–3 weeks before orthodontic bonding for patients who have a history of in-office bleaching with 38% hydrogen peroxide.

REFERENCES

1. Goldstein RE. In-office bleaching: where we came from, where we are today. *J Am Dent Assoc.* 1997;128(suppl): 11S–15S.
2. Donly KJ, Seguna A, Henson T, Banker ML, Gerlach RW. Randomized controlled trials of professional at-home tooth whitening in teenagers. *Gen Dent.* 2007;55:669–674.
3. Turkun M, Sevgican F, Pehlivan Y, Aktener BO. Effects of 10% carbamide peroxide on the enamel surface morphology: a scanning electron microscopy study. *J Esthet Restor Den.* 2002;14:238–244.
4. Bulut H, Turkun M, Kaya AD. Effect of an antioxidizing agent on the shear bond strength of brackets bonded to bleached human enamel. *Am J Orthod Dentofacial Orthop.* 2006;129: 266–272.
5. Cacciafesta V, Sfondrini MF, Stifanelli P, Scrbante A, Klerisy C. The effect of bleaching on shear bond strength of brackets bonded with a resin-modified glass ionomer. *Am J Orthod Dentofacial Orthop.* 2006;130:83–87.
6. Bishara SE, Sulieman AH, Olson M. Effect of enamel bleaching on the bonding strength of orthodontic brackets. *Am J Orthod Dentofacial Orthop.* 1993;104:444–447.
7. Langsten RE, Dunn WJ, Hartup GR, Murchison DF. Higher-concentration carbamide peroxide effects on surface roughness of composites. *J Esthet Restor Dent.* 2002;14:92–96.
8. Broome JC. At-home use of 35% carbamide peroxide bleaching gel: a case report. *Compend Contin Educ Dent.* 1998;19:824–829.

9. Jorgensen MG, Carroll WB. Incidence of tooth sensitivity after home whitening treatment. *J Am Dent Assoc.* 2002;133:1076–1082.
10. Allison R, Symons AL, Meyers IA. The effect of a vital bleaching technique on the surface integrity of enamel. *Aust Dent J.* 1991;36:312.
11. Covington JS, Friend GW, Lamoreaux WJ, Perry T. Carbamide peroxide tooth bleaching: effects on enamel composition and topography. *J Dent Res.* 1990;69:175.
12. Ernst CP, Marroquin BB, Willershausen-Zonnchen B. Effects of hydrogen peroxide-containing bleaching agents on the morphology of human enamel. *Quintessence Int.* 1996;27:53–56.
13. Reynolds I. A review of direct orthodontic bonding. *Br J Orthod.* 1975;2:71–78.
14. Seghi RR, Denry I. Effects of external bleaching on indentation and abrasion characteristics of human enamel in vitro. *J Dent Res.* 1992;71:1340–1344.
15. Rotstein I, Lehr Z, Gedalia I. Effect of bleaching agents on inorganic components of human dentin and cementum. *J Endod.* 1992;18:290–293.
16. 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;20:61–63.
17. Lee C, Cobb C, Zargartalebi F, Hu N. Effect of bleaching on microhardness, morphology, and color of enamel. *Gen Dent.* 1995;43:158–160.
18. Lai SC, Tay FR, Cheung GS, et al. Reversal of compromised bonding in bleached enamel. *J Dent Res.* 2002;81:477–481.
19. Josey AL, Meyers IA, Romaniuk K, Symons AL. The effect of a vital bleaching technique on enamel surface morphology and the bonding of composite resin to enamel. *J Oral Rehabil.* 1996;23:244–250.
20. Cullen DR, Nelson JA, Sandrik JL. Peroxide bleaches: effect on tensile strength of composite resins. *J Prosthet Dent.* 1993;69:247–249.
21. Miles PG, Pontier JP, Bahiraei D, Close J. The effect of carbamide peroxide bleach on the tensile bond strength of ceramic brackets: an in vitro study. *Am J Orthod Dentofacial Orthop.* 1994;106:371–375.
22. Homewood C, Tyas M, Woods M. Bonding to previously bleached teeth. *Aust Orthod J.* 2001;17:27–34.
23. Uysal T, Basciftci FA, Usumez S, Sari Z, Buyukerkmen A. Can previously bleached teeth be bonded safely? *Am J Orthod Dentofacial Orthop.* 2003;123:628–632.
24. Torneck CD, Titley KC, Smith DC, Adibfar A. The influence of time of hydrogen peroxide exposure on the adhesion of composite resin to bleached bovine enamel. *J Endod.* 1990;16:123–128.
25. Bishara SE, Donsombat C, Soliman MM, Aijouni R, Laffoon JF. The effect of tooth bleaching on the shear bond strength of orthodontic brackets. *Am J Orthod Dentofacial Orthop.* 2005;128:755–760.
26. Ruse ND, Smith DC, Torneck CD, Titley KC. Preliminary surface analysis of etched, bleached, and normal bovine enamel. *J Dent Res.* 1990;69:1610–1613.
27. Cavalli V, Reis AF, Giannini M, Ambrosano GM. The effect of elapsed time following bleaching on enamel bond strength of resin composite. *Oper Dent.* 2001;26:597–602.
28. Uysal T, Sisman A. Can previously bleached teeth be bonded safely using self-etching primer systems? *Angle Orthod.* 2007;78:711–715.
29. Bulut H, Turkun M, Kaya AD. Effect of an antioxidizing agent on the shear bond strength of brackets bonded to bleached human enamel. *Am J Orthod Dentofacial Orthop.* 2006;129:266–272.