Original Article

Sandblasted Metal Brackets Bonded with Resin-modified Glass Ionomer Cement In Vivo

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Abstract: The aim of this in vivo study was to evaluate the effects of sandblasting metal brackets on their clinical performance when resin-modified, chemically cured glass ionomer cement was used for bonding. A total of 60 patients with a range of malocclusions were allocated randomly into two groups. For the first 30 cases, teeth were divided into quadrants so that sandblasted, mesh-based metal brackets (SB) were bonded directly to the upper left and lower right quadrants using the resin-modified glass ionomer cement. The mesh-based (no sandblasting) brackets bonded to the other quadrants with the same adhesive were used as control (CO). A split-mouth design was used, and the allocation of the brackets per quadrant was reversed for the second 30 cases. Sandblasting of the bracket bases was accomplished using 25-μm aluminum oxide particles for three seconds. The manufacturer's instructions were followed for bonding. The number, site, and date of first-time bracket failures were monitored throughout active orthodontic treatment, and the observation time was 20 months. The bond failure rates were 4.9% and 4.3% for the SB and CO brackets, respectively. No statistically significant difference was found between the groups for failure rates. The bond failure sites were predominantly at the enamel-adhesive interface in both groups. Sandblasting did not have a positive effect on the clinical performance of the mesh-based metal brackets when bonded with resin-modified glass ionomer cement. (*Angle Orthod* 2005;75:406–409.)

Key Words: Clinical performance; Failure rates; Sandblasting; Resin-modified glass ionomer cement

INTRODUCTION

Improvement of the function and esthetics of orthodontic appliances is one purpose of research. It is also desired to develop orthodontic appliances and materials, which are more hygienic and less harmful for the oral environment and teeth. This desire has led to the development of resin-modified glass ionomer cements for orthodontic bonding. The advantages of this hybrid combination cement include elimination of the acid-etch technique and an ability to absorb and release anticariogenic fluoride ions, which is because of the glass ionomer cement component.[1,2]

Air abrasive technique (sandblasting) has been used extensively in restorative dentistry to enhance the mechanical adhesion between the metals and adhesive resins.[3] This technique uses a high-speed stream of aluminum oxide particles propelled by compressed air to remove unfavorable oxides and contaminants and increase the surface energy and bonding surface area by increasing the surface roughness. It also has been used to improve the bond strength of new brackets and bands and to remove the remaining adhesive parts from the base of the accidentally debonded brackets in orthodontics.[4,5]

Several studies have investigated the effect of sandblasting metal bracket bases on the bond strength of conventional chemically cured, no-mix or light-cured composite resins.[4–7] It was reported that sandblasting (three seconds) significantly increased in vitro shear bond strength values and mean survival time of mesh-based metal brackets bonded with a glass ionomer cement.[4] However, to date, there have been no clinical studies regarding the clinical performance of the sandblasted brackets when bonded with resin-modified glass ionomer cements. Therefore, the aim of this in vivo investigation was to evaluate the clinical performance of sandblasted metal brackets bonded to teeth using chemically cured resin-modified glass ionomer cement. The bond failure sites were also investigated.

MATERIALS AND METHODS

The complete orthodontic pretreatment records of 60 patients (age of the patients ranged from 12.2 to 14.9 years at the onset of the orthodontic treatment) with a range of malocclusions were obtained and treatment plans with full

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TABLE 1. Sample Characteristics

	Number	%
Number of patients	60	100
Males	23	38.33
Females	37	61.67
Mean age (y)	13.7	
Range of age (y)	12.2 to 14.9	
Observation time (mo)	20	
Number of bonded brackets	1107	100
Sandblasted	554	50.05
Control	553	49.95

straight-wire–fixed appliances were established. A total of 34 subjects had no teeth extracted. Twenty subjects were treated with extraction of four first premolars and six with extraction of upper first premolars only. The details of sample size, observation time, and patient distribution by sex and age are shown in Table 1.

For the first 30 cases, teeth were divided into quadrants so that sandblasted (SB), mesh-based metal brackets (Midi Diogonal, Leone Sesto, Italy) were bonded directly to the upper left and lower right quadrants using the resin-modified glass ionomer bonding cement (Fuji Ortho, GC Corp, Tokyo, Japan). The brackets in the control group (CO) were not sandblasted and bonded to the other quadrants with the same adhesive. For an equal distribution between right and left sides, a split-mouth design was used and the allocation of the brackets per quadrant was reversed for the second 30 cases.

Sandblasting of the bracket bases were accomplished using 25-μm aluminum oxide particles for three seconds (Figure 1). The line pressure of the sandblasting unit (Bego-Wilhelm, Herbst, Germany) was kept at 58 psi (four bar). A special device was made to maintain the 90° angle and 30-mm distance between the tip of the sandblasting handpiece and the bracket base surface. After sandblasting, all brackets were cleaned in an ultrasonic bath for 10 seconds.

For all patients, a standardized protocol of tooth preparation was adopted and all fixed appliances were placed at a single visit by the same operator (Dr Ozer). After molars were banded, the remaining teeth were pumiced and rinsed for 10 seconds. Then, a 10% polyacrylic acid solution was applied to the enamel surface for 20 seconds, rinsed with water, and slightly dried with a light flow of air. Fuji Ortho is a powder and liquid system, in which the powder and liquid were mixed in recommended proportions for 30 seconds before it was applied to the bracket base. After seating the bracket on the tooth surface with firm pressure, excess adhesive was removed carefully with a scaler. Two brackets were bonded with each mix.

Once all the quadrants were bonded in a case, initial archwires were fitted approximately 20 minutes after the last bracket was bonded. To minimize variation in the magnitude of forces applied to brackets and teeth, in all cases, the initial archwires were 0.0175-inch coaxial stainless steel

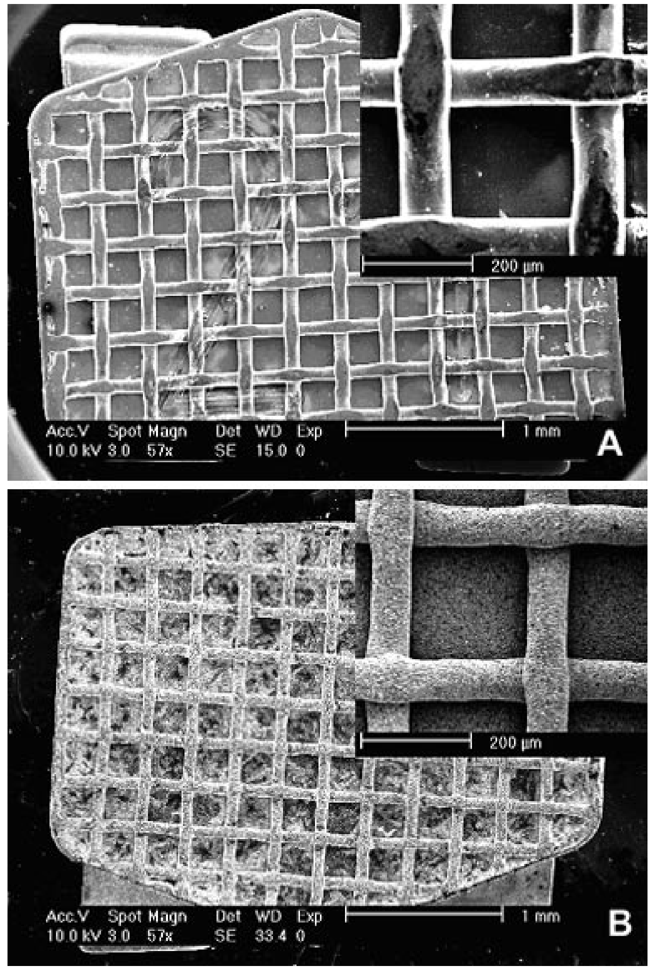

FIGURE 1. Scanning electron microscope (SEM) photographs of the bracket bases used in this study. (A) Nonsandblasted (CO). (B) Sandblasted (SB).

wires. Both verbal and written instructions in relation to fixed appliance and oral hygiene maintenance were given to all patients.

The number, site, and date of first-time bracket failures were monitored throughout active orthodontic treatment. Patients were examined at four-week intervals but were instructed to attend as soon as possible once a bond failure was detected.

When a bond failure was notified, the debonded bracket and its tooth surface were examined with a magnifying glass at 5× magnification to classify the enamel surfaces according to the adhesive remnant index (ARI) of Årtun and Bergland.[8]

For each group, the survival rates of brackets were estimated using the Kaplan-Meier statistic, and log-rank test at the .05 level of significance was used to find any significant difference between the groups. To analyze the failure sites, contingency tables were designed and subjected to the chi-square (χ^2) test.

TABLE 2. Failure Rates by Group, Sex, and Jaw

Failure by[a]		Bracket Bond	Failed	%	P[b]
Group	CO	553	24	4.3	ns
	SB	554	27	4.9	
Sex	Male	432	22	5.1	ns
	Female	675	29	4.3	
Jaw	Upper	547	30	5.5	ns
	Lower	560	21	3.8	

[a] CO indicates new (nonsandblasted) bracket control group; SB, sandblasted bracket group.

[b] ns indicates difference between the compared groups was not significant at the .05 level of significance.

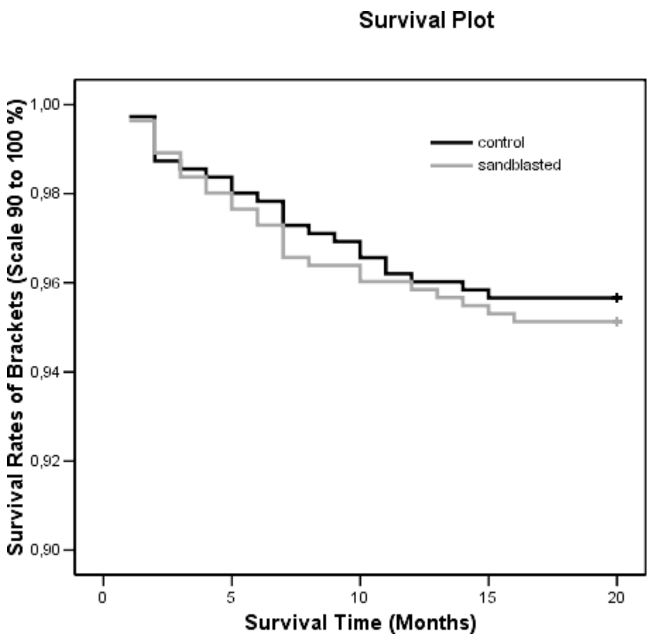

FIGURE 2. Kaplan-Meier estimates of the bracket survival distribution over time for both groups.

RESULTS

Table 2 shows bond failure rates observed in both SB and CO groups. The overall failure rate for the brackets (percentage of brackets requiring rebonding) was 4.6%. A total of 554 sandblasted and 553 nonsandblasted brackets were bonded in SB and CO groups, respectively. Whereas 27 failures were observed in the SB group, the number of failed brackets in the CO group was 24. In other words, the bond failure rates were 4.9% and 4.3% for the SB and CO groups, respectively. Figure 2 shows the bracket survival distribution for a 20-month time for both groups. Kaplan-Meier survival distribution and subsequent log-rank test showed no statistically significant correlation between the groups and bracket failure rates ($P = .670$). No statistically significant correlation between the sex and bracket failure rates was also found ($P = .389$).

Table 3 shows the distribution of ARI scores expressed as frequency of failure. For both groups, bond failures predominantly were at the enamel-adhesive interface (ARI scores 0 and 1). The χ^2 test did not show a statistically significant difference ($P = .44$) between the groups.

DISCUSSION

In this prospective clinical investigation, a split-mouth technique was used and patients were allocated randomly into two groups. Thus, unequal distribution for the quadrants bonded and pseudorandomization because of openness of the allocation system were minimized. To eliminate interexaminer variation, patients in both groups were bonded by the same clinician. It was stated that failure rate of the second- and third-time bonds were observed more frequently compared with first-time.[9] Therefore, it is recommended that clinical studies evaluating bond failure rates should either only record first-time failures or analyze multiple failures of the same site in a different category.[9,10] Hence, only first-time bond failures were evaluated in this study.

Previous studies[11,12] have reported that patients below 12 years of age had higher bond failure rates compared with those greater than 16 years of age. However, in this study, no patient was older than 15 years of age at start of treatment.

This study also has several limitations. First, new brackets instead of accidentally debonded brackets were sandblasted and bonded to teeth. This was done because it would have not been ethical and easy to bond, debond, and later to re-

TABLE 3. Frequency and Percentage Occurrence of ARI Scores for Both Groups[a]

Group[b]		ARI Scores 0	1	2	3	Total
CO		7	10	3	4	24
	% within group	29.2	41.7	12.5	16.7	100
SB		8	15	3	1	27
	% within group	29.6	55.6	11.1	3.7	100
Total		15	25	6	5	51
	% within group	29.4	49	11.8	9.8	100

[a] Adhesive remnant index (ARI) scores: 0 = no adhesive left on the tooth, 1 = less than half of the adhesive left on the tooth, 2 = more than half of the adhesive left on the tooth, 3 = all adhesive left on the tooth.

[b] CO indicates new (nonsandblasted) metal brackets control group; SB, sandblasted brackets group.

bond the brackets after cleaning the rest of the adhesive on their bases by sandblasting to simulate the accidental debonding. Second, the effects of the presenting malocclusion on bracket failure rate could not be tested because of an uneven distribution of the types of malocclusion.

It was reported that brackets bonded with conventional composite resins fail more in the lower jaw than the upper jaw.[13–15] On the contrary, as in this study, brackets bonded with resin-modified glass ionomer cements more frequently failed in the upper jaw.[12,16] However, this difference between the two jaws was not statistically significant in our study ($P = .283$). The higher rates of bracket failures in upper jaw (particularly maxillary incisor area) could have been because of the moisture requirements of the glass ionomer component of resin-modified glass ionomer cement for optimal performance[16] and the excessive force application because of the torque requirements of these teeth during treatment.

In previous in vivo studies, a wide range of failure rates from 3.2% to 28% has been reported for the brackets bonded with resin-modified glass ionomer cements.[12,16–22] The overall failure rate was around 4.6% in this study. Using resin-modified glass ionomer cements for bracket bonding, failure rates that were reasonably close to that obtained in this study were recorded by Fricker[17] (5%), Hitmi et al[12] (7%), and Summers et al[21] (6.5%). In two clinical studies, Silverman et al[18,19] reported lower bracket failure rates than that of this study (3.2% and 3.3%). Higher bracket failure rates were recorded by Oliveira et al.[20] However, it should be noted that the observation periods, materials (brackets, adhesives), and enamel surface conditioning widely differ from one study to another.

Accidentally debonded brackets in both groups predominantly showed enamel-adhesive interface failures (ARI scores 0 and 1). ARI scores 0 and 1 denote that less cement was left attached to the tooth surface in both SB and CO groups. This also suggests that when the resin-modified glass ionomer cement is used for the bonding of metal brackets, tooth cleanup after debonding is likely to be easier and faster.

CONCLUSION

There was no significant difference in failure rates between the sandblasted and nonsandblasted metal brackets bonded with resin-modified glass ionomer cement after 20 months of observation time.

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