SCIENTIFIC SECTION

Effect of sandblasting on the retention of orthodontic brackets: a controlled clinical trial

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Objective: To study the effect of chairside sandblasting of the bases upon the retention of mesh backed orthodontic brackets.

Design: Prospective controlled clinical trial.

Methods: Brackets were bonded to 60 successive patients who were treated at an orthodontic practice in Amman, Jordan. Using a crossover system of allocation, quadrants were bonded using either sandblasted or non-sandblasted brackets respectively. Rely-A-Bond adhesive was used throughout. Bond failures were monitored over one year.

Results: 1112 brackets were assessed. The overall failure rate was 4.0% and the failure rates for non-sandblasted and sandblasted brackets were 4.7 and 3.4% respectively. The odds ratio for at least one bracket failure within the control quadrant compared with the experimental quadrant was 0.50 (95% CI 0.185 to 1.238), which was not statistically significant.

Conclusion: Sandblasting did not significantly improve the retention of mesh based orthodontic brackets in this study.

Key words: Bracket bonding, Sandblasting

Received 25th July 2005; accepted 15th October 2007

Introduction

It has been suggested that bond strengths of 1.38 MPa,[1] 2.9 MPa[2] and 60–80 kg cm^{-2} or 7 MPa[3] are appropriate for the retention of orthodontic brackets during treatment. However, a few longitudinal clinical studies have tested the results of *ex vivo* findings and the suggested values have been considerably exceeded by bond strengths obtained in laboratory studies, which may range from 11 to 22 MPa.[4]

However, bond strength is not the only criterion by which the success or failure of orthodontic bonding should be judged. Unlike in restorative dentistry, where a restoration should last for as long as possible, an orthodontic appliance remains in the mouth for only two years. At the end of treatment it should be possible to remove attachments from the teeth quickly and without discomfort to the patient, leaving no evidence of their temporary presence on the teeth.

Bond failure may represent either adhesive failure at the enamel surface, cohesive failure within the bonding agent, adhesive failure at the base of the attachment, or a combination of the three main effects. Studies using the Adhesive Remnant Index[5] have shown that 66% of the enamel surfaces beneath brackets are covered by either a thick or thin layer of adhesive.[4] This finding suggests that the tooth surface may be over-prepared by present etching regimes.

The situation might be improved by reducing the strength of the bond at the enamel surface and/or increasing the strength of the bond between the adhesive and the bracket base.

Sandblasting enhances the retentive nature of metals by increasing the surface area and thinning the oxide layer of stainless steel and it has been suggested as a way of improving the bond at the bracket base. Sandblasting with 60 μm alumina for 3 seconds at a distance of 10 cm has been shown by SEM examination to produce the best microroughened surface to allow effective mechanical bonding. Sandblasting has been shown to increase bond strengths by 22% and mean survival time in a ball mill was significantly longer for brackets bonded to premolars after sandblasting than for untreated brackets.[6] Similar bond strength increases were reported by

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DOI 10.1179/146531207225022410

MacColl *et al.*[7] who found that use of a portable sandblasting unit for 5 seconds increased bond strength by between 18 and 24%, depending upon the area of the bracket base.

These encouraging findings were not supported by Johnson and McSherry[8] who tested the bond strengths between sandblasted and non-sandblasted molar tubes and etched enamel. In this study, 50 μm alumina grit was applied for 3 seconds, although the distance was not given. The mean debond forces for sandblasted and non-sandblasted molar tubes were 4.4 and 3.7 MPa respectively. The difference was not statistically significant and the conclusion of the study was that the small increase in bond strength was unlikely to be of clinical importance.

Objectives of the present study

To compare the clinical failure rate of orthodontic brackets with sandblasted bases against the failure rate of non-sandblasted brackets.

Null hypothesis

Sandblasting the bases of metallic orthodontic brackets before applying adhesive does not affect the number of bond failures during clinical treatment.

Material and methods

Ethical approval for the study was obtained by letter from the Jordanian Orthodontic Society (21st March 2006), which is the relevant licensing body in Jordan. In addition informed consent was obtained from each subject and their parents by one of the authors (SS).

Previous clinical studies of orthodontic bonding have shown failure rates in the range 4.4–7.7%,[9–13] with an overall mean of 6.32%. In a previous study by the authors, 6% of brackets were lost over a one-year period.[9] Assuming a similar bond failure rate for non-sandblasted brackets in the proposed new study, sample size was calculated on the basis that sandblasting would reduce the number of bond failures by two-thirds.

The formula in Altman[14] which is appropriate for non-continuous data was used since the proposed study would have a binary outcome, indicated by success or failure of bracket bonding. On the basis of bond failure rates of 6% for non-sandblasting and 2% for sandblasted bracket bases the formula produces a standardized difference of 0.2. The Altman nomogram suggests that a sample size of 1000 brackets would be required to support 90% power and a significance level of <0.05.

Figure 1 A sandblasted (left) and non-sandblasted bracket base

In order to safeguard the study within limits against drop-outs and unexpected results, sample size was increased by around 10%. Sixty successive patients presenting at the practice of one of the authors (SS) with various malocclusions and requiring orthodontic treatment with either single or double arch fixed appliances, formed the study group, giving a total of 1112 brackets to be bonded. Only subjects with normal and healthy teeth were selected so that the teeth showed no signs of decay, decalcification, fluorosis, hypoplasia or other abnormality that would affect bracket bonding.

All subjects were treated by one clinician (SS) using Roth prescription pre-adjusted edgewise appliances, using brackets with a 0.022×0.028-inch slot size. The base of each bracket was covered with a fine woven mesh to assist penetration of the bonding adhesive (Figure 1). Each subject was allocated two quadrants for bonding using mesh based Omni Arch brackets (GAC International Inc., La Porte, IN, USA) with sandblasted bases, and two quadrants for bonding using similar brackets with non-sandblasted bases. To ensure equal distribution of brackets with sandblasted bases between the right and left sides, the first 30 patients had brackets with sandblasted bases bonded on the upper right and lower left quadrants while the upper left and lower right quadrants were bonded with brackets that had not been sandblasted. This quadrant allocation was reversed for the next 30 patients.

The bases of selected brackets were sandblasted by the same dental nurse for 3 seconds each using a Microetcher II intraoral sandblaster (Danville Engineering, San Remo, CA, USA) (Figure 2) with 90 μm aluminium oxide powder at a range of 4 cm. Before the study the dental nurse was trained to carry out the sandblasting in a standard way. Each procedure was timed using a Casio digital stop watch and the distance between the sandblaster and bracket base was standardized at 4 cm by holding each bracket in a Hu-Friedy bracket holder (No. 678–212M) with the crossing of its arms against 4 cm on a steel ruler (Figure 3). After sandblasting the bracket base was rinsed with

Figure 2 The Microetcher 11 intraoral sandblaster, current model

atomized water for 10 seconds and dried using a triple syringe air blast to remove residual grit particles. Sandblasting was performed just before bonding to minimize possible contamination of sandblasted surfaces. Each sandblasted bracket base was checked by the clinician (SS) before fitting to check that it had a matt sandblasted appearance and was free from debris (Figure 1).

A standardized protocol of tooth preparation and bracket bonding was adopted.[9] All anterior teeth and bicuspids were bonded using Rely-A-Bond, a chemically cured fluoride-releasing no-mix composite resin. Where it was necessary occlusal interferences were prevented by the use of Fuji LC glass ionomer cement on the occlusal surfaces of lower molar teeth. This was done in nine subjects, five in the first group of 30 subjects and four in the second group.

The number, site and date of first time bond failures as reported by each subject were recorded over a one-year period. Subsequent bracket losses from the same teeth were not counted. Patients were seen at intervals of 4–6 weeks, but were requested to attend as soon as possible once a bond failure was detected.

Bracket data were entered directly onto an Excel spreadsheet (Microsoft Corporation, Redmond, WA, USA) and following statistical advice between-group differences were analysed using an odds ratio for one or more bracket failure within the control quadrant compared with the contralateral experimental quadrant. The analysis was carried out separately for the upper and lower arches, which might mean that there are clustering effects within the patients, however it was considered that the difference between the brackets would be reduced by the crossing over of experimental and control quadrants in the upper and lower arch. Differences between right and left sides and upper and lower arches were analysed using the Mann–Whitney U-test.

Kaplan–Meier estimates of survival curves were constructed and compared using the log rank test in order to estimate likely bracket bond failures over a period of 30 months, which would exceed the duration of most orthodontic treatments.

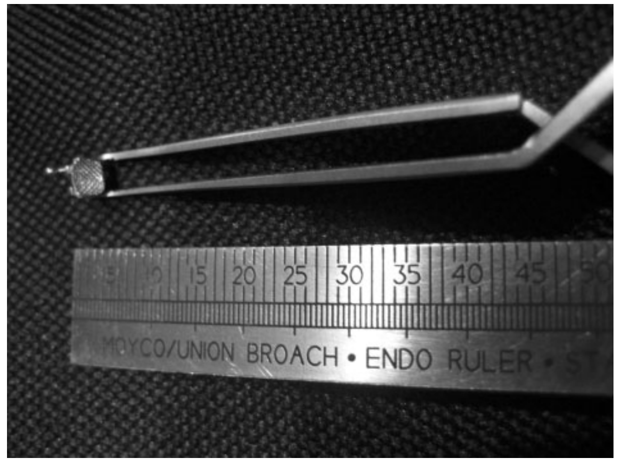

Figure 3 A bracket held for sandblasting in the Hu-Friedy bracket holder

Results

Sixty subjects agreed to participate in the trial. A diagram showing the flow of participants through each stage of the trial, as suggested by the CONSORT group, is shown in Figure 4. The first 30 included 16 females and 14 males; 15 had Class I malocclusions, 7 Class II division 1, 6 Class II division 2 and 2 Class III. Ages ranged from 10 to 14 years with a mean of 12.6 years. The second 30 included 15 females and 15 males; 12 had Class I malocclusions, 8 Class II division 1, 5 Class II division 2 and 5 Class III. Ages ranged from 10 to 15 years with a mean of 13.3 years. Two subjects relocated early during treatment and were excluded from the analysis.

1112 brackets were bonded and there were 45 bond failures (4.0%) (Table 1). Nineteen (3.4%) sandblasted and 26 (4.7%) non-sandblasted brackets had failed to adhere. Bracket bond failures per quadrant are shown in Table 2. Using these data the odds ratio was 0.50 (95% CI=0.185–1.238), which is not statistically significant.

Comparisons between bond failures according to the site of the brackets in the mouth (Table 3) were made. Twenty-five (4.5%) were lost from the upper arch and 20 (3.6%) from the lower, which was not statistically significant (P=0.45). Twenty-seven (4.9%) brackets were lost from the right side of the mouth and 18 (3.2%) were lost from the left side, which again was not statistically significant (P=0.17). Because of the small number of bracket bond failures, results were combined into three groups: incisors, canines and premolars. Twenty-three (4.8%) incisor bracket bonds failed, 9 (3.8%) canine

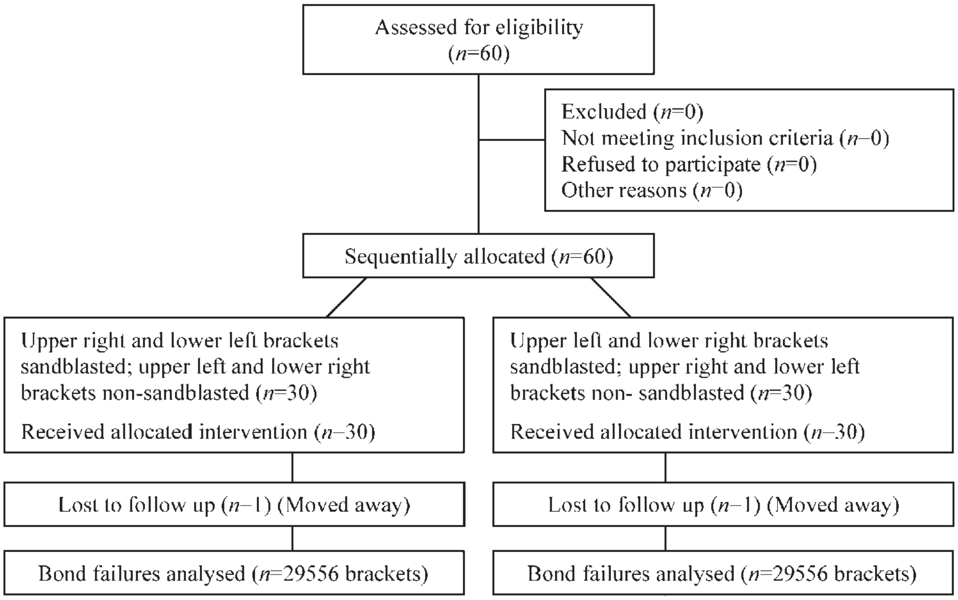

Figure 4 A CONSORT diagram, showing the progress of the study

bracket bonds failed and 13 (3.3%) brackets were lost from premolars. Differences between bond failures for incisors, canines and premolars were not examined due to the small group sizes. Kaplan–Meier estimates of survival curves are shown in Figure 5.

Table 1 Bond failures with sandblasted and non-sandblasted brackets.

Overall results	Brackets bonded	No. failed	% failed
Sandblasted	556	19	3.4
Non-sandblasted	556	26	4.7
Total	1112	45	4.0

Table 2 Numbers of bracket bond failures per arch.

		Experimental	
		Sandblasted brackets	
Control		Yes	No
Non-sandblasted brackets	Yes	$a=16$	$b=15$
	No	$c=5$	$d=136$
		$a+b+c+d=n$	

'*a*' is the number of arches where there was one or more debonded brackets both on the experimental and the control quadrants.
'*b*' is the number of arches where there was one or more debonded brackets on the control quadrant, but not on the experimental quadrant.
'*c*' is the number of arches where there was one or more debonded brackets on the experimental quadrant, but not on the control quadrant.
'*d*' is the number of arches where there were no debonded brackets on either the experimental or the control quadrant.
Experimental=sandblasted.
Control=non-sandblasted.

Discussion

The present study found that sandblasting bracket bases before the application of adhesive did not influence the number of brackets lost over one year or reduce the chances of bracket bond failure, compared with the non-sandblasted brackets.

The wide confidence limits for the odds ratio suggest that the present study does not have sufficient power to allow firm conclusions. The study was planned in the belief that the independent study unit would be a bracket. Later statistical advice indicated that data should be analysed on the basis that a quadrant is the independent unit. A subsequent post hoc power calculation based on a per quadrant bracket failure was therefore performed. An overall bracket bond

Table 3 Bond failures according to site.

Site	Brackets bonded	No. failed	% failed
Upper arch	554	25	4.5
Lower arch	558	20	3.6
Right side	556	27	4.9
Left side	556	18	3.2
Incisor teeth	480	23	4.8
Canine teeth	240	9	3.8
Premolar teeth	392	13	3.3

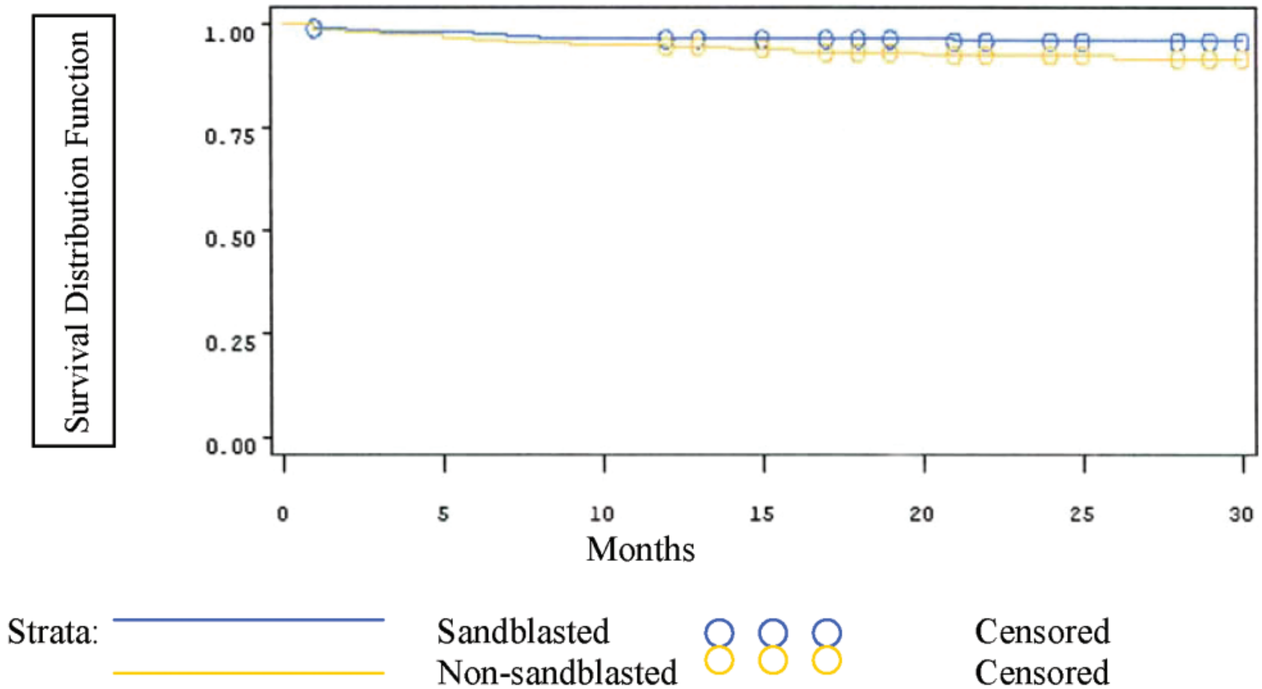

Figure 5 Survival analysis for sandblasted and non-sandblasted teeth

failure rate of 6% would produce an expected quadrant failure rate of 1.5%. On the basis of a two-thirds reduction in failures a standardized difference of 0.1 was calculated. In order to provide 90% power and $P<0.05$ this calculation suggests that 4000 quadrants or 1000 subjects would be required to obtain a statistically significant difference. This would obviously cause great logistical difficulties to the completion of the study. In fact the bond failure rate in the present study was only 4% overall so that the sample would need to be even larger to ensure sufficient power.

In order to limit the effects of technique variation this study was carried out by one experienced orthodontist (SS) in familiar surroundings assisted by the same dental nurse throughout and using one type of stainless steel mesh based bracket. An attempt to test several different brackets would have increased the sample size to an extent that would have made the study unmanageable in a private practice. Brackets with fine woven mesh were used in this study since they have been shown to produce the best bonding results.[15] The present results should be generalizable to mesh based brackets produced by other manufacturers.

The sandblasting regime used in the present study was carefully controlled for both time and distance and the sandblaster was similar to that used by MacColl *et al.*[7] Although the present study was carried out at the chairside rather than in the more circumscribed surroundings of the laboratory it is reasonable to assume that a similar increase of 18–24% in resistance to debond stress would have been produced. Brackets were bonded immediately after sandblasting since laboratory studies have shown that bands fitted immediately after sandblasting had bonds that were 10–15% stronger than those fitted one week later.[16]

The study ran for one year since previous research has shown that 80% of all bond failures occur during the first year of treatment.[9] Sandblasting was performed for a duration of three seconds per bracket base as this has been shown by SEM examination to produce the best microroughened surface.[6] Other laboratory studies referred to earlier in this paper reported bond strength increases of 20% following sandblasting of the mesh bases of metallic brackets.[7,8] In one of these studies the survival time of sandblasted brackets in a ball mill was significantly longer than that of brackets with untreated bases.[7]

This investigation does not support the suggestion of MacColl *et al.*[7] that chairside sandblasting will produce a clinically significant enhancement in appliance retention, although it does support the suggestion by Johnson and McSherry[8] who proposed, on the basis of a laboratory study, that sandblasting the bases of orthodontic attachments was unlikely to produce results of clinical importance.

Conclusions

- Chairside sandblasting of mesh backed orthodontic brackets bonded using a standard etching technique and Rely-A-Bond adhesive did not improve the retention rate during clinical treatment against that of non-sandblasted brackets.
- Routine sandblasting of bracket bases cannot be recommended to improve retention rates of orthodontic brackets.

Contributors

Peter Rock was responsible for study design, analysis and interpretation of data and final approval of the article. Samer Sunna was responsible for the study conception, clinical work and drafting of the article. Peter Rock is the guarantor.

Acknowledgement

The authors are grateful to Dr PE Benson for statistical advice.

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