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The effect of micro-etching on the retention of orthodontic molar bands: a clinical trial

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SUMMARY Failure of orthodontic bands occurs most frequently at the band–cement interface, when conventional glass ionomer cements are used. Modification of the band surface may improve clinical performance by increasing the mechanical interlock at this junction. The aim of this prospective study was to compare the retention of micro-etched and untreated first molar orthodontic bands in a randomized, half-mouth trial.

Seventy-nine patients had 304 bands cemented as part of routine fixed appliance therapy. The effect of micro-etching, patient age and gender, operator, molar crossbite, treatment mechanics, and arch on band failure was investigated. Failure rates and survival times were compared for each variable assessed.

Micro-etched molar bands showed a significant reduction in clinical failure rate over untreated molar bands and an increase in mean survival time ($P < 0.001$). Of the other variables examined, only the presence of a molar crossbite had any significant effect on band failure ($P = 0.004$).

Introduction

The orthodontic band has been in use for more than 100 years (Weinberger, 1926) and, despite the popularity of bonded orthodontic attachments, over 85 per cent of orthodontists still use bands on molar teeth (Gottlieb *et al*., 1986). It is an essential requirement of fixed appliance therapy that molar bands remain firmly attached to the tooth surface throughout the duration of orthodontic treatment. Decalcification, failure of treatment mechanics, unscheduled visits, and increased clinical time may result if bond failure occurs. Retention of the band is due to its close adaption to the crown's surface, assisted by the physico-chemical bond to the base metal and enamel if a glass ionomer luting cement is used.

Posterior teeth are subject to the highest tensile and shear forces from mastication, and molar bands are susceptible to loosening and failure. The failure rate of molar bands cemented with glass ionomer cement has been diversely reported as 0.6 per cent (Fricker and McLachlan, 1985), 3.5 per cent (Mizrahi, 1988) and 15.6 per cent (Millett and Gordon, 1992). These failure rates may be influenced by many factors, such as the length of time over which the performance of the band was examined, operator, and patient variables. The individual operator will affect the choice of correct band size, the cementing technique, mechanics used, and patient motivation. Patient age, sex, attitude to treatment, and malocclusion may also be variables (Mizrahi, 1977a,b).

When using glass ionomer cements, the commonest site of bond failure has been shown to occur at the band–cement interface (Norris *et al*., 1986; Mizrahi, 1988). Increasing the bond strength at this interface should decrease the risk of band loosening during treatment. Recent research has focused on the treatment of metals to increase the retentive surface area of the band and improve chemical and mechanical bonding. Several methods of roughening the surface of bands have been described and it is possible that the different methods, and whether each is carried out commercially or at the chairside, may affect the bond strength. Zachrisson and Buyukyilmaz (1993) looked at electron micrographs of metal surfaces that had been roughened with a diamond bur or green stone. The apparent roughness was caused by periodic ridges and grooves, which provide little micromechanical retention and they recommended that microscopic undercuts, as produced by sandblasting, would be more advantageous. Guray and Karaman (1997) roughened maxillary first premolar bands by either micro-etching with aluminium oxide or by a low speed micromotor using tungsten carbide burs or green stones. All bands were cemented with conventional glass ionomer cement. While the treated bands showed significantly greater retention than the untreated bands, there was no statistically significant difference between the different methods of roughening. Mennemeyer *et al*. (1999) compared strips of band material that had been photoetched by the manufacturer with untreated band material cemented with hybrid ionomer and resin cements. There was no significant difference between the band materials in the as-received state.

Sandblasted stainless steel band material has been evaluated in several laboratory studies. The sandblasting process increases the surface area of the band's retentive surface, removes contaminants and thins the stainless steel oxide layer leaving a more firmly attached layer for bonding. Wood *et al*. (1996) found that sandblasting the inner surface of bands cemented to extracted third molar teeth doubled their retention strength. Miller and Zernik (1996) showed increased shear bond strength of sandblasted stainless steel discs to bovine maxillary incisors when cemented with glass ionomer cement *in vitro*. The retention of photo-etched and untreated band material both increased following air abrasion (Mennemeyer *et al*., 1999), although there was still no significant difference between their relative bond strengths.

To date there are only two published reports of the clinical performance of surface modified orthodontic bands. Seeholzer and Dasch (1988) compared groups of patients where premolar and molar bands had been cemented using either copper cement or conventional glass ionomer. The groups were observed over an average of 19 and 15 months, respectively. They found 19.7 per cent fewer loose bands with the glass ionomer cement. The inner surfaces of loose molar bands were sandblasted and recemented. The authors report that this resulted in a 30 per cent increase in adhesion, although no details were given for the band failures or their survival times. Millett *et al.* (1995) investigated the effect of sandblasting on the retention of molar bands in a clinical study. Sandblasting was carried out in the laboratory using 60-μm alumina particles. One-hundred-and-seven patients with equal numbers of sandblasted and untreated bands were followed over a mean observation period of 14.5 months. They found that the failure rate of sandblasted bands was 4 per cent compared with 20 per cent for untreated bands.

Commercially sandblasted molar bands have been introduced and have been described as micro-etched ('Micro-Etched', Victory Series™, 3M Unitek, Bradford, UK). The finished bands are secured in a holding fixture and the interior surface sandblasted by spraying 80-μm aluminium oxide particles in a uniform pattern. The aim of the present study was to investigate the failure rates and survival times of micro-etched molar bands and untreated molar bands (Victory Series™, 3M Unitek) in a prospective, randomized, controlled clinical trial. The effect of variables relating to both patient and operator on the failure rate of each band type was examined.

Materials and methods

Ethical approval was granted for the study by the Eastman Dental Institute and Hospital Joint Research and Ethics Committee, and written consent was obtained for each subject. Patients receiving fixed appliance treatment were entered into the study if they required treatment involving the cementation of at least one pair of bands on first permanent molar teeth in the same arch. A half-mouth trial (Glavind, 1977) was used, where a micro-etched band was cemented on one side of the arch and an untreated band on the opposite side. The micro-etched and trial sides were allocated in each arch by reference to a randomized number chart.

The teeth to be banded were cleaned with a pumice slurry, washed and dried with an air syringe. Appropriately-sized first molar bands were selected and adapted to the crown of each tooth. The trial fitted bands were removed and thoroughly dried. A resin-modified glass ionomer cement was used as the luting agent for all molar bands (Multi-Cure Glass Ionomer Orthodontic Band Cement, 3M Unitek). The glass ionomer was mixed according to the manufacturer's instructions, with one mix of cement used for each pair of bands in the same arch. The teeth were isolated with cotton wool rolls, dried with an air syringe, and the dry field maintained during the banding process. The surface of the band was loaded with cement and firmly seated onto the tooth. Excess material was removed with dry cotton wool rolls and the cement light-cured for 40 seconds. Headgear was fitted at the same visit as the bands were cemented when required.

Fifteen operators of similar experience carried out the fixed appliance treatment. Orthodontic procedures and mechanics, using pre-adjusted edgewise appliances, followed those routinely undertaken in the department. Retention of bands was checked at each appointment at approximately 4- to 6-weekly intervals. Bands that were loose were deemed to have failed. The date of failure was identified as accurately as possible and, in cases where it was not possible to elucidate this information, the date that the patient attended the department was noted. All cases were followed to the end of treatment or the end point of the study after 2 years 7 months (944 days). Molar bands were censored at this time for those patients still in treatment and whose molar bands had not failed.

A data sheet retained in the patient's notes was used to record the following information:

1. age and gender of the patient;
2. presence of molar crossbite;
3. use of headgear;
4. quadrant in which band failure occurred;
5. date of failure;
6. duration of treatment.

Patient age was examined for linear correlation and also by age group in order to undertake direct comparison.

Failure rates of micro-etched and untreated bands were compared amongst subjects and amongst bands. Due to the clustering of multiple bands within subjects, it was necessary to initially explore band survival using multi-level analysis techniques, to account for the inherent hierarchical data structure (Goldstein, 1995). However, the effect of clustering was not significant, and analysis proceeded using standard single-level survival analysis (Cox's regression) undertaken within SPSS 8.0 (SPSS Inc., Chicago, USA). The analysis determined the impact of the several explanatory variables on failure during the study period. Survival plots were generated for specific variables.

Results

Seventy-nine patients had a total of 304 molar bands cemented, with equal numbers of untreated and micro-etched bands used. The sample characteristics and summary statistics for band failures are shown in Table 1.

Band failure occurred in 26 patients involving 29 bands, representing a failure rate of 33 per cent amongst subjects, and 9.5 per cent amongst bands. Of the 29 band failures, 26 (17 per cent) were untreated bands and three (2 per cent) micro-etched bands. This corresponded to 25 patients (32 per cent) with untreated bands failing and two patients (3 per cent) with failed micro-etched bands, although for one patient both types of band failed. The survival time of all molar bands is shown in Table 2. The mean survival time for micro-etched bands was 579 days compared with 504 days for untreated bands. At the end of the study period there was a significant difference ($P < 0.001$) between the two band types.

Cox's regression was used to determine the impact of potential explanatory variables. All variables were entered into the model. Figure 1 shows the comparison of survival times between micro-etched and untreated bands, and Table 3 the coefficients of the explanatory variables in the proportional hazards model. There was no

Table 1 Sample characteristics.

No. of patients	79	73 dual arch treatment 6 single arch treatment
No. of bands	304	152 micro-etched, 152 untreated
Gender	45 female (57 per cent) 34 male (43 per cent)	
Age range	11–43 years (mean 15.4 ± 5.1 years)	
No. of headgears	13	
No. of operators	15	
Observation time	299–944 days (mean 583 ± 166 days)	
Total number of band failures	29 (9.5 per cent)	
Number of micro-etched band failures	3 (2 per cent)	
Number of untreated band failures	26 (17 per cent)	

Table 2 Survival time (days).

	n	Minimum	Maximum	Mean	SD
All bands	304	42	944	541	201
Untreated	152	42	944	504	221
Micro-etched	152	126	944	579	173

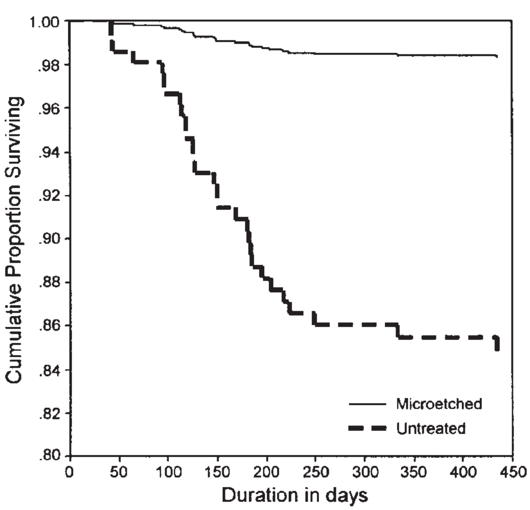

Figure 1 Effect of micro-etching on the survival of molar bands.

correlation between patient age and band failure, nor was there a significant difference when patients were grouped by age as less than or older than 12 years. In the survival analysis, although there was a visible difference between patients less than and those older than 12 years of age, no significant difference was found (Figure 2). No significant relationship was found

Table 3 Parameter estimates of Cox's regression analysis.

Explanatory variable	Coefficients of the explanatory variables in proportional hazards model (95 per cent confidence interval)
Micro–etched band*	–2.27 (–3.47, –1.07)
Age > 12 years	–0.61 (–1.63, 0.41)
Gender	–0.34 (–1.10, 0.42)
Lower molar bands	0.15 (–0.68, 0.97)
Headgear	0.55 (–0.69, 1.79)
Molar crossbite*	1.58 (0.50, 2.66)

*Significant result ($P<0.05$).

with respect to patient gender (Figure 3) or use of headgear (Figure 4). Presence of molar cross-bite was found to have a significant effect on the failure of bands (Figure 5).

Discussion

The effect of micro-etching on the retention of orthodontic bands cemented to first permanent molar teeth in 79 patients undergoing fixed appliance treatment was examined. Although the retention of roughened bands has been investigated *in vitro*, there have been few reports on clinical performance. The use of a prospective study allows certain clinical conditions to be controlled, eliminating any variation due to cementing techniques, and types of bands used. Half-mouth trials, where the patient acts as their own control, also attempt to eliminate some of the patient influenced variables.

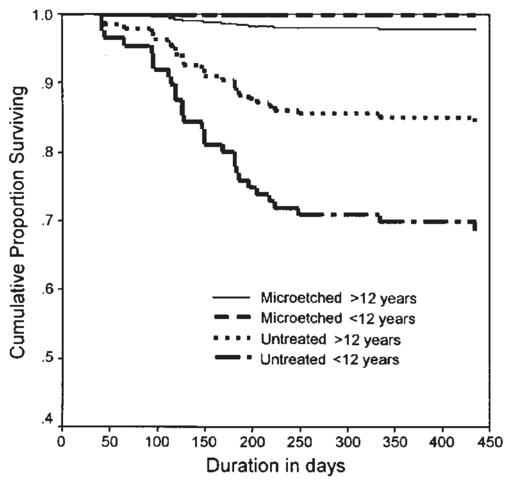

Figure 2 Effect of age grouping on survival time of micro-etched and untreated bands.

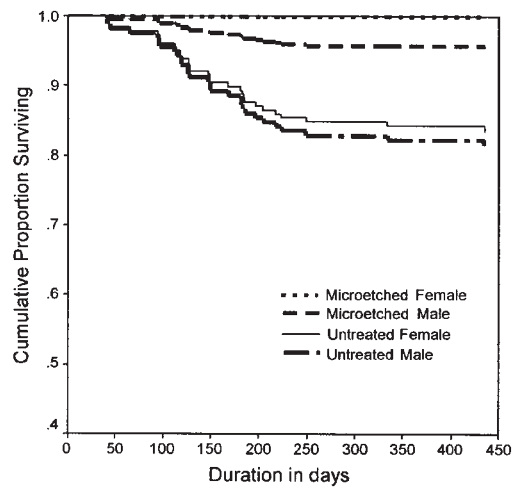

Figure 3 Effect of gender on survival time of micro-etched and untreated bands. There were no failures in the micro-etched, female group.

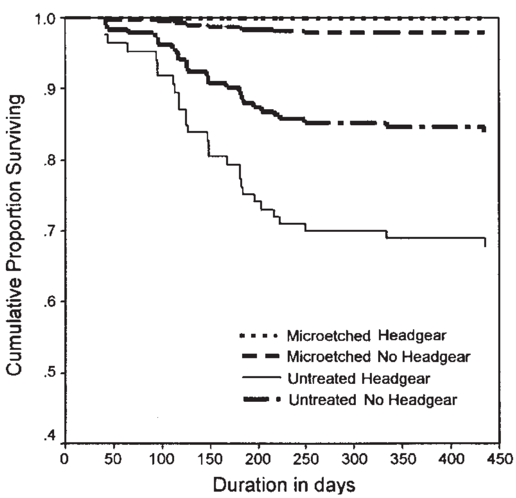

Figure 4 Effect of headgear on survival time of micro-etched and untreated bands. There were no failures in the micro-etched, headgear group.

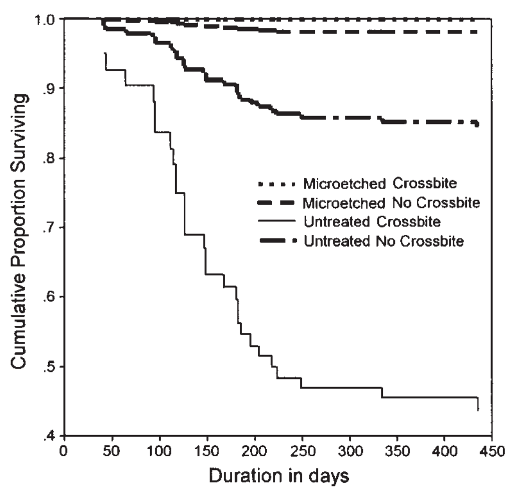

Figure 5 Effect of molar crossbite on survival time of micro-etched and untreated bands. There were no failures in the micro-etched, crossbite group.

The failure rates seen in the present study compare favourably with those from previous clinical trials, with 17 per cent of the untreated molar bands failing over a mean observation period of 19.5 months. The lower failure rate, compared with some previous studies, may be due to the use of multi-cured, rather than chemically-cured, glass ionomer cement. A laboratory investigation of chemically- and dual-cured glass ionomer cements has shown significantly higher mean tensile bond strength for the bands cemented with the dual-cure glass ionomer, less probability of band failure for a given force, and increased mean survival time (Millett *et al*., 1998).

The failure rate of 2 per cent for the commercially sandblasted bands compares favourably with that found by Millett *et al.* (1995) who carried out their own sandblasting process. The mean observation period in the present study of 19.5 months was slightly longer than the 14.5 months quoted by Millett *et al.* (1995). This low failure rate would support the use of micro-etched bands in clinical practice.

Effects of other explanatory variables

The effect of various factors on the failure rates of micro-etched and untreated bands was examined in this study. Patient age was found to be a factor affecting failure rates by Mizrahi (1977b), and Millett and Gordon (1992). However, the present study found no correlation with age, nor a significant relationship with age group. Patient gender was not found to be a significant factor affecting band failure and this is in agreement with previous authors (Mizrahi, 1988; Millett and Gordon, 1992).

The effect of band location has been found to be significant in some reports where lower molars were found to have the highest failure rates (Mizrahi, 1983; Fricker and McLachlan, 1985). There are, however, several reports which did not find any difference in failures occurring between the upper and lower arches, or right and left sides (Maijer and Smith, 1988; Stirrups, 1991), and these agree with the present study.

Fifteen operators of similar experience treated the patients in this trial and it was not possible to determine any significant differences amongst them with respect to band failure. Millett and Gordon (1992) failed to find any significant difference in operator experience related to band failures, although differences amongst operators were observed. The interaction between operators and treatment mechanics is important as those operators with higher failure rates also used treatment mechanics that had shown a greater probability for failure, for example, Begg mechanics. All patients in the present study were treated with pre-adjusted edgewise appliances and headgear used where clinically indicated. No increase in the failure rate of bands to which headgear was attached was seen. Mizrahi (1977b), and Millett and Gordon (1992) have previously shown extra-oral traction to increase the clinical failure of molar bands.

Molar crossbite was the only variable found to have a significant effect on the survival of molar bands. Six patients presented with a unilateral molar crossbite and, of the 12 bands cemented to these teeth, five were micro-etched and seven untreated. It may be that the occlusion of the lower molar onto the upper band, particularly as headgear tubes were positioned occlusally, may have had some effect. However, of the bands cemented to teeth in crossbite, three bands failed in the lower arch and one in the upper arch. It is possible that a mandibular displacement was associated with the crossbite and that contact with the molar bands may have occurred during functional jaw movements.

Conclusions

Commercial sandblasting of the fitting surface of first permanent molar orthodontic bands significantly reduced the failure rate during fixed appliance treatment. The failure rate of micro-etched orthodontic molar bands in a comparative clinical trial over a mean observation period of 19.5 months was 2 per cent compared with 17 per cent for untreated molar bands. Mean survival time was also increased for micro-etched bands. None of the variables examined had an effect on the clinical failure of molar bands with the exception of the presence of a molar crossbite.

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