The Effect of Timing of Archwire Placement on *in vivo* Bond Failure

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Abstract. *At the commencement of fixed appliance therapy the operator has the choice of either placing bands, brackets, and archwires at one visit, and hence loading the brackets within an hour of initial placement, or placing the brackets and separators at one visit, and the bands and archwires at a subsequent visit. In the case of the latter, the brackets will only be loaded intermittently during the intervening period, for example during mastication. The present study investigated the effect of loading bonded brackets for 2 weeks prior to measuring shear debonding force* in vitro*, and compared the results with* in vivo *bond failure rates for two groups of patients whose brackets were loaded by the archwire either immediately after bonding, or not less than 1 week later. Shear testing and survival analysis indicated* in vitro *loading prior to testing had no significant effect on the shear debonding force. When the* in vivo *data were studied there was no significant difference in the rate of bond failure between those patients whose archwires were placed at the time of fitting the appliance, and those whose archwires were placed no less then 1 week after bracket placement.*

Index words: Bond Failure Rates, Debonding Force.

Introduction

It is common practice at the beginning of orthodontic treatment with fixed appliances either to place the bands, brackets, and archwires at one visit, or to place the brackets and separating elastics at the first appointment, and then to place the bands and archwires between 1 and 2 weeks later. Thus, the brackets may be loaded within an hour of placement or may not be continuously loaded for up to 2 weeks after placement. Only intermittent loading is likely to occur, for example, during mastication. Previous *in vitro* work (Ireland and Sherriff, 1996) has shown that static loading of attachments bonded to enamel increases shear bond strength, as well as a tendency to cohesive enamel fracture on debonding. A possible explanation for this is a modification of the stress field within the bonded system, effecting not only the bond strength, but the locus of bond failure. The effect of stress raisers at the bracket base/bonding resin interface on bond failure has been discussed by Dickinson and Powers (1980). Other factors which will influence measured bond strength and perhaps locus of bond failure include bracket base design/bonding resin combination (Regan and van Noort, 1989), the fit of the bracket base to the enamel surface (Evans and Powers, 1985) and the film thickness (Knoll *et al.*, 1986; Alster *et al.*, 1996). The film thickness maybe related to the filler content and viscosity of the bonding agent (Moin and Dogon, 1978; Winchester, 1992).

The optimal bond strength required for clinical use of the orthodontic bracket/bonding agent/enamel system is as yet unknown. Ideally, the brackets should be easily bonded to the enamel, not undergo any in service bond failures and yet be easily removed at the end of treatment without damage to the enamel surface. *In vivo* bond failure rates using steel brackets and diacrylic bonding agents have been reported to be in the region of 4–10 per cent on all but molar teeth (Zachrisson, 1977; Newman, 1978; Geiger *et al.*, 1983). The aim of this present study was to assess the effect of loading brackets for 2 weeks prior to shear bond testing *in vitro* and to determine whether this had any effect on clinical bond failure rates.

Materials and Methods

Forty human premolar upper second premolar teeth extracted for orthodontic purposes were mounted in acrylic with the buccal enamel remaining exposed. The acrylic block with its embedded tooth measured 35 × 15 × 15 mm and was constructed to fit into a custom made shear testing jig (Ireland and Sherriff, 1994). In each case the enamel surface was pumiced using a rubber cup in a contra-angle handpiece before being etched for 30 seconds with 37 per cent orthophosphoric acid, washed with copious amounts of water, and then air-dried with oil-free compressed air until frosty white in appearance. 'A' Company 0·022-inch minitwin straightwire upper second premolar brackets (Precision Orthodontics, Walton-on-Thames, Surrey, U.K.) were then bonded to the buccal enamel using Right-On (T.P. Orthodontics, La Porte, U.S.A.), a 'no-mix' bonding agent. After 1 hour, 20 specimens had 78 g lead fishing weights suspended from the brackets using nylon fishing line for 2 weeks. These weights were used because 78 g lies approximately midway in the optimal force range for the various types of tooth movement discussed by Proffit (1986), most of which might occur during initial alignment. The remaining 20 specimens were allowed to bench cure for 2 weeks without being loaded in this way. All the specimens were then shear tested to failure on an Instron Universal Testing Machine using the custom made testing

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jig at a cross-head speed of 2 mm per minute. In the case of the preloaded specimens, the shear force was applied in the same direction as the 2-week loading force. The load at bond failure was noted in each case, and the failure surfaces on both the tooth and bracket were examined using a binocular microscope.

In the second part of the investigation a retrospective analysis of the bond failure rate of brackets bonded to enamel *in vivo* were studied in 60 patients undergoing orthodontic treatment with upper and lower fixed appliances. All the patients were being treated by four postgraduate students at the Royal United Hospital, Bath who were on the MSc/MOrth course at Bristol Dental Hospital. At Bath they were supervised by two consultants. One consultant preferred to fit the brackets, bands, and archwires at the same visit, whilst the other preferred brackets and elastic separators to be placed at the first visit, and the bands and, therefore, archwires to be placed at a subsequent visit, usually 1 week later. Thus, one group of 30 patients had brackets bonded to the teeth which were loaded by an archwire approximately 1 hour after bonding and the second group of 30 patients had brackets bonded to the teeth which were not loaded with an archwire for at least 1 week. In all cases the initial aligning wires were light 0·012 inch nickel titanium and the archwire sequence was similar thereafter in each group. The 60 patients were selected at random, and were evenly matched for factors such as age, sex, and starting malocclusion. The number of patients in each group were also fairly evenly divided amongst the postgraduate students. Only bond failures which occurred over the initial 6 months of treatment were counted. If a bracket was rebonded and subsequently failed again it was not recounted.

Results

Data was analysed using Stata Version 4·0 (Computing Resource Center, 1640 Fifth Street, Santa Monica, California 90401, USA) and StatXact Version 3.0.2 (Cytel Software Corporation, ASRU, The University, Canterbury, Kent CT2 7NF, U.K.). The mean shear debonding force for the *in vitro* loaded group was 73·7 N and for the unloaded group 72·8 N. The difference between the sample means was 0·9 N with a 95 per cent confidence interval from −10·4 to 8·5 N, indicating that static loading prior to shear testing had no effect on the measured *in vitro* shear debonding force with this system. The Kaplan–Meier survival curve for this data is given in Fig. 1. The two groups were compared using the log rank test. The probability associated with this test was 0·93, calculated by exact inferential techniques, again indicating no difference between the groups.

Since the majority of *in vivo* bond failures occur within 6 months of placement the failure data reported in Table 1 is restricted to this time period. The relative risk of failure of the immediate placement group relative to the delayed placement group was 0·97 with an associated confidence interval from 0·92 to 1·03. The difference between the failure proportions for the two groups was −0·02 with an associated 95 per cent confidence interval from −0·08 to 0·03. Again, exact inferential computational techniques were used and there was no difference between the two groups.

TABLE 1 In vivo *failure data and associated statistics*

Outcome	Immediate placement	Delayed placement
Failed	75	76
Successful	430	369
Total	505	445
% Failure	14·9	17·1

Relative risk immediate: delayed = 0·97, 95 per cent confidence interval 0·92–1·03. Difference between proportions = −0·02, 95 per cent confidence interval 20·08–0·03.

Discussion

Previous work examining the effect of static loading prior to shear testing demonstrated an increased mean shear debonding and a tendency to cohesive enamel failure following 2 weeks of such loading (Ireland and Sherriff, 1996). In that study, a bracket base design similar to that suggested by Kinami *et al.* (1990) was used in conjunction with Orthodontic Concise (3M, St. Paul, U.S.A.) and a flat enamel surface. Kinami *et al.* (1990) developed this base design in order to promote bond failure at the enamel/resin interface and thus reduce clean up time at debond. The base was unsuitable however, for use with 'no-mix' bonding agents due to the increased film thickness in the area of the base recess and the setting mechanism of the bonding agent. In this present work, static loading prior to shear testing had no effect on the mean shear debonding force. There are a number of possible explanations for this. It may be related to the 'no-mix' bonding agent and its lower filler content than Orthodontic Concise, or to a less complete mixing of the former material compared with the latter twin paste material. A less homogeneous mix of material is considered less able to resist the stresses set up beneath an integral cast or milled base compared with the mesh based bracket (Ferguson *et al.*, 1984; Regan and van Noort, 1989). Equally, the lack of any effect of loading prior to shear testing in the present work may be due to the very different stress fields beneath a mesh-based bracket

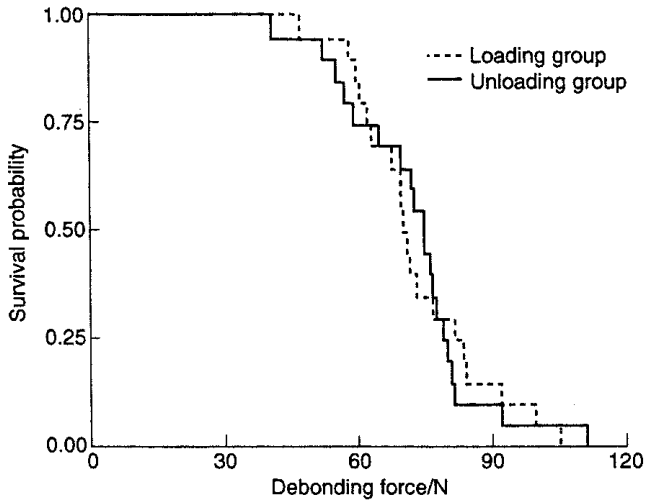

FIG. 1 Kaplan–Meier Survival curve for the loaded versus unloaded brackets after 2 weeks of bench curing.

bonded to an anatomically correct buccal surface, compared to that beneath a close fitting experimental milled recessed bracket base bonded to a prepared flat enamel surface.

Both the mean shear debonding force and 95 per cent confidence intervals and the Kaplan–Meier Survival Probability (Fig. 1) data show that *in vitro* static loading has no effect on shear debonding force. Examination of the *in vivo* bond failure results (Table 1) also demonstrates no significant difference between the two groups. Overall the bond failure rates were found to be high when compared with the results from previous workers (Zachrisson, 1977; Newman, 1978; Geiger *et al.*, 1983) which were in the region of 4–10 per cent. This may be related to the experience of the operators, all of whom had just stared their postgraduate training at the time of bracket placement.

In the *in vitro* experiment one of the specimens in the loaded group demonstrated significant cohesive failure of the enamel. In all the other specimens in both groups, the locus of bond failure was usually mixed mode being adhesive at the enamel/resin interface and cohesive within the resin. There was no record of any cohesive enamel fractures in the *in vivo* part of this study.

Since the timing of archwire placement after bonding brackets to the teeth has no effect on bond failure rates, the operator should consider other factors when deciding how to proceed at the commencement of orthodontic treatment. These could include the safety aspects of patients debonding brackets that are not attached to an archwire versus both the operator and patient fatigue if the whole appliance is to be fitted at one visit.

Conclusions

The following conclusions can be drawn from this work:

1. Loading of brackets for 2 weeks prior to shear bond testing had no significant effect on measured mean shear debonding force.
2. There was no significant difference in the *in vivo* bond failure rates between those patients who had archwires fitted at the same visit as bracket placement and those who had archwire placement delayed for at least 1 week after bracket bonding.

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