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Effects of dietary oil contamination and absence of prophylaxis on orthodontic bonding

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SUMMARY The effect of contamination by dietary oil on acid etching has not been reported in the literature. If dietary oil adversely affects acid etching, then a decrease in bond strength is expected. This *in vitro* study investigated the bond strength of brackets bonded to tooth surfaces that had been contaminated with dietary oil and on which prophylaxis was not carried out. The mean shear bond strengths for the control, teeth with oil contamination and teeth with oil contamination but no prophylaxis undertaken were 53.33 ± 14.31 (SD), 61.76 ± 19.32 and 64.12 ± 17.09 N, respectively. An analysis of variance (ANOVA) test showed that there was no significant difference between the three groups. The power of the ANOVA was calculated forthe minimum clinical change that would be worth detecting and was found to be approximately 1.0. It can therefore be concluded that the presence of dietary oil on the tooth surface does not adversely affect shear bond strength, even if prophylaxis is not carried out. Bond failures for all three groups occurred mainly at the tooth–adhesive interface.

Introduction

Acid etching has become a routine procedure of enamel conditioning in orthodontic bonding. Although it has been extensively investigated (Buonocore, 1955; Gwinnett and Matsui, 1967; Chow and Brown, 1974; Beech and Jalaly, 1980; Legler *et al.*, 1989), the literature is scant concerning the effect of enamel surface contaminants on the efficacy of acid etching.

Contamination of the tooth surface by residues of food may protect the enamel surface from the acid etchant. This is particularly so for dietary oil, which is not water-soluble. Although saliva can wash off the lipid film covering the tooth, it takes a period of time before this film reverts back to the equilibrium state. If bonding is performed on the contaminated tooth surface, the normal procedure of pumicing the tooth and etching the surface with phosphoric acid may not completely remove the oil to produce an optimal etch pattern (Buonocore *et al.*, 1968). Thus the adhesion of composite resin to the tooth surface and bond strength are likely to be adversely affected.

Since the introduction of acid etching by Buonocore in 1955, prophylaxis of the tooth surface with pumice and water has always been carried out prior to acid etching, being taught in dental schools and appearing in all instructions on enamel bonding. Recently some orthodontists have questioned the need for this procedure and also advocated that it be bypassed (Swartz, 1994).

The purpose of this study was to investigate the effect of dietary oil on the *in vitro* shear bond strength of orthodontic brackets. In addition, the result of not pumicing tooth surfaces covered with dietary oil was evaluated. All bond failures were examined and the distributions of the type of bond failure analysed.

Materials and method

Sixty maxillary premolars recently extracted for orthodontic purposes were used in this study. The teeth were non-carious and showed no evidence of restoration or defective enamel on the buccal surfaces, as viewed under a ×10

magnifying lens. To prevent desiccation, the teeth were stored in normal saline until bonding.

The teeth were randomly divided into three equal groups. The buccal surfaces of the teeth in the first group, which acted as the control, were cleaned with a slurry of pumice and water, then etched for 60 seconds using the etching solution provided in the Right-On adhesive kit (TP Orthodontics Inc., LaPorte, IN). This was followed by rinsing for 60 seconds and drying with an oil-free air jet for 10 seconds.

Standard Edgewise premolar brackets (Dentaurum Ultratrimm, Pforzheim, Germany) were bonded to the teeth according to the instructions in the adhesive kit. In order to ensure consistency in placement, the bracket was positioned at the facial axis point (Andrews, 1985) and aligned to the facial axis of the clinical crown. This step was necessary because the enamel prism orientations of the occlusal, middle and cervical third of the tooth surface are slightly different (Scott and Symons, 1982).

The bracket base was placed on the tooth surface with firm pressure from cervical to incisal, squeezing out excessive adhesive incisally, thereby minimizing air voids trapped between the bracket base and tooth surface. The excess adhesive around the bracket was removed with a dental probe.

For the second group (oil-with-pumice group), the teeth were subjected to the same procedure as the control group except that a layer of edible oil (Knife brand, Lam Soon Pte Ltd, Singapore) was painted on the buccal tooth surfaces using a disposable brush just prior to pumicing. The teeth in the third group (oil-without-pumice group) were painted with oil but pumicing was omitted.

After bonding the orthodontic brackets to the teeth, all specimens were kept in normal saline solution for 24 hours to achieve maximum bond strength. Each specimen was then embedded in autopolymerizing polymethacrylate in a cylindrical aluminium ring placed on a glass slab. Only the buccal tooth surface and the attached orthodontic bracket were exposed. To standardize the embedding of the teeth, a straight length of 0.017 × 0.025 stainless steel wire was ligated to each tooth–bracket assembly and the wire placed on the rim of the aluminium ring, thus suspending the assembly. This allowed uncured autopolymerizing resin to be poured into the ring (Fig. 1). The resin was left to harden for an hour before it was taken out of the aluminium ring. The block of acrylic containing the tooth was then stored in normal saline for a week to ensure complete polymerization.

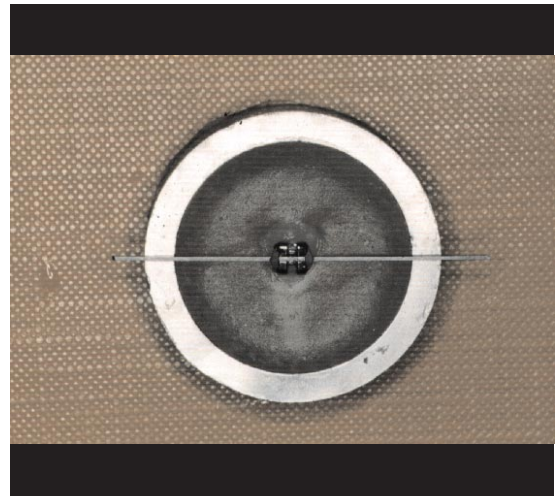

Figure 1 The tooth–bracket assembly suspended by a 0.017 × 0.025 stainless steel wire so that autopolymerizing acrylic can be poured into the ring.

Testing of shear bond strength was carried out on a specially designed apparatus. The acrylic block containing the specimen was held in a vice. Using a travelling microscope to observe the frontal view of the bracket, the acrylic block was adjusted until the two occlusal tiewings of the bracket were level. Similarly, by viewing the bracket from the side, the occlusal and gingival tiewings were aligned to the true vertical. This step ensured that the points of application and direction of the force were standardized for all samples.

A rigid loading rod was used to apply a shear force to the bracket. The metal rod contacted only the two occlusal tiewings, without touching the tooth surface. Movement of the rod was controlled by a hydraulic pump (Owatonna, MN). A pressure transducer (PWF-100, Sokki Kenkjujo Co. Ltd, Tokyo, Japan) linked to a digital strain indicator (model P-3500, Raleigh, NC) displayed the force applied to the bracket

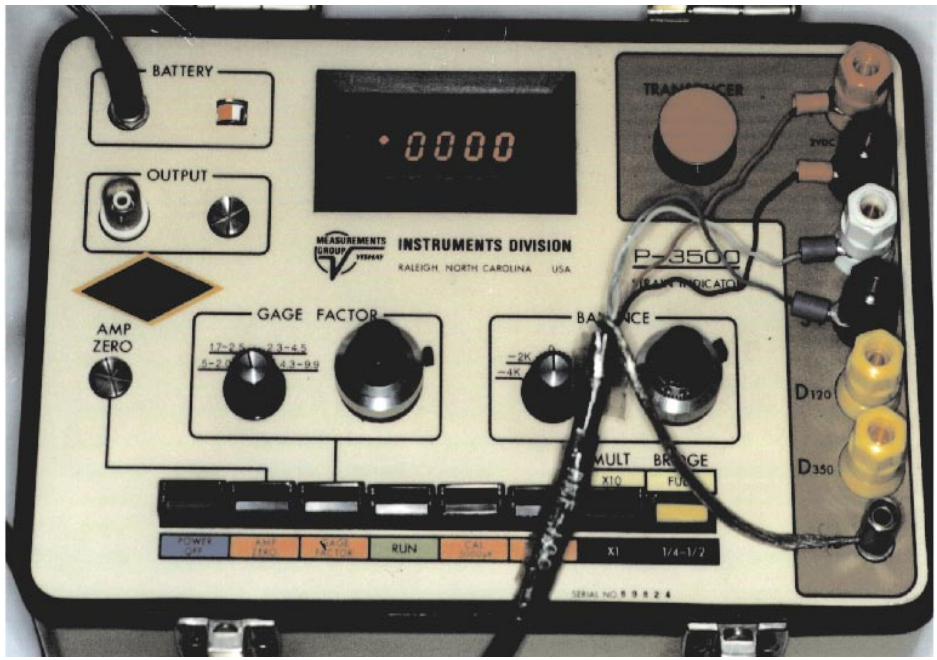

Figure 2 Digital strain indicator.

Table 1 Summary of parameters.

Parameter	Control	Oil-with-pumice	Oil-without-pumice	*F* ratio
Mean (*n*)	53.33	61.76	64.12	2.215 (NS)
SD (*n*)	14.31	19.32,17.09		
Coefficient of variation (%)	26.84	31.27	26.65	

NS, not significant.

(Fig. 2). At the point of bracket bond failure, the reading of the force was recorded. Mean shear bond strengths of the three groups were calculated and subjected to a one-way ANOVA test.

The broken tooth–bracket assemblies were examined under a light stereomicroscope at a magnification of ×40. If less than 50 per cent of the tooth surface was covered by adhesive, the type of bonding failure was classified as tooth–adhesive failure. If 50 per cent or more of the tooth surface was covered, the failure was cohesive failure. Note that in the latter situation, whether the failure occurred at the bracket–adhesive interface or in the body of the adhesive, the classification would still be cohesive failure. This is appropriate because in bracket–adhesive failure, adhesive is always retained in the apertures of the wire mesh, indicating that failure occurs in the body of the adhesive (Reynolds and Von Fraunhofer, 1976). The frequencies of bond failure in the three groups were analysed using Fisher's exact test (two-tailed).

To ensure a standardized technique, one operator performed all the bonding procedures, measurements of shear force and examinations of bond failure.

Results

Table 1 shows the means, standard deviations and coefficients of variation of the three groups.

There was no significant difference in mean shear bond strength between the three groups.

Since the hypothesis test failed to detect a significant difference, it is important to calculate the power of the test. The power of a test gives the probability of detecting a statistically significant result when, in reality, a predetermined difference exists. If the power of a test is low, then the chance of making a type II error, i.e. concluding no treatment effect when in the actual situation there is an effect, is high. There may then be a need to increase the sample size of the test to reduce the type II error.

The minimum clinical change worth detecting was first defined to be 27 N, which represented a change of 50 per cent in the mean bond strength of the control. To detect this change at a confidence level of 95 per cent, the power of the ANOVA test was calculated to be approximately 1.0.

The frequencies of the two types of bond failure for the three groups are summarized in a 3 × 2 contingency table (Table 2).

From Table 2 it can be seen that the control and oil-with-pumice groups have almost similar frequency distributions. Thus Fisher's exact test (two-tailed) was used only to compare the control group with the oil-without-pumice group. No significant difference was found ($P > 0.05$) with this test. As before, the power of the test was calculated, and a value of approximately 0.96 obtained. For our calculations a difference was defined as clinically worth detecting if all thesamples in the control group failed at the tooth–adhesive interface while half of the samples in the oil-without-pumice group failed cohesively. The confidence level was set at 95 per cent.

Thus both the ANOVA test and contingency table were of adequate power and there was no need to increase the sample size in this study.

Table 2 Frequency of bond failure in the three treatment groups.

Treatment group	TA*	CO*	Total
Control	19 (17)	1 (3)	20
Oil-with-pumice	18 (17)	2 (3)	20
Oil-without-pumice	14 (17)	6 (3)	20
Total	51	9	60

Numbers in parentheses are the expected frequencies if the various treatment conditions did not affect the frequencies of bonding failure observed.
*TA = tooth–adhesive failure; CO = cohesive failure.

Discussion

Authors studying shear bond strength have invariably used an Instron machine to measure the force that corresponded to the bond failure point (Gwinnett, 1988; Lew *et al.*, 1993). The specially designed equipment in this study provides an alternative method to measure shear force. It is acknowledged that the rate of increase of shear force was determined manually, which may introduce certain variability into the reading. However, this variability was minimized by having one operator carrying out all the shear force testings.

The mean shear bond strengths for the control, oil-with-pumice and oil-without-pumice groups were 53.33, 61.76 and 64.12 N, respectively. Many authors have reported their results in pressure units, either as MPa or kg/cm^2. We chose to express in force rather than pressure units because several authors have found that shear bond strength was not influenced by the area of the bracket base (Reynolds and Von Fraunhofer, 1976; Dickinson and Powers, 1980; Lopez, 1980).

It is difficult to compare our findings with other studies on shear bond strength due to the differences in the brackets, adhesives and/or experimental methods used. Reynolds (1975) reported that 50 kg/cm^2 was the minimum tensile bond strength required for successful clinical orthodontic bonding. However, there are no published data on the minimum shear bond strength required.

The one-way ANOVA test showed that there was no significant difference between the three groups. In fact, contrary to our expectation, the control group had the lowest mean shear bond strength. The power of the ANOVA test was found to be approximately 1.0. These findings suggest that the routine procedure of orthodontic bonding is robust enough to obtain

good shear bond strength in the presence of contamination by dietary oil. They also suggest that prophylaxis may be a redundant step. It appears that the acid is able to etch the enamel surface successfully even when oil is present, and in addition, the acid–oil combination is able to be washed off completely with just the water jet spray, thus allowing maximal wetting of the enamel surface by the resin primer and the bond strength to develop.

However, our *in vitro* results cannot be fully extrapolated to the clinical situation. The purpose of prophylaxis is to remove dental plaque and the amorphous acquired pellicle, thus exposing the crystalline enamel structure. In this study, the experimental teeth were painted with a layer of oil and probably had no dental plaque or pellicle covering their surfaces. It has been shown that acid etching can remove the acquired pellicle (Jendresen and Glantz, 1981). Based on his own experiences, Swartz (1994) has found that he can achieve 97 per cent bond success rate without pumicing the teeth of his patients.

The coefficients of variation of the three groups were almost similar. They were also comparable to other studies (Keizer *et al.*, 1976; Lew *et al.*, 1993). This lent support to our contention that the method used in this study to measure shear bond strength did not introduce more variability than that using an Instron machine.

The resolution power of a light stereomicroscope is limited and observations made with it must be viewed with caution. To increase the precision of the observations, there were only two well-defined categories for the observations, and the area of adhesive coverage was used rather than the description of morphological or structural details.

Examination of the broken tooth–bracket assemblies showed that most of the bond failures occurred at the tooth–adhesive interface. There was no significant difference in the pattern of bonding failures among the three groups. Other studies of *in vitro* bond testing have characteristically shown that bond failures occurred at the bracket–adhesive interface for metal bases (Reynolds and Von Fraunhofer, 1976; Lee *et al.*, 1974; Keizer *et al.*, 1976; Faust *et al.*, 1978; Dickinson and Powers, 1980; Gwinnett, 1988). There are many possible explanations that could account for this difference, including type of adhesive used, bonding procedure (etching and washing time; whether excess adhesive is removed from the periphery of the bracket), sample storage condition (in alcohol, saline, etc.), sample preparation and bracket base type (foil mesh, perforated base, integral bracket-base, etc.). Another possible explanation is moisture contamination from the particular air jet used in this study.

In a study using almost similar protocol and Right-On adhesive, Lew *et al.* (1993) found that the majority of the bond failures occurred at the tooth–adhesive interface. This result is similar to that found in our study.

Conclusion

The presence of dietary oil on the tooth surface prior to acid etching does not adversely affect the shear bond strength of orthodontic brackets, even without prophylaxis.

No significant difference in the pattern of bond failures was found among the three groups studied. The majority of the bond failures occurred at the tooth–adhesive interface. The pattern of bonding failures was also similar when oil was present but prophylaxis was not carried out.

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