

The effects of bracket removal on enamel

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Background: Enamel cracks, which may develop during debonding orthodontic brackets, may jeopardise the integrity of the enamel and detract from the appearance of the teeth.

Aim: To compare the adhesive remnant scores (ARI), the number, lengths and directions of enamel cracks before bonding and after debonding metal orthodontic brackets with three different methods.

Methods: Metal brackets were bonded with a self-curing orthodontic adhesive to the buccal surfaces of 75 recently extracted upper and lower premolars. The teeth were randomly divided into three groups, and the brackets removed either with a side-cutter, a single-blade bracket remover or a two-blade bracket remover. The number, directions and lengths of the enamel cracks before bonding and after debonding were compared. The number of 'pronounced' cracks (i.e. cracks that could be identified with the naked eye) and the ARI scores in each group were also compared.

Results: After debonding, the number of enamel cracks and pronounced cracks, and the lengths of the enamel cracks increased in all groups ($p < 0.001$). There were no statistically significant differences between the groups. The ARI scores and the direction of propagation of the enamel cracks were not influenced by the debonding method used ($p = 0.73$).

Conclusions: Concerns about the enamel damage caused by the three methods of debonding justify caution. Despite widespread use of these methods, it would be sensible to search for methods that result in less enamel damage. (Aust Orthod J 2008; 24: 110–115)

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Introduction

Several studies have shown that enamel loss can occur during debonding, particularly when the site of fracture occurs at the adhesive-enamel interface. Enamel damage may also take the form of enamel cracks, which may spread during debonding.^{1–4} Enamel cracks may jeopardise the integrity of the enamel and detract from the appearance of the teeth.^{5,6}

Methods used to remove bonded orthodontic brackets involve either deforming the bracket wings or bracket base and 'peeling' the loosened bracket from the tooth, or applying a shear force across the adhesive. Detachment of metal orthodontic brackets with ligature cutters is considered by some clinicians to result in the least amount of enamel damage.^{2,3} Adhesive failure can occur in the resin (cohesive failure), at one of the interfaces between the bracket, the adhesive and the enamel or at a number of different sites.^{7–11} Factors that may influence the site of detachment are the procedure used to prepare the tooth for bonding, the type of bonding material

and the type of instrument used to remove the brackets.^{12,13}

We compared the adhesive remnant indices (ARI) after debonding metal orthodontic brackets with instruments used for this purpose. We also compared the number, lengths and directions of propagation of enamel cracks before and after debonding the brackets.

Materials and methods

Seventy-five upper and lower premolars, extracted for orthodontic purposes, were selected and stored in normal saline at room temperature until required. No teeth had carious lesions or enamel surface defects. Using a stereomicroscope (Blue Light Industry, Waltham, Massachusetts, USA) and colour digital video camera (Exwave HAD, Sony Corporation, Japan) a magnified image (23.9x) was taken of the buccal surface of each tooth. The number of enamel cracks, the length and direction of each crack relative to the long axis of each tooth (i.e. Vertical,

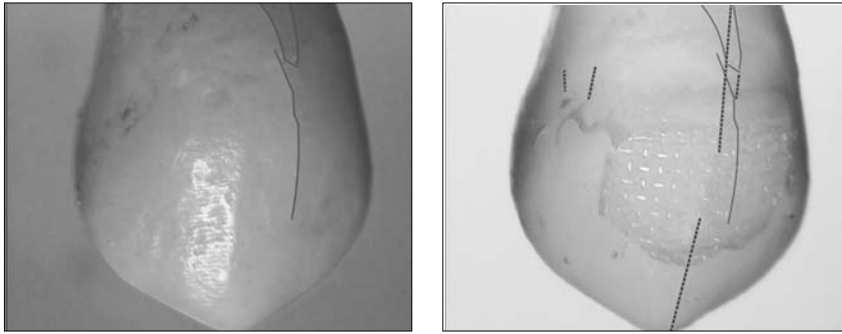


Figure 1. Enamel cracks before bonding the bracket (left) and after debonding (right). The new cracks are hatched.

Horizontal, Oblique or Mixed) were then assessed with the aid of Adobe Photoshop CS software (Adobe Systems Incorporated, USA). The number of 'pronounced' cracks in each group (i.e. cracks visible to the naked eye) was also recorded (Figure 1).

The buccal surface of each premolar was conditioned with the phosphoric acid supplied by the composite manufacturer (Dent Zar Inc., USA). A standard edgewise twin metal bracket (Dentaurum, Pforzheim, Germany) was then bonded with a no-mix orthodontic composite adhesive (Dent Zar Inc., USA) to the most prominent part of the buccal surface of each tooth. The teeth were then placed in distilled water in an incubator at 37°C for 24 hours, to allow the adhesive to harden.^{2,14}

The teeth were then randomly divided into three equal groups. The brackets in the first group were removed with medium ligature cutters (Dentaurum, Pforzheim, Germany) by placing the blades of the side cutters on the tie-wings and applying a peeling force in a mesio-distal direction. In the second group, the brackets were debonded with a bracket remover (Dentaurum, Pforzheim, Germany). The single blade was placed under the gingival tie-wings and the plastic-covered beak rested on the buccal cusp of the tooth. A peeling force was applied in a gingivo-occlusal direction. In the third group, a two-blade bracket remover (Dentaurum, Pforzheim, Germany) was used to apply a mesio-distal shear force on the tooth-bracket interface (Figure 2). All debonding procedures were carried out by the same clinician.

After debonding, the adhesive remnants on the teeth were left untouched.¹⁵ The buccal surfaces of the teeth were again examined with the stereomicroscope, and magnified images (23.9x) taken with the colour digital video camera. The number of enamel cracks,

the length and the direction of each crack were assessed with the aid of the same software. The number of pronounced cracks in each tooth was also recorded. The directions of the enamel cracks were classified as: Vertical (0–30 degrees to the long axis of the crown); Oblique (31–45 degrees to the long axis of the crown); Horizontal (46–90 degrees to the long axis of the crown); Mixed (when a crack altered direction).

The adhesive remnants on each tooth were then assessed with the adhesive remnant index (ARI). This index ranges from 0 to 3: 0, no composite left on the tooth; 1, less than half of the composite left on the tooth; 2, more than half of the composite left on the tooth; 3, all the composite left on the tooth with a distinct impression of the bracket base.¹⁶

The enamel crack data in each group (before and after debonding) were compared with the paired *t*-test, and the groups with the one-way ANOVA or the group differences with the Kruskal-Wallis test if the data were not normally distributed. The ARI scores for the three groups were compared using the chi-squared test. A significance level of 0.05 was used for all tests.

Results

Number of cracks

There were no significant between-group differences in the number of enamel cracks either before or after debonding (Table I). There were significantly more enamel cracks in all groups after the brackets had been removed. However, the Kruskal-Wallis test showed that the difference in the number of cracks among the groups was not statistically significant, chi-squared test: $p = 0.73$; Kruskal-Wallis test: $p = 0.51$.



Figure 2. Bracket removing pliers. From left to right: medium ligature cutters, single-blade bracket remover and two-blade bracket remover.

Table I. Number of enamel cracks before and after debonding.

	Before Mean $\pm$ SD	After Mean $\pm$ SD	Difference Mean $\pm$ SD	p^*
Ligature cutter	4.7 $\pm$ 2.6	7.8 $\pm$ 3.6	3.1 $\pm$ 1.9	< 0.001
Single-blade remover	5.3 $\pm$ 2.9	8.2 $\pm$ 3.2	2.8 $\pm$ 1.8	< 0.001
Two-blade remover	4.1 $\pm$ 1.5	6.9 $\pm$ 1.7	2.8 $\pm$ 1.7	< 0.001
p	0.23 [†]	0.32 [†]	0.88 ⁺	

Significant values are in bold

* Paired t -test

[†] ANOVA

+ Chi-squared test

Table II. Number of pronounced cracks before and after debonding.

	Before Mean $\pm$ SD	After Mean $\pm$ SD	Difference Mean $\pm$ SD	p^*
Ligature cutter	1.4 $\pm$ 1.08	2.0 $\pm$ 1.3	0.60 $\pm$ 0.91	0.003
Single-blade remover	1.6 $\pm$ 1.0	2.4 $\pm$ 1.3	0.80 $\pm$ 1.2	0.005
Two-blade remover	1.4 $\pm$ 1.1	2.0 $\pm$ 1.0	0.60 $\pm$ 0.91	0.003
p	0.68 ⁺	0.46 [†]	0.96 ⁺	

Significant values are in bold

* Paired t -test

[†] ANOVA

+ Chi-squared test

Table III. Lengths of enamel cracks before and after debonding, in millimetres.

	Before Mean $\pm$ SD	After Mean $\pm$ SD	Difference Mean $\pm$ SD	p^*
Ligature cutter	8.3 $\pm$ 4.1	11.5 $\pm$ 4.8	3.2 $\pm$ 1.8	< 0.001
Single-blade remover	9.6 $\pm$ 4.6	13.1 $\pm$ 5.2	3.5 $\pm$ 1.9	< 0.001
Two-blade remover	8.1 $\pm$ 3.2	11.3 $\pm$ 3.1	3.1 $\pm$ 2.0	< 0.001
$p^{\dagger}$	0.39	0.30	0.75	

Significant values are in bold

* Paired t -test

[†] ANOVA

Although the number of pronounced cracks increased significantly in all groups after debonding, the differences between the groups were not statistically significant (Table II).

Lengths of enamel cracks

There were no between-group differences in the lengths of the enamel cracks either before the brackets were bonded or after they had been removed (Table III). The mean length of the enamel cracks before bonding was 8.3 mm in the ligature cutter group, 9.6 mm in the single-blade remover group and 8.1 mm in the two-blade remover group. After debonding the increases in the lengths of the enamel cracks were remarkably consistent: 3.2 mm (38 per cent) in the ligature cutter group, 3.5 mm (36 per cent) in the single-blade remover group, and 3.1 mm (38 per cent) in the two-blade remover group. There were, however, significant intra-group differences in the lengths of enamel cracks (Table III).

Table IV. Directions of enamel cracks before and after debonding.

		After							
		Vertical		Oblique		Mixed		Total	
		Number	%	Number	%	Number	%	Number	%
Before	Vertical	2	2.7	0	0	16	21.3	18	24
	Oblique	0	0	1	1.3	1	1.3	2	2.7
	Mixed	0	0	0	0	55	73.3	55	73.3
	Total	2	2.7	1	1.3	72	96	75	100

Table V. Adhesive remnant index.

ARI	Ligature cutter		Single-blade remover		Two-blade remover		Totals	
	Number	%	Number	%	Number	%	Number	%
1	1	4	2	8	1	4	4	5.3
2	9	36	8	32	13	52	30	40
3	15	60	15	60	11	44	41	54.7
Totals	25	100	25	100	25	100	75	100

Direction of the cracks

Before bracket placement, 73.3 per cent of the enamel cracks were mixed in direction, 24 per cent of the cracks ran vertically and only 2.7 per cent were oblique. After debonding, however, the percentage of mixed cracks rose to 96 per cent and the percentage of vertical cracks fell to 2.7 per cent (Table IV). There were no horizontal cracks in our samples.

The results showed that the changes in crack direction were not statistically different among groups ($p = 0.73$). However, there was strong agreement (Contingency coefficient: 0.606; $p = 0.003$) between the direction of cracks before and after debonding.

Adhesive remnant index (ARI)

Table V presents the ARI data for the groups. The chi-squared test showed that the differences were not statistically significant ($p = 0.66$). In no sample was the ARI zero: after debonding some adhesive remained on all teeth. Furthermore, in about 95 per cent of the samples more than half of the adhesive was left on the tooth surface, irrespective of the method of debonding.

Discussion

Some investigators have suggested that the method of debonding brackets may influence the size of existing

enamel cracks and the number of new cracks.^{5,6} We compared the number, lengths and directions of enamel cracks and the ARI following removal of bonded orthodontic brackets with either a medium ligature side-cutter, a single-blade bracket remover or a two-blade bracket remover: all used by the same clinician. After debonding, the number and lengths of the enamel cracks increased in all groups, but there were no differences between the groups. We found minor differences between the ARI scores, and concluded that although the three debonding instruments were used differently, the resin fractured at similar sites. However, Oliver⁴ showed that when the two-blade bracket remover was applied to the base of the bracket at the enamel-resin interface, as opposed to the wings, the ARI score was significantly lower. In his study, he used the Concise composite and enamel bond system (3M/Dental Products, St. Paul, Minn.) in both base and wings groups.

We found that most of the resin remained on the tooth after debonding, which suggests that either the resin was weak close to the bracket base or the mechanical lock between the mesh and resin was broken by distortion of the bracket base. In agreement with Toledano et al. we found few bonding failures were located at the adhesive-enamel interface.² When the ligature cutter and single-blade remover

were used, the majority of bonds failed at the bracket-adhesive interface, but when the two-blade remover was used about half of the brackets were debonded by fracturing the resin cohesively. Air entrapment behind the bracket base may inhibit polymerisation and result in a lower bond strength between the bracket mesh and the composite or a weak resin.¹⁷ It would appear that in spite of failure at the bracket-adhesive interface or within the resin, debonding can produce stresses that cause new enamel cracks or existing cracks to propagate.

We found that the directions of the majority of the enamel cracks changed during debonding. While Zachrisson⁵ reported that the majority of the enamel cracks ran vertically before bracket placement, we found that only about a quarter of the enamel cracks were vertical and the majority of the cracks ran in two or more directions. We found that after debonding the directions of more than 90 per cent of the enamel cracks were mixed. Thus, during debonding a crack may extend in a new direction. One possible cause of this observation may be the pattern of stresses in the enamel during debonding.

We did not polish the teeth or attempt to remove the adhesive remnants before taking magnified images of the buccal surfaces and recording the number and directions of the enamel cracks. We found that it was possible to see the cracks through the adhesive remnants.¹⁵ By leaving the teeth untouched we avoided obliterating shallow cracks and filling cracks with debris, which may have made it difficult to distinguish them from the surrounding intact enamel. If the cracks had been filled with dye beforehand, it may have affected the bond strength and thus the results. The effects of polishing could be tested by recording details of the cracks before and after polishing.

In the mouth many other variables may affect the number of enamel cracks. For example, orthodontic brackets can be present in the mouth for several years and subjected to complex thermal, chemical and physical stresses, all of which may affect existing enamel cracks or initiate new cracks. Further studies are required to investigate the depths and volumes of enamel cracks, and the stresses induced in the tooth and resin during debonding.

Conclusions

1. In this in vitro experiment the number of enamel cracks, the lengths and the directions of the cracks

relative to the long axis of each tooth were recorded before and after steel orthodontic brackets were bonded to the buccal surfaces of 75 human premolars, and removed with one of three types of bracket removers.

2. All methods fractured the adhesive at the bracket base-adhesive interface or cohesively.

3. After debonding the number and lengths of the enamel cracks increased and existing enamel cracks changed direction.

4. Despite widespread use of these methods of debonding, it would be sensible to search for methods that result in less enamel damage.

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