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DOI: 10.2478/aoj-2009-0004

Effect of adhesive types on enamel discolouration around orthodontic brackets

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Background: Unsightly colour changes may occur in the enamel around bonded orthodontic brackets.
Aim: To determine the enamel colour changes around orthodontic brackets bonded with different adhesives.
Methods: One hundred extracted upper first premolars were divided into five equal groups. Fiducial holes were drilled in the buccal and palatal surfaces of the teeth and metal orthodontic brackets were bonded to the buccal surfaces with different combinations of adhesives and primers. The teeth were immersed in a tea-coffee solution for one week. The brackets were then debonded and the teeth polished. The colour of the enamel surface was measured around each fiducial hole before bonding (baseline), after debonding and after polishing. The colour differences (ΔE) were compared using one-way ANOVA and the paired *t*-test.
Results: There were no significant differences between the five adhesive groups in baseline-debonding ΔE and baseline-polishing ΔE, but statistically significant differences were found between the baseline-debonding ΔE on the buccal and palatal surfaces and the baseline-debonding ΔE versus baseline-polishing ΔE on the buccal surfaces. Although statistically significant, the colour changes would not be visible to many observers. Approximately 75 per cent of the staining was attributed to the enamel components.
Conclusions: The type of adhesive and the methods of application had no effect on enamel colour change. Most of the colour change was attributed to uptake of stain by the components of the enamel, not the resin tags.
(Aust Orthod J 2009; 25: 19–23)

Received for publication: July 2008
Accepted: January 2009

Introduction

Adverse colour changes can occur in the enamel around bonded orthodontic brackets due to damage caused during bonding, debonding and cleaning.[1–4] In addition, colour changes may be due to decalcification around a bonded bracket because of poor oral hygiene and uptake of stains by the enamel and resin tags.

Failure to remove resin tags, which can reach depths up to 50 µm, is considered to be a major cause of enamel discolouration.[2,3] The resin residues absorb food colourants as well as corrosion products arising from the orthodontic appliances.[5] The purpose of this study was to determine the enamel colour changes associated with orthodontic brackets bonded with different adhesives.

Material and methods

One hundred extracted upper first premolars were used in this study. The teeth were cleaned and stored in distilled water until required. Only premolars free of damage from the extraction forceps and with no evidence of enamel hypoplasia or enamel defects were used. The centre points of buccal and palatal surfaces were determined along the long axes of the crowns. A fiducial hole, with an approximate diameter of 1 mm, was drilled with a slow speed handpiece at the centre point of the palatal surface of each tooth, and a second fiducial hole was drilled 3 mm mesial to the centre point of the buccal surface (Figure 1). These marks ensured that the same area of the enamel surface was measured with the colorimeter. The teeth were embedded in acrylic resin and randomly assigned to five equal groups. The colour of the

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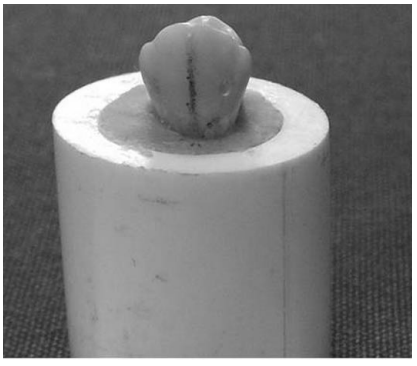


Figure 1. Prepared premolar with fiducial hole on buccal surface.

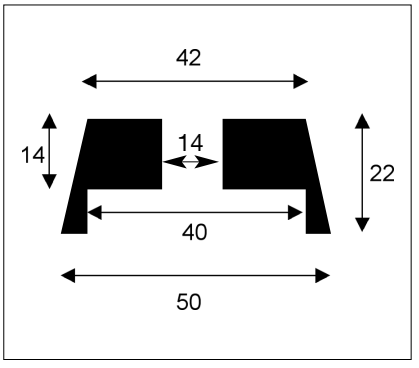


Figure 2. Dimensions (mm) of the cap attaching the fibre optic to the colorimeter.

enamel around the buccal hole was then measured with a colorimeter (Minolta, Model C-10, Tokyo, Japan) according to the Commission International d'Eclairage system. The CIE system describes the colours visible to the human eye and is used to specify a spectral colour precisely in terms of the proportions (tristimulus values) of three additive primary colours: red, green and violet. The CIELAB has a lightness scale, L*, and opponent colour axes for redness-greenness versus yellowness-blueness designated a* and b*, respectively. Negative values of a* indicate green while positive values indicate magenta and negative values of b* indicate blue and positive values indicate yellow.[6,7]

A tapered teflon cap fitted with a short length of light fibre was attached to the colorimeter, in order to limit investigations of enamel discolouration to the area around each fiducial hole (Figure 2). To minimise the effect of ambient light on the results, all colorimetric evaluations were carried out between 9 and 10 am.

The teeth were cleaned and polished with pumice and rubber prophylactic cups for 10 seconds and then thoroughly washed and dried. The entire buccal surfaces of all teeth were etched with 37 per cent phosphoric acid gel (Ultra etch, Ultra- Dent, USA) for 30 seconds, washed with water for five seconds and dried for 15 seconds. Metal orthodontic brackets (Dentarum, Ispringen, Germany) were bonded to the buccal surfaces of the teeth in Group A with a chemically cured composite resin (Prime-Dent, Prime Dental, USA) without an application of primer. In Group B, the buccal surfaces were primed and orthodontic brackets bonded with the same composite resin as Group A, used according to the manufacturer's instructions. In Group C, a light-cured composite resin (Amelogen Plus, Ultra-Dent, USA) was used without any primer, and in Group D the same composite resin was used following application of an enamel bonding agent (Margin Bond, Colten, Switzerland). The primer was polymerised with a light curing unit (Astralis 3, Viva Dent, Austria) for 20 seconds and the composite resin for a total of 120 seconds by positioning the light in turn on the buccal, incisal and gingival aspects. In Group E, the brackets were bonded with an orthodontic no-mix (one-phase) adhesive resin (Unite, 3M, Unitek, USA) used according to the manufacturer's instructions. Brackets were not bonded to the palatal surfaces.

All specimens were submitted to 3000 thermal cycles in baths at 5°C and 55°C with 25 second dwell times. The teeth were then immersed in a tea-coffee solution for one week at room temperature. The brackets were debonded with a debonding plier and a second colour determination performed at the same sites. The colour parameters were averaged for each group, and colour differences (ΔE) were calculated using the following equation:[8]

$\Delta E^* = [(L_1^* - L_2^*)^2 + (a_1^* - a_2^*)^2 + (b_1^* - b_2^*)^2]^{1/2}$, where L_1 and L_2 are the first and the last measured lightness values respectively, and a_1 and a_2 are the first and the last measured opponent colour axes.

All specimens were then polished with a rotating brush and pumice for 15 seconds. Remnants of adhesive were removed with sequential use of 12 and 30 fluted tungsten carbide burs (Fressima, FIT, Turin, Italy) used at slow speed. The efficacy of the cleaning process was confirmed with a light microscope.

The colour parameters were determined again and ΔE calculated. To improve reliability, all colorimetric

Table I. Colorimetric comparisons after debonding and polishing.

Group	Buccal surface			Palatal surface		
	Baseline-debonding Mean ± SD	Baseline-polishing Mean ± SD	*p**	Baseline-debonding Mean ± SD	Baseline-polishing Mean ± SD	*p**
A	2.18 ± 1.05	1.38 ± 0.93	**0.004**	1.31 ± 0.73	1.09 ± 0.50	0.330
B	2.53 ± 1.38	1.84 ± 1.01	**0.006**	1.53 ± 0.65	1.31 ± 0.59	0.310
C	2.52 ± 1.16	1.72 ± 1.09	**0.001**	1.68 ± 1.05	1.25 ± 0.65	0.100
D	2.64 ± 1.26	1.84 ± 1.06	**0.001**	1.59 ± 0.76	1.28 ± 0.62	0.130
E	2.75 ± 1.36	1.67 ± 1.10	**0.001**	1.91 ± 1.17	1.35 ± 0.72	0.061
p†	0.68	0.62		0.32	0.74	

A, Prime-Dent composite resin without primer
B, Prime-Dent composite resin with primer
C, Amelogen Plus composite resin
D, Amelogen Plus composite resin and Margin Bond enamel bonding agent
E, Unite composite resin
* Paired *t*-test, significant values in bold
† ANOVA

Table II. Colorimetric comparisons of the buccal and palatal surfaces.

Group	Buccal surface			Palatal surface		
	Baseline-debonding Mean ± SD	Baseline-polishing Mean ± SD	*p**	Baseline-debonding Mean ± SD	Baseline-polishing Mean ± SD	*p**
A	2.18 ± 1.05	1.31 ± 0.73	**0.010**	1.38 ± 0.93	1.09 ± 0.50	0.260
B	2.53 ± 1.38	1.53 ± 0.65	**0.009**	1.84 ± 1.01	1.31 ± 0.59	0.080
C	2.52 ± 1.16	1.68 ± 1.05	**0.010**	1.72 ± 1.09	1.25 ± 0.65	0.110
D	2.64 ± 1.26	1.59 ± 0.76	**0.004**	1.84 ± 1.06	1.28 ± 0.62	0.070
E	2.75 ± 1.36	1.91 ± 1.17	**0.050**	1.67 ± 1.10	1.35 ± 0.71	0.330

A, Prime-Dent composite resin without primer
B, Prime-Dent composite resin with primer
C, Amelogen Plus composite resin
D, Amelogen Plus composite resin and Margin Bond enamel bonding agent
E, Unite composite resin
* Paired *t*-test, significant values are in bold

evaluations were carried out twice by the same person. Data was evaluated using the SPSS 10.0 statistical programme and the ΔE values derived from the three colour recordings for each material compared with a one-way ANOVA. Paired *t*-tests were used to determine if there were significant differences in the ΔE values of each adhesive between the buccal and palatal surfaces and between the two instances.

Results

Colorimetric comparisons of the buccal and palatal surfaces after debonding and polishing are given in Tables I and II. There were no statistically significant group differences between the colour changes baseline-debonding and baseline-polishing for the buccal (p = 0.68 and 0.62 respectively) and palatal surfaces (p = 0.32 and 0.74 respectively) (Table I). The buccal surfaces of the teeth in all groups were significantly more discoloured after debonding as compared with the same surfaces after polishing. After debonding the palatal surfaces were slightly more discoloured than the same surfaces after polishing, but the differences (baseline-debonding versus baseline-polishing) were not statistically significant.

The colorimetric differences, baseline-debonding and baseline-polishing, for the buccal and palatal surfaces are given in Table II. After debonding the buccal surfaces in all groups were significantly more discoloured than the palatal surfaces. After polishing, the buccal surfaces retained some staining, but the colour differences between the buccal and palatal surfaces were not statistically significant.

Discussion

We measured the colour of the buccal and palatal surfaces of extracted premolars before bonding stainless steel orthodontic brackets with different combinations of adhesives and primers, after the teeth had been immersed in a tea-coffee solution and the brackets debonded and, again, after polishing the teeth. In general, colour changes that fall below one unit are considered exact colour matches.[8] Differences greater than two units may indicate a change in colour, but most clinical studies set the limit for a visible change at 3.7 units.[9] We used a colour difference of 3.7 units as the threshold between an acceptable and unacceptable colour change.

The lack of a statistically significant difference in the baseline-debonding colour changes in the adhesive groups indicates that the type of adhesive did not have a significant effect on enamel discolouration: the different composite-resins systems appear to have absorbed and/or retained stain more-or-less equally. After debonding, but before the teeth were polished, the results show that the buccal surfaces were more discoloured than the palatal surfaces of the same teeth, but the colour change (baseline-debonding) was less than 3.7 units and would not be visible to an observer. At the debonding stage, adhesive debris on the buccal surfaces appears to have contributed to enamel discolouration. After both surfaces had been polished, the buccal surfaces were slightly more discoloured than the palatal surfaces, but the differences were not statistically significant and an observer would not be able to distinguish between the two surfaces. The cleaning and polishing protocol we used removed the adhesive debris lying on the enamel surface and, probably, some stained enamel components and resin tags as well, all of which would have contributed to enamel discolouration.

Enamel discolouration may be due to penetration and staining of the resin tags and enamel components, which are not removed by conventional cleaning procedures.[3,10] On the buccal surfaces, the resin tags may have extended 30–50 μm into the enamel, affecting the refractive index and modifying the reflected components of light, thus influencing the colour parameters. Our data suggest that we managed to remove most, but not all, of the stained resin tags and enamel damaged by acid-etching and stained by the tea-coffee solution: the mean ΔE values for the buccal surfaces fell after polishing, but did not return to their baseline levels.[4,10,11]

After polishing, the colour of the palatal surfaces also failed to return to baseline levels: it was approximately three quarters the colour change on the buccal surfaces after polishing (Palatal surface overall mean after polishing: 1.26; Buccal surface overall mean after polishing: 1.69) and approximately 1 unit above baseline. Retention of the tea-coffee stain by the palatal surfaces suggests that the enamel components contribute to enamel discolouration, as well as the resin tags. Further studies should investigate the nature and depth of the staining in enamel with and without bonded attachments.

The staining solutions used, the immersion time, dilution with saliva and other drinks/foods and whether or not the teeth are cleaned during the study are some of the factors that may determine the enamel severity of staining in vivo.[12] We immersed extracted teeth in a tea-coffee solution at room temperature for one week, but in the mouth the teeth would be intermittently exposed to a hot tea/coffee solution, and it is likely that a longer period of time would be necessary for a drink to produce the colour changes we observed. It is also possible that other beverages and foods may modify the severity of any enamel staining. Finally, we re-emphasise that the colour changes we found were small and are not likely to be distinguished by most observers.[13]

Conclusion

The type of adhesive and the methods of application had no effect on changes in enamel colour. The colour changes were not marked enough to be visible to the majority of observers.

Most of the colour change was attributed to uptake of stain by the components of the enamel, not the resin tags.

Acknowledgment

We wish to thank Dr Habibollah Esmaili, for assistance with the statistical analysis, and Drs Hossein Pezeshkirad and Nima Mokhber for their valuable comments. This study was supported by a grant from the Vice Chancellor of Research of Mashhad University of Medical Sciences (Grant: 86208).

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