

## Excess Adhesive Flash Upon Bracket Placement

*A Typodont Study Comparing APC PLUS and Transbond XT*

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### ABSTRACT

**Objective:** To determine if there is any significant difference in excess adhesive flash (EAF) with the use of APC PLUS adhesive coated appliance system and Transbond XT and if other variables such as side of the mouth, time taken to bond the brackets, the age of the orthodontic specialist, or the years of clinical experience affected the amount of EAF.

**Materials and Methods:** Twenty orthodontic specialists bonded 20 preadjusted straight wire brackets (Victory, 3M Unitek) on a typodont with a Class I crowded malocclusion in a split-mouth design, with one-half of the brackets bonded with APC PLUS adhesive system and the other half with Transbond XT. The teeth were sputter coated with gold and an image was taken at 32× magnification in a scanning electron microscope (Philips XL30). The resultant tagged image file (TIF) was opened in AnalySIS Pro 3.1 (Soft Imaging System, Munich, Germany) and the area of EAF was measured.

**Results:** *t*-Tests demonstrated that: (1) there was no statistically significant difference in EAF between two adhesives when bonding in different quadrants of dentition; and (2) there was no statistically significant difference in EAF between two adhesives overall. Analysis of variance models demonstrated there were no statistically significant differences found regarding the age of the orthodontic specialists, years of clinical experience, and time in performing the bonding.

**Conclusions:** The addition of a coloring agent to assist in the visualization of the excess adhesive does not reduce the amount of excessive adhesive around orthodontic brackets.

**KEY WORDS:** Brackets bonding; Bonding adhesive; Excess adhesive

### INTRODUCTION

Despite the advances in dental care and the reduced prevalence of dental caries in children, the formation of white spot lesions (WSL) is not uncommon around orthodontic brackets.<sup>1</sup> Gorelick et al<sup>2</sup> found that half of the patients treated with fixed appliances had at least one WSL after treatment, and there were no differences in incidence between banding or bonding.

Other authors<sup>3,4</sup> indicated that the incidence ranges from 2% to 96%. The most affected teeth are the upper lateral incisors, upper canines, and lower premolars.<sup>5</sup> What should concern us the most is that WSL associated with orthodontic appliances can develop as quickly as one month.<sup>6</sup> These WSLs formed on the labial surface have an obvious cosmetic significance and, even though they may regress,<sup>7</sup> mostly due to surface abrasion, there still may be an esthetic problem 5 years after removal of the appliances.<sup>8</sup>

It is commonplace in a clinic that a certain amount of excess adhesive flash (EAF) remains alongside the borderline between the bracket and the enamel upon bracket bonding. The attribution of EAF to the formation of WSL has been investigated. It is thought that if the adhesive excess is not removed it can act as a mechanical irritation to the gingiva, especially on teeth where the distance from the bracket pad to the gingiva is small.<sup>9</sup> In addition, it has also been demonstrated that bacteria will readily colonize the surface of rough materials such as composites and potentially increase in the incidence of WSL.<sup>10,11</sup> Therefore, good flash re-

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**Figure 1.** The typodont with Class I crowding malocclusion was set up for bracket bonding using APC PLUS and Transbond XT.

moval is essential; it should reduce the amount of plaque accumulation and may reduce the incidence of WSL.<sup>9</sup>

There are two ways light-cured bonding materials can be applied to the brackets: (1) the adhesive is applied to the bracket by the manufacturer, ie, the bracket is precoated and the amount of adhesive is set at a minimum level, which is independent of the manipulation of orthodontists or dental assistants; and (2) the adhesive is applied to the bracket at the chair-side by the dental assistant. The amount that is placed on the bracket is usually determined by the dental assistant conforming to the orthodontist's preference. This adhesive is usually color-free, whereas the APC PLUS precoated bracket adhesive is fluoride-releasing and provides a color change feature, which gives the clinician a visual marker of adhesive placement and is especially convenient in flash clean-up.<sup>12</sup> This study was therefore designed to determine: (1) If there is any significant difference in amount of excess adhesive flash with the use of bonding adhesive precoated on the bracket (APC PLUS adhesive coated appliance system) and adhesive separate from the bracket (Transbond XT bonding system); and (2) if other var-

iables such as the quadrant of the dentition, time taken to bond the brackets, the age of the orthodontic specialist, or the specialist's years of clinical experience affected the amount of excess adhesive flash.

## MATERIALS AND METHODS

### Typodont Simulation and the Operators

A custom-made Class I malocclusion typodont was prepared with severe crowding, but no tooth was so severely displaced that it prevented ideal bracket placement. The teeth to be bonded were sandblasted (Danville, San Ramon, CA) with 50  $\mu$ m aluminum particles for 10 seconds and then mounted on an adjustable rod, which allowed each operator to reposition the typodont to simulate a supine patient ready for bonding. Synthetic latex lips were placed to prevent direct vision of the premolar teeth, and a cheek retractor (Sasa, Kongivor, Norway) was added to create a more realistic clinical simulation (Figure 1).

Twenty orthodontic specialists (13 men, 7 women) were recruited to participate in this study for which they were asked to bond brackets on typodonts. The mean age of these operators was 41.72 years, ranging

between 29 and 53 years (SD 6.69 years). Mean years of experience as specialist orthodontist was 9.64 years, ranging between 1 and 25 years (SD 7.36 years).

### Study Design and Brackets Bonding

The brackets used in this study were preadjusted straight wire brackets (Victory Low Profile, 3M Unitek, Monrovia, Calif). Half of the brackets were precoated (APC PLUS adhesive coated appliance system, 3M Unitek); the adhesive (Transbond XT, 3M Unitek) for the other half of the brackets was applied at the chairside by the same assistant.

The operators were divided into two groups, and the brackets were bonded using a split-mouth design. Group 1 (operators 1–10) bonded brackets with APC PLUS on the upper right and lower left teeth, and with Transbond XT on the upper left and lower right teeth. Group 2 (operators 11–20) bonded brackets with APC PLUS on the upper left and lower right teeth, and with Transbond XT on the upper right and lower left teeth.

The operators started the bonding procedure by reading a prepared handout with photographic images, defining the exact position each bracket was to be placed, and requesting that they remove the excess cement as if it was for a patient in their own practice. Each operator was given a selection of instruments (mirror, probe, periodontal probe, scaler,  $\frac{1}{2}$  Hollenbeck, flat plastic, ruler, and height gauges [4–5.5 mm, 3M Unitek]) and was asked if any other instruments were required. The teeth were then primed with Transbond XT (3M Unitek). After bonding the brackets using the two adhesives respectively, the brackets were then set using the available curing light at each surgery. As the bond strength of the brackets was not to be tested, standardization of the curing lights was not necessary. The time taken to bond the brackets was recorded.

### Measurement and Assessment of EAF

The teeth were removed from the typodont and the wings of the brackets were detached using a diamond burr. This would prevent the wings from obscuring excess adhesive when a straight-on image was taken with the scanning electron microscope (SEM). The root of each tooth was removed and the lingual surface was trimmed flat so that the typodont teeth were stable when mounted on the 12 mm pin stubs. The teeth were attached to the pin stubs by double-sided conductive tape and a small amount of conductive carbon paste to ensure good contact. The teeth were then sputter coated by gold (Edwards coating system E306A) to a standard thickness of 10 nm (Figure 2). Each tooth was then placed in the SEM (Philips XL30, Eindhoven, Netherlands) and an image at 32 $\times$  mag-

nification was taken and saved as a tagged image file (TIF). The digital images were opened using analySIS Pro 3.1 (Soft Imaging System, Munich, Germany) and calibrated using the scale on the digital image. The area of EAF was outlined and measured three times and an average was taken (Figure 3).

The results were analyzed using the statistical software SPSS for Windows (release 12.0, SPSS Inc, Chicago, Ill). *t*-Tests were used (1) to examine in each group whether there was a difference in the amount of EAF between the two adhesives (APC PLUS and Transbond XT) and (2) to analyze if there was a difference in the amount of excess between the two adhesives overall. Also, analysis of variance models were used to examine whether other variables (quadrant of dentition, time taken, and demographic variables such as age and years of experience) affected the amount of excess. Since multiple and dependent tests were carried out, a significance level of  $P < .01$  was used. To measure the method error using Bland approach,<sup>13</sup> one operator had the brackets remeasured three times with a 2-week interval between measurements.

### RESULTS

The removal of the wings resulted in debonding of a number of the brackets. This led to the exclusion of two subjects in Group 2 and 20 missing brackets in the remaining 18 subjects. Therefore, 340 SEM images were taken and measured.

The average amount of EAF for the 20 teeth is demonstrated in Table 1. The analysis of variance models demonstrated that there were no statistically significant differences in amount of EAF regarding age of orthodontic specialist ( $P = .14$ ), years of clinical experience ( $P = .30$ ), and time ( $P = .51$ ).

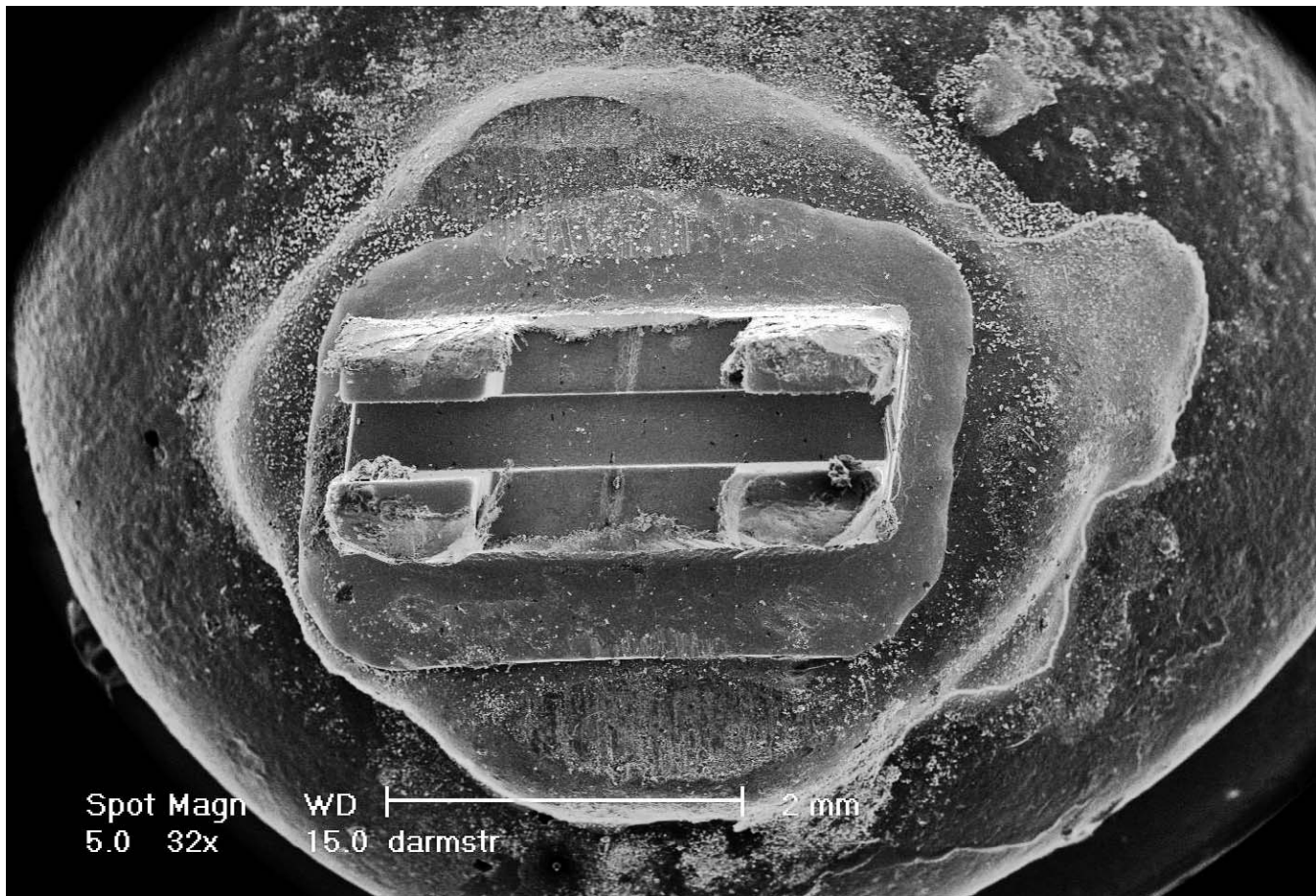
The first *t*-test between the two groups showed that there were no statistically significant differences in using the two adhesives (APC PLUS and Transbond XT) for the upper left and lower right teeth vs the upper right and lower left teeth (Table 2). However, there was a tendency to difference for the upper lateral incisors ( $P = .048$ ), the lower canines ( $P = .012$ ), and the lower second premolars ( $P = .03$ ) (Table 2).

The second *t*-test determining if there was a difference between the adhesives overall (two groups combined) showed that there was no difference in amount of EAF (Table 3). However, there was a tendency to difference for the upper second premolars ( $P = .053$ ), the upper first premolars ( $P = .040$ ), and the lower central incisors ( $P = .034$ ) (Table 3).

To measure the method error using the Bland approach,<sup>13</sup> the brackets of one subject were remeasured. The measurements were made one after the



**Figure 2.** After bracket bonding, typodont teeth were removed and mounted on 12 mm pin stubs coated in gold. Please note that the tie wings of the brackets were trimmed off to expose EAF well.



**Figure 3.** SEM image was produced and EAF was outlined and its area was measured.

other with the image being reopened and then calibrated each time. Standard deviation (between repeated measurements) was 0.079 and coefficient of variance ( $CV = 100 \times SD/\text{mean}$ ) was 0.6% for the remeasuring; SD was 0.561 and CV was 4.3% for the reimaging and remeasuring (calculated using the overall mean measurement of 13.0).

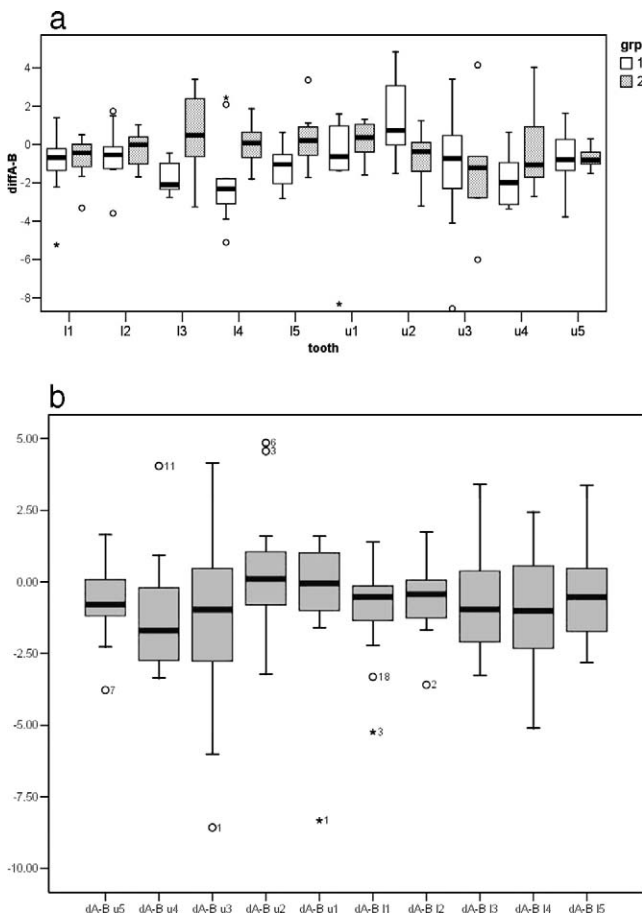
## DISCUSSION

It is recognized that if the EAF is not removed, it increases the amount of plaque and can act as a mechanical irritation to the gingiva, and, therefore, potentially increase the incidence of WSL.<sup>14–17</sup> With the introduction of light-cured composite materials, clinicians were able to more easily remove EAF before it set, while it was still soft. Previously used chemical-cured composites required removal of the EAF with a bur, once it had set.<sup>18,19</sup>

One of the difficulties in assessing the amount of excess adhesive around orthodontic brackets in a typodont study is that if you inform the operators that you are measuring the excess they may spend more time removing it, and therefore the results would not

reflect the true clinical picture. If the subjects, on the other hand, are blinded to the fact that excess adhesive is being measured, they may think it is not important and may not remove as much as they would normally, once again not really reflecting the true clinical picture. This study was part of the main study aiming to assess the accuracy of bracket placement, where the operators were unaware that EAF was being measured. However, they were asked to remove the excess adhesive as if it were for a patient treated in their orthodontic clinic. We would assume that as willing participants they followed the instructions, and the amount of EAF measured is a true reflection of what is actually left clinically.

Two subjects were excluded in group 2 due to multiple brackets coming off as a result of wings being removed, and in the remaining 18 subjects 20 brackets were excluded. This resulted in 340 SEM images measured, with 161 pairs compared. This may reflect a different bond strength achieved due to either less retention from the sandblasting, a poorer cure due to a different light being used, or perhaps bluntness of the bur. Ideally, a three-dimensional analysis would



**Figure 4.** Boxplot depicting the results of *t*-tests aiming to examine the differences in amount of AEF between APC PLUS and Transbond XT (a) within each group and (b) combining two groups overall.

have negated the need to remove the wings, but the software used was unable to form a three-dimensional image from a stereo pair and three-dimensional computerized tomography imaging did not provide enough contrast between the typodont tooth material and the composite resin. The imaging method used in this study was a straight-on SEM image and proved simple and reasonably reproducible, with repeated imaging and measuring demonstrating a SD of 0.561 and a CV of 4.3%.

An alternative technique could have been to take an impression of the individual teeth and then study the reproduction (the cast) in the SEM.<sup>20</sup> The wings could have then been removed without the risk of debonding the brackets. There is the possibility that there is some loss of detail at the impression stage or in the casting of the impression; however, it has been suggested that this method would provide adequate accuracy up to 500 $\times$  magnification,<sup>18,19</sup> provided that there is no pellicle, plaque, or debris on the tooth surface when the impression is taken.

It has been suggested in an accuracy of bonding

study<sup>20</sup> that for linear measurements there was a trend for left-sided bonds (direct or indirect) to be more accurate in the upper arch and for right-sided bonds to be more accurate in the lower arch. This raised the possibility that there may be a bias in the arch or in the side in which the brackets were placed. In this study, as each operator was compared right side to left side (effectively APC PLUS to Transbond XT) it was possible that if there was a side or arch bias in bonding it could mask a difference in the excess adhesive. Therefore, the first *t*-test analyzed if there was a difference in EAF in bonding the brackets on the upper right and lower left vs the upper left and lower right. Because there were no statistically significant differences, it indicated that there was no bias in the arch or in the quadrant in which the brackets were bonded (Table 2).

However, there was a tendency to difference for the upper lateral incisors ( $P = .048$ ), the lower canines ( $P = .012$ ), and the lower second premolars ( $P = .03$ ) (Table 2). For the upper lateral incisors the mean demonstrated more EAF on the right regardless of adhesive used, which may indicate that the upper right lateral incisor was more difficult to clean up. The most likely reason is that the upper right lateral incisor was set up in a more crowded position than the left. The data for lower canines and the lower second premolars demonstrated that there was more EAF on the lower right side than the left regardless of the adhesive used (Table 2). The amount of crowding was similar for each quadrant, and this indicates that it may be more difficult to remove the excess adhesive from the lower right side for second premolars and canines.

The second *t*-test, which aimed to analyze if there was a difference in amount of EAF between the two adhesives overall, found that there were no statistically significant differences (Table 3). Therefore, there is no difference in the amount of excess adhesive around orthodontic brackets bonded with APC PLUS and with Transbond XT. However, there was a tendency for more EAF with Transbond XT for the upper second premolars ( $P = .053$ ), upper first premolars ( $P = .040$ ), and the lower central incisors ( $P = .034$ ) (Table 2). Although this tendency was present, there were no statistically significant, and therefore clinically significant, differences.

The correlation between the amount of excess adhesive for each operator and the time taken for the bonding is not at all significant ( $P = .51$ ). This indicates that the time taken is not a factor and the amount of EAF left after bonding orthodontic brackets may reflect the skill of the clinician. It may also be associated with whether they feel that EAF removal is important. However, in retrospect the operators were not asked if they think excess adhesive removal was

**Table 1.** The Measured Area (mm<sup>2</sup>) of Excess Adhesive Flash (EAF) for Each Tooth in the Two Operator Groups

		Tooth									
		15		14		13		12		11	
Group		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1		12.61	1.33	12.26	1.72	13.12	1.20	12.55	2.60	12.58	1.59
2		12.24	1.22	12.70	2.21	13.81	2.20	11.36	2.00	12.96	2.38
		Tooth									
		21		22		23		24		25	
Group		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1		13.43	2.14	11.07	1.36	14.63	2.83	14.16	2.63	13.09	2.08
2		12.13	1.68	10.70	1.42	13.52	1.94	12.12	1.61	11.74	1.04
		Tooth									
		45		44		43		42		41	
Group		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1		15.64	1.29	15.65	2.28	13.95	2.38	11.84	2.07	12.25	1.88
2		14.36	1.85	13.69	1.81	13.62	1.93	10.79	0.73	10.48	1.15
		Tooth									
		31		32		33		34		35	
Group		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1		11.29	1.42	11.29	2.24	12.36	2.04	14.10	1.48	14.44	1.61
2		11.21	2.09	10.95	1.03	13.05	1.23	13.67	1.57	14.01	1.39

important, which may have biased the overall results. As mentioned earlier, there exists a tendency that less EAF was present at the brackets bonded with APC PLUS than those with Transbond XT. Although this

**Table 2.** Statistical Analysis Testing the Significant Level of Difference in Amount of Excess Adhesive Flash (EAF) Between the Two Operator Groups

Tooth	Group	EAF Difference, mm <sup>2</sup> (Group 1 vs Group 2)		SD	t-Test P
Upper second premolar	1	−0.71	1.65	.997	
	2	−0.71	0.61		
Upper first premolar	1	−1.79	1.55	.157	
	2	−0.26	2.43		
Upper canine	1	−1.41	3.40	.953	
	2	−1.29	3.69		
Upper lateral incisor	1	1.37	2.27	.048	
	2	−0.66	1.36		
Upper central incisor	1	−0.85	2.83	.408	
	2	0.19	1.06		
Lower central incisor	1	−0.97	1.82	.825	
	2	−0.79	1.31		
Lower lateral incisor	1	−0.55	1.50	.678	
	2	−0.27	1.01		
Lower canine	1	−1.68	0.88	.012	
	2	0.57	2.20		
Lower first premolar	1	−1.88	2.55	.071	
	2	0.02	1.12		
Lower second premolar	1	−1.17	1.12	.030	
	2	0.35	1.51		

study demonstrated that there were no statistically significant differences in EAF with the use of these two adhesives, it is possible that the addition of the coloring agent may act as a visual marker and therefore facilitate the localization of EAF and enhance its removal. It may be especially useful for clinicians with reduced visual acuity.

CONCLUSIONS

- There were significant amounts of EAF suggesting that clinicians need to be more vigilant in its removal to reduce plaque retentive areas, gingival irritation, and potential white spot lesions.

**Table 3.** Statistical Analysis Testing the Significant Level of Difference in Amount of Excess Adhesive Flash (EAF) Between the Two Adhesives

Tooth	EAF Difference, mm <sup>2</sup> (APC vs XT)	SD	t-Test (P)
Upper second premolar	−0.71	1.30	.053
Upper first premolar	−1.18	2.02	.040
Upper canine	−1.37	3.36	.152
Upper lateral incisor	0.35	2.09	.509
Upper central incisor	−0.46	2.34	.444
Lower central incisor	−0.89	1.58	.034
Lower lateral incisor	−0.44	1.29	.181
Lower canine	−0.62	1.96	.21
Lower first premolar	−0.98	2.18	.081
Lower second premolar	−0.46	1.50	.226

- There is no reduction in the amount of excessive adhesive around orthodontic brackets with the addition of a color change feature in the bonding cement.

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## REFERENCES

1. Travess H, Roberts-Harry D, Sandy J. Orthodontics. Part 6: Risks in orthodontic treatment. *Br Dent J*. 2004;196:71–77.
2. Gorelick L, Geiger AM, Gwinnett AJ. Incidence of white spot formation after banding and bonding. *Am J Orthod*. 1982;81:93–98.
3. Mitchell L. Decalcification during orthodontic treatment with fixed appliances—an overview. *Br J Orthod*. 1992;19:199–205.
4. Chang HS, Walsh LJ, Freer TJ. Enamel demineralization during orthodontic treatment. Aetiology and prevention. *Aust Dent J*. 1997;42:322–327.
5. Geiger AM, Gorelick L, Gwinnett AJ, Griswold PG. The effect of a fluoride program on white spot formation during orthodontic treatment. *Am J Orthod Dentofacial Orthop*. 1988;93:29–37.
6. O'Reilly MM, Featherstone JD. De- and remineralization around orthodontic appliances: in vivo study. *Am J Orthod Dentofacial Orthop*. 1987;92:33–40.
7. Artun J, Thylstrup A. A 3-year clinical and SEM study of surface changes of carious enamel lesions after inactivation. *Am J Orthod Dentofacial Orthop*. 1989;95:327–333.
8. Ogaard B. Prevalence of white spot lesions in 19 year olds. A study on untreated and orthodontically treated persons 5 years after treatment. *Am J Orthod Dentofacial Orthop*. 1989;96:423–427.
9. Eliades T, Eliades G, Brantley WA. Microbial attachment on orthodontic appliances: I. Wettability and early pellicle formation on bracket materials. *Am J Orthod Dentofacial Orthop*. 1995;108:351–360.
10. Brennan JV, Soo PP, James D. APC PLUS Adhesive coated appliances: a bonding study. *Orthodontic Perspectives XII*. No. 1:12–14.
11. Zachrisson BU. A posttreatment evaluation of direct bonding in orthodontics. *Am J Orthod*. 1977;71:173–189.
12. Wilner FJ, Oliver RG. Evaluation of a reproduction technique for the study of the enamel composite/bracket base area. *J Orthod*. 2000;27:261–266.
13. Bland M. *An Introduction to Medical Statistics*. 3rd ed. Oxford: Oxford University Press; 2000:269–272.
14. Oh K, Choo S, Kim KM, Kim KN. A stainless steel bracket for orthodontic application. *Eur J Orthod*. 2005;27:237–244.
15. Vorhies AB, Donly KJ, Staley RN, Wefel JS. Enamel demineralization adjacent to orthodontic brackets bonded with hybrid glass ionomer cements: an in vitro study. *Am J Orthod Dentofacial Orthop*. 1998;114:668–674.
16. Alexander SA, Ripa LW. Effects of self applied topical fluoride preparations in orthodontic patients. *Angle Orthod*. 2000;70:424–430.
17. Ogaard B, Rolla G, Arends J, Tencate JM. Orthodontic appliances and enamel demineralization. Part 2. Prevention and treatment of lesions. *Am J Orthod Dentofacial Orthop*. 1988;94:123–128.
18. Barnes IE. Replication techniques for the scanning electron microscope. 1. History, material and techniques. *J Dent*. 1978;6:327–341.
19. Barnes IE. Replication techniques for the scanning electron microscope. 2. Clinical and laboratory procedures: interpretation. *J Dent*. 1979;7:25–37.
20. Aguirre MJ, King JG, Waldron JM. Assessment of bracket placement and bond strength when comparing direct bonding and indirect bonding techniques. *Am J Orthod*. 1982;82:269–276.