Decalcification in relation to brackets bonded with glass ionomer cement or a resin adhesive

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Abstract: Forty randomly selected patients had brackets bonded on one side of the of the maxillary labial segment with glass ionomer cement. Teeth on the opposite side were bonded with a resin adhesive. Teeth were assessed for decalcification pretreatment, at debond, and at review using a standardized photographic technique and a modified DDE index. The mean number of teeth affected by decalcification and the mean extent of decalcification per tooth increased during the treatment period, but from debond to review both of these measurements decreased for teeth bonded with either material ($p<0.01$, t-test). Decalcification appears to become less severe posttreatment, but does not appear to be significantly affected during 12 to 18 months of orthodontic treatment by bonding with glass ionomer cement. Dietary and other environmental factors, including fluoride preparations, may be of greater importance in the prevention of decalcification during fixed appliance therapy.

Key Words: Decalcification, Glass ionomer cement, Resin adhesive, Modified DDE index

Demineralization (decalcification) is a common side effect of fixed appliance orthodontic treatment. It occurs when the pH of the oral environment favors diffusion of calcium and phosphate ions out of enamel, and is reported to occur in anywhere from 2% to 96% of orthodontic patients.[1] Decalcification often follows plaque accumulation promoted by the appliance components and bonding materials,[2-4] with subsequent acid production leading to an alteration in the appearance of the enamel surface.[4] Early lesions appear clinically as opaque white spots, caused by mineral loss in the surface or subsurface of the enamel.[5] If mineral loss continues, cavitation will result.[6,7] Following appliance removal, white spot lesions may regress or even disappear, primarily as a result of surface abrasion,[8] but they may still present an esthetic problem more than 5 years after treatment.[9]

Fluoride is known to inhibit lesion development during fixed appliance treatment and to enhance remineralization following treatment.[4,10] Daily use of a fluoride rinse combined with oral hygiene instruction can lead to a significant reduction in decalcification,[11] the cariostatic effect of topical fluoride treatment resulting primarily from calcium fluoride formation.[10] Unfortunately, patient cooperation with home-use of topical fluoride agents and maintenance of optimal oral hygiene levels is frequently inadequate.[7,12-14] As a result, the arrival of fluoride-releasing composite resins for bracket bonding has attracted considerable interest,[15-20] offering a means of fluoride delivery adjacent to the bracket-enamel interface and independent of patient cooperation. However, the ability of these materials to reduce decalcification clinically remains equivocal.[18-20]

Glass ionomer cements have been used in recent years as a bonding agent.[21] These cements may offer greater potential than composites in preventing decalcification, as enamel etching is often unnecessary for bracket bonding;[21] a less caries-inducing microflora and a lower acid production in plaque are other benefits.[22,23] Of greater relevance to the cariostatic potential of glass ionomer cements is their ability to release fluoride into saliva and plaque adjacent to bonded brackets.[24] Although most of the fluoride release occurs during the first day after bonding,[25] continued release has been recorded over several months when a glass ionomer has been used for restorative purposes.[26,27] In addition, in vitro experiments have indicated that glass ionomer cements are capable of fluoride uptake when exposed to a high concentration fluoride solution, thereby acting as a continuous reservoir for fluoride release.[28] To date,

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however, it appears that evaluation of the cariostatic potential of glass ionomer cements as a bonding agent over the entire course of orthodontic treatment has received very limited attention.[29,30]

As decalcification is of greater esthetic concern if it affects the upper anterior teeth, the aim of this study was to compare decalcification in the upper labial segment only, at the time of bracket removal and at the 12-month review, when brackets were bonded with a glass ionomer cement or a resin adhesive. The null hypotheses tested were that there was no difference in the mean number of teeth per patient with decalcification or in the mean extent of decalcification per tooth when brackets had been bonded using either a glass ionomer cement or a resin adhesive.

Table 1
Inter- and intraexaminer reliability for assessment of type and extent of enamel opacities

	Kappa scores		
	Examiner 1	Examiner 2	Examiner 3
Examiner 1	0.57 (T) 0.58 (E)	0.73 (E) 0.81 (T)	0.74 (T) 0.65 (E)
Examiner 2	0.74 (T) 0.65 (E)	0.58 (E) 0.88 (T)	0.82 (T) 0.85 (E)
Examiner 3	0.81 (T) 0.85 (E)	0.65 (E) 0.78 (T)	0.88 (T) 0.80 (E)

T = Type; E = Extent

Materials and methods

Forty patients (23 females; 17 males) were randomly selected from a list of patients awaiting fixed appliance treatment. Ethical approval was obtained and informed consent was received from the parent or patient. All participants had a normal complement of teeth in the upper labial segment with a similar degree of crowding on both sides. Pretreatment, all patients had a good standard of oral hygiene, with a plaque score of ≤10% as assessed by the plaque index of Silness and Löe.[31] This trial took the form of a half-mouth study with patients allocated alternately to have the right or left side of the upper labial segment bonded with the conventional glass ionomer cement, Ketac-Cem (Espe, Oberbay, Germany). Brackets ("A"-Company, Orthologic, UK) were bonded on the upper right canine and incisors with Ketac-Cem and on the opposite side (upper left canine and incisors) with a resin adhesive, Right-on (TP Orthodontics, La Porte, Indiana), and vice versa. Prior to bonding with glass ionomer, the teeth were dried with a cotton roll. No enamel etching was required for teeth bonded with glass ionomer cement. Enamel of the teeth bonded with the resin adhesive was etched for 15 seconds prior to bonding. Archwires were tied into brackets within 10 minutes of bracket bonding. Two hundred forty brackets were bonded in 40 patients, half with glass ionomer and half with the resin adhesive. Patients were instructed to use a fluoride-containing dentifrice throughout fixed appliance treatment and to brush after every meal. Thirty-eight patients brushed with their right hand and two brushed with their left hand. A fluoride mouthwash was not prescribed.

The mean age of the patients pretreatment was 13.4 years (SD ± 2 months), and the mean treatment time was 15.3 months (SD ± 3.2 months). All patients were followed to completion of their orthodontic treatment. Mean time to review was 13.7 months (SD ± 4.1 months). The mean age of patients at review was 14.8 years (SD ± 2.1 months).

During treatment, 20 brackets bonded with glass ionomer failed and 5 brackets bonded with the resin adhesive failed. Due to the paired nature of the data analysis, where a bracket bonded with glass ionomer failed, the tooth concerned and its opposite number bonded with the resin adhesive were not included in the data for analysis of decalcification. In 23 patients (9 males, 14 females) none of the brackets bonded with either material failed and objective assessment of decalcification was, therefore, confined to this subgroup.

To assess decalcification, three color views were taken of the teeth in the upper labial segment pretreatment, at debond, and at review. All six upper anteriors (canine through canine) were recorded photographically, on three separate views on Ectachrome 64 color transparency film using a Nikon FM_2 camera with a 135 mm lens with full bellows extension and a multiblitz ring-flash in a standardized way. On all occasions the condition of the labial enamel surface was recorded in the wet state.

In a darkened room, the three transparencies for each patient pretreatment, at debond, and at review were projected simultaneously at a magnification of x20 and scored independently by three examiners (one orthodontist and two pediatric dentists) who had been previously calibrated in the use of the modified DDE index as described by Clarkson and O'Mullane.[32]

The modified DDE index is a system of classification of developmental defects of enamel used as an international epidemiological index.[33] The classification system and terminology are advocated for use in general surveys of tooth defects, while the recording system is com-

Table 2
Distribution of opacities according to tooth type and experimental group pretreatment, at debond, and at review

	Glass ionomer									Resin						
	Tooth	13	12	11	21	22	23			13	12	11	21	22	23
Pretreatment	(46)	2	9	12	13	8	2	Pretreatment	(45)	1	9	13	13	8	2
Debond	(55)	2	12	13	14	11	3	Debond	(53)	1	11	13	15	9	3
Review	(51)	2	11	13	13	10	2	Review	(50)	1	11	13	14	9	2

Numbers in brackets represent number of teeth affected at each time of assessment.

Table 3
Mean number of teeth affected by opacity/decalcification per patient and mean extent score of enamel opacity/ decalcification per tooth (pretreatment, at debond, and at review)

	Glass ionomer			Resin		
	Pretreatment	Debond	Review	Pretreatment	Debond	Review
Mean number teeth affected per patient	2.1 ± 0.9	2.8 ± 0.4[1]	2.5 ± 0.8[2]	2.1 ± 1.1	2.7 ± 0.6[1]	2.3 ± 0.8[2]
Mean extent score per tooth	1.5 ± 0.7	1.9 ± 0.7[1]	1.5 ± 0.6[2]	1.5 ± 0.7	1.8 ± 0.8[1]	1.6 ± 0.5[2]

[1] indicates significant difference from baseline ($p < 0.01$)
[2] indicates significant difference from debond to review ($p < 0.01$)

Table 4
Frequency of enamel opacity types recorded (per the modified DDE index) pretreatment, at debond, and at review for teeth bonded with glass ionomer or resin

	Glass ionomer			Resin		
Enamel opacity type	Pretreatment (n=69)	Debond (n=69)	Review (n=69)	Pretreatment (n=69)	Debond (n=69)	Review (n=69)
Normal enamel	23	16	18	24	16	19
Demarcated	8	4	6	9	4	6
Diffuse	38	37	38	34	36	35
Hypoplasia	-	-	-	-	1	-
Demarcated and diffuse	-	14	7	2	12	8
Demarcated and hypoplastic	-	-	-	-	-	1
Demarcated, diffuse, and hypoplastic	-	-	-	-	-	-

prehensive and suitable for full-mouth assessment and adaptable for partial-mouth recording. Enamel opacities characterized by white or discolored areas and enamel hypoplasia characterized by defective enamel, which in some instances may involve partial or complete absence of enamel, are classified by the index. The patients who participated in this study had all been residents since birth in an area where the domestic water supply had been artificially fluoridated at 1.0 ppm since 1969,[34] and all had one or more upper labial segment teeth affected by an enamel opacity, confirming the findings of other epidemiological studies on residents of this area.[35,36] As the caries insult imposed by an orthodontic appliance could lead to formation of white spot opacity or more radical enamel loss, the modified DDE index was chosen for assessment of decalcification in this study.

Examiners were blinded as to which teeth had been bonded with either material. Each assessor scored the teeth independently for type and extent of enamel opacity and the data were recorded on assessment forms designed for this purpose. The types of opacity were categorized according to normal, demarcated, diffuse, hypoplastic or a combination of these defects and were coded according to the criteria set out in the modified DDE index as follows: code 1, normal enamel; code 2, demarcated opacity; code 3, diffuse opacity; code 4, hypoplastic; code 5, demarcated and diffuse; code 6, demarcated and hypoplastic; code 7, diffuse and hypoplastic; code 8, all three defects present. The extent of the opacity was then assessed by visually aggregating the area which the defect occupied and was coded on a scale of 0 to 3: 0 = normal enamel; 1 = less than one-third of the surface affected; 2 = one-third to two-thirds of the surface affected; 3 = at least two-thirds of the surface affected.

A random sample of 21 slides was reexamined 1 week after the initial assessment to give an indication of intra- and interexaminer reliability. These were judged using a Kappa statistic. Intra- and interexaminer reliability was moderate to high for both type and extent of enamel opacity recorded (Table 1). Guidelines have been suggested by Landis and Koch[37] for the interpretation of the Kappa statistic. Kappa values in the range 0.41 to 0.6 indicate moderate agreement while those from 0.61 to 0.8 and from 0.81 to 1 represent substantial and almost perfect agreement, respectively. As examiner 3 demonstrated the best inter- and intraexaminer reliability, the scores recorded by this examiner were used for comparative analyses of the two experimental groups.

To analyze the data, a mean opacity score was ascribed to each patient pretreatment, at debond, and at review, for type and extent of opacity for each material tested. Paired *t*-tests were used to compare the mean opacity scores for each patient for type and extent of opacity, in relation to each material tested at debond and at review.

Results

Most of the teeth were affected by some form of intrinsic enamel opacity before treatment, especially central and lateral incisors (Tables 2 and 3). There was, however, no significant difference between those teeth bonded with either material with respect to mean number of teeth affected per patient (2.1 Ketac-Cem; 2.1 Right-on; $t = 0.24$ on 22 d.f.; $p > 0.05$) or mean extent of opacity per tooth (1.5 Ketac-Cem; 1.5 Right-on; $t = 0.86$ on 22 d.f.; $p > 0.05$). The most common type of enamel opacity recorded pretreatment was diffuse, but there was an increase in the number of demarcated and diffuse-type opacities posttreatment, with one lateral incisor cavitated (Table 4). The mean number of teeth affected per patient increased by about 30% during the observation period (from 2.1 to 2.8 for Ketac-Cem and from 2.1 to 2.7 for Right-on), amounting to an additional tooth being affected in the control and test groups. The upper lateral incisors showed the greatest increase in number of opacities recorded posttreatment (Table 2). There was also a mean increase in extent of opacities/decalcification per tooth for both the test and control material (from 1.5 to 1.9 for Ketac-Cem and from 1.5 to 1.8 for Right-on) and these differences were significant ($p < 0.01$). At debond no significant difference in decalcification was recorded between male or female patients in relation to the teeth bonded with either bonding material. The mean increase in the number of teeth with opacities in males was 0.5 and in females was 0.3 for glass ionomer, while with resin the mean increase in number of teeth with opacities in males and females was 0.3. From debond to review, however, there was a significant reduction in the mean number of teeth affected per patient and in the mean extent of decalcification per tooth. The distribution of opacities reduced for most tooth types from debond to review, but despite this a higher number of opacities was recorded at review than were present pretreatment (Table 2).

Discussion

The results of the present study indicate that orthodontic treatment with multibonded appliances imposes a significant caries risk, confirming the findings of previous studies.[3,4,7,9] Before treatment, an average of two of the three teeth later bonded with either of the bonding materials were affected by some form of enamel opacity, the most common type identified being a diffuse opacity. The opacities recorded covered on average less than one-third of the labial enamel surface. These findings confirm those of Nunn et al.[35,36] Although other studies[3,7] on decalcification in orthodontic patients have found approximately 7% of the examined teeth to be affected by white spots before treatment, none of the subjects in those studies appear to have resided in an area where the community water was fluoridated. The baseline opacity data in the study reported here indicate a high prevalence of developmental white spots most likely due to the participants being resident since birth in an area with water fluoridation at a level of 1 ppm. Each participant had also used a fluoride-containing dentifrice from a young age. Nunn et al.[36] examined the prevalence of enamel opacities using the modified DDE index[32] in children resident in northeast England, the area from which the children in the present study were drawn. All children had enamel opacities affecting one or more of the teeth examined.

The sample size of the present study was comparable to that used by previous workers in recent studies of decalcification in orthodontic patients.[7,29,30] A split mouth design was adopted ensuring an equal number of right and left test sides. A conventional glass ionomer cement was used as the test material, and although similar cement formulations have been shown to have inferior mechanical properties to more recently marketed resin-modified glass ionomer materials,[19] at the time this study commenced there was no consensus from laboratory or clinical trials about the use of these conventional glass ionomer cements for bracket bonding. Due to the study design, crossover of fluoride from the glass ionomer segment to the resin adhesive segment may have occurred in our study and those of Marcusson et al.[29,30] The only way of overcoming this possible problem of fluoride contamination from test to control sites would be to have independent test and control groups but it would then be virtually impossible to standardize environmental influences of, for example, diet and oral hygiene practices between the groups.

Only upper labial segment teeth were assessed, as decalcification occurs commonly in this area[3,9] and recording decalcification in this area is easy. A color transparency was taken using a standardized photographic technique to record the condition of the labial enamel surface at each of the three time points—pretreatment, at debond, and at review. The method adopted was similar to that of Marcusson et al.[29,30] To record enamel opacities, a modified DDE index[32] was used. Although it has not been employed previously to record enamel opacities in orthodontic patients, it proved to have good intra- and interexaminer reliability, confirming the findings of other epidemiological studies[35,36] where it has been used. It was a particularly useful index to adopt for the present study due to the high prevalence of developmental enamel opacities, and it also allowed the type of opacity to be recorded.

Over a mean treatment time of 15.3 months, there was a significant increase in enamel opacities recorded with respect to the mean number of teeth affected per child and the mean extent recorded per tooth. The mean number of teeth affected increased by about 30% for both materials tested, confirming previous reports of an increase in decalcification during orthodontic treatment.[2-4,7,9] Marcusson et al.[29,30] in a half-mouth study confined to upper lateral incisors and lower canines, found a reduction in the number of white spots on teeth with brackets bonded with glass ionomer compared with those having brackets bonded with a resin adhesive. However, in analyzing their results[38] more closely, they indicate that there was an increase in white spot formation during longer treatment times, with no significant difference between materials. Although there was a tendency for teeth bonded with glass ionomer to be less affected if treatment times were longer than 16.7 months, there was no significant difference between materials when treatment time was in the 9.7-to-16.7-month range. In our study the mean treatment time was 15.3 months; the lack of a significant difference in recording of white spots between the glass ionomer and resin groups over this time scale confirms the findings of Marcusson et al.[36] Interestingly, Mitchell,[17] with a sample size similar to the study reported here of 23 patients and 124 teeth (62 test; 62 control), found no significant difference either in decalcification at debond related to brackets bonded with a fluoride-releasing composite and a resin adhesive. Her results with a fluoride-releasing composite are very similar to those reported here for Ketac-Cem.

From debond to 1 year review there was a significant decrease in the number of teeth affected by white spots per patient and in the mean extent of opacity recorded for both materials tested, supporting the findings of other studies where decalcification has been shown to regress following appliance removal.[27,28,36]

Laboratory studies have shown glass ionomer cements to release and absorb fluoride[26] and to inhibit decalcification in the short term up to one month after bonding.[37] The results of this clinical study, however, would appear to cast doubts on their cariostatic ability over a longer treatment period of at least 1 year. The narrow film thickness of cement that results following placement of the bracket has a limited surface area available for fluoride release, which may account in part for the limited cariostatic effect. Dietary and other environmental influences, such as regular use of a fluoride dentifrice or other fluoride-containing preparations, as well as maintenance of a high standard of oral hygiene, may be of greater importance in the prevention of decalcification for the duration of fixed appliance therapy.

Conclusions

1. There was no significant difference at debond in the mean number of upper labial segment teeth affected by decalcification or in the mean extent of decalcification per tooth when glass ionomer cement and a resin adhesive were compared as bonding materials.

2. At review, 12 months post-debond, there was a reduction in the mean number of teeth affected and the mean extent of decalcification per tooth for teeth bonded with either material.

3. Other fluoride preparations combined with thorough oral hygiene practices and dietary control may have a greater effect on the prevention of decalcification during orthodontic treatment than the apparently limited potential offered by bracket bonding with glass ionomer cement.

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