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Evaluation and Comparison of Enamel Demineralization around Orthodontic Brackets using two different Adhesive Material

Abstract

Aim: The aim of the study is to evaluate in vivothe effect of resin modified glass ionomer cement in reducing enamel demineralization around orthodontic brackets. **Material and Method:** Fourteen patients undergoing orthodontic treatment scheduled to have premolars extracted for orthodontic reasons were randomly divided into two groups of seven each. 28 brackets were bonded for each group, one group with Fuji Ortho LC, a resin modified glass ionomer cement (experimental group) and the other group with Transbond XT, a composite resin. After 30 days, teeth were extracted, sectioned and tested for demineralization.

Result: The study showed that less enamel demineralization was found in enamel around the bracket cemented with glass ionemer in comparison with the composite resin.

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Key Words

Enamel demineralization; knoop hardness

INTRODUCTION

The presence of clinically detectable areas of enamel demineralization following the removal of orthodontic appliances is well recognized. The white spot lesion is considered to be the pre cursor of frank enamel caries. Demineralization, which can be seen as white spot lesion, is due to the mineral loss at the very surface of enamel. Any covering that provides a sheltered area for accumulation of food debris can encourage plaque formation and increase caries hazard.[1-3] Demineralization though treatable, prevention is better than cure. This can be achieved partially by better patient oral hygiene and use of topical fluoride applications. Fluorides have shown not only to reduce demineralization[4-14] and plaque formation but also help ion remineralization of enamel.[15-16] However this requires patient compliance which in some cases may be difficult to obtain. Fluoride releasing cements can be used to prevent demineralization.[17-20] However, the low adhesive strength of the material has been a limitation of its clinical use.[21-22] Hence the ideal banding cement should not only release fluorides but should also adhere well to the enamel surface of the tooth. The study showed that the use of glass ionomer in orthodontic bonding will result in the significant reduction in number of white spot lesion at debonding compared with the use of conventional diacrylate cement.[23] A study was conducted which showed that teeth bonded with hybrid glass ionomer cement demonstrated significantly smaller white spot lesions adjacent to the bracket base than teeth bonded with composite resin control.[24] Resin modified glass ionomer cements have greater adhesive strength than conventional ones[25-27] and the advantage of not promoting changes on the tooth surface after debonding.[28] The aim of this study was to evaluate the invivo effect of glass ionomer cement in reducing dental caries and enamel demineralization around the orthodontic bracket , because there is good correlation between enamel microhardness and percentage of mineral in carious lesions.

MATERIALS & METHODS

Fourteen patients undergoing orthodontic treatment, aged 12 to 17 years, scheduled to have premolars extracted for extracted for orthodontic reasons, were randomly divided into two groups of seven each. The patients had prior clinical and radiographic examinations. Salivary flow and buffer capacity were also determined.

Criteria for selection were:

Table 1: ANOVA Results

GROUP	N	MEAN	Std.Deviation	F	p
Transbond XT					
10	21	202.9683	15.09476	1478.04	.001 vhs
20	21	270.7754	13.95968		
30	21	329.0652	17.08067		
60	21	343.2246	12.97147		
90	21	356.6900	8.72198		
Fuji Ortho LC					
10	23	223.8478	15.38208	400.22	.001 vhs
20	23	272.9286	5.83109		
30	23	336.1429	6.44233		
60	23	361.5079	5.42051		
90	23	374.6341	5.34472		

Tukey test

GROUP	(i) DEPTH	(j) DEPTH	Mean difference (i-j)	p
Transbond XT	10	20	-69.9603	.001 vhs
		30	-133.1746	.001 vhs
		60	-158.5397	.001 vhs
		90	-171.6659	.001 vhs
	20	30	-63.2143	.001 vhs
		60	-88.5794	.001 vhs
		90	-101.7056	.001 vhs
	30	60	-25.3651	.001 vhs
		90	-38.4913	.001 vhs
	60	90	-13.4913	.001 vhs
Fuji Ortho LC	10	20	-46.9275	.001 vhs
		30	-105.2174	.001 vhs
		60	-119.3768	.001 vhs
		90	-141.8422	.001 vhs
	20	30	-58.2899	.001 vhs
		60	-72.4493	.001 vhs
		90	-94.9194	.001 vhs
	30	60	-14.1594	.001 vhs
		90	-36.6248	.001 vhs
	60	90	-22.4654	.001 vhs

1. No active caries was present.
2. Patients with a normal salivary flow (>1.0ml/min).
3. Patients with a normal buffer capacity of saliva (final pH between 6.0 & 7.0)

The two groups, equivalent with regards to the caries risk pattern, received brackets (TP Orthodontics, Inc) bonded with Fuji Ortho LC (Experimental Group), a composite resin Transbond XT (control group). The manufacturer's recommendations were followed. Excessive adhesive around the brackets and between the bracket base and the tooth was removed during bonding. Twenty eight brackets were attached for each group (14 maxiallary and 14 mandibular premolars). After 30 days the teeth were extracted and stored in a flask containing cotton soaked in 2% formaldehyde, pH 7.0 until the analysis. Dental caries in enamel around the bracket was evaluated by cross sectional microhardness testing. During the experimental period and three month before it started, the subjects brushed their teeth with non fluoridated dentrifice. No instructions were given regarding oral hygiene and the patients were instructed not to use any antibacterial substance. The extracted teeth were longitudinally sectioned into halves in the bucco palatal direction, through the disk. The half crown section was embedded in acrylic. The surfaces were grounded using belt grinder. The sample was polished using different grades of emery paper such as 1/0,2/0,3/0 and 4/0. The final polishing was done using alumina power suspension and polishing cloth. A microhardness tester with a knoop diamond under a 10 gm load for

Table 2: Knoop micro hardness (avg +/- SD) for materials at different depths from enamel surface

DEPTH	GROUP	N	MEAN	Std. Deviation	Z
10	Transbond XT	21	202.9683	15.09476	3.80000
	Fuji Ortho LC	23	223.8478	15.38208	p = .001 vhs
20	Transbond XT	21	270.7754	13.95968	.90600
	Fuji Ortho LC	23	272.9286	5.83109	p = .365 ns
30	Transbond XT	21	329.0652	17.08067	.69400
	Fuji Ortho LC	23	336.1429	6.44233	p = .488 ns
60	Transbond XT	21	343.2246	12.97147	4.96800
	Fuji Ortho LC	23	361.5079	5.4251	p = .001 vhs
90	Transbond XT	21	365.6900	8.72198	3.91500
	Fuji Ortho LC	23	374.6314	5.34472	p = .001 vhs

Table 3: Knoop micro hardness (avg +/- SD) for materials at different positions, under the occlusal and cervical to the brackets on labial and lingual (control) surfaces

GROUP	**N**	**MEAN**	**Std. Deviation**	**Z**
OCCL 200 TransbondXT	21	321.6762	62.58448	.82300
Fuji Ortho LC	23	324.0348	44.76154	p = .411 ns
OCCL 100 TransbondXT	21	313.0095	64.53614	2.2700
Fuji Ortho LC	23	303.5739	55.53568	p = .023 sig
OCCL 0 TransbondXT	21	295.8476	73.97086	1.58900
Fuji Ortho LC	23	294.3913	56.18355	p = 112 ns
UNDER TransbondXT	21	327.0348	48.77462	1.44500
Fuji Ortho LC	23	328.6857	71.43923	p = .148 ns
CERV 0 TransbondXT	21	280.7652	57.37509	2.32500
Fuji Ortho LC	23	295.0095	63.84649	p = .02 sig
CERV 100TransbondXT	21	290.4783	54.11511	2.89400
Fuji Ortho LC	23	307.0381	65.76604	p = .014 sig
CERV 200 TransbondXT	21	312.2174	46.18513	2.10700
Fuji Ortho LC	23	322.6476	58.32419	p = .35 sig

Lingual

GROUP	N	MEAN	Std.Deviation	Z
Transbond XT	21	345.6571	13.43634	.25400
Fuji Ortho LC	22	345.8609	13.96040	P = .8 ns

5 seconds was used for the microhardness analysis. The knoop hardness was calculated by the formula:

$$KHN=1.854P^2/d$$

Where P= load, d= mean diagonal length of indentation. Forty indentations were made according to diagram in the Fig 1 on the buccal surface indentations were made under the brackets. In the occlusal and cervical region, indentations were made at the edge (0) of the bracket and at 100 and 200μm away from it. Indentations were also made in the middle third of the lingual surface of each half crown, as another control in all these positions five indentations were made at 10, 20, 30, 60 and 90 μm from the external surface of the enamel. Cross sectional micro hardness testing was used to evaluate caries, because there is a good correlation (0.91) between enamel microhardness and percentage of minerals in carious lesion. During the study, brackets were lost for different reasons: during extraction procedure, or during the sectioning of the teeth. Thus, 23 premolars (10 maxillary and 13 mandibular) with brackets bonded with Fuji Ortho LC, and 21 premolars (12 maxillary and 9 mandibular) cemented with Transbond XT were evaluated. These numbers of teeth were considered in statistical analysis. Analysis of variance (ANOVA) was used to evaluate the effect of the materials (Fuji Ortho LC and Transbond XT), depth from the enamel surface (10, 20, 30, 60 and 90μm), position (under the bracket, and on the buccal surface, in the occlusal and the cervical regions at 0, 100 and 200 μm from the brackets and in the lingual surface), and their interctions. ANOVA was followed by Tukey test. For the analysis, statistics for SPSS version 11.5 was used, and the statistical significance was setup at p=0.05.

RESULT

ANOVA shows significance for the factors material, position, and depth; the interaction between them were also statistically significant

Table 4: Knoop micro hardness (avg +/- SD) for materials and position at depth of 10 μ m

Interaction of material / placement / depth	GROUP	N	MEAN	Std. Deviation	Z
Fuji Ortho LC / Transbond XT / OCCL200 μm / 10 μ	Transbond XT Fuji Ortho LC	21 23	218.0952 260.6957	9.68971 17.98847	5.63500 p = .001 vhs
Fuji Ortho LC / Transbond XT / OCCL 100 μm / 10 μ	Transbond XT Fuji Ortho LC	21 23	205.1905 217.0000	8.31035 14.58829	2.60300 p = .009 hs
Fuji Ortho LC / Transbond XT / OCCL 0 μm / 10 μ	Transbond XT Fuji Ortho LC	21 23	177.7619 199.8696	12.34060 15.05537	4.17100 p = .001 vhs
Fuji Ortho LC / Transbond XT / Underneath / 10 μ	Transbond XT Fuji Ortho LC	21 23	224.2381 265.1304	75.34382 17.71056	3.9880 p = .001 vhs
Fuji Ortho LC / Transbond XT / CERV 0 μm / 10 μ	Transbond XT Fuji Ortho LC	21 23	192.1429 193.8261	26.16732 14.19876	1.09600 p = .296 ns
Fuji Ortho LC / Transbond XT / CERV 100 μm / 10 μ	Transbond XT Fuji Ortho LC	21 23	200.3810 206.5652	9.62536 14.76121	1.04800 p = .295
Fuji Ortho LC / Transbond XT / CERV200 μm / 10 μ	Transbond XT Fuji Ortho LC	21 23	226.3333 247.7826	11.23091 17.16486	3.82800 p = .001 vhs

(P <0.05). Table 2 shows significant difference in interaction of depth and material at the distance of 10 and 20 μm from the enamel surface; less enamel demineralization was found in enamel around the bracket cemented with glass ionomer in comparison with the control. Table 3 showed there was greater demineralization in the cervical area than in the occlusal area, and the demineralization was more in transbond XT. Table 4 showed significant differences on the buccal side, Fuji Ortho LC showed highest hardness value on 10μm from the surface of the enamel. There was no significant difference between the material hardness on the lingual side.

DISCUSSION

In this study the samples were randomly divided into two groups; they had prior clinical and radiographic examinations. Salivary flow and buffer capacity were also determined. They had no active caries and salivary flow was normal. The 2 groups were equivalent with regard the caries risk. Several studies have been conducted on the cariostatic effect of fluoride – releasing materials by using a split mouth design.[28,30] To avoid the carry across effect due to fluoride release by the glass ionomer cement on enamel around the brackets bonded with composite resin, this experimental design was chosen. The patients did not know what bonding material was used (blind study): they brushed their teeth with a non fluoridated dentrifice, but they drank fluoridated water. They received no instruction regarding oral hygiene, kept their usual habits, and received instructions not to use mouthrinse. The experimental period of 4 weeks was used, because measureable demineralization can be observed around the orthodontic appliances 1 month after bonding.[2,9] In the occlusal and cervical regions the indentations were made at the edge (0) of the bracket and at 100 and 200μm away from it. The indentations were made in the middle third of the lingual surface of each half of the crown in all these positions, 5 indentations were made at 10, 20, 30, 60 and 90μm from the external surface of the enamel to observe mineral changes at the outermost part of the enamel. Two internal controls (under the bracket and at the lingual surface) were used to evaluate the effect of acid etching. Regarding the additional controls, the findings showed that the enamel demineralization might be attributed to the experimental material evaluated. Thus the microhardness of the enamel under the brackets bonded with Fuji Ortho LC was statistically similar (Table 3), showing that the results regarding demineralization are due to caries and not to the acid etching effect of the material. Also, the results found at the lingual surface (control, not treated) showed that the teeth of the 2 groups were similar, because the enamel hardness was statistically similar (Table 3). The findings in table 3 showed that a narrow caries lesion (up to 30 μm depth) developed adjacent to the material, but statistically significant differences between the treatments were found at distance of 10 and 20μm from the enamel surface. The mineral loss in enamel was 33% adjacent to the composite resin and 21% adjacent to the glass ionomer. Thus, Fuji Ortho LC reduced enamel demineralization adjacent to the brackets by 12%. The mineral loss adjacent to Transbond XT agrees with the results of O'Reilly and Featherstone,[9] who found 15% mineral loss at the 25μm depth. The effect of Fuji Ortho LC agrees with invitro data observed with this material and other glass ionomer cements for orthodontic bonding.[7,15,30-31] The data in Table 3 shows two relevant aspects about dental caries of the material in reducing enamel demineralization. First, the enamel hardness was less around the composite resin in the cervical area when compared with the occlusal area. This is because of greater accumulation of plaque and the patient's difficulty to clean this area. This higher mineral loss in the cervical region than in the occlusal area has been observed by others in vitro.[30] This is due to lower mineralization and the higher carbonate on the cervical face than in the occlusal region. The second consideration about the finding in Table 3 is the statistically significant differences between the material at p=0.05 were observed in cervical area, but not in the occlusal region. Thus, the effect of Fuji Ortho LC in reducing enamel demineralization adjacent to the bond is more evident in the cervical area. This shows the effect of this material occurs on the tooth surface where the patient has difficulty in cleaning dental plaque with a toothbrush. This effect is due to the fluoride releasing ability of glass ionomer cements when submitted to cariogenic challenges.[32] The data in the Table 4 shows that at 10μm from the surface, the only position with no significant difference between the materials was on the lingual surface. The difference in the enamel hardness under the bracket bonded with Transbond XT and Fuji Ortho LC is due to acid etching during bonding with the resin. This effect was also described by O'Reilly and Featherstone.[10] They found a mineral loss of 3% to 8% directly under the brackets retained with composite resin. Nevertheless, the reduced hardness in enamel adjacent to the brackets cemented with Transbond XT in comparison with those with Fuji Ortho LC can be attributed to dental caries and not acid etching. This is clear because Fuji Ortho LC reduces enamel demineralization not only at the edge of the bracket 0 but also at 100 and 200μm away from it.

CONCLUSION

The results obtained from this study leads to the following conclusions: Enamel demineralization was found to be less around the bracket cemented with resin modified glass ionomer in comparison with the composite resin. Therefore its use as a bonding agent in orthodontic treatment should be encouraged.

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