

## ORIGINAL RESEARCH

# Evaluation and Comparison of Quantity and Pattern of Fluoride release from Orthodontic Adhesives: An *in vitro* Study

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## ABSTRACT

**Background:** Orthodontic treatment has gained popularity since beginning of era of dentistry. Now a day, everyone is conscious about their appearance, smile and function. During orthodontic treatment use of brackets and adhesives are common. The bonding of brackets will cause demineralization which requires the fluoridation. So the study has been undertaken to analyze the pattern of fluoride release by commercially available adhesive bonding material for the prevention of demineralization.

**Aim:** To evaluate and compare the clinical significance of quantity and pattern of fluoride release from three commercially available adhesives.

**Objectives:** To assess the pattern of fluoride release and quantity, to reduce the decalcification of enamel around orthodontic brackets and bands during treatment and to prevent further use of topical fluoride both office and self-use agents for prevention of demineralization/for remineralization.

**Materials and methods:** The comparison of quantity and pattern of fluoride release study involved commercially available bonding adhesives. They are: Group I—resin reinforced glass ionomer light cure material (OrthoLC), Group II—fluoride releasing composite resin material (Excel) and Group III—conventional composite (Relay-a-bond) evaluated on 78 freshly extracted premolar teeth divided into three groups consisting

26 specimens in each group. The prepared specimens were stored in artificial saliva at 37°C in an incubator for subsequent fluoride analysis using ORION ion selective electrode coupled with ionalyzer 901.

Fluoride analysis made at 24 hours intervals for first 3 consecutive days and thereafter at the end of 10th, 17th, 24th and 31st day of bonding. The data obtained were tabulated and interpreted by statistical analysis using 't' test and one-way analysis of variance (ANOVA).

**Observations and Results:** The quantity of fluoride release in groups I and II was significant even at the end of 31st day. The one-way AVOVA showed intra and inter group significance in the quantity of fluoride release. But group III with zero fluoride release with significant decalcification on enamel which requires external use of topical fluorides. The pattern of fluoride released was 3.06 ppm for group I and 2.01 ppm for group II and was declined sharply after 24 hours; and continued to decline in subsequent weeks. Mean quantity of fluoride release by group I was 15.08 ppm were as group II was 9.02 ppm over the test period of 31 days. At the end of 31st day the group I bonding adhesive was releasing considerable amount of fluoride compared to group II whereas group III was nil. At all the periods inter and intra group mean values were highly significant. And group III acted as base line or control group as it was non fluoride releasing material.

**Conclusion:** Both the fluoride releasing adhesive bond material are useful to reduce the risk of demineralization and further prevent the usage of topical fluoride application and reduce cost and clinical visiting time for both patient and clinician.

**Keywords:** Orthodontic adhesive, Fluoride release, Fluoride analysis, Artificial saliva, Orthodontic treatment, Demineralisation, Remineralisation, Fluoridation, Orthodontic brackets, Orion ionalyzer 901.

**How to cite this article:** Regalla RR, Jadav C, Babu DA, Sriram RRS, Sriram SK, Kattimani VS. Evaluation and Comparison of Quantity and Pattern of Fluoride release from Orthodontic Adhesives: An *in vitro* Study. J Contemp Dent Pract 2014;15(1):99-102.

**Source of support:** Nil

**Conflict of interest:** None declared

## INTRODUCTION

Orthodontic treatment has gained popularity since beginning of an era of the dentistry. Today everyone is conscious about their appearance, function and smile. During orthodontic treatment use of brackets and adhesive bonding agents are common. The presence of fixed appliance will reduce the

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efficacy of oral hygiene maintenance which leads to enamel demineralization/decalcification. Decalcification is a microscopic change which produces white spots on enamel and even cavitation due to leaching out the mineral content of enamel.<sup>1</sup> The incidence of decalcification ranging from 2 to 96% seen among the orthodontic patients.<sup>1,2</sup> In an attempt to minimize the decalcification around fixed orthodontic appliances, orthodontists have always emphasized the need for good oral hygiene and further for application of local fluorides.<sup>2-4</sup> All these preventive measures have been proved either patient dependent or of limited clinical significance.<sup>3,4</sup> A variety of commercially available bonding adhesives which claim to have sufficient bond strength and also ability to release the fluoride to protect the enamel surface were introduced which requires clinical assessment for successful usage.

An ideal preventive system should be independent of these factors and would release low concentration of fluorides locally, i.e. adjacent to bonded orthodontic brackets. Therefore the aim of the present study is to analyze the pattern of fluoride release and the quantity, to reduce the decalcification of enamel around orthodontic brackets and bands during treatment by commercially available fluoride releasing bonding adhesives.

**MATERIALS AND METHODS**

The present study involved commercially available three bonding adhesives, are (I) resin reinforced glass ionomer light cure material (Fuji OrthoLC), (II) fluoride releasing composite resin material (Excel), and (III) conventional composite (Relay-a-bond) evaluated on 78 freshly extracted premolar teeth divided into three groups consisting 26 specimens in each group. Group I the teeth bonded with standard metal brackets using fluoride releasing resin reinforced glass ionomer cement, group II using fluoride releasing composite resin bonding material, and group

III using conventional nonfluoride releasing composite according to manufactures instructions. All these specimens were prepared by single operator for standardization and uniformity of samples to overcome the examiner bias.

All the prepared specimens were stored into individually capped polystyrene tubes containing 4 ml of artificial saliva at 37°C in an incubator for 24 hours for subsequent fluoride analysis using ORION ion selective electrode coupled with ionalyzer 901. The solutions TISAB (Total Ionic Strength Adjusting Buffer) and standard fluoride solutions were prepared which are required for fluoride analysis. All the samples were kept at same temperature as that of standard solutions, to prevent measurement error.

**Principle and Method of Fluoride Ion Concentration Analysis**

Fluoride electrode consists of a single crystal lanthanum fluoride membrane which is an ionic conductor and an internal reference bonded in to epoxy body where only fluoride ions are mobile. The membrane is in contact with fluoride solution, an electrode potential develops across the membrane which depends upon the free fluoride ions in the solution; which, is measured against an external constant. After the standard potential and blank correction storage, the meter is calibrated for repeated sample measurements. Fluoride analysis was done at 24 hours intervals for first 3 consecutive days and thereafter at the end of 10th, 17th, 24th and 31st day of bonding.

**OBSERVATIONS AND RESULTS**

The data obtained were tabulated (Table 1) and interpreted by statistical analysis using ‘t’ test and one-way analysis of variance (ANOVA). The quantity of fluoride release in groups I and II was significant even at the end of 31st day. The one-way ANOVA showed intra and inter group significance in the quantity of fluoride release (Table 2 and 3).

**Table 1:** Showing mean fluoride release profiles of group I: (Ortho Lc), group II: (Excel) and group III (control group)

Sr. no.	1st day	2nd day	3rd day	4-10 day	11-17 day	18-24 day	25-31 day	Total
Group I	3.069	1.900	1.069	3.512	3.210	1.620	1.261	15.088
Group II	2.057	0.953	0.592	2.511	2.038	0.857	0.276	9.284
Group III	0	0	0	0	0	0	0	0

**Table 2:** Analysis of variance for mean difference over time periods: Group I

Source	DF	Sum of squares	Mean sum of squares	‘F’ ratio	Critical value F 0.001	Level of significance
Between groups	6	180.580	30.096	567.835	3.740	0.001
Within groups	175	0.928	0.005	1.000		
Total	181	181.508				

p < 0.001 the difference of fluoride release is highly significant



**Table 3:** Analysis of variance for mean difference over time periods: Group II

Source	DF	Sum of squares	Mean sum of squares	'F' Ratio	Critical value F 0.001	Level of significance
Between Groups	6	77.440	12.906	4052.702	3.740	0.001
Within Groups	175	0.557	0.003	1.000		
Total	181	77.990				

p < 0.001 the difference of fluoride release is highly significant

**Table 4:** Mean values and significance of difference in fluoride emission by periods of observation: Groups I and II

Days of observation	Group I mean	Group II mean	Mean difference	DF	't' value	p-value	Level of significance
1st day	3.069	2.257	1.012	50	38.071	<0.001	***
2nd day	1.900	0.953	0.947	50	31.000	<0.001	***
3rd day	1.069	0.592	0.477	50	19.821	<0.001	***
4-10 days	0.551	0.359	0.192	50	44.810	<0.001	***
11-17 days	0.459	0.291	0.168	50	38.812	<0.001	***
18-24 days	0.232	0.122	0.110	50	37.401	<0.001	***
25-31 days	0.181	0.039	0.142	50	49.101	<0.001	***
All together	15.61	9.284		50	5.421	<0.001	***

DF: Degree of freedom; p < 0.001 \*\*\*: Highly significant

Group III showed zero fluoride release with significant decalcification on enamel which requires external use of topical fluorides. The pattern of fluoride released was 3.06 ppm for group I and 2.01 PPM for group II which declined sharply after 24 hours (Table 4); and continued to decline in subsequent weeks. Mean quantity of fluoride release by group I was 15.08 PPM whereas by group II was 9.02 PPM over the test period of 31 days. At the end of 31st day the group I bonding adhesive was releasing considerable amount of fluoride compared to group II whereas group III was nil. At all the periods inter and intra group mean values were highly significant, while group III was used base line or control group as it was nonfluoride releasing material along with decalcification of enamel.

## DISCUSSION

The presence of fixed appliance will reduce the efficacy of oral hygiene maintenance which leads to enamel demineralization.<sup>1</sup> To minimize the decalcification around fixed orthodontic appliances, orthodontists have always emphasized the need for good oral hygiene and further application of local fluorides.<sup>2-4</sup> This will increase clinical visits as well as cost for patients; hence, commercially available fluoride releasing bonding adhesives are of much more interest for clinician to prevent further use of topical fluoride both office and self-use agents for prevention of demineralization/for remineralization.

The fluoride release during first 24 hours in relation to Ortho LC is in accordance with previous studies.<sup>5,6</sup> According to previous studies the elution of fluoride occurs as two different processes.<sup>5,6</sup> The first process characterized by initial burst from the surface, after which the elution is markedly reduced. Furthermore, the bulk diffusion process in

which a small amount of fluoride continuously to be released in to surrounding medium for a period up to at least 2 to 2.5 years in glass ionomer cement restorations.<sup>5</sup>

The elution process of the fluoride release noticed in the present study is in accordance with findings of Tay and Braden.<sup>7</sup> The mean amount of fluoride released from group I in three consecutive days is 3.06, 1.90 and 1.06 PPM respectively and this amount was declined to 0.18 PPM at the end of experiment. At all points of study there is a highly significant amount of difference in fluoride release which is observed from day one to day 31. The mean quantity of fluoride released in the present study for group I over a period of 31 days is 15.08 PPM (Table 1). This was not in accordance with previous studies may be because of chemical composition and difference in the experimental design of the study.<sup>8-10</sup> As the fluoride ions might be firmly encapsulated by the resin matrix and consequently its fluoride release rate into the aqueous environment might be smaller and slower than conventional glass ionomer cements.<sup>11</sup>

The results of group II was in accordance with many studies done previously in regard to fluoride release.<sup>1,2,12-22</sup> The mean fluoride release was 9.284 PPM (see Table 1). The initial high fluoride release could be advantageous because of initial post etch period after bonding, as it was reported that positive correlation exists between the fluoride released by material and the fluoride uptake into enamel.

The statistical analysis showed repeatability in terms of fluoride emission throughout the test period. Also it showed the fluoride release tapered with time. There is no known ideal level of fluoride in an enamel to provide protection from demineralization. Continuous exposure of enamel to very low level of fluoride 0.014 PPM have protective

effect against demineralization, rather it was intermittent exposure to higher level of fluoride delivered from the topical fluoride solution and from dentifrices for shorter periods of time. In our study mean fluoride levels required to protect enamel against demineralization even at the end of 4th week of study was above the minimum requirement to prevent demineralization, i.e. 0.18 PPM for group I and 0.039 PPM for group II. The correlation regression showed the pattern of decline with time was same among both the groups. Correlation coefficient was 0.9878 for group I, and 0.9506 for group II which was significant. The magnitude of difference of fluoride release from the first day till the end of the experiment was also found significant.

The fluoride component released from group I was higher compared to group II. The fluoride added may affect the properties of resin material by phase separation between organic phase of resin and highly polar nature of fluoride ions. Furthermore possibility of recharging the resin with topical fluoride seems doubtful. The fluoride release was significant but the concentration was declined which was above minimum quantity required to prevent decalcification and it was continued to decline over the experiment period. The group I released consistently higher fluoride than group II at all point of study. Hence the group I material is choice for direct bonding in patients to reduce decalcification during orthodontic treatment. It also prevents the clinical time of patient and clinician. It is economic as it prevents local application of fluoride.

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