In vitro Evaluation of Topical Fluoride Varnishes Effect on Enamel Demineralization Around Orthodontic Brackets

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The aim of this in vitro study was to test the effectiveness of applying the fluoride varnish on bracketed teeth with 2 types of bonding agent. 10 patients aged 12-18 (mean age 13.06 +/- 1.72 years) were scheduled to have the four fist premolar teeth extracted. The teeth were dived in 4 groups: 2 experimental and 2 controls. The teeth were cut in half so 80 surfaces were analyzed. The brackets were collated with Transbond XT and Fuji Ortho Lc. For each of the materials that have been used there was a test and a control group. The tests groups received one single application of Duraphat. The content in fluoride was measured by spectrophotometer. The mean values of fluoride indicated an important increase in the fluoride content after using resin modified glass ionomer cement and fluoride varnish. Statistically significant differences were determined between each of the control and treatment group when both materials have been used, after 10 days and one month application of the varnish. The study pointed out that the fluoride varnish combined with resin modified glass ionomer cement is more efficient than the classical resin composite in preventing demineralization around orthodontic brackets.

Keywords: preventing demineralization, enamel, fluoride varnish

Fixed orthodontic appliances have become more used today specially for the aesthetic and functional reasons. The treatment decision will have to analyze the carious risk of the patient, especially in the situations where the oral hygiene is inadequate. Dental plaque accumulation around the brackets is inevitable and sometimes followed by demineralization of enamel or inflammation of the gingiva [1].

White spot, the initial carious lesion is the most common side effect and it is the first clinical sign of mineral loss of the enamel that is characterized by opacity compared with the healthy tissue [2,3].

In literature were described many methods that could decrease or prevent white spot lesions as improving oral hygiene, modifying dietary habits (low carbohydrate) and applying fluoridation treatment [4].

During orthodontic treatment in addition to fluoridated toothpaste, in clinical practice the application of topical fluorides (e.g. mouth rinse, gel, varnish, professional toothpaste) and fluoride-releasing materials (e.g. cements, bonding materials, modified resins, elastics) is a proven approach for enhancing enamel remineralization [5,6].

The fluorapatite crystal that is incorporated into the surface of enamel has lower solubility in the oral environment compared with hydroxyapatite and helps in reducing tooth decay by enhancing remineralization of small decalcified areas and reduction in the formation of new lesions [7].

Both in vitro and in clinical trials it has been shown that varnishes provide high concentration of fluoride having the advantage of adhering to enamel surface longer than other topical fluoride products, which indicates that their ability to increase fluoride uptake in enamel is better [8-10].

Long duration of orthodontic treatment influence the caries risk that can be minimized by a continuous fluoride release from the bonding system around the bracket base [11]. As an alternative to composite material for bracket bonding fluoride- releasing GIC (glass ionomer cement) and RMGIC (resin-modified glass-ionomer cement), have been shown to exert cariostatic effects in both prospective and longitudinal clinical trials. Glass ionomers have been shown in vitro to be effective at protecting the enamel from decalcification beneath and also 1 mm around an orthodontic attachment. The ability to absorb fluoride from topical fluoride applications allows GIC to act like a long-term fluoride releasing agent [9,12].

Because of recent improvements in the fluoride-releasing capabilities and the shear bond strength of RMGIC, teeth with RMGIC-bonded brackets demonstrated a 50% reduction in lesion depth with or without fluoride varnish application. Fluoride is released from the RMGI adhesives long after initial application, but they only protect a limited area immediately adjacent to the orthodontic bracket. In addition, bond failures with RMGIC have been found to be similar or worse than composite resins [13-15]. The preventive effect of adhesives adjacent to brackets has been investigated in vitro and in vivo by quantifying the demineralization depths and the mineral losses with various evaluation methods [8,16,17].

The purpose of the present study was to evaluate in vitro effects of using fluoride varnishes combined with resin-modified glass ionomer cement RMGIC in reducing enamel demineralization around orthodontic brackets and compare it with non-fluoride releasing composite resin.

Experimental part

Material and method

Ten orthodontic patients, aged 12-18 years (mean age: 13.06 +/- 1.72 years), were invited to participate in the study. The inclusion criteria for the patients were: the absence of carious lesions or periodontal disease and normal salivary flow rate (>1.0 mLD min) and buffer capacity (*p*H: 6.8-7.5).

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Group no.		No. of surfaces	Bonding material	Varnish	Evaluation
1 control	1A	10	Transbond XT	No	10 days
	1B	10		No	1 month
2 test	2A	10	Transbond XT	Duraphat	10 days
	2B	10		Duraphat	1 month
3 control	3A	10	Fuji Ortho LC	No	10 days
	3B	10		No	1 month
4 test	4A	10	Fuji Ortho LC	Duraphat	10 days
	4B	10		Duraphat	1 month

Table 1
TEETH SAMPLING

From 3 male participants (39.29%) and 7 females (60.71%) signed consent was obtained. The four first premolars teeth for each of the patient were extracted for orthodontic reasons. This study was approved by the Research Ethical Committee of Faculty of Dentistry, University of Medicine and Pharmacy Timisoara.

Forty sound human premolars were collected and stored in water containing 0.2% thymol. The collected teeth were examined macroscopically, both buccal and lingual enamel surfaces of the teeth had no developmental defects, white spots or loss of tissue due to caries or trauma. The teeth had not been exposed to any chemical agents such as alcohol or peroxide hydrogen.

According to the materials that have been used the teeth were divided randomly into four groups containing each 10 teeth: group 1- Transbond XT without applying additional fluoride varnish; group 2: resin bonding -Transbond XT (3M Unitek, USA)) with additional fluoride varnish Duraphat; group 3: resin-modified glass ionomer cement RMGIC (GC Fuji Ortho LC, GC Corporation/Japan) used as bracket adhesive and group 4 -GC Fuji Ortho LC, used as bracket adhesive with additional fluoride varnish Duraphat.

The teeth were cleaned with a pumicing paste for 10 seconds. Each tooth was then rinsed with tap water for 15 seconds and dried with oil free air for 10 s. The teeth were cut in half so a total of 80 surfaces were analyzed (Table 1).

For each of the 4 groups, 20 Stainless-steel brackets (Ortho technology Co., USA) were bonded. Conventional etching was performed with 37% phosphoric acid (3M Dental Products; St Paul, Minnesota, USA) for 20 s followed by rinsing for 10 s and drying for 10 s and bonding layer were applied and air dried.

Liquid primer of the Transbond XT was applied to the etched surface and the stainless-steel orthodontic premolar brackets were bonded to teeth with Transbond XT for the groups 1and 2 and Fuji Ortho LC for the groups 3 and 4. Excess adhesive was removed.

After brackets bonding, the premolars (test specimens from group 2 and 4) were kept dried carefully and the enamel received a single topical application of a 5% sodium fluoride varnish/ 22.600ppm (Duraphat®; Colgate) with the aid of a brush applicator. 4 min later, the teeth were wet with mild air/water spray and stored in artificial saliva (20 mmol/L $NaHCO_3$, 3 mmol/L NaH_2PO_4 and 1 mmol/L $CaCl_2$, neutral *p*H) until analysis, which was done 10 days and 30 days thereafter. The manipulation of the dental materials was performed in according to the Green Paper on the management of bio-waste in the European Union. Fluoride concentrations were measured by spectrophotometer.

Statistical analysis

Data analyses were performed using the Statistical Package for Social Sciences (SPSS, Version 19.0, SPSS Inc; Chicago, Illinois, USA) and Excel (Office 2007) (Microsoft Corporation; Redmond, WA, USA). For statistical evaluation, a 1-way analysis of variance (ANOVA) followed by Post Hoc Tukey's test was used to see if there was a significant difference between groups.

Results and discussions

The mean concentrations of total fluoride in enamel in the groups of teeth bonded with Transbond XT versus the groups bonded with Fuji Ortho LC 10 days after topical application of Duraphat varnish is shown in table 2. After 10 days, the mean value of fluoride in the test group of teeth bonded with Transbond XT was 611.50 ppm, and in the control group of teeth the mean value of F was 170.80 ppm which were lower than the mean values of fluoride in both test and control groups for Fuji Ortho LC (mean 916.00 versus mean 611.50) and (mean 712.56 versus mean 170.80). Between the values of fluoride in the enamel in all examined groups of teeth, 10 days after the fluoride application there was a statistically significant difference ($p<0.05$) (table 3).

Table 2
THE MEAN CONCENTRATIONS OF TOTAL FLUORIDE (ppm) IN ENAMEL IN THE GROUPS OF TEETH BRACKETS BONDED WITH COMPOSITE RESIN-TRANSBOND XT COMPARED WITH RMGIC-FUJI ORTHO LC 10 DAY S AFTER TOPICAL APPLICATION OF A FLUORIDE VARNISH-DURAPHAT

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
composite/no varnish	10	170.8000	15.61908	4.93919	159.6268	181.9732	148.00	190.00
composite+varnish	10	611.5000	125.59127	39.71545	521.6574	701.3426	420.00	800.00
RMGIC/no varnish	10	712.5650	43.39935	13.72408	681.5190	743.6110	657.00	798.00
RMGIC+varnish	10	916.0000	82.60078	26.12066	856.9110	975.0890	817.00	1036.00
Total	40	602.7163	286.03990	45.22688	511.2363	694.1962	148.00	1036.00

Table 3

MULTIPLE COMPARISONS BETWEEN THE GROUPS OF TEETH BRACKETS BONDED WITH COMPOSITE RESIN-TRANSBOND XT COMPARED WITH RMGIC- FUJI ORTHO LC 10 DAYS AFTER TOPICAL APPLICATION OF A FLUORIDE VARNISH- DURAPHAT

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
composite/no varnish	composite+varnish	-440.70000*	35,15929	,000	-535,3920	-346,0080
	RMGIC/no varnish	-541.76500*	35,15929	,000	-636,4570	-447,0730
	RMGIC+varnish	-745.20000*	35,15929	,000	-839,8920	-650,5080
composite+varnish	composite/no varnish	440.70000*	35,15929	,000	346,0080	535,3920
	RMGIC/no varnish	-101,06500*	35,15929	,033	-195,7570	-6,3730
	RMGIC+varnish	-304,50000*	35,15929	,000	-399,1920	-209,8080
RMGIC/no varnish	composite/no varnish	541,76500*	35,15929	,000	447,0730	636,4570
	composite+varnish	101,06500*	35,15929	,033	6,3730	195,7570
	RMGIC+varnish	-203,43500*	35,15929	,000	-298,1270	-108,7430
RMGIC+varnish	composite/no varnish	745,20000*	35,15929	,000	650,5080	839,8920
	composite+varnish	304,50000*	35,15929	,000	209,8080	399,1920
	RMGIC/no varnish	203,43500*	35,15929	,000	108,7430	298,1270

*. The mean difference is significant at the 0.05 level.

The mean values of fluoride concentration in the enamel of the bracketed teeth with Transbond XT and Fuji Ortho LC after 1 month are shown in table 4. The mean values of fluoride are decreasing progressively in all groups after 1 month with a considerable higher value for Fuji Ortho LC. There was a statistically significant difference of the values of total fluoride in enamel in the group of test teeth compared to the control group of teeth 1 month after brackets bonded with Fuji Ortho LC and topical application of a fluoride varnish. Post hoc analysis indicated significant difference between all the groups 1 month after the single application of Duraphat (table 5).

By using fluoride-releasing materials and providing continuous presence of low concentrations of fluoride in the oral medium, decalcification prevention of enamel has been reported in many studies [11,13]. Besides the positive impact on local fluoride-release, the cement used for bonding the brackets also have influence on inhibition of demineralized enamel around orthodontic brackets and bands [18, 19].

If the mean values of fluoride are plotted in a diagram and compared between them Fuji Orho LC has indicated the highest values in both evaluations (fig. 1). The efficacy of glass ionomer cement (GIC) and GIC containing casein phosphopeptide-amorphous calcium phosphate (CPP-ACP) in preventing the formation of initial carious lesion adjacent to orthodontic brackets and bands by acting as a surface sealant has also been proven. The results concluded that the use of GIC alone or incorporating CPP-ACP significantly reduced demineralization compared with other materials [15,20,21].

The results indicated that the content of fluoride in the enamel increased substantially after the application of varnish (mean value 916.00 versus mean value 712.56 for

Table 4

THE MEAN CONCENTRATIONS OF TOTAL FLUORIDE (ppm) IN ENAMEL IN THE GROUPS OF TEETH BRACKETS BONDED WITH COMPOSITE RESIN-TRANSBOND XT COMPARED WITH RMGIC-FUJI ORTHO LC, 1 MONTH AFTER TOPICAL APPLICATION OF A FLUORIDE VARNISH-DURAPHAT

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
composite/no varnish	10	165,2750	41,61964	13,16128	135,5021	195,0479	100,42	220,89
composite+varnish	10	383,8330	28,73122	9,08561	363,2799	404,3861	310,14	410,35
RMGIC/no varnish	10	494,6000	61,39707	19,41546	450,6792	538,5208	411,00	589,00
RMGIC+varnish	10	655,4000	128,73763	40,71041	563,3066	747,4934	512,00	890,00
Total	40	424,7770	194,60052	30,76904	362,5407	487,0133	100,42	890,00

Table 5

MULTIPLE COMPARISONS BETWEEN THE GROUPS OF TEETH BRACKETS BONDED WITH COMPOSITE RESIN- TRANSBOND XT COMPARED WITH RMGIC-FUJI ORTHO LC, 1 MONTH AFTER TOPICAL APPLICATION OF A FLUORIDE VARNISH

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
composite/no varnish	composite+varnish	-218,55800*	33,83833	,000	-309,6923	-127,4237
	RMGIC/no varnish	-329,32500*	33,83833	,000	-420,4593	-238,1907
	RMGIC+varnish	-490,12500*	33,83833	,000	-581,2593	-398,9907
composite+varnish	composite/no varnish	218,55800*	33,83833	,000	127,4237	309,6923
	RMGIC/no varnish	-110,76700*	33,83833	,012	-201,9013	-19,6327
	RMGIC+varnish	-271,56700*	33,83833	,000	-362,7013	-180,4327
RMGIC/no varnish	composite/no varnish	329,32500*	33,83833	,000	238,1907	420,4593
	composite+varnish	110,76700*	33,83833	,012	19,6327	201,9013
	GIC+varnish	-160,80000*	33,83833	,000	-251,9343	-69,6657
RMGIC+varnish	composite/no varnish	490,12500*	33,83833	,000	398,9907	581,2593
	composite+varnish	271,56700*	33,83833	,000	180,4327	362,7013
	GIC/no varnish	160,80000*	33,83833	,000	69,6657	251,9343

*. The mean difference is significant at the 0.05 level.

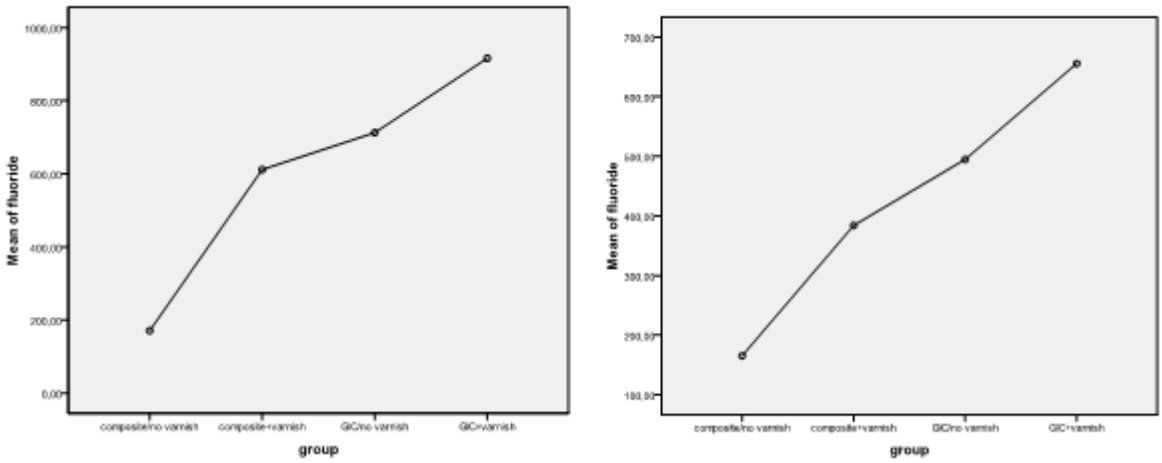

Fig. 1. Mean values of fluoride in all groups after 10 days and 1 month after varnish application

Fuji Ortho LC). After 1 month the mean value (655,40) was still high for the test group that used for bonding Fuji Ortho LC -compared with the test group where bonding was done with Transbond XT (383.83) which indicated the positive effect of the varnish material but also of the bonding material that released slowly fluoride and maintained a favorable concentration that inhibited demineralization.

The outcomes of the present study are in accordance with other studies, where the enamel was treated with a conventional fluoride varnishes (5% NaF) and compared to those treated with a white fluoride varnish (5% NaF) enhanced with functionalized tri-calcium phosphate (TCP) [22]. The results of this study suggest that the use of a fluoride varnish significantly improves the resistance for developing carious lesions. Also remineralization agents containing different Ca-Ph formulas and fluoride have increased remineralization potential. Casein phospho-peptide-amorphous calcium phosphate (CPP-ACP) is reported to have remineralizing effects because of its calcium and phosphate ion content. Calcium and phosphate ions released from ACP materials are delivered over the enamel surface where they form a hydroxyl apatite-like structure [20].

Conclusions

Within the limitation of this in vitro study, it was concluded that the use of a fluoride varnish combined with GICs enhanced remineralization around brackets more efficiently than the conventional composite resin. Fluoride varnishes might be included as a standard treatment for the patients with fixed orthodontic appliances.

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