Research Article

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Effect of Silver Diamine Fluoride on Surface Microhardness of Enamel of Permanent Molars: An in-vitro study

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ABSTRACT

Background: Early stages of dental caries are reversible and can be modified or eliminated by protective factors such as fluoride exposure and salivary flow. Professionally applied topical fluorides are recommended for individuals who present moderate to severe caries activity and aim at preventing and/or arresting new or recurrent dental caries. The aim of this study is to compare the effect of three types of topical fluorides on the microhardness of enamel of permanent molars using pH cycle in vitro.

Materials and methods: 45 sound extracted human permanent molars were collected and decoronated. Baseline surface microhardness was measured using Vickers microhardness testing machine. All specimens were randomly divided into 3 groups of Fluoride varnish, Acidulated Phosphate Fluoride (APF) gel and Silver Diamine Fluoride (SDF) solution. After the application, all samples were placed in pH cycle. Microhardness was measured again after seven days, and these values were compared with baseline values.

Results: Significant decrease in mean microhardness values after pH cycling (from baseline) were seen in all groups. Samples treated with fluoride varnish demonstrated the least reduction of mean microhardness followed by samples treated with SDF and APF gel with the difference being non-significant.

Conclusion: The highest cariostatic effect was achieved by fluoride varnish and lowest by APF gel. There was no significant difference in fluoride varnish, APF gel and SDF solution regarding prevention of demineralization.

Keywords: Enamel microhardness, dental caries, topical fluoride solutions.

INTRODUCTION

Tooth decay is the most common chronic disease in childhood. Effective efforts to prevent caries and non-invasive treatment of initial caries lesions in young children are needed. Fluoride is widely accepted as the most effective tool for caries prevention.[1] The cariostatic effect of fluoride is primarily due to its ability to decrease the rate of demineralization by forming fluor-hydroxyapatite and enhancing the remineralization of incipient carious lesions.

In the last two decades, the application of fluoride varnish has been very much simplified, due to its advantages such as ease of manipulation, safety and simplicity of application. Fluoride varnish requires less treatment time in comparison with fluoride gel, which needs tray and suction for its application.[2] The exposure time between fluoride and the tooth surface increases when fluoride varnishes are used due to its adhesion to the tooth surface.[3] Fluoride gels are acidic, highly concentrated fluoride

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products that can be applied topically and professionally which helps in preventing enamel demineralization. However, recently, the use of silver diamine fluoride (SDF), an active cariostatic agent used in caries prevention since 1960[4], has been proposed to arrest enamel caries lesions. Silver diamine fluoride is an inexpensive topical medicament used extensively in other countries to treat dental caries across the age spectrum.

India is a country with a large population deprived of quality dental treatment and poor accessibility to preventive care. Most affected among them are young children. Prevention of dental caries is essential as caries affects a person's self-esteem, quality of life and also indirectly contributes to the decrease in a nation's productivity. The topical application of fluoride agents over the past four decades has produced significant anticaries benefits to human dentition.[5] Thus if these topical fluoride agents prove to be beneficial, they can be used to tackle the caries problem in community dental health program in developing countries like India.

Surface microhardness is a physical property which accesses the effect of chemical and physical agents on hard tissues of teeth, and a useful way to examine the resistance of fluoride-treated enamel against caries.[6] Keeping this in mind, the following study was conducted in order to evaluate the effect of 0.1% fluor protector fluoride varnish, 1.23% APF gel and 38% SDF solutions on enamel microhardness by using pH cycle, thereby promoting the use of topical fluoride agents which could be used for the low socio-economic population on a mass scale.

MATERIALS AND METHODS

This is an experimental design using a microhardness tester to test the strength of the enamel after repeated cycles of demineralisation and remineralisation. A total of 45 sound extracted permanent molars were collected for the study. Caries free, permanent molars and teeth with normal morphology were included in the study. However, permanent molars with caries, hypoplastic defects, developmental malformations and discolourations were excluded.

After selecting, the teeth were decoronated at cementoenamel junction and sectioned buccolingual into two halves using a high-speed diamond disc. Specimens were prepared by embedding the crown sections in a self-cure acrylic resin block. Baseline surface microhardness was measured for all specimens using a Vickers microhardness testing machine, with an applied load of 500g for 15 seconds. Then the teeth were randomly divided into 3 groups namely: Group I (fluoride varnish group), Group II (Acidulated phosphate fluoride [APF] gel group) and Group III (SDF solution group) with 30 samples in each group. Each sample from all three groups was first kept in demineralising solution for 3 hours. After drying, all the samples were immersed in the remineralising solution for 21 hours. This cycle was repeated every day for 7 days. On 8th day, all the samples were taken out of the solution and surface microhardness was measured. The obtained data were evaluated using Statistical Package for the Social Sciences (SPSS version 18.0) for windows.

RESULTS

As shown in **Table I,** the mean and standard deviation (SD) values of surface microhardness at baseline and after seven days of pH cycle were 245.03±38.51 and 231.97±43.79 for varnish, 240.53±42.53 and 224.63±39.31 for APF gel, 251.10±49.70 and 236.27±48.60 for SDF group. Statistically highly significant decrease in mean surface microhardness values after pH cycling (from baseline) was seen in all three groups. On inter-group comparison, the samples treated with fluoride varnish demonstrated the least decrease in mean surface micro hardness after pH cycling (from baseline) followed by the samples treated with SDF solution and APF gel. Though the difference between the groups was non-significant. As shown in **Chart I,** the results of the ANOVA test suggested that there was no significant difference in baseline surface microhardness values in all three groups. The mean surface microhardness of SDF was highest (250.27±49.53), while that of APF gel was lowest (240.13±42.46) at baseline.

As shown in **Chart II,** the results of the ANOVA test suggested that there was no significant difference in surface microhardness values in all three groups after pH cycling. The mean surface microhardness of SDF was highest (234.70±48.42), while that of APF gel was lowest (224.17±39.21) after pH cycling.

Table I: Comparison of mean surface microhardness values at baseline and after pH cycle within each group.

Group (N=30)	Microhardness	Mean±SD	*p*-Value
Group I (Varnish)	Baseline	245.03±38.51	<0.001 (HS)
	After pH cycle	231.97±43.79	
Group II (AFP gel)	Baseline	240.53±42.53	<0.001 (HS)
	After pH cycle	224.63±39.31	
Group III (SDF solution)	Baseline	251.10±49.70	<0.001 (HS)
	After pH cycle	236.27±48.60	

Paired T test, p value < 0.001 (Highly significant-HS)

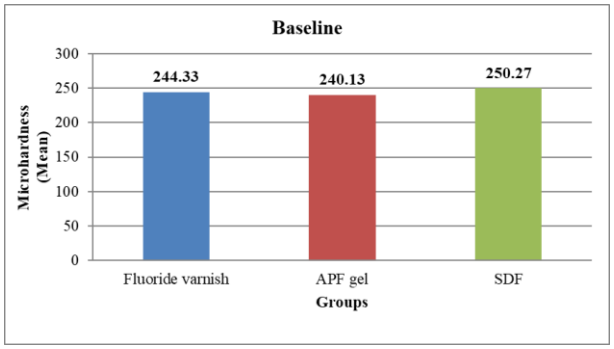

Chart I: Comparison of baseline mean surface microhardness among three groups.

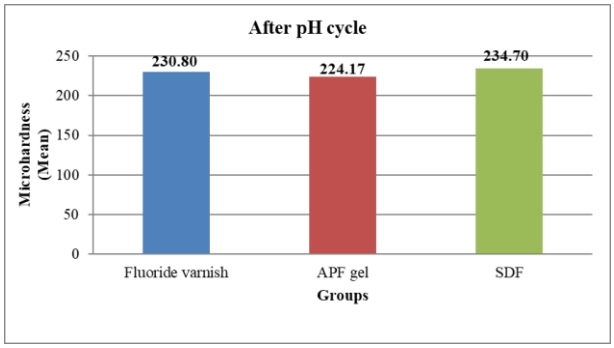

Chart II: Comparison of mean surface microhardness among three groups after pH cycle.

As shown in **Table II**, difference of mean (±SD) values of surface microhardness among three groups at baseline and after pH cycle was not statistically significant. The difference of mean values of surface microhardness (at baseline and after pH cycle) of APF gel was highest while that of fluoride varnish was lowest.

Table 2: Difference of mean surface microhardness among three groups at baseline and after pH cycle.

Group	Mean±SD	*p*-value
Group I (Fluoride Varnish)	-13.53±9.31	0.686 Non-significant (NS)
Group II (AFP gel)	-15.57±11.19	
Group III (SDF solution)	-15.02±11.55	

ANOVA Test, *p*-value ≤ 0.05 [Statistically significant]

DISCUSSION

The purpose of this in vitro pH cycling study was to evaluate the ability of topical fluoride products to protect enamel surface against demineralization challenges. Simulation of the natural mouth environment forced us to use pH-cycling techniques. Different modifications of this technique have been applied for investigating caries processes and effect of caries preventive agents. Therefore, pH-cycle creating models could be accepted as an excellent evaluating method of the caries process and also provide standard study conditions.[7] Because of these reasons, the present research was designed on a pH cycle and determined the effects of three different topical fluoride products on permanent enamel in vitro. In pediatric dentistry, the topical application of fluoride is a necessary routine preventive procedure. Therefore, it is essential to identify more effective methods of fluoride application.

Considering the importance of the surface layer in caries progression, the evaluation of changes in this region was relevant. Thus, Surface microhardness measurement was a suitable technique for studying de-remineralization process. Microhardness measurement was appropriate for a material having fine microstructure, brittle nature, non-homogenous or prone to cracking like enamel. In the present study, Vickers microhardness number (VHN) was adopted as the basis for investigation because the square shape of indent obtained in VHN is more accurate to measure. Even the minute changes in the rectangular shape indent obtained after the test could be easily detected.[8] Mineral loss or gain in enamel could be measured as hardness

change after demineralization or remineralization processes.

In the present study, the values of surface microhardness indicate that demineralization resistance of enamel was more in samples of group I (Varnish) followed by group III (SDF) and group II (APF gel). Fluoride varnish had almost two-fold higher concentrations in comparison to that of fluoride gel, and it also had longer contact duration with the teeth, and its protective effect against demineralization was more senior to that of fluoride gel. It has been mentioned that the concentration and exposure time of topical fluorides affect the properties of fluoride reaction on the tooth surface.[9] Lucineide *et al.* in 2009[10] in an *in-vitro* pH cycle study reported that highest cariostatic effect was achieved by fluoride varnish as compared to APF gel. On the contrary, Lee *et al.* in 2010[11] found that APF gel showed a better effect in terms of fluoride uptake. This could be explained on the basis that the acidic pH of APF gel may have etched the enamel surface and helped to increase the incorporation of fluoride into the enamel.

In the present study, Group III (SDF group) showed more mineral loss as compared to Group I (fluoride varnish group). Fluoride varnish was more efficient to delay lesion progression when compared to SDF. This result was in accordance to a study done by Alberto CB *et al.* in 2006.[12] He reported that lower reactivity of SDF group may be attributed to the formation and dissolution of silver phosphate and silver proteinate and re-precipitation of silver chloride, silver oxide and metallic silver crystals during pH-cycling. Silver may have interfered with the formation of fluoridated deposits and formed silver phosphate, which may compete with fluoride. The silver fluoride products are more often used in dentin caries, which present a greater amount of protein substrate, carbonates and phosphates for the reaction. On the other hand, the enamel is short of these substrates in comparison with dentin, which may have decreased the silver diamine fluoride reactivity. The present study showed a reduction of hardness in all treated groups indicating that, although fluoride products can inhibit dental erosion, they do not entirely prevent it. These results were in accordance with those of previous studies done by Mcdonald SP *et al.* in 1994[13], Jones L *et al.* in 2002[14], Magalhaes A *et al.* in 2008[15] and Murakami C *et al.* in 2009[7] on dental erosion.

CONCLUSION

Based upon the experimental conditions of this study, all the fluoride products tested in this *in vitro* study promoted a reduction in the demineralisation of the artificial carious lesions in the enamel of permanent teeth. However, none of the products used here was able to completely prevent the formation of lesions. The highest cariostatic effect was achieved by the fluoride varnish and the lowest by the APF gel. However, there was no statistically significant difference in fluoride varnish, APF gel and SDF solution regarding prevention of demineralisation. The outcome of the present *in vitro* study may be different when carried out in the presence of dynamic interactions occurring at the tooth surface in the oral cavity. Therefore, *in vivo* studies should be conducted to validate the observations of this study.

CONFLICTS OF INTEREST

The authors declare they have no potential conflict of interests regarding this article.

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