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EFFICACY OF FLUORIDE VARNISHES IN PREVENTING ENAMEL DEMINERALIZATION

Efka Zabokova Bilbilova[1,2], Ana Igić[3], Zlatko Georgiev[1,2], Ivona Kovačevska[4], Maja Lazarova[5]

Demineralization is a process in which the inorganic content of the enamel structure is lost leading to occurrence of white spot lesions. The purpose of this study was to examine fluoride varnish effect on enamel. The study involved 20 premolars extracted for orthodontic reasons. Before the extractions, brackets were bonded with one type of adhesive according to manufacturers 'bonding instructions. After bracket bonding, ten left premolars (the test group) were kept dried by careful tooth isolation and the enamel received a topical application of fluoride varnish (Duraphat®, Germany). Ten right premolars (the control group) did not receive any varnish application and brackets were fixed using identical procedures. After two months, the premolars were extracted and prepared for SEM analysis. Samples treated with fluoride varnish showed a nearly smooth surface, with complete obtrusion of interrod spaces in some fields. The rods appeared as they were fused together with some globules deposited on the surface, relatively no evidence of porosities or irregularities. Within control group demineralization started on enamel surface, but still with adequate and genuine prisms together within interprismatic space. Micro-morphological surface observation of the enamel surfaces showed demineralized surface as rough and uneven tooth enamel (shrinking of prisms, due to the widening of the prismatic spaces). Fluoride varnish application on enamel surface prevents demineralization processes. Fluoride application could act as a 'barrier' against the demineralization processes on enamel.

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Key words: *fluoride varnish, demineralization*

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Introduction

Caries lesions result from the demineralization process of the tooth enamel, which primarily causes white spots on enamel surface and it is caused by bacterial products such as acids in cariogenic environment. White spots can clinically be found on the tooth surface when it comes to mineral dissolution of the enamel. Their appearance changes the color of the tooth on that particular spot from translucent to opaque. Because of that it can be considered as an esthetic problem knowing that they can't spontaneously disappear (1, 2).

Demineralization and remineralization are dynamical but also balanced processes that normally happen in oral cavity. Many factors can cause disbalance of these two processes such as diet variations, oral hygiene or microbial activity and result in the predominance of demineralization. The remineralization process represents the buffering capacity of the saliva with calcium and phosphate ions that form minerals for enriching tooth enamel.

Fluoride has been recognized as the main propriety for the decline in caries due to its cariostatic potential. Even though its major efficiency is in preventing caries, there are certain limitations when it comes to its effects. It means that fluoride cannot eliminate caries completely. On the contrary, it can even cause harmful effects on the tooth if applied in high concentrations (3, 4).

At a neutral pH of 7, low ion concentrations are sufficient to keep dental hard tissues in equilibrium. When pH drops below 7 as the result of acidogenic bacterial production and the presence of plaque, higher ion concentrations are needed to prevent appearance of incipient caries lesions. Enamel starts to dissolve when pH drops to 5.5 or less. When that happens undersaturation begins, which means that calcium and phosphate ion concentrations in saliva and plaque fluid are not sufficient to provide minerals for enamel and keep it in balance. On the contrary, fluorhydroxyapatite (FHAP) and fluorapatite (FAP) dissolution begins at much lower pHs of about 4.7. Supersaturation begins when pH starts to increase. First, it begins within the FHAP followed by the FAP, all that it takes is some fluoride present in the oral cavity, which represents and explains the process of remineralization. Consequently, during remineralization after acid attack, a redistribution of mineral phases occurs, in which the proportion of stable, carbonate-poor FHAP in the enamel increases at the expense of carbonate-rich HAP. After this redistribution of minerals in processes of demineralization and remineralization, tooth enamel becomes more reluctant and acid resistant in comparison to undamaged enamel. During remineralization, the contribution of saliva with Ca^{2+}, PO_4^{3-} and OH^- ions in addition to the presence of dissolved F–is important.

Nowadays there are products that can be used for remineralization such as toothpastes and tooth mousses. From the clinical point of view the use of fluoride varnish could be more effective. The explanation lies in the fact that fluoride varnish will remain adhered to the tooth surface longer than toothpaste or dental cream prefunding its contact with the enamel (5, 6).

In the process of remineralization comes to ionic release which shows us that these products can act like a physical barrier and also show protective effect on the enamel when it comes to acid attack. Despite the fact that the use of varnishes can prevent white spots during orthodontic treatment, their effects regarding interproximal reduction procedures cannot be neglected (7, 8). It has been studied by Peng et al. (9) by measuring microhardness, density and mineral loss after applying fluoride varnish and resin infiltration on demineralized enamel surfaces. Fluoride catalyzes the diffusion of Ca and phosphate over the dental surface, which causes remineralization of the enamel crystalline structure to create fluorapatite crystals, which is the most resistant crystalline phase (10).

The purpose of this study was to examine the preventive effect of fluoride varnish on the enamel.

Materials and methods

The study involved 20 healthy premolars extracted for orthodontic reasons. Before extractions brackets were bonded with one type of adhesive according to manufacturers bonding instructions. The adhesive used in this study for bonding brackets was Con Tec LC (Dentaurum, Germany). After bracket bonding, ten left premolars (the test group) were kept dried by careful tooth isolation and the enamel received a topical application of fluoride varnish (Duraphat®, Germany) with the aid of a brush applicator. Ten right premolars (the control group) did not receive any varnish application and brackets were fixed using identical procedures.

After two months, the premolars were extracted and the teeth were disinfected by keeping them in 10% formalin for 48 hours and then stored at room temperature in distilled water till the time of SEM analysis. For the SEM analysis, the samples were coated with 40 nm to 60 nm of gold using a sputter coater and then observed in the microscope (VEGA3 LMU; TESCAN, a.s., Brno, Czech Republic) with the magnification ranging from x2000 to x3000.

By SEM analysis, micromorphologic changes in the enamel structure were monitored in the places where the brackets had been previously bonded.

Results

The initial demineralization of enamel prisms was observed in the control group (Figure 1).

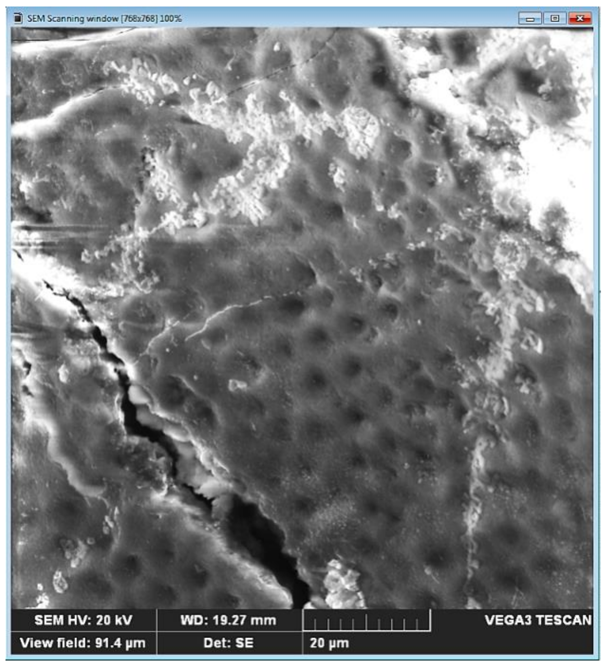

Figure 1. Initial demineralization of enamel prisms

The demineralized enamel showed a rough surface with a honeycomb appearance. Shallow depressions and fine porosities within these depressions were observed.

SEM examination of enamel surfaces adjacent to orthodontic brackets revealed calcium fluoride-like material (CaF_2) deposition as a product of topical fluoride varnish application. An adhered thin layer of fluoride varnish was also seen in some teeth of the test group, which was in close contact with the enamel around the orthodontic brackets (Figure 2 a, b).

Samples treated with fluoride varnish showed a nearly smooth surface, with complete obtrusion of inter-rod spaces in some fields. The rods appeared as they were fused together with some globules deposited on the surface, there were relatively no evidence of porosities or irregularities.

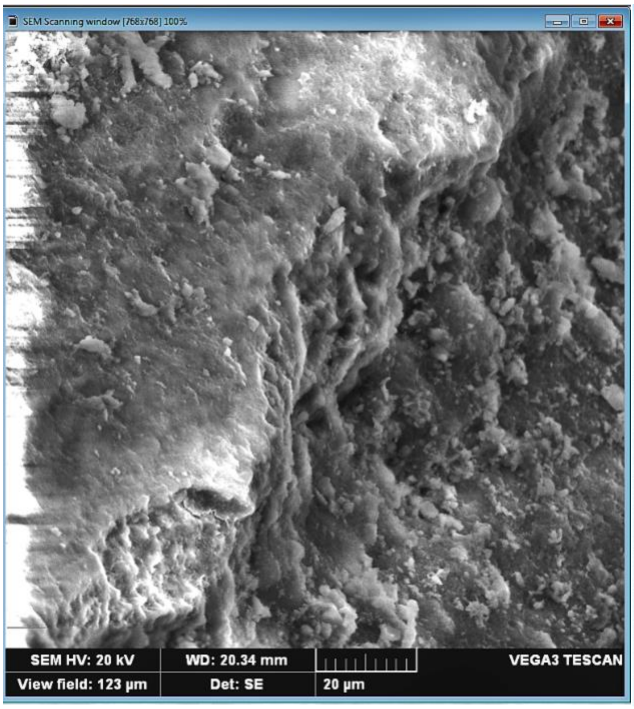

Figure 2 a. Calcium fluoride-like material (CaF_2) deposition

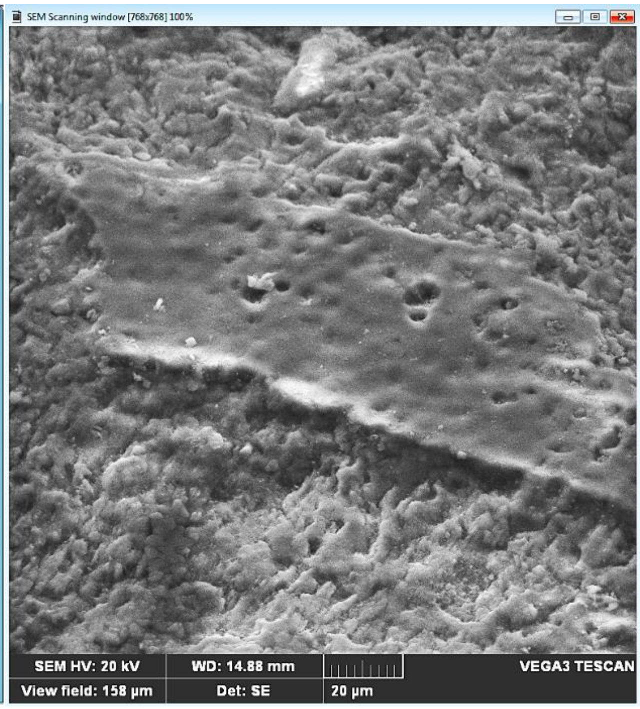

Figure 2 b. Smooth surface, with complete obtrusion of interrod spaces in some fields

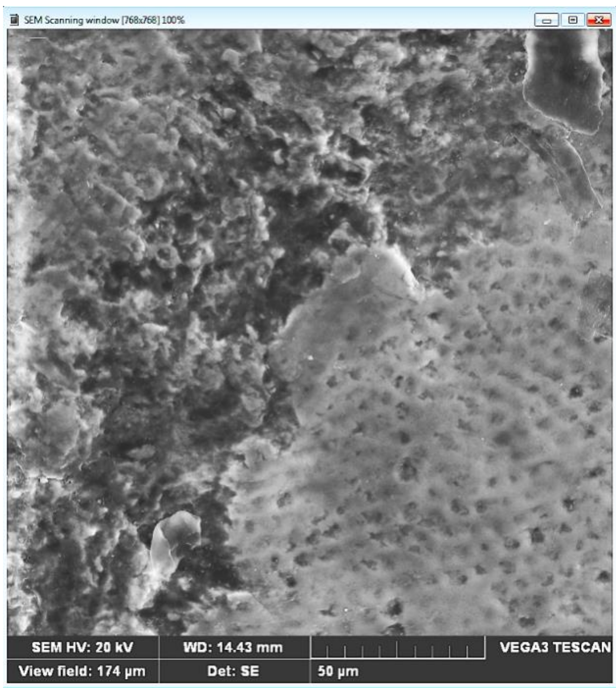

Figure 3. Shrinking of prisms, due to the widening of the prismatic spaces

SEM examination showed multilayer surface dissolution with a minor honeycomb pattern of demineralization. The demineralization started on an enamel surface, but still with adequate and genuine prisms together within interprismatic space. We can see the teeth enamel in Figure 3, as demineralized surface showed through the uneven and rough surface of teeth enamel (shrinking of prisms, due to the widening of the prismatic spaces).

Discussion

Demineralization is a process which damages tooth surface, primarily enamel by obtaining its minerals and causing the loss of strength and hardness of the structure. White spots appear where demineralization takes place. Critical point for starting demineralization process is dropping pH at 5.5. In such conditions of oral environment, hydroxyapatite becomes more soluble because of more acidic environment. In the process of remineralization comes to replacement of the lost minerals by regaining fluoride ions and forming structure of fluorapatite crystals that are more resistant to acidic dissolution and subsequently larger than the original crystals. If pH continues to drop because of the acid attacks and gets to the point of 4.5, the efficiency of

'F' may be disputable yet ineffective in controlling caries progression (11, 12).

Early carries lesions such as white spots can be effectively cured with fluoride varnishes which can push the remineralization process to the formation of fluorapatite. However, if there is no certain amount of available ions of calcium and phosphate when applying fluoride topically then the process of remineralization can meet some limitations. If present in small amounts in solution around the tooth, fluoride has greater inhibition power regarding demineralization than incorporated fluoride. It means that small amounts of fluoride in solution have better impact on tooth demineralization and higher caries protective potential than large amounts of FAP in enamel (13).

The hypothesis above was confirmed. In those circumstances fluoride ions are adsorbed onto the crystalline surface and are in dynamic equilibrium with the fluoride ions that remain in solution in the immediate vicinity. In fluid that surrounds crystals this can lead to either equilibrium or supersaturation of fluorhydroxyapatite and due to that to reprecipitation of minerals. This adsorption of fluoride to the crystals shows the direct protection from demineralization. As for fluoride unprotected areas, enamel structure can easily be disrupted when acid attack occurs. Low fluoride concentrations could also be attained when consuming foods and beverages that contain fluoride salts. Only 30 minutes after the intake, the amount of fluoride concentration in saliva notably increases (14).

When observing CaF_2 in SEM its morphology appears as spherical globules which can come in different size and amount. Using an acidic amine fluoride solution first CaF_2 globules are formed within 20 s, but using acidic sodium fluoride or sodium monofluorophosphate (MFP) no CaF_2 globules can be formed *in vitro* at all (15). Since fluoride in MFP is covalently bound, it is very important for it to be released before its reaction with calcium in the oral cavity. After applying low dosage of amine fluoride dentifrice (250 ppm), significant amounts of soluble fluoride were found on the enamel which was not the case after applying a toothpaste with MFP. This facilitation of CaF_2 formation by low pH was confirmed in an in-situ study comparing a neutral-pH toothpaste containing sodium fluoride with an amine fluoride-containing toothpaste of pH 5.5.

After topical application of fluoride varnishes on dental tissues one of the most important products that comes out as the reaction product is calcium fluoride and as some may say the only product (16). Calcium fluoride that covers tooth enamel shows equal protective effects which is explained by releasing fluoride ions from it depending on pH and has major role in caries prophylaxis.

Pure CaF_2 does not form in vivo because of the substances and minerals that are deposited on it, which also makes it more resistant to acids. This stability comes from adsorption of hydrogen phosphate ions HPO_4^{2-} on the surface of CaF_2 crystals by creating protective film which inhibits solubility. When acid attack occurs, CaF_2 depot releases fluoride ions because of the reduced phosphate ions concentration which normally happens in acidic environment. Consequently, CaF_2 performs as fluoride depot dependent of pH level, which releases F^- at low pH but remains stable at neutral pH. By knowing these mechanisms, CaF_2 is considered to be the main source of free F^- ions during acid attack. These free F^- ions take part in both processes of demineralization and remineralization. In addition to that, they are far more important than high fluoride content of the enamel crystalline structure especially when it comes to caries attack (17).

Since most fluoride in Duraphat® varnish is insoluble and the CaF^{2-} like fluoride reservoirs chemically formed on enamel from soluble fluoride reactivity are considered responsible for the anticaries mechanism of action of professional fluoride application, in principle, it is challenging to explain how this product is effective to control caries (18).

This study explains the reaction of fluoride fractions from the varnish soluble and insoluble with the enamel surface and in that way extends scientific discoveries of Retief et al. (19) and Bruun and Givskov (20) who pointed out how important retaining of the fluoride varnish applied to dental surfaces for a longer time could be (21).

Duraphat® is often used fluoride varnish product and has been tested in many experiments by different authors (22). There has been *in vitro* study carried out by Shen et al. (23) who examined fluoride ion release of Duraphat® into artificial saliva. That study has shown that Duraphat® released roughly 30% of its total fluoride only 7 days after exposure. Fluoride ion release can occur in a much easier way from the varnish than from saliva because of the undersaturation of distilled deionized water. Having acknowledged this fact, it is important to understand what the addition of calcium and phosphate actually does. They do not reduce the availability of fluoride ions since fluoride from the varnish has provided great caries preventive efficacy in clinical trials.

Conclusion

Tooth surfaces that were treated with fluoride varnish could offer protection against demineralization of enamel.

Fluoride varnish applied to the tooth surfaces could act as a barrier against demineralization and also be recommended for caries prophylaxis to high caries risk patients.

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EFIKASNOST LAKA SA FLUOROM U PREVENCIJI DEMINERALIZACIJE GLEĐI

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Demineralizacija gleđi predstavlja proces gubitka mineralnih materija, što dovodi do nastanka belih mrlja. Cilj rada bio je da se ispita dejstvo lakova sa fluoridima na gleđ, koja je demineralizovana.

Ispitivanjem je obuhvaćeno 20 premolara, ekstrahovanih iz ortodontskih razloga. Pre ekstrakcije, na premolare su fiksirane bravice adhezivnim materijalom, po uputstvu proizvođača. Nakon fiksiranja bravica, gleđ 10 levih premolara (ispitivana grupa) tretirana je lakom sa fluoridima (Duraphat®, Nemačka). Deset desnih premolara (kontrolna grupa) nije bilo tretirano lakom sa fluoridima. Nakon dva meseca, premolari su ekstrahovani i pripremljeni za SEM analizu.

Gleđ premolara u ispitivanoj grupi imala je na izgled skoro glatku površinu sa potpunom opstrukcijom interprizmatičnih prostora. Prizme su bile povezane depozitima globula na površini, bez znakova poroznosti i iregularnosti. U premolarima iz kontrolne grupe zapažena je demineralizacija na površini gleđi, ali su prizme i interprizmatični prostori još uvek bili očuvani. Mikromorfološkom analizom površine gleđi, uočena je demineralizacija (hrapava i neravna površina gleđi).

Lak sa fluoridima, koji je aplikovan na površinu zuba, predstavlja barijeru i na taj način sprečava procese demineralizacije gleđi.

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Ključne reči: *lak sa fluoridima, demineralizacija*