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Remineralization effect of varnish on early tooth decay.

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Abstract

Enamel demineralizing can occur due to various conditions, while white spot can be formed as an early tooth decay lesion. If these are neglected, weakened tooth due to enamel demineralizing can become chipped or it can progress into tooth decay. The most commonly used remineralization material is fluoride varnish. This study investigated remineralization and the physical changes of the tooth surface with erosion by using three different types of fluoride varnish. The specimen was prepared by using the anterior tooth of cattle, and early decay lesion was produced by using artificial demineralizing solution. Fluoride varnish was applied to each demineralized surface by using GC, ivoclar, and 3 M products according to the instruction of the manufacturer. Meanwhile, the remineralization degree of the surface after application was identified by using Quantitative Light-induced Fluorescence Detection (QLF-D). In addition, surface roughness before and after application was measured and recorded as Ra values. The surface roughness showed the most decreased value in the 3 M product, while the QLF-D of the early decaying lesion showed remineralization effect in all three products. The 3 M product has the most decreased ΔF_{max} value. This study demonstrated changes in tooth surface roughness after fluoride varnish application and remineralizing effect of the most commonly used products. Among the three products, 3 M varnish product showed the most favorable results.

Keywords: Remineralization, Fluoride varnish, Early tooth decay, Demineralization, Surface roughness.

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Introduction

The tooth surface should be in an appropriate balanced state with repeated demineralization and remineralization in order to maintain a healthy tooth surface. However, dental decay can occur if the pace of demineralization becomes faster. Dental caries can occur at any age; therefore, it is the most representative oral disease with continuous accumulation, and it is difficult to revert to the original state once it occurs [1]. Therefore, it is necessary to achieve recovery from demineralization, which is dissolution of calcium, phosphate, and hydroxyl crystal caused by the acid of the dental plaque. It is very important to treat appropriately in early enamel caries [2]. Although various methods have been developed and presented, fluoride is known as a non-repair recovery by remineralization for rebuilding lost or damaged rod due to demineralization [3]. It is most commonly used in the prevention of early dental caries and remineralization. Various fluoride products have also been used [4]. The anti-caries mechanisms and remineralization of fluoride are known in that fluoride reduces solubility of acid through fluoride deposited on the tooth surface to demineralization caused by acid produced by plaque bacteria, and they facilitate remineralization of early dental enamel caries lesion. Fluoride is also known for depositing calcium and phosphate in the saliva to the tooth, and preventing the growth of microorganism [5].

The NaF local fluoride application was introduced in 1943 [6] and the APF gel, which acidified NaF to phosphate, was developed and generally used. However, it has a disadvantage of not having a lasting effect as it is water soluble, and it has a short contact time with the tooth surface [7]. Therefore, non-aqueous fluoride varnish was developed, and it can be applied fast and easily. It also releases fluoride continuously and induces remineralization [8]. The main ingredient is NaF and it is also known that shellac (a natural resin that prevents varnish dissolved in saliva and makes a sturdy surface), artificial sweetener (e.g., mastic or saccharin), beeswax, ethanol for making a gel-type structure, and kolophonium for regulating fluidity are added [9]. Fluoride varnish is known for being the surest way for preventing dental decay, and for its excellent dental caries prevention effect [10]. The major advantage is that it has a longer contact time to the dental surface, so more fluoride can be deposited [11]. Such fluoride varnish has been developed since 1970, and there are many types of fluoride

varnish that are commercially available. However, there are only a few studies conducted on fluoride varnish and limited studies on the comparison of products.

Therefore, this study selected three different types of fluoride varnish made by different manufacturers, investigated the effect of fluoride varnish on the demineralization of enamel, and conducted a comparative evaluation of the effect of fluoride varnish on the remineralization of early tooth decay.

Materials and Methods

Varnish

Varnish products of 3 M, Ivoclar, and GC were used (Table 1).

Tooth preparation

A healthy anterior enamel tooth of cattle was selected and embedded in epoxy resin, and then polished to #800 using a diamond paper. The crown of the anterior tooth enamel of cattle was separated by a diamond disk and embedded in epoxy resin in order to create a 2 mm × 2 mm window size on the tooth surface. To complete the process, nail varnish was applied, except for the window.

Specimen demineralization

For early tooth decay, the specimen was prepared by using 1 M lactic acid, 1% carbopol, HAP/0.1 M lactic acid, and regulated to pH 5. The prepared specimen underwent demineralization in incubators set at 37°C. Ten specimens for each group were applied, thereby resulting in a total of 30 specimens.

Observation of physical changes after demineralization

In order to investigate the physical changes of surface roughness after demineralization, the Ra value was measured by using a 3D surface topography (3D-ST) evaluation and indicated by the μm unit. In order to identify the demineralization degree of the minerals, the measurement was conducted after leveling the tooth surface using the Quantitative Light-induced Fluorescence Detection (QLF-D) Biluminator 2 (Amsterdam, Netherlands). The degree of demineralization was identified by ΔF, ΔF_{max} of early dental caries, and remineralization using the QA2 version 1.23 (Inspektor Research Systems BV, Amsterdam, Netherlands).

Varnish application

All of the demineralized tooth specimens were divided into three groups. The first group was applied with a brush according to the 3 M manufacturer, dried for 1 min, and then washed. In the second group using ivoclar, the product was applied with a brush, dried for 1 min, and then washed. In the third group, the GC products were applied with a brush, dried for 1 min, and then washed. The specimen with the varnish applied was stored in artificial saliva in a 37°C incubator.

Remineralization

In order to identify the degree of remineralization of the tooth specimen stored in the artificial saliva for 7 d, the ΔF value and ΔF_{max} value were used to measure the surface roughness and demineralization by using QLF-D, which was equal to the method after demineralization.

Statistical analysis

Statistical analysis was conducted by using the IBM 22 statistical program. A matching sample test was conducted in order to investigate before and after the experiment.

Results

Study results of surface roughness

The roughness of the specimen surface after being immersed into a demineralization solution and the roughness after remineralization by applying varnish were compared (Table 2). As a result of the matching sample test, the 3 M group showed a significant decrease from demineralization to remineralization. Although the roughness was decreased from demineralization to remineralization in Ivoclar and GC, there was no statistical significance ($p>0.05$).

Changes in the ΔF value after fluoride varnish

The results of the fluorescence loss (ΔF) before and after the fluoride varnish application were shown below (Table 3). All study groups showed significant loss after fluoride varnish application and remineralization effect ($p<0.05$).

Changes in the ΔF_{max} value after fluoride varnish application

The ΔF_{max} value, which represents the maximum fluorescence loss of early dental caries before and after the fluoride varnish application, was identified below (Table 4). All study groups showed a significant decrease after the fluoride varnish application, as compared to before the application ($p<0.05$). The 3 M group showed the most decreased value, followed by GC and Ivoclar products.

Table 1. *The type of fluorine varnish used in this study.*

Group	Products	Manufacturer	Main contents
1	Clinpro white varnish	3 M ESPE, USA	5% NaF, fTCP
2	Fluor Protector	Ivoclar vivadent, Liechtenstein	1% difluorosilane/ 0.1% F
3	MI Varnish	GC, Japan 5%	NaF, CPP-ACP

Table 2. *The result of surface roughness mean ± S.D (μm).*

Group	Before varnish treatment	After varnish treatment
3 M	2.92 ± 0.26^{a}	2.15 ± 0.47^{b}

Ivoclar	2.25 ± 0.58[a]	1.98 ± 0.59[a]
GC	2.56 ± 0.71[a]	1.34 ± 0.25[a]

The values are presented as mean ± standard deviation. The a, b superscript letters denote significant differences by paired t-test.

Table 3. *The ΔF values before and after the varnish treatment.*

Group	Before varnish treatment	After varnish treatment
3 M	-8.63 ± 3.49[a]	-5.54 ±2.60[b]
Ivoclar	-6.35 ± 1.17[a]	-2.52 ± 3.01[b]
GC	-6.47± 1.79[a]	-3.33 ± 3.18[b]

The values are presented as mean ± standard deviation. The a, b superscript letters denote significant differences by paired t-test.

Table 4. *The ΔF_{max} values before and after the varnish treatment.*

Group	Before varnish treatment	After varnish treatment
3 M	-16.00 ± 8.52[a]	-6.11 ±9.86[b]
Ivoclar	-7.73 ± 8.09[a]	-2.66± 3.23[b]
GC	-11.22± 6.64[a]	-4.53 ± 4.49[b]

The values are presented as mean ± standard deviation. The a, b superscript letters denote significant differences by paired t-test.

Discussion

As a result of the recent increase in the interest on oral health, preventing dental caries, which is an oral disease with the highest morbidity in all ages, should be the first priority, and early detection and treatment are very important [12].

Enamel in early dental caries was presented as a white spot and compared to normal enamel by increased porosity, demineralized regions caused by loss of minerals that undergo dental caries underneath the surface, and dissolved minerals from enamel [13]. Interminable demineralization will result in the production of cavity. However, this lesion can be stopped or remineralized during early dental caries, which can be recovered by inducing remineralization with saliva and fluoride, etc. [14].

Although there are many methods of remineralization of early dental caries, the most commonly used and proven method by various clinical studies is by using fluoride [15]. Fluoride reduces the acid solubility of enamel, promotes remineralization of early tooth decay, and prevents the growth of microorganism [16]. It is also known to increase the hardness of the tooth surface and prevent dental caries by increasing the acid resistance of the tooth or promote the remineralization of the demineralized tooth [17].

The recent use of fluoride varnish has been increasing as one of the safer and more effective methods of applying fluoride. The study reported that fluoride varnish is non-aqueous. It also creates an adhesive film on the tooth when applied, it can be in contact with the tooth surface for a long time, and it has shown an excellent dental caries prevention effect [4].

After investigating studies on fluoride application effect of commercially available fluoride varnish, fluoride gel, fluoride wash, and fluoride toothpaste, it was reported that fluoride varnish showed the highest dental caries prevention effect [4]. Peyron et al. [18] mentioned that it has a dental caries prevention effect in the deciduous dentition of children from 3 to 6 years old. Sievers and Silk [19] stated that fluoride varnish has a dental caries prevention effect equivalent to 46% of permanent teeth and 33% of deciduous teeth. Furthermore, a study on remineralization effect, which prevents early tooth decay and delays the progression of the existing enamel lesion, has been reported [20].

QLF-D is well-known equipment that can detect early mineral changes in the teeth, and it can analyse the degree of progression by fluorescence loss. It is widely used clinically as it shows much closer color to the natural color of the tooth [21]. This study investigated the degree of mineral loss by using the QLF-D application, which shows microchanges of dental caries lesion after fluoride varnish application by fluorescence loss. Furthermore, the roughness was measured in order to identify the surface change patterns and evaluate the degrees of demineralization and remineralization under the surface. As a result, the 3 M application group showed significantly decreased roughness after the application ($p<0.05$), and the ΔF value was statistically significant ($p<0.05$). This means that it prevented under surface demineralization in dental caries. It also showed the most apparent effect in remineralization of early tooth decay and excellent acid resistant effect. Although the ivoclar and GC groups did not show significant differences after the application ($p>0.05$), the roughness was decreased and the ΔF value after the application was statistically significant, thereby showing the remineralization effect on the tooth ($p<0.05$). These results showed the dental caries prevention effect of fluoride varnish, and it confirmed that the 3 M product was the most effective in dental caries prevention.

Therefore, the fluoride varnish application to the tooth surface in early dental caries showed an excellent enamel surface demineralization prevention effect and remineralization. Early detection of dental caries and preventive treatment of fluoride varnish will help in preventing the development of dental caries.

Conclusion

This study compared the effect and efficacy of three different types of fluoride varnish on artificially formed early dental caries lesion. Based on the result of this study, fluoride varnish is not only easy to use clinically, but it is also found to have a superior preventive effect on enamel early tooth decay. Therefore, it can be appropriately used as a fluoride application agent for dental caries prevention with its superior remineralization effect.

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