In Vitro Properties of Fluoride Varnishes

Abstract: Aim: of this study was to compare physic-chemical properties of varnishes. Materials and methods: drying time, solvent concentration, viscosity and fluoride releasing after 30 and 60 minutes in distillate water, for 6 commercially available varnish with fluoride were tested. Results: Drying time of fluoride varnish can varied from 4-30 minutes, depended on the solvent concentration (70% or 18%). A large amount of solvent also affects the low viscosity of the material (1 Pa/s). Concentration of fluoride releasing is decreasing over the time. Conclusion: Fluoride varnishes are widely used in dentistry due to their ease of application.

Keywords: Dental caries, fluorides varnishes, physicochemical properties, fluoride releasing.

INTRODUCTION

Tooth caries are infected from 70-90% of the population (Hendaus, M. A. et al., 2016; & Bonetti, D., & Clarkson, J. E. 2016). Therefore, all types of methods of its prevention are very important. One of the so far known so-far is good oral hygiene, consisting in regular teeth cleaning with the use of toothpastes and dental flossing. Unfortunately, especially in the case of young patients, we very often existing deep fissures on the surfaces of molars, in which bacteria may accumulate causing caries (Bonetti, D., & Clarkson, J. E. 2016; Chakraborty, S. et al., 2020; & de Sousa, F. S. D. O. et al., 2019).

This therapy may be particularly effective in the case of the use of fixed braces, when the patient has limited access to proper hygiene (Chakraborty, S. et al., 2020).

At the moment, there are two main preventive methods, one is the use of crevice sealants, the other is the use of varnishes containing fluorine or chlorhexidine (Petersson, L. et al., 2004).

In the case of using pit and fissure sealants, the help of a dentist is necessary, who will properly prepare the enamel surfaces by etching, before using the resin varnish. It is also often necessary to broaden the deep and close fissures with diamond burs (Petersson, L. et al., 2004; & Da Silva, K. et al., 2020).

In the next stage, a final material is applied (based on methacrylate resins or glass ionomer cements) (Chakraborty, S. et al., 2020), and then it is hardened with a polymerization lamp (resins) (Da Silva, K. et al., 2020).

When using varnishes, the application is much easier, because it requires cleaning the teeth with a brush and toothpaste, and the surface is then covered with varnish (Da Silva, K. et al., 2020).

Since the process of hardening the varnish requires a longer period of time, which in the case of children can be quite problematic, the hardening time is an important parameter of each material. Another important issue is the viscosity of the material, which will translate into the ease of application in the form of an even layer applied to the tooth surface.

The aim of this research was to compare the properties of 6 varnishes available on the market. Their hardening time, volatile solvents content and viscosity were examined. Also, because these materials contain similar constituents (MSDS) they will have similar physicochemical properties.

MATERIALS AND METHODS

For the investigation was choosing 6 products from the market. Fluor Protector (Ivoclar Vivadent, Lichtenstein), Bifluorid (Voco, Germany), Clinpro White Varnish (3M ESPE, USA), Profluorid Varnish (Voco), Enamel Pro Varnish (Primer Dental), Fluoride – containing Desensitizing Varnish (Identa, Germany) (Table 1).
Table 1. Material and fluoride concentration used for studies

<table>
<thead>
<tr>
<th>Material</th>
<th>Fluoride concentration according to instruction for use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluor Protector (Ivoclar Vivadent)</td>
<td>77 mg F (1.5% NH4F)</td>
</tr>
<tr>
<td>Bifluorid (Voco)</td>
<td>50 mg NaF (23 mg F) and 50 mg CaF2 (24 mg F)</td>
</tr>
<tr>
<td>Clinpro White (3 M ESPE)</td>
<td>25 mg NaF (5% NaF)</td>
</tr>
<tr>
<td>Profluorid Varnish (Voco)</td>
<td>50 mg NaF (23 mg F)</td>
</tr>
<tr>
<td>Enamel Pro Varnish (Premier Dental)</td>
<td>20 mg NaF</td>
</tr>
<tr>
<td>Fluoride – containing Desensitizing Varnish (Identa)</td>
<td>50 mg NaF (23 mg F)</td>
</tr>
</tbody>
</table>

Drying Time

One drop of varnish was taken from the original package, and spread to a circle about 2 cm by plastic spatula. Stopper is switch on. Every 10 second the surface of varnish was touch by the clean plastic spatula. Tested was performed at temperature 23°C. This process was repeated until the material was not touch to spatula, and the surface of the varnish was not deformed after touch with a plastic tool. Each test were performed 3 times. As an result average of the results was used.

Solvent Concentration

On the analytical balance was placed polyester foil, and the mass was written (M1). After on the surface of the foil was put about 0.5 g of varnish and the second mass was detected (M2). Samples were balanced until the mass was constant (M3). Samples were storage at room temperature 23°C. The concentration of solvents was calculated from below equation 1. Each test was performed 3 times, and as results the average was calculated.

\[(M2 - M1) - M3 \quad (1)\]

Results: Results from the tests were shown in Table 2.

Table 2. Results from the physicochemical tests of the tested varnishes

<table>
<thead>
<tr>
<th>Material</th>
<th>Drying time [min]</th>
<th>Solvent concentration [%]</th>
<th>Viscosity [Pa/s]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluor Protector (Ivoclar)</td>
<td>30±2</td>
<td>72±1.6</td>
<td>0.87±0.09</td>
</tr>
<tr>
<td>Bifluorid 12 (Voco)</td>
<td>4±0.5</td>
<td>72±1.05</td>
<td>1.07±0.12</td>
</tr>
<tr>
<td>Clinpro White Varnish (3 M ESPE)</td>
<td>30±1.5</td>
<td>12±0.45</td>
<td>187±18</td>
</tr>
<tr>
<td>Profluorid Varnish (Voco)</td>
<td>20±0.5</td>
<td>18±1.1</td>
<td>213±5.1</td>
</tr>
<tr>
<td>Enamel Pro Varnish (Premier Dental)</td>
<td>3±0.5</td>
<td>17±4.09</td>
<td>78±2.1</td>
</tr>
<tr>
<td>Fluoride– containing Desensitizing Varnish (Identa)</td>
<td>20±1</td>
<td>17±0.66</td>
<td>75±3.33</td>
</tr>
</tbody>
</table>

The shorter drying time was observed for Enamel Pro Varnish, Fluor Protector. Concentration of solvent in such materials is very high more that 70%. Other groups of varnish have lower concentration of solvents and longer drying time.
Fluoride ions released from different varnishes are shown in Table 3. The higher concentration was established for 30 minutes on the level 235 µg (Fluor Protector).

**Table 3.** Results of fluoride ions in µg releasing after 30 and 60 minutes  

<table>
<thead>
<tr>
<th>Material</th>
<th>30 [min]</th>
<th>60 [min]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluor Protector (Ivoclar)</td>
<td>235±0.2</td>
<td>122±3.5</td>
</tr>
<tr>
<td>Bifluorid 12 (Voco)</td>
<td>224±2.5</td>
<td>132±3.5</td>
</tr>
<tr>
<td>Clinpro White Varnish (3 M ESPE)</td>
<td>230±3.7</td>
<td>187±3.67</td>
</tr>
<tr>
<td>Profluorid Varnish (Voco)</td>
<td>207±6.5</td>
<td>110±3.3</td>
</tr>
<tr>
<td>Enamel Pro Varnish (Premier)</td>
<td>112±5.5</td>
<td>88.3±7.2</td>
</tr>
<tr>
<td>Fluoride-containing Desensitizer Varnish (Identa)</td>
<td>220±3.6</td>
<td>117±6.6</td>
</tr>
</tbody>
</table>

**DISCUSSION**

The thesis made at the beginning of these studies was not fully confirmed. The materials available on the market may differ depending on the amount of solvent, which affects both the viscosity of the product itself and the drying time. The cure time may also be related to the resin used to prepare the materials. They can be materials of natural origin (colophony), then the material has a yellow color, or synthetic resins, then the resin is transparent.

The viscosity of the material is in turn related to the possibility of the varnish penetrating into the fissures. This issue was described in the in vitro study of Muntean *et al.*, (2019), who report that Fuji Trail resin modified glass ionomer cement has better penetrating properties than Admira Seal® (Voco GmbH).

The color and the translucency of the varnish after application and drying are also important from the clinical point of view, which influences later diagnostics, whether secondary caries may develop under the varnish. This problem was described by the authors (Bahrololoomi *et al.*, 2014) who tested it with a device DIAGNOdent (Kavo, Biberach, Germany), which is influenced by the color and transparency of the varnish. According to the authors, the Diagodent device is not very effective for transparent pit and fissure sealants.

Resin and other ingredients (calcium phosphate) may reduce the depth of the fissures and the mineral density of enamel lesions. This has been discussed in more detail in the article Shahmoradi *et al.*, (2017).

Fluoride varnished (Bifluoride and Fluorprotector) and increase the enamel microhardness due to fluoride ions releasing, according to Subramaniam, P., & Telegeti, S. (2016).

The effectiveness of ion release from the varnish may also be influenced by the resin itself and the composition of the material, as described by Yadav *et al.*, (2019), who investigated the growth inhibition of *Streptococcus mutans*, in vitro, for fluoride varnish containing CPP-ACP (Casein phosphopeptide-amorphous calcium phosphate), fluoride varnish containing xylitol; and fluoride varnish with 0.9% difluorosilane. The largest zone of growth inhibition was observed for CPP-ACP.

The release of fluoride from varnishes in an acidic environment (citric acid) by means of an ion exchange electrode was presented by Chakraborty *et al.*, (2017). These results are close to the test performed in current study, when the total concentration of fluoride ions is decreasing during the time. This is related to the total amount of fluoride ion available in the composition (Rirattanapong, P. *et al.*, 2016; Virupaxi, S. G. *et al.*, 2016; & Piesiak-Pańczyszyn, D., & Kaczmarek, U. 2017).
CONCLUSION

- Fluoride-releasing varnishes are essential materials that are widely used as prevention.
- The amount of released flora decreases over time, but its release is determined by the resin used to create the varnish.
- The drying time and the viscosity of the material depends on the amount of solvent and resin.

Conflict of interest
None.

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REFERENCE