Clinical and Laboratory Evaluation of the Ability of Fluoride Gels to Reach Approximal Dental Regions*

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The objective of this study was to evaluate on a clinical and laboratory basis the ability of certain fluoride gels considered to be thixotropic to reach the approximal surfaces up to the cervical regions during topical dental treatment. Volunteers were submitted to treatment with three different commercial products applied in disposable trays. An auxochrome compound based on triaminotriphenylmethane (gentian violet) was added to the gels to reveal their reach in the approximal areas, as indicated by bacterial staining in dental plaque. Dental hygiene was interrupted for 60 hours before the experiment. Dental plaque samples were carefully collected for the determination of the number of organisms reached by the stained fluoride products. A relatively reduced quantity of stained bacteria was detected. The volume of accumulated plaque, among other factors, probably acted as a mechanical and chemical barrier against the ability of the tested products to reach the enamel surfaces studied.

Key words: topical fluoride application, fluoride gels, thixotropy.

Introduction

Topical fluoride application, a procedure of proven efficacy, has been considered to be one of the most important tools in programs of dental caries prevention, as long as it is performed in a controlled and systematic manner.

The National Dental Caries Prevention Program has recently approved the use of topical fluorides as a viable alternative. Treatment would then consist of application of fluoride gels with trays on a large-scale basis, representing a "safe, technically feasible and financially viable" Public Health procedure (Ministério da Saúde, 1990). However, it is necessary to determine whether the method permits penetration of the gels into interproximal spaces, especially in the areas of approximal contact. The use of thixotropic gels has been recommended based on the concept that, when pressure is applied to the gel in the tray, the

* This paper was awarded the ESTIMULO KOLYNOS/91 prize by the Faculdade de Odontologia, Universidade do Estado do Rio de Janeiro.
gel would behave as a fluid and reach all the crown surfaces. However, little is known, in effect, about this property.

The objective of the present study was to test the flowing off to approximal areas of some commercial fluoride products sold as gels. Stains were added to the gels to reveal the microorganisms present in dental plaque situated in approximal areas, thus acting as indicators of the reaching power of the gels.

**Literature Review**

Many products have been developed in order to obtain the topical effect of the action of fluoride on dental enamel (Bibby, 1942; Cheyne, 1942). Gels containing acidulated phosphate fluoride (APF) have been widely accepted, probably due to their easy application. Furthermore, their use reduces treatment time both for the professional and for the patient. Today their use is widespread in many countries, and especially the United States (Wefel, 1985). It should be emphasized that, from a clinical viewpoint, there are no significant differences between the results obtained when APF is applied as a gel or as a solution of similar chemical composition (Horowitz and Heifetz, 1976).

Several of these gels are thixotropic. According to Gron (1977), thixotropy is the property of a solution "that behaves like a gel (a viscous solution) but is not a real gel." Wefel (1985) considers gels to be thixotropic when they "have variable viscosity under inconstant pressure." In terms of physics, thixotropy is a property attributed to certain fluids whose viscosity decreases when they are shaken due to the organization of particles present in the fluid which require a certain time to stabilize. This is a property of colloidal solutions as well as of clay and iron hydroxide suspensions (Macedo, 1976).

Products claiming to be thixotropic have been recently launched on the market. Thus, their formulation differs from that of common APF gels which are based on carboxymethyl cellulose. A thixotropic gel is stable at lower pH, with an increased shelf life. Also, the gel does not flow when it is not submitted to pressure, so that it does not spread throughout the patient’s mouth (Gron, 1977; Wefel, 1985). Cobb et al. (1980), in a clinical study comparing the effectiveness of an APF solution and of a thixotropic gel, found no differences between the results obtained with the two products. Commenting on that study, Wefel (1985) stated that the products were applied with a cotton tip, with no biting pressure on the tray and therefore not favoring gel penetration into approximal areas.

In a study at the population level consisting of two tray applications of APF to children aged 7 to 10 years, Mestrinho et al. (1983) reported a fall in the prevalence of caries, especially on mesial and distal surfaces.

A similar situation had been previously reported by Horowitz et al. (1974) after APF application as a gel and as a solution at pH close to 3.0 by supervised self-brushing (which does not promote a uniform pressure on the gel as occurs with the tray) by adolescents aged 14 to 17 years. The group presenting the best results was that to which fluoride was applied in a gel. Lack of plaque removal interfered with the results of fluoride gel application. The most significant reduction in caries lesions occurred on approximal dental surfaces.
Finally, a study demonstrated approximal covering of the teeth with the use of fluoride gel applied in the laboratory to plaster casts from patients (Retzlaff and Bores, 1978). The authors suggested that the gel would reach the approximal contact area under \textit{in vivo} conditions, but the question continued to be open to proof on a more scientific basis.

\section*{Material and Methods}

Seventeen volunteers participated in the study. All were undergraduate students at the Dental School of UERJ who were required to discontinue oral hygiene measures for 60 uninterrupted hours before the topical applications. After treatment, dental plaque was collected from each volunteer from previously established regions.

Three commercial products available at the Pediatric Dentistry Clinic of the Dental School of UERJ were used. The products are recommended for topical fluoride treatment and their manufacturers claim they are thixotropic: a) NUPRO, neutral gel (Johnson & Johnson, São José dos Campos, SP); NUPRO, acidulated gel (Johnson & Johnson, São José dos Campos, SP); TOPEX, acidulated gel (Dental Ind. & Com. Ltda. (DLF), Rio de Janeiro, RJ). A 10\% aqueous solution of gentian violet was added to each product at a 1:100 proportion to act as a bacterial marker, thus indicating the reach of the gels in the different areas (Merck Index, 1968; Suassuna and Suassuna, 1972).

The gels were applied according to the recommendations of Johnson & Johnson since disposable double-arch NUPRO trays supplied by the same manufactures were used. Individual trays for the upper arch were filled on the right side with acidulated NUPRO gel and on the left side with TOPEX gel. The tray for the lower arch was filled throughout with neutral NUPRO gel up to the line indicating the correct dose. Topical application was performed over a period of 4 minutes.

Dental plaque was collected from 6 approximal regions, two of them from the upper right hemiarch, two from the upper left hemiarch, and one from each lower hemiarch, corresponding to molar and premolar approximal regions for each gel. The procedure was carried out using an exploring tube after simultaneous bilateral aspiration of excess gel, and disposable tips connected to a mechanical saliva suction device. The material collected was smeared onto a glass slide for bacterial detection under the light microscope. Two smears were obtained from the material collected from each site, for a total of 192 smears. The microscopic reading of the material was performed by counting the gentian violet-stained bacteria in 10 fields for the first smear from each site. In the second smear, the inoculated material was stained with a 0.05\% aqueous solution of fuchsin for 3 seconds and readings were taken as described above. This second, differentiating staining with fuchsin (red) represents the limit of the reach of the gel on dental plaque bacteria, revealing the bacteria that were not reached by the gentian violet incorporated into the gels.

As a control of the staining of the bacteria present in plaque, an aqueous solution of gentian violet at a concentration equal to that introduced into the gels, was applied to the upper teeth of a volunteer using the same tray system.
Results

With respect to the viscosity and flowing properties of the gels, TOPEX, which was more fluid than the others, was the only one that overflowed the edges of the tray into the buccal cavity.

After topical gel application, the patients' teeth presented three clinical patterns of staining intensity. Plaque was most intensely stained after treatment with TOPEX and less intensely stained after treatment with acidulated NUPRO and neutral NUPRO.

Thixotropy, which is considered to be the variation of a product from the physical state of gel to the fluid state, i.e., a variation from greater to lesser viscosity that permits flowing, was not observed in the preliminary laboratory parameters adopted. The NUPRO gels, when submitted to the internal pressure of a syringe with a sealed end and containing an air bubble, did not present visual variation in physical state. The air bubble would move more easily if the gel became more fluid.

The readings of the slides containing the dental plaque smears did not follow the same order of proportionality as observed clinically with respect to the staining intensity promoted by the gels. Besides the fact that few dental plaque bacteria were reached by the stain in the gels, the best yield in terms of mean number of bacteria was obtained with acidulated NUPRO, followed by neutral NUPRO and finally by TOPEX. The overall mean number of stained bacteria counted per field was 12.0 (see Table 1).

Table 1 - Mean number of bacteria in dental plaque from patients after topical application of gels containing gentian violet (N = 16).

<table>
<thead>
<tr>
<th>Gel</th>
<th>Approximal regions</th>
<th>Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>14-15</td>
<td>16-17</td>
</tr>
<tr>
<td>Neutral NUPRO</td>
<td>15.7</td>
<td>11.1</td>
</tr>
<tr>
<td>TOPEX</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Acidulated NUPRO</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As a random example, Table 2 illustrates the specific values of bacteria counted in each field in the smear of material collected from the region between teeth 24-25, corresponding to the TOPEX gel, of volunteer no. 14. In all microscopic observations, cocci were the predominant bacterial forms, whereas the amount of rods was relatively smaller. In the microscopic fields of the remaining 96 smears, stained with fuchs in as a double-check, there was a large number of bacteria that had not been reached by the gentian violet stain
Table 2 - Number of bacteria stained by the TOPEX gel in a smear from the approximal region between teeth 24-25 of patient no. 14.

<table>
<thead>
<tr>
<th>Microscopic fields</th>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
<th>e</th>
<th>f</th>
<th>g</th>
<th>h</th>
<th>i</th>
<th>j</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of bacteria</td>
<td>6</td>
<td>2</td>
<td>17</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>35</td>
<td>8</td>
<td>9</td>
<td>12</td>
</tr>
</tbody>
</table>

Mean = 10.9

added to the gels. In this case, the mean number of bacteria stained by fuchsin per field was 163.3 (Table 3).

As another random example, Table 4 presents the number of bacteria counted in each field of the fuchsin-stained smear of material collected from approximal region 36-37 volunteer no. 3, submitted to neutral NUPRO.

The control, who was submitted to treatment with the stain in water, showed a larger number of bacteria than obtained with the gel and a smaller number than obtained by fuchsin staining in the second smear.

**Discussion**

In principle, the observations and results of the present study raise questions about the adoption of certain materials and the procedures for their application. This is due to the

Table 3 - Mean number of bacteria in dental plaque from patients after topical application of gels containing stains, visualized by direct application of fuchsin to the smear (N = 16).

<table>
<thead>
<tr>
<th>Gels</th>
<th>Approximal regions</th>
<th>Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>14-15</td>
<td>16-17</td>
</tr>
<tr>
<td>Neutral NUPRO</td>
<td>146.2</td>
<td>131.4</td>
</tr>
<tr>
<td>TOPEX</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Acidulated NUPRO</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
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</tr>
</tbody>
</table>
fact that the beneficial protective effect of topical fluoride application on the teeth requires a definition of yield, of fluoride vehicles, of access to and permanence on the various dental surfaces, of the mechanisms of $F^-$ ion release, of the ability to overcome interfering barriers such as the composition and quantity of saliva flow, and the composition, thickness and age of dental plaque etc.

Under the experimental conditions described, gels considered to be thick and dense did not lose their original characteristics under greater pressures.

The challenge of having fluoride products reach the approximal regions of teeth in the arches and consequently reaching dental enamel requires the analysis of mechanical, biochemical and structural factors as well as the analysis of technical conducts at all their different levels.

The use of certain products with the objective of exploring their thixotropic properties is still the subject of controversy in terms of factors ranging from applied experimental science to commercial interests with respect to the dissemination of technical aspects.

The shape of open trays with no mechanical condition for the retention and pressure of the gels against the teeth not only permits the outflow of material into disperse areas, but also prevents full covering of all cervical regions of the tooth. This may involve a time expenditure during topical application of the gel similar to that for the topical application of solutions.

To evaluate the reach of the gels, a stain was used as a marker, and the number of bacteria stained in plaque was used as a reading parameter. Although we are aware of the existence of more sensitive techniques, these are the methods available to us at present.

Clinically, dental plaque was more intensely stained by the TOPEX gel, probably due to the greater fluidity of this product. However, TOPEX had a relatively lower yield in terms of bacterial staining when compared to the other gels used. Surprisingly, few dental plaque bacteria were directly stained by the gels (an overall mean of 12.0 per field; see the example presented in Table 2). The fact that the remaining bacteria were visualized with the
counterstain fuchsin (overall mean of 163.3 bacteria per field) implies that the TOPEX gel does not provide penetration and diffusion of the compound through dental plaque to a greater extent, probably due to its thickness.

The present results are somewhat similar to those reported by Horowitz et al. (1974) who stated that the lack of plaque removal interferes with the results of topical treatment with fluoride compounds in the form of gels. Additional studies are needed to clarify the questions still pending.

Conclusions

On the basis of the experimental conditions used in the present study, we may conclude that:

1. Thixotropy was not fully demonstrated in the gels studied.
2. The gels considered to be thicker and more dense did not present changes in their physical characteristics.
3. The disposable trays used and the volume determined for their filling did not favor a covering of all exposed dental surfaces by the fluoride gels.
4. Dental plaque still represents a mechanical and chemical barrier against the concentration of products that should reach the surface of dental enamel in approximal spaces.

References

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Accepted September 22, 1993