THE EFFECT OF TOPICALLY APPLIED 1.23% ACIDULATED PHOSPHATE FLUORIDE ON ZINC PHOSPHATE CEMENT

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ABSTRACT
Topically applied fluoride preparations play an important role in reduction of caries incidence. It was found that the commonly used 1.23% acidulated phosphate fluoride (APF) gel has a deleterious effect on different dental materials. The effect of the gel on zinc phosphate cement is still not known. It is expected that 1.23% APF gel may affect the microstructure of the zinc phosphate cement. Thirty Teflon rings were prepared. Zinc phosphate cement was mixed and loaded into the rings. Excess cement material was removed and samples were stored in 20 ml of distilled water at 37°C for 24 hours. They were then equally divided into five groups. Samples of the control group were stored in 20 ml of distilled water at 37°C for 24 hours. The other four groups received four times application of 1.23% APF gel for 1, 4, 6 and 10 minutes at each application with an intermediate washing and immersion in 20 ml of distilled water at 37°C for one hour between applications. Samples were prepared for examination under the scanning electron microscope. Results showed that as the application time of the gel is increased, more reaction products are formed on the surface of the set zinc phosphate cement. These products mask and may protect the surface from erosion by the acidic APF gel. However, more surface roughness is produced that may accumulate bacteria and affect the gingival health.

INTRODUCTION:
Topical fluorides are capable of enhancing the remineralization of partially decalcified tooth structure. They also reduce dentinal sensitivity. Three types of fluoride preparations have been advocated for professional applications: Acidulated Phosphate Fluoride (APF), Stannous Fluoride (SnF2) and Sodium Fluoride (NaF). The efficiency of various topical fluoride preparations depends on the local pH and concentration of fluoride. 1.23% APF gels are used as topical fluoride treatments in almost all dental offices because of their ease of application and their clinical effectiveness. Different application times of 1.23% APF gels (1, 4, 6 and 10 minutes) have been used. For adults at high risk for caries development, office application of APF gels at 6-month intervals or more frequently is appropriate.1 However, one of the problems associated with the application of 1.23% APF gel is its deleterious damaging effect on the different restorative materials like composite resins2-7, Glass ionomer7,10 and porcelain11-14. APF gels have the ability to etch the inorganic substances incorporated in those materials. Therefore, it is pos-

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sible that the zinc phosphate cement film at margins of cast restorations is also adversely affected by the acidic nature of the 1.23% APF gel.

The purpose of this study is to evaluate the effect of topical application of 1.23% APF gel on the microstructure of the zinc phosphate cement at different application times using the Scanning Electron Microscope (SEM).

MATERIAL AND METHOD:

Thirty Teflon rings of 10mm internal diameter and 2mm thickness were prepared. Each ring was seated on a Mylar strip that was placed on a glass slab. The powder of zinc phosphate cement (Fleck's Cement, mizzy, INC. Cherry Hill, NJ) was weighed on an electronic microbalance to insure proper proportioning and consistency. Mixing was then done at room temperature on a glass slab following the manufacturer's directions and the cement was loaded into the rings. They were again covered with another Mylar strip and a glass slab to extrude excess cement material and to create a uniform surface texture. Excess cement material was then removed. All samples were immersed in 20 ml of distilled water at 37°C for 24 hours. The specimens were then equally divided into 5 groups, each containing five samples. Samples of the control group were stored in 20 ml of distilled water for 24 hours. The other samples were repeatedly exposed to 1.23% acidulated phosphate fluoride (APF) gel (Butler, Sunstar Inc, Chicago, IL. USA) for four different application times (1, 4, 6 and 10 minutes). The process of APF application was repeated for a total of four times for each sample simulating two-years exposure to prophylactic fluoride treatment (one application/six months). Each application was followed by washing with distilled water and subsequent immersion in distilled water at 37°C for one hour. After completion of A,PF application, samples were then stored in 20 ml distilled water at 37°C for 24 hours. All samples were prepared, gold coated and examined under a JEOL JSM-6360LV (JEOL, Tokyo, Japan) scanning electron microscope. The surface micromorphology of the samples were evaluated and compared.

RESULTS:

Figure 1 (a & b) shows the micro-morphology of the samples of the control group. The surface of the set zinc phosphate cement (ZPC) matrix is more or less smooth with areas of cracks and small voids. There is an evidence of many un-reacted irregularly shaped particles on the surface of the set ZPC. There is a wide variation in the shape and size of the incompletely dissolved particles of zinc oxide overlaying the set cement matrix. These particles are characterized by their smooth surfaces and sharp and well-defined edges. There are Small voids and cracks on the surface of the set cement matrix.

Samples that received four times 1-minute application of APF gel have lost the fine and smooth characteristics of the set ZPC matrix and the surrounding unreacted particles (Fig 2-a & b). The surface particles vary in size and shape. Most of them have smoother and flatter surfaces than those of the samples of the control group. At many areas, the particles are joined together. The surface of the cement is rough due to the formation of reaction products on it of varying sizes and shapes. They partially mask the underlying set cement surface. Voids and cracks are still evident.

Figure 3 (a, b & c) shows the micro-morphology of the samples that received four times 4-minute application of APF gel. The surface particles are flattened more than those of the previous groups. At many areas, the unreacted cement particles are found adhering to each other to form bundles that are overlaying the surface of the set cement. The bundles have a characteristic feature at this group of being narrow at their middle area and widely separated at both ends giving them a fan-shaped appearance. They have pitted surfaces with rough edges. There is an evidence of formation of globules precipitating on the surface of the set cement that completely mask the surface of the set cement.
Figure 4 (a, b & c) shows the micro-morphology of the samples that received four times 6-minute application of APF gel. The surface particles are flattened more than those in the previous group. They are condensed together and adhere to each other. The fan-shaped structures are still evident, but are more packed together than the previous group. However, the globules that are formed on the surface of the set cement is similar to those seen in samples of the 4-minute application of APF gel.

Samples that received four times 10-minute application of APF gel shows further flattening and smoothening of the surface particles by the acidic APF gel (Fig 5- a, b & c). The fan-shaped structures are not evident. The appearance of globules that completely mask the surface of the set cement is similar those of globules that are formed in the 4-and 6-minute APF application groups.

Fig 1-a&b: Micromorphology of a sample of a control group. Unreacted irregularly shaped cement particles of different sizes Cracks are evident. (Magnification a: x100, b: x200)

Fig 2-a&b: Micromorphology of a sample that received four times 1-minute 1.23% APF gel. Surface particles have smooth surfaces. The reaction products partially cover the set cement surface (Magnification a: x100, b: x500)
Fig 3-a,b &c: Micromorphology of a sample that received four times 4-minute 1.23% APF gel. Most of the unreacted cement particles form fan-shaped bundles that have pitted surfaces and rough edges. Globular reaction products completely mask the set cement. (Magnification a: x100, b: x500, c: x500)

Fig 4-a,b &c: Micromorphology of a sample that received four times 6-minute 1.23% APF gel. More unreacted particles are condensed and closely adhere to each other. More flattening of the surfaces is evident. Globular reaction products are similar to those seen in fig 3. (Magnification a: x100, b: x500, c: x500)
DISCUSSION:

When the zinc phosphate powder is brought into contact with the liquid to begin the cement mixing, wetting occurs and a chemical reaction is initiated. The surface of the alkaline powder is dissolved by the acidic liquid resulting in the formation of a relatively insoluble zinc phosphate as follows:

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3 \text{ZnO} + 2 \text{H}_3\text{PO}_4 + \text{H}_2\text{O} \rightarrow \text{Zn}_3(\text{PO}_4)_2 \cdot 4\text{H}_2\text{O}
\]

Only the surface layers of the zinc oxide particles react, leaving unconsumed cores of residual zinc oxide particles bound together by the phosphate matrix. The set cement is essentially a hydrated amorphous network. It is very porous. In this study, there are unreacted irregularly shaped particles with smooth surfaces and well-defined edges on the surface of the zinc phosphate cement of the control group. Because of the nature of the cement and also due to preparation for Scanning Electron Microscope (SEM) examination where the residual moisture is removed, shrinkage of the cement occurs which eventually leads to formation of cracks and small voids. Trapped air bubbles during cement mixing may also contribute to the formation of small voids in the set cement.

Some studies reported the significant adverse effect of the APF on other restorative materials. The application time of the APF gel have been recommended by manufacturers to be 1 min. However, some of the studies used a 4-minute application time. Other studies used a topical application of APF gel for 6 minutes. A 10-minute application time was also used by some researchers. El-Badrawy & McComb and Yip et al found that the application of 1.23% APF gel to composite and glass ionomer cements for 4 minutes resulted in increased surface roughness and erosion of composite resin and glass ionomer cements. The low pH value affects the cement by etching and eroding its surface. The APF has a tendency to affect the inorganic substances incorporated in the restorative materials. Therefore, it may affect the zinc phosphate cement by etching both the unreacted cement particles and matrix. However, the globular reaction products that are formed on the surface of the cement may inhibit etching and erosion of ZPC. They may act as a barrier that prevents damage of the cement by the acidic effect of 1.23% APF gel. In this study, the 1-minute APF application resulted in formation of reaction products that are partially covering the set cement surface. However, when APF application time is increased more than 1 minute the cement particles completely mask the underlying set cement surface. The appearance of the globular prod-
ucts is similar in the groups where APF was applied for 4, 6 and 10 minutes. Therefore, APF application for 4, 6 and 10 minutes have the advantage of protecting the surface of the ZPC from erosion by the acidic effect of the APF. On the other hand, they may contribute to increased surface roughness of the cement due to the formation of reaction products on the surface of the ZPC. It was found that colonization of bacteria may occur as a result of surface roughness of the cement that is produced by the acidic effect of the APF gel. In this study, the roughness that are produced by the formation of the globules may harbor bacteria and bacterial products which may initiate gingival inflammation due to proximity of the margin of the crown restoration to the gingival tissues.

In this study, as the APF application time is increased, the surfaces of the unreacted particles on the surface of the ZPC become flatter and smoother. Some particles are joined together by the acidic effect of the gel. The characteristic feature of samples at 4-minute APF gel application is the close adherence of particles forming fan-shaped bundles due to the increased exposure time to the acidic gel. When the application time of APF gel is increased to 6 minutes, the fan-shaped appearance is still evident, but the particles are more condensed together. They closely adhere to each other and are packed more than those of the samples of 4-minute APF gel application. The samples in this study were placed in distilled water for 24 hours after each APF application. Consequently, any loose cement particles were probably dislodged.

**CONCLUSIONS:**

Professionally applied 1.23% APF gel was found to resulted in formation of reaction products on the surface of the ZPC. At the 1-minute APF application, the reaction products partially mask the surface of the set cement. Whereas at the other groups receiving APF for 4, 6 and 10 minutes, the globular reaction products completely mask the underlying set cement surface. Thus, they have the advantage of protecting the cement surface from further damage by the acidic APF. Therefore, they inhibit cement erosion by the acidic APF gel. In addition, the globular structures may act as a reservoir of fluoride that is beneficial in the oral environment. However, they may result in a rough surface of the cement which may accumulate bacteria. Consequently, it may start the inflammatory process of the gingival tissues due to the closed positioning of the margin of the crown restoration to the gingiva.

Further studies on the effect of topical application of the other fluoride preparations on the zinc phosphate cement is needed.

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**REFERENCES:**

7. El-Badrawy W, McComb D, Wood R. Effect of home-use


