Scientific Article

The effect of topical APF foam and other fluorides on veneer porcelain surfaces

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Abstract

Some topical fluorides cause surface changes in dental materials. The purpose of this study was to compare the effects of a topical acidulated phosphate sodium fluoride (1.23% APF) foam with the effects of other topical fluorides on the surface of veneer porcelain. Forty porcelain specimens (Ceramco) were placed into eight groups (N = 5). Four groups were immersed in either 1.23% APF foam, 1.23% APF gel, 2.0% sodium fluoride (NaF) gel, or water (reference) for 1 min. The other four groups were immersed in one of the above agents for four 1-min immersions. The surface topography of two scanning electron micrographs of each specimen was scored visually by two raters and by computer digital analysis (CDA). Inter-rater reliability was r = 0.67 (intraclass correlation coefficient). There were no significant differences in the mean visual scores or CDA scores among any of the groups immersed for 1 min. Porcelain immersed 4 min in APF gel had significantly greater mean visual scores and CDA scores than the other treatments (P ≤ 0.0001; one-way ANOVA and Tukey's Studentized Range Test). The average surface topography scores of veneer porcelain immersed for 1 min in 1.23% APF gel, 2.0% NaF gel, 1.23% APF foam, or water were not significantly different. Significantly greater surface topography scores occurred following 4 min of immersion in 1.23% APF gel than all other agents. (Pediatr Dent 17:356–61, 1995)

Adolescents with carious, hypoplastic, or discolored anterior teeth may require veneer porcelain for esthetic restoration. Some of these patients also may receive topical fluoride treatments to control dental caries,[1–6] hypersensitivity,[4] decalcification,[7–9] or plaque accumulation.[10–11] However, concern has been expressed[12–24] that topical fluorides may cause several problems.

In vitro studies show that some topically applied fluoride agents cause surface changes and weight loss of dental materials including porcelain, composite resins, sealants, and glass ionomer materials.[12–24] These dental materials are composed of glass-like elements susceptible to reaction at acidic pH. Hydrofluoric and/or phosphoric acid are added to topical APF agents to lower the pH. Hydrofluoric acid also is added to increase the fluoride concentration in topical APF agents. The presence of these acids may cause changes in surface and weight of the dental materials.[13–15] Hydrofluoric acid is a well-known glass etchant, and phosphoric acid is used to etch glass-ionomer materials prior to placing a superficial layer of posterior composite resin.[25]

The length of time a material is exposed to an APF agent influences the weight loss and the surface changes.[13,20] However, limited information is available on the effect of a 1-min application of APF agents and the effect of an APF foam on porcelain. These topical APF agents were introduced to minimize fluoride ingestion and increase patient acceptance.[26]

The purposes of this study were to compare visually and by computer image analysis the effects of these four agents — 1.23% APF gel, 2.0% NaF gel, 1.23% APF foam, and water (reference) — for 1-min immersion and for 4-min immersion on the surface topography of a veneer porcelain.

Materials and methods

Topical fluorides

The following topical fluoride agents were used:

1. 1.23% APF gel (Oral-B Minute-Gel, Oral-B Co, Palo Alto, CA), 1.23% F^- (w/w), pH 3.0-4.0, specific gravity 1.13-1.20
2. 2.0% neutral sodium fluoride gel (Neutra-Care, Oral-B Co, Palo Alto, CA), 0.9% F^- (w/w), pH 6.2-7.2, specific gravity 1.05-1.11
3. 1.23% APF foam (Minute-Foam, Oral-B Co, Palo Alto, CA), 1.23% F^- (w/w), pH 3.0-4.0, specific gravity 0.15
4. Deionized, distilled water used as a reference agent.

The fluoride products were labeled only with a reference number; specific products were identified at the end of the study. However, the physical consistency of

the foam made identification evident when compared with the gels. Therefore, all specimens and micrographs were coded so that raters and the electron microscopist were blinded as to the treatment groups.

Specimen preparation

Forty specimens of an autoglazing dental porcelain used for veneers (Ceramco Vacuum Porcelain - incisal shade 52, Johnson & Johnson Co, East Windsor, NJ) were prepared from the same bottle (Lot #0075) by the Ceramics Laboratory at the University of North Carolina Dental School. The specimens were condensed into stainless steel dies (0.7x0.1 in.) placed on glass slabs. The specimens were fired according to manufacturer's directions in a porcelain oven (Jelenko Commodore VPF, Jelenko Dental Health Products, Armonk, NY) at 1100°F for 6 min and then to 1700°F at a rate of 100°/min under vacuum. The vacuum was released at 1700°F and the specimens were air-fired to 1740 degrees F. All specimens were polished, cleaned by air abrasion (Micro Blaster, Comco Inc, Burbank, CA), and rinsed in distilled water. All specimens were autoglazed using a preheating of 1100°F for 1 min and a heat rate of 100°/min from 1100° to 1740°F without vacuum. Specimens were fired at 1740°F for 45 sec, then cooled to room temperature, and stored dry at room temperature.

Specimen treatment

The specimens were divided into eight groups with five specimens per group. Four groups were treated for a total of 1 min and four groups were treated for a total of 4 min(four 1-min immersions).

Five specimens were immersed individually in approximately 10 mL of 1.23% APF gel for 1 min, rinsed with distilled, deionized water, blotted, and reimmersed for three more 1-min immersions (a total of 4 min). The immersion procedure was repeated with additional specimens (N = 5 each) in each fluoride product and water (reference). The above procedure was repeated with the last four groups except that each group was immersed one time only in an agent for 1 min.

Following treatment, all specimens were stored dry until they were examined using the scanning electron microscope.

Scanning electron micrographs

All specimens were sputter coated (Polaron 5200 coating unit, Polaron Instruments, Inc, Hatfield, PA) with palladium and gold and examined using the scanning electron microscope (ETEC Autoscan, Hayward, CA). Each specimen was photographed twice, once in the center and once approximately 1–2 mm from the edge of the specimen.

Each micrograph (two micrographs per specimen) was randomly coded and evaluated visually by two raters for surface defects. A micrograph of a nontreated specimen was selected as a reference for a score of 1 and a picture of a specimen showing extensive surface defects was selected as a reference for a score of 4. The raters were asked to score the topography on each micrograph using the following criteria:

1. Surface similar to nontreated specimen (small defects found throughout the surface)
2. Surface shows either more or larger defects than nontreated specimen but not as much as 3
3. Surface shows somewhat fewer or smaller defects than 4 but more or larger than 2
4. Surface shows large defects covering extensive surface area.

Micrographs representing the scores 1–4 are shown in Fig 1. One rater used 0.5 increments from 1 to 4. The sum of the four scores for each specimen (two raters x two micrographs per specimen) was calculated as the outcome measure. Thus, the lowest possible score was 4 and the highest possible score was 16 for either a specimen or as the average score for a treatment group.

Image analysis was performed on negatives of the micrographs. Using a Cohu 4812 CCD camera over a standard fluorescent light box, images of each negative were captured by a pc-Vision (Imaging Technology Inc, Woburn, MA) frame grabber board in a computer. The images were displayed and analyzed using JAVA Video analysis software (Jandell Scientific, Corte Madera, CA). A histogram of intensity values (0–255) was displayed. To account for variations in exposure of each negative, thresholds for each image were set to count all dark structures (defects) on the surface with intensity values that fell within the area that ranged from black (0) to the first standard deviation of the intensity values. The areas of all dark structures (defects) were determined and computed as a percent of the surface area.

Data analysis

The null hypotheses were that there were no significant differences among the treatment groups treated for 1 min or among the groups treated for 4 min. Data from visual scoring and from digital analysis were analyzed for significant differences using a one-way ANOVA and Tukey's Studentized Range Test. The intraclass correlation coefficient was used to determine inter-rater reliability. A paired *t*-test was used to determine intrarater reliability by comparing the scores of 10 micrographs scored on two separate days by each rater. Statistically significant differences among data were accepted if $P \leq 0.01$.

Results

Inter-rater reliability was r = 0.67 for scoring all micrographs. No significant difference in intra-investigator scores was found.

No significant differences in the mean visual scores (Table 1) were found among any of the 1-min treatment groups.

Significantly higher mean sum of visual scores (Table 2) was found for porcelain treated four times (4

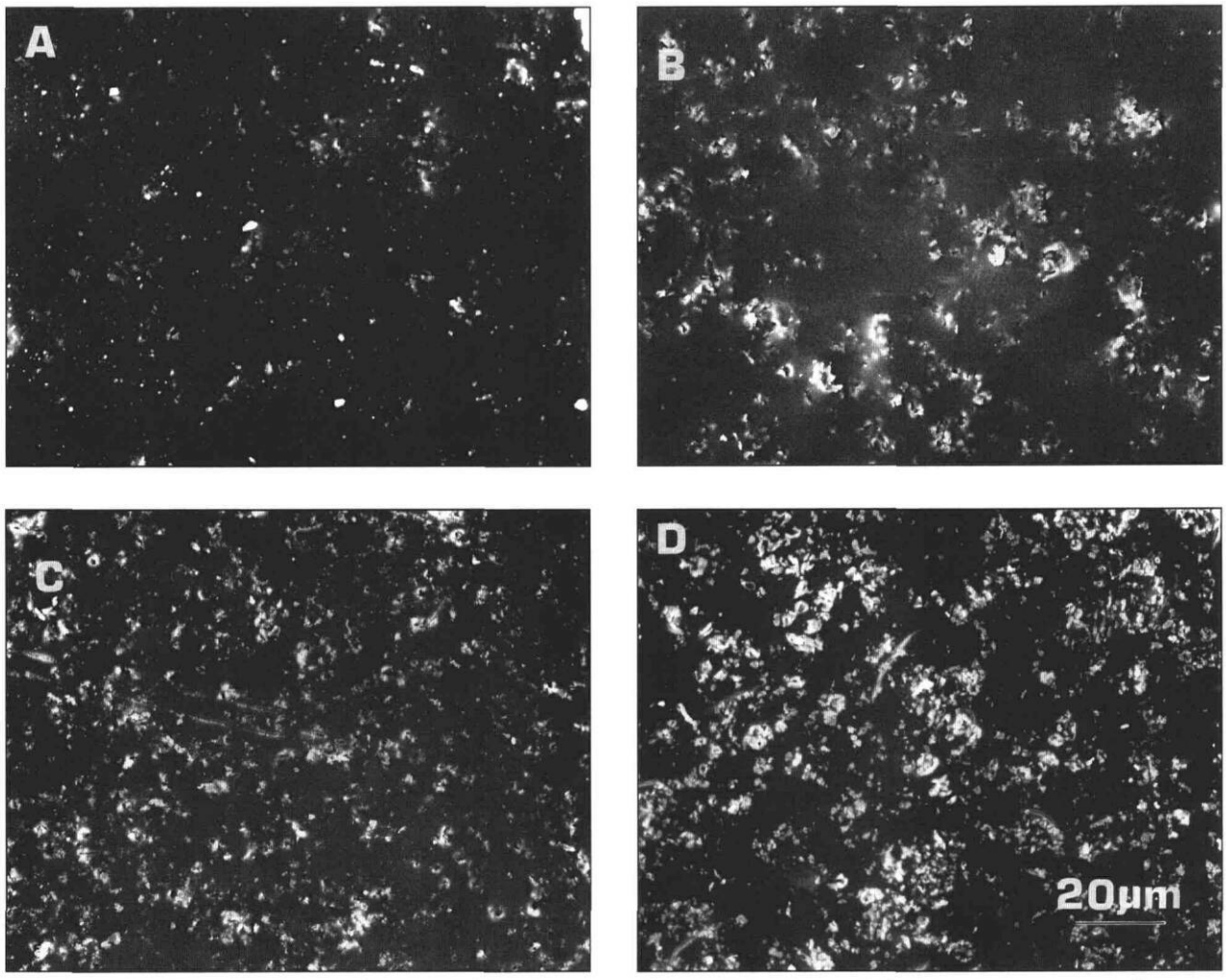

Fig 1. Scanning electron micrographs representing the scores of (a) 1, (b) 2, (c) 3, and (d) 4. The bar represents the magnification of all micrographs.

min total) with 1.23% APF gel as compared with the other treatment groups. Porcelain treated with 1.23% APF foam had significantly higher scores than porcelain immersed in water, but not significantly higher scores than 2.0% NaF.

No significant differences among the 1-min treatments in mean percent area of defects (Table 3) were found among the computer image analysis scores. Porcelain (Table 3) treated in 1.23% APF gel for four immersions (4 min) showed significantly greater mean percent area of defects than porcelain immersed in any other agent.

Discussion

Our study shows that a 1-min immersion in either 1.23% APF foam or 1.23% gel does not cause a visually apparent increase in defects in the surfaces of veneer porcelain compared with water or 2.0% NaF gel. The visual data are confirmed by computer image analysis. Although the ADA Council on Dental Materials, Instruments, and Equipment and the Council on Dental Therapeutics[28] state that the effect of APF preparations is not noticeable after one clinical application, visually detectable surface changes on dental materials such as porcelain[20] and glass ionomer[27] after a 4- or 5-min treatment in APF gel in vitro are reported.

Our study confirms that changes are detectable on scanning electron micrographs of porcelain treated for 4 min in APF gel. The visual data are confirmed by computer image analysis. Kula et al.[13] also report distinct differences in weight loss between a strontium glass-filled composite resin treated 4 min with 1.23% APF gel compared with the control treated with water. The 1.23% APF foam does not appear to cause as much surface change as does the 1.23% APF gel. Significant surface changes cannot be detected visually or by computer analysis of scanning electron micrographs of the porcelain surfaces following 1-min treatment in 1.23% APF foam or 1.23% gel compared with a neutral sodium fluoride gel or to a reference agent such as water. However, significantly greater surface defects are detected visually after 4 min of treatment in 1.23% APF gel as compared with all the other treatments. The 1.23% APF foam does appear to cause some change in

Table 1. Mean visual scores ($\bar{X} \pm SD^{*}$) of porcelain surfaces immersed for 1 min

	Treatment Groups[†‡]			
	Water	1.23% APF Gel	2.0% NaF Gel	1.23 APF Foam
Scores	6.8 ± 1.2	9.0 ± 1.1	8.4 ± 1.6	8.6 ± 2.0

* SD = standard deviation.

† $N = 5$ per group.

‡ No significant differences (one-way ANOVA; df = 3; f = 1.98; $P = 0.16$).

Table 2. Mean visual scores ($X \pm SD^{*}$) of porcelain surfaces immersed for 4 min

	Treatment Groups[†]			
	Water	1.23% APF Gel	2.0% NaF Gel	1.23 APF Foam
Scores	6.9 ± 1.2	13.6 ± 1.4[‡]	8.0 ± 1.9	10.0 ± 2.2[§]

* SD = standard deviation.

† $N = 5$ per group.

‡ One-way ANOVA; df = 3; f = 14.79; $P = 0.0001$; Tukey's Studentized Range Test (1.23% APF gel > 1.23% APF foam, 2.0% NaF or water).

§ One-way ANOVA; df = 3; f = 14.79; $P = 0.0001$; Tukey's Studentized Range Test (1.23% APF foam > water).

Table 3. Percent area of defect (Mean ± SD*) in the porcelain surface as determined by computer image analysis

	Treatment Groups[†‡]			
No. of Immersions	Water	1.23% APF Gel	2.0% NaF Gel	1.23 APF Foam
1	19.08 (± 1.42)	21.21 (± 1.03)	19.94 (± 2.28)	19.74 (± 0.34)
4	19.88 (± 1.06)	27.76[§] (± 1.21)	19.94 (± 0.86)	21.73 (± 1.06)

* SD = standard deviation.

† $N = 5$ per group.

‡ No significant differences among groups after 1-min immersion (one-way ANOVA; df = 3; f = 1.9; $P = 0.17$).

§ One-way ANOVA; df = 3; f = 62.24; $P < 0.0001$; Tukey's Studentized Range Test—1.23% APF gel > 1.23% APF foam, 2.0% NaF or water; no other significant differences.

porcelain surfaces after 4 min of treatment since significantly greater surface changes are detected visually in porcelain treated with 1.23% APF foam compared with water. However, these data are not confirmed by computer image analysis.

Our data suggest that time is a factor in the amount of change that occurs on porcelain surfaces treated with 1.23% APF gel since significant differences were apparent at 4 min but not at 1 min. The data also suggest that the amount of surface change is not as extensive with the same number of 1.23% APF foam applications as with 1.23% APF gel treatments. The difference in the amount of detectable surface change between the gel and the foam may be related to diffusion of active ions and byproducts through a gel compared with a foam. However, studies are required to determine the differences in chemistry, such as available fluoride and hydrogen ions and diffusion gradients between the gel and the foam on porcelain surface. Ceramco porcelain is a low-fusing dental porcelain composed of silica, feldspar, and other glasses. Dental porcelains are generally resistant to chemical attack, although strong acids such as hydrofluoric acid are capable of dissolving porcelain.[29] Clinically, the fitting surface of a veneer is etched with hydrofluoric acid prior to bonding with composite resin to the tooth surface.[30] The reaction of hydrofluoric acid with porcelain[16] is represented as follows: $12HF + 3SiO_2 \rightarrow 2H_2SiF_6 + Si(OH)_4 + 2H_2O$

The clinical significance of surface changes of dental materials caused by APF is still somewhat speculative because of the paucity of in vivo studies. However, visually apparent changes in composite resins[14,15] and porcelain[28] occur following 1.23% APF treatments in vitro. In addition to changes in translucency — which can affect esthetics — roughened surfaces can accumulate stains and organic debris that will also affect esthetics and can require restoration replacement. Increased susceptibility of composite resins to wear is hypothesized,[13–15] although there is limited information concerning wear.[31] Erosion of glass ionomer restorations in xerostomic patients who use daily noncommercial acidic topical fluorides is reported by Wood et al.[32]

The ADA Council of Dental Materials, Instruments, and Equipment and Council on Dental Therapeutics[28] recommends that nonacidic fluoride preparations effective in reducing caries be considered as alternatives for patients with porcelain or composite restorations who need fluoride treatment. Similar to other studies,[22,24] our study shows that 2.0% NaF gel causes no significant surface defects in porcelain. Maximum cariostatic benefit from 2.0% NaF[33] occurs when a series of four treatments is given several days apart following a single prophylaxis. The recommended schedule for treatment consists of application at age 3, 7, 11 and 13 years. In contrast, 1.23% APF agents are applied on a semiannual basis. Stannous fluoride (SnF_2), an alternate fluoride treatment, also should be considered with caution. Although 0.4% SnF_2 gels are not reported to cause surface changes in porcelain,[16] 8% stannous fluoride solution, which is the preferred concentration[33] for professionally applied stannous fluoride treatment, causes significant surface roughness of porcelain following a 4-min treatment, as compared with the control.[22]

The difference in the ability to cause surface roughness could be related to such factors as difference in pH, difference in fluoride concentration, or that 8% SnF_2 solution has an aqueous solvent as compared with the nonaqueous glycerin base of the 0.4% SnF_2.

Clinically, the data suggests changes will not be apparent in veneer porcelain following a 1-min treatment although changes could be apparent in 1 1/2 years if 1-min treatments are given at the usual 6-month intervals. The data also suggest that a continuous 4-min treatment for a patient with veneer porcelain could cause significant topographical changes to the porcelain. The series of four 1-min immersions was selected so that the total time would be similar to a standard 4-min treatment. A series of 1-min immersions was more appropriate than one 4-min immersion to simulate a clinical situation where these APF agents are used as originally formulated and marketed.

Although there is little clinical information concerning the efficacy of 1.23% APF foam on caries reductions, studies[34, 35] show that the enamel uptake of fluoride following treatment with 1.23% APF foam is equal to or greater than that following treatment with 1.23% APF gel. Based on the results of this in vitro study, 1.23% APF foam may be an acceptable alternative fluoride treatment for patients with veneer porcelain requiring four or less topical fluoride treatments. However, in vivo studies are needed to determine the effects of 1.23% APF foam and 1.23% APF gel on restorative materials. Given the preponderance of in vitro studies, 1.23% APF gel should be used with caution on patients who have veneer porcelain.

Conclusions

1. No significant differences in either visual scores or mean percent area of defects as determined by computer image analysis were found among porcelain groups following a 1-min immersion in either 1.23% APF foam, 1.23% APF gel, 2.0% NaF gel, or water.
2. Significantly greater mean sum of visual scores and mean percent area of defects was found in porcelain specimens following four 1-min immersions in 1.23% APF gel compared with immersion in the other agents.
3. Significantly greater mean sum of visual scores was found in porcelain specimens following four 1-min immersions of a porcelain in 1.23% APF foam compared with immersion in water, but not significantly greater than 2.0% sodium fluoride gel.
4. No significant differences in visual scores or mean percent area of defects were found between porcelain groups treated 4 min in 2.0% NaF or water.

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Organ Donation from Anencephalic Newborns Should Be Allowed

Certain criteria must be met

Parents of anencephalic newborns should be allowed to donate their child's organs, according to the Council on Ethical and Judicial Affairs of the American Medical Association, as reported in a recent *Journal of the American Medical Association.*

The AMA's Council writes: "Permitting such organ donation would allow some good to come from a truly tragic situation, sustaining the lives of other children and providing psychological relief for those parents who wish to give meaning to the short life of the anencephalic neonate."

Anencephaly is a developmental abnormality of the central nervous system that results in the congenital absence of a major portion of the brain, skull, and scalp. Because anencephalic newborns lack functioning cerebral hemispheres, they never experience any degree of consciousness or have any thoughts, feelings, or emotions. Many die within a few hours and fewer than 10% survive more than a week.

Legally it is permitted to donate organs from a anencephalic neonate once the newborn has died, but not while the baby is still clinically alive.

The authors write that there is an acute shortage of organs available for transplant for young children and infants. "As a result, each year approximately 500 children need heart transplants, another 500 need liver replacements, and approximately 400 to 500 children in the U.S. need kidney transplants. With the scarcity of hearts, liver, and kidneys available for transplantation, 30 percent to 50 percent of children younger than two years die while waiting for transplants. Overall, 40 percent to 70 percent of children on the transplant waiting list die while waiting for a suitable organ."

Besides helping another child, the authors believe that organ donation can be beneficial to the parents of the anencephalic neonate. "When confronted with the tragedy of bearing a child who can never experience consciousness and who will die in a matter of days, parents may find much of their psychological distress alleviated by the good that results from donating their child's organs and thereby providing lifesaving benefits to other children."

Concerning the morality of the procedure, the authors write: "In a survey of leading medical experts in anencephaly and leading experts in ethics, two-thirds of those surveyed stated that they consider the use of organs from anencephalic infants 'intrinsically moral' and more than half stated their support for a change in the law to permit such use."

The Council believes that certain criteria must be met for the donation to be allowed. "It is ethically permissible to consider the anencephalic neonate as a potential organ donor, although still alive under the current definition of death, only if: 1) diagnosis of anencephaly is certain and is confirmed by two physicians with special expertise who are not part of the organ transplantation team; 2) parents of the neonate initiate any discussions about organ retrieval and indicate their desire for retrieval in writing; and 3) there is compliance with the Council's Guidelines for the Transplantation of Organs."