Barcoll hardness of dental materials treated with an APF foam

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The hardness of a dental material is generally related to its mechanical properties. The purpose of this study was to evaluate the hardness of several resins and cements exposed to an APF Foam (Minute Foam, Oral-B). Four molds 6 x 2 mm were prepared for each experimental condition with each of the following materials: Filtek P 60 (3M); Silux Plus (3M); Ariston pHc (Vivadent); F 2000 (3M); Vitremer Restorative (3M) and lonofil Molar (Voco). Immediately after prepared, the samples were stored in water or in the APF foam. To evaluate the Barcoll hardness, measurements were made on both sides of the specimens (top - T and bottom - B), immediately, and after 1 min, 24 h and 7 d. The results, expressed as percentages of the loss of hardness of each sample from the baseline readings, were analyzed with an ANOVA and Tukey's test. ANOVA revealed the significant influence of material, time and treatment. The surface analyzed (T or B) had no significance. Among the glass-ionomers tested the loss of hardness was significantly higher (+30%) than for resin-based composites (±15%). Treatment with the APF foam for 7 days produced the greatest loss of hardness (42%) and at 24 h the least (less than 5%). There were no other significant findings. It can be concluded that the effect of the APF foam is material dependent, but is significantly more pronounced with the glass-ionomers than the resins tested. The application time of the foam is the main factor for the loss of hardness.
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INTRODUCTION

Resin-based composites, polyacid-modified resin-based composites (compomers) and glass-ionomers (conventional and resin-modified) have been extensively used to restore the primary and permanent dentition.

Frequently patients with these types of restorations receive preventive treatment based on fluoride-containing dentifrices, mouthrinses and topical applications of fluoride gels or foams.

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Topical applications of acidulated phosphate fluoride (APF) gels may alter the surface texture of restorative materials.[1,2] Also, the daily use of fluoride could affect the stability and structure of the glass-ionomers.[2,3]

Laboratory studies have shown that restorative materials such as porcelain, resin-based composites, sealants, and glass-ionomers are susceptible to changes in surface morphology when treated with topical fluoride gels.[4,6] Thompson *et al*.[7] reported that porcelain exposed for 20 minutes to an APF solution revealed visual changes in the surface as well as weight loss.

Relatively recently, APF foams have become more popular because it stays in the application trays allowing less ingestion by the patients.

The purpose of this study was to evaluate the Barcoll hardness of several cements and resins treated or not with an APF foam.

MATERIALS AND METHODS

Four molds 6 x 2 mm were prepared for each experimental condition with each of the following materials:

Resin-based composites
Filtek P 60 (3M); Silux Plus (3M); Ariston pHc (Vivadent);
Compomer
F 2000 (3M)
Glass-ionomer cements
Vitremer Restorative (3M) and lonofil Molar (Voco).

Immediately after prepared, the samples were stored in water or in the APF foam. To evaluate the Barcoll hardness, measurements were made on both sides of the specimens (top and bottom), immediately, and after 1 mm, 24 h and 7 d.

All materials were handled according to the suggestions by the manufacturer.

The light-cured materials were cured with an XL 2500 (3M) unit with a fiberoptic tip of 7 mm diameter.

Each material was placed in two increments of 1 mm each, and light-cured for 40 seconds each.

The encapsulated lonofil Molar cement was mixed in an automatic mixer (Duomat, Degussa, Germany). This material, which is a conventional glass-ionomer, was placed in the mold and left for 1 hour before any further treatment to allow the acid-base reaction to take place.

All materials were placed on the molds. An acetate strip was placed over the materials on both ends of the molds and microscopic cover slides were placed at the bottom and the top of the molds and gently pressed to obtain a flat surface.

The initial Barcoll hardness was obtained from both sides of the specimens (top and bottom) with a Barber Colman device immediately after light-curing. With lonofil Molar the initial hardness reading was conducted 1 hour after the start of mixing.

The Barcoll reading were made in three different points of each one of the surfaces (top and bottom). The mean of the readings of the Barcoll hardness for that surface was calculated.

After the hardness reading, the molds containing the specimens were submerged in distilled water or APF One-Minute Foam (Oral-B acidulated phosphate fluoride with 1.23% fluoride ion at pH 3.5) at 37˚C as follows:

Group 1: Oral B Minute-Foam for 7 days.
Group 2: Oral B Minute-Foam for 24 hours.
Group 3: Oral B Minute-Foam for 1 minute.
Group 4: Distilled water for 7 days.
Group 5: Distilled water for 24 hours.

After treatment, the Barcoll hardness was determined as mentioned. The results were expressed in percentage as the loss of hardness values calculated in the following manner:

$$\text{Loss of hardness (in \%)} = \frac{\text{Initial hardness - Final hardness x 100}}{\text{Initial hardness}}$$

Three factors [material, treatment (storage media/time) and surface] were considered for the statistical analysis of the results using an ANOVA and a Tukey's tests.

RESULTS

The results are displayed in Tables 1 to 3. Table 1 shows the ANOVA results. The surface analyzed (top or bottom) had no statistically significant effect. However, the factors treatment (storage media/time) and material were important factors.

The interactions surface/treatment, surface/material and surface / treatment / material were not statistically significantly different. The only interaction showing significant difference was between treatment and material.

Table 2 depicts the comparisons between the results of loss of hardness in relation to the different treatments, performed with Tukey's test. Three homogeneous groups were identified as I, II and III.

In Group I, the loss of hardness during application of the APF foam, for 7 days, was of 42.6%.

In Group II, the loss of hardness were 16.36% for 7 days in distilled water, and 16.96% and 23.71% for APF foam for 1 minute and 24 hours, respectively. These values were not significantly different.

In Group III, samples immersed in distilled water for 24 hours revealed a loss of hardness of 4.63%, which were significantly lower than for all other groups.

Table 3 shows the comparisons of the loss of hardness between the different materials tested using the Tukey's test. Two statistically similar groups were found. The first group, showing the highest loss of hardness was recorded for lonofil Molar and Vitremer Restorative with a mean value of 34.13% and 31.65%, respectively. The second group, was represented by F2000, Ariston pHc, Filtek P 60 and Silux Plus, with no significant differences between these materials.

DISCUSSION

The hardness of a material is generally related to several of the mechanical properties. One of these properties, and with clinical relevance, is the resistance to abrasion or wear. Barcoll measurements allow relative determination of this behavior.

The results of this study showed that both sides of the specimens were similarly affected, independent from the treatment rendered and material used.

The hardness of the different materials was reduced in both storage media, although the percentage was much lower in water than in the APF foam. When the samples were stored in APF for 7 days, the hardness of the materials decreased compared to the baseline readings. This reduced hardness was similar at 1 minute and 24 hours APF foam storage or after storage in water for 7 days.

The glass-ionomers were more affected than the resins and among them, lonofil Molar (conventional glass-ionomer) was more significantly affected than Vitremer Restorative (resin-modified glass-ionomer). The presence of polymerizable monomers in Vitremer

Table 1. Analysis of variance for the final hardness

Source	DF	SS	MS	F	P
Surface (A)	1	0.0026	0.0026	0.13	NS
Treatment (B)	4	3.7434	0.9358	47.99	<0.05
Material (C)	5	1.8602	0.3720	19.08	<0.05
A*B	4	0.0139	0.0349	0.18	NS
A*C	5	0.0671	0.0134	0.69	NS
B*C	20	1.4113	0.0705	3.62	<0.05
A*B*C	20	0.3106	0.0155	0.80	NS
Residual	180	3.5099	0.0195		

Table 2. Comparison of the final loss of Barcoll hardness (%) by treatment. Tukey's test

Treatment	Mean (%)	Homogenous Groups
APF Foam 7 days	42.60	I
APF Foam 24 hours	23.71	II
APF Foam 1 minute	16.96	II
Water 7 days	16.36	II
Water 24 hours	4.63	III

could be the reason for a greater resistance to acidic challenges.

Akselsen *et al.*[5] noted a reduction in hardness of Fuji II (GO, Tokyo, Japan) glass-ionomer cement after immersion in a 2% NaF solution. This treatment produced a surface degradation attributed to an increasing level of alkalinity of the NaF during the ion exchange between the glass-ionomer and the storage solution.

The Oral-B Minute-Foam contains 2.14% NaF and 0.23% hydrofluoric acid. Both components may produce dissolution of the materials used in this study after contact for at least 24 hours.

The reason for choosing the application times used in this study (1 minute, 24 hours, and 7 days) was mainly based on the fact that 24 hours would be equivalent to daily 4-minute applications of the foam on the materials. Although this is not a clinically realistic application time nor APF foam regime, it simulates a long-term use of the foam. Therefore, the 24 hours and 7 days experimental times are extreme tests. Also, in the oral environment the presence of salivary proteins may in some way protect the material surface immediately before and after the foam application. It should also be considered that in clinical preventive programs a variety of fluoride products are used that may also enhance or decrease the effects of the APF foam. This should be further evaluated.

Kula *et al.*[8-10] determined that the topical APF agents they evaluated, produced a significant material weight loss of the resin-based composites tested. This material weight reduction was also confirmed with the scanning electron microscope as an apparent loss of filler particles.

Considering the resins and compomers as a group, F2000 was the material most affected in its hardness, although not significantly different from Ariston pHc, Filtek P60 and Silux Plus.

Sposetti *et al.*[11] suggested that the silicon dioxide present in dental ceramics is susceptible to the hydrofluoric acid. The filler particles present in resin-based composites are many times composed (partially or totally) of silica; therefore, the type of filler, may influence the loss of surface hardness after the APF foam application.

Table 3. Comparison of the final loss of Barcoll hardness (%) by material after treatment with Oral-B Minute Foam. Tukey's test

Material	Mean (%)	Homogenous Groups
Ionofil Molar	34.13	I
Vitremer	31.65	I
F2000	19.33	II
Ariston pHc	13.61	II
Filtek P60	13.40	II
Silux Plus	13.00	II

The Council on Dental Materials[4] has noted that the treatment of caries with non-acidic fluorides is effective in patients with resin-based composites. Using non-acid (neutral) fluorides the effect on the material is reduced.

The hardness loss of a dental material may contribute to the deterioration of the material in a clinical environment, including loss of anatomical form and discoloration.

CONCLUSION

Treatment with the APF foam tested may be material dependent and it seems to be preferable to apply them for shorter times (1 minute versus 4 minutes) to reduce any adverse effect.

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