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The effect of home-use fluoride gels on glass–ionomer, compomer and composite resin restorations

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SUMMARY **The purpose of this study was to investigate the resistance to dissolution by two home-use fluoride gels on the surface integrity of glass–ionomer, resin modified glass–ionomer, compomer and composite resin restorations. Class V cavities prepared in extracted teeth were restored with a glass–ionomer (Fuji II), a resin modified glass–ionomer (Vitremenr), two compomers (Dyract and F-2000) and a composite resin (Z-100). Groups of five specimens of each material were treated for 24 h with one of the following: (i) distilled water, (ii) neutral fluoride gel and (iii) acidulated phosphate fluoride (APF) gel. Surface degradation of the restorations was studied using standard electron microscopy (SEM), rated according to specific criteria and statistically analysed by the Wilcoxon test (rank sums). Acidulated phosphate fluoride was found to have a significant effect on all examined materials, while minimal effects resulted from the neutral fluoride gel compared with the control group. The effect of home-use fluoride gels on glass–ionomer, compomer and composite resin restorations.**

KEYWORDS: **fluoride gels, glass–ionomer, compomer, composite resin**

Introduction

Glass–ionomer materials have been introduced as restorative materials, and they may offer certain advantages in resisting secondary caries formation around restorations (Hicks, Flaitz & Silverstone, 1986; Forss & Seppä, 1990; Dionysopoulos *et al*., 1994). The conventional glass–ionomer systems, however, suffer from certain disadvantages. These disadvantages are the short working time, the long set time, susceptibility to early moisture contamination, desiccation after setting and brittleness. Recently, in order to overcome these limitations and yet preserve their benefits, two types of hybrids of glass–ionomers and resin composites were introduced. The first is the resin-modified glass–ionomer, or a glass–ionomer modified by the addition of methacrylate resins. This hybrid of glass–ionomer offer longer working and controlled setting times, rapid development of strength, and lower sensitivity to environmental moisture changes, and can be finished and polished immediately after being light-cured (Sidhu & Watson, 1995; Musa, Pearson & Gelbier, 1996). The second hybrid is the polyacid-modified resin composite (or 'compomer'), which contains some components of a glass–ionomer but lacks the typical glass–ionomer acid/base reaction during the initial setting process.

Various studies have been conducted to study durability of glass–ionomer restorative materials (McLean & Wilson, 1977; Paterson, 1984; Earl & Ibbetson, 1986; Mount, 1986; Knibbs, Plant & Pearson, 1986). Erosion of glass–ionomers was studied in neutral and acidic media. Acidic solutions were found to accelerate the erosion process (Crisp Lewis & Wilson, 1980; Mesue, 1982; Fukazawa, Matsuya & Yamane, 1987; Walls, McCabe & Murray, 1988).

In a clinical study that used conventional glass–ionomer cements for treatment of caries, restorations showed evidence of degradation within 6 months when using an acidic (pH 5·8) home-use sodium fluoride gel as a preventive measure (Wood, Maxymiw & McComb, 1993). El-Badrawy, McComb and Wood (1993) studied the effect of different home-use fluoride gels on conventional glass–ionomers *in vitro* and reported significant surface disintegration with the acidulated gels. Kramer *et al*. (1986) also reported that acidulated

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Table 1. Materials used in the study

Product	Type of material	Composition	Manufacturer
Fuji II	Conventional glass–ionomer	Aluminum fluorosilicate glass polyacrylic acid	G.C. Corporation, Tokyo Japan
Vitremer	Resin modified glass–ionomer	Powder: fluoroaluminosilicate glass Liquid: modified polyalkenoic acid and HEMA	3M Dental Products, St Paul, MN, USA
Dyract	Compomer	Filler [75% (wt)]: strontium–Al–Na-fluoro–P–silicate–glass, strontium fluoride Matrix [25% (wt)]: UDMA, TCB resin, methacrylate – monomer	Caulk/Dentsply, Milford, DE, USA
F-2000	Compomer	Filler [84% (wt)]: Fluoro–Al–silicate–glass, dispersive silica Matrix [16% (wt)]: CDMA – oligomer, GDMA, hydrophilic polymer	3M Dental Products, MN, USA
Z-100	Compomer resin	Filler [66% (wt)]: zirconia/silica (size range: 3·5–0·01 μm) Matrix: BIS–GMA and DEGDMA resins	3M Dental Products, MN, USA

phosphate fluoride (APF*) gel caused the greatest conventional glass–ionomer dissolution compared with other fluoride gels.

Kula *et al*. (1986) studied the effect of an APF gel on composite resins *in vitro* and reported visually perceptible changes in composite surface reflectivity.

The purpose of this study was to investigate the resistance to dissolution by two home-use fluoride gels on the surface integrity of glass–ionomer, resin modified glass–ionomer, compomer and composite resin restorations.

Materials and methods

The materials tested in this study are listed in Table 1. Seventy-five class V cavities with the same dimensions ($2 \times 3 \times 1{\cdot}5$ mm) were prepared in extracted permanent teeth. They were washed, light-dried and randomly divided into five equal groups and preparations were restored with the test materials.

For all materials, proportioning and mixing were completed according to the manufacturers' instructions. For the photopolymerized materials each restoration was cured for 40 s using a light-curing unit, Elipar Visio[†]. Finishing was performed with multifluted No. 7901 burs[‡] and polishing was carried out using Sof-Lex discs[§], keeping the restoration surface wet. Specimens were then stored in water for 24 h at 37 °C. The Fuji II[¶] group preparations were restored utilizing an aluminium scervical matrix. Following removal of the matrix, the restoration surface was protected using the manufacturer's recommended varnish (G.C. varnish)[¶]. Finishing and polishing for this group was carried out after 24 h using multifluted bur and Sof-Lex discs.

The groups of materials were subsequently divided into three treatment groups, each containing five specimens. Treatment groups were comprised of the two fluoride gels (see Table 2) and a control group stored in distilled water.

Each experimental group was treated with one of the gels for a total of 24 h which is equivalent in time to 1 year of 4-min daily use. Specimens were stored in bottles containing 20 mL of distilled water. Each day for 3 days, every specimen was taken out, patted dry, and placed in a plastic bottle containing 20 mL of the specific fluoride gel for 8 h. Throughout treatment period, teeth stored in gel were manually shaken every hour in order to prevent chemical equilibrium around the restoration surface.

At the end of the specified time period specimens were washed, dried, gold sputtered and examined using scanning electron microscopy (SEM). A representative image was collected from each of the different specimens at ×500 and ×2000 magnification.

Table 2. Fluoride gels used in the study

Material	Composition	Manufacturer
Nupto APF	1·23% acidulated phosphate fluoride (APF)	Dentsply/Ash, York, PA, USA
Nupto Neutral	2% NaF	Dnetsply/Ash, York, PA, USA

*Dentsply/Ash, York, PA, USA.
[†]Espe GmbH, Seefeld, Germany.
[‡]SS Write, Lakewood, NJ, USA.
[§]3M Dental Products, St Paul, MN, USA.
[¶]G.C. Corporation, Tokyo Japan.

The SEM micrographs of the restoration surface were rated by two evaluators. Any visual degradation of the glass particles was rated according to the same criteria used in a previous study (El-Badrawy & McComb, 1998) (0) particles appear intact with no visible etched surface; (0·5) mild effect with minimal surface pitting; (1) moderate pitting and slight cracking of the glass particles and (2) severe cracking and pitting present. The rating for the glass–ionomer matrix was carried out as follows: (0) surface appears undisturbed, glass particle level with and embedded in matrix; (0·5) mild degradation with disturbed matrix and minimal changes; (1) moderate degradation with irregular surface, particles partially protruding and a limited number of voids present; (2) severe degradation with little or no matrix around particles and a considerable number of voids present. Statistical analysis was carried out using the non-parametric Wilcoxon test rank sums method ($P < 0{\cdot}01$).

Results

Figure 1a shows a representative micrograph of Fuji II stored in distilled water. The surface was smooth and intact and the matrix was undisturbed, except for dehydration cracks that run through the matrix. Fuji II specimens treated with Neutral gel* (Fig. 1b) were essentially comparable with the control specimens except for the presence of more dehydration cracks. Fuji II specimens treated with APF gel (Fig. 1c) revealed considerable dissolution of the matrix. A significant etching effect of this gel on the glass particles was evident as pitting and cracking.

Vitremer[§] restorations stored in distilled water showed a smooth and intact surface with minor dehydration cracks (Fig. 2a). The matrix of Vitremer restorations treated with Neutral gel was uneroded, but the surface showed more dehydration cracks that the control (Fig. 2b). The treatment of restorations with APF gel caused swelling of the Vitremer matrix and the particles were loosely attached and partially covered by the matrix (Fig. 2c,d).

Dyract** specimens stored in water showed a relatively smooth surface free from dehydration cracks (Fig. 3a). Neutral gel had no significant effect on the erosion of Dyract matrix (Fig. 3b).

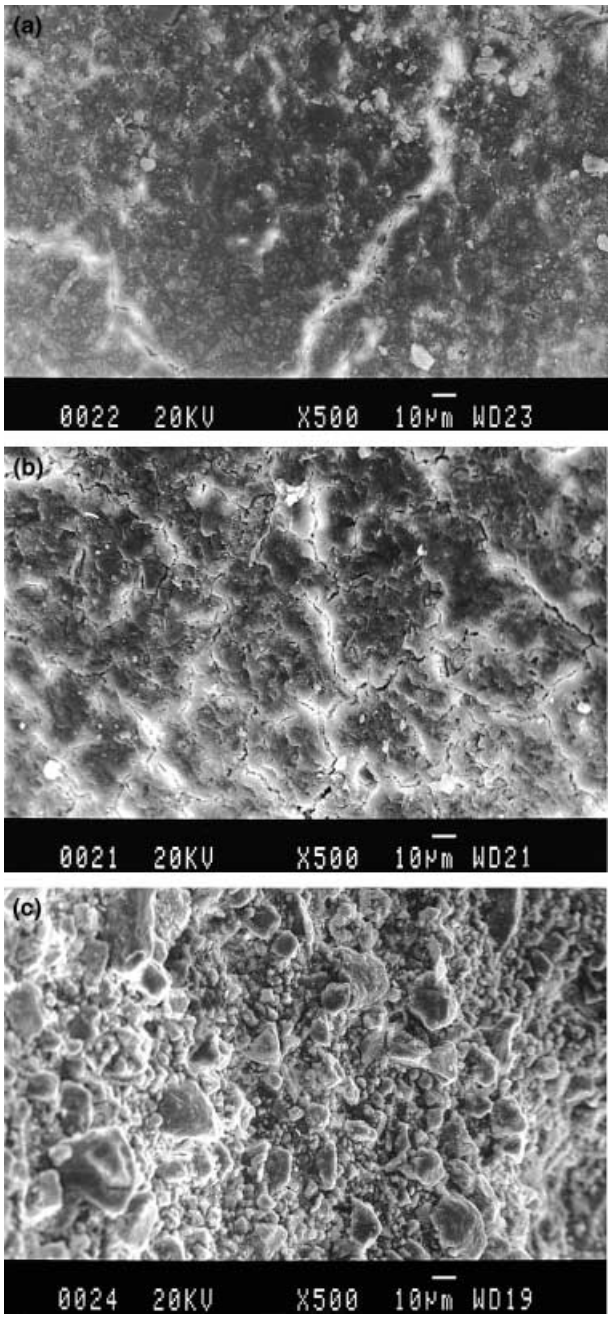

Fig. 1. (a) Fuji II control stored in distilled water. (b) Fuji II stored in Neutral gel. (c) Fuji II stored in APF gel.

The treatment with APF gel caused a flat surface with moderate pitting (Fig. 3c). Higher magnification revealed that small glass particles had been totally eroded and larger glass particles were etched (Fig. 3d).

The F-2000[‡] stored in water showed a relatively smooth surface with small dehydration cracks (Fig. 4a). The matrix of F-2000 specimens treated with Neutral

**Caulk/Dentsply, DE, USA.

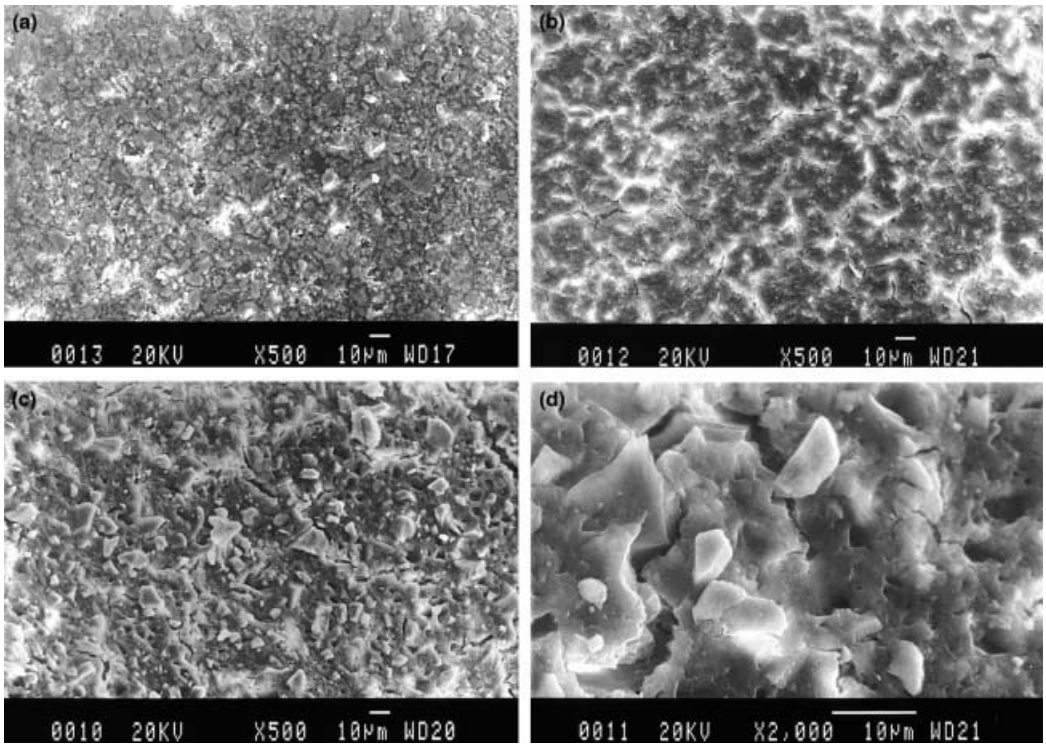

Fig. 2. (a) Vitremer control stored in distilled water. (b) Vitremer stored in Neutral gel. (c) Vitremer stored in APF gel. (d) Vitremer stored in APF gel (×2000).

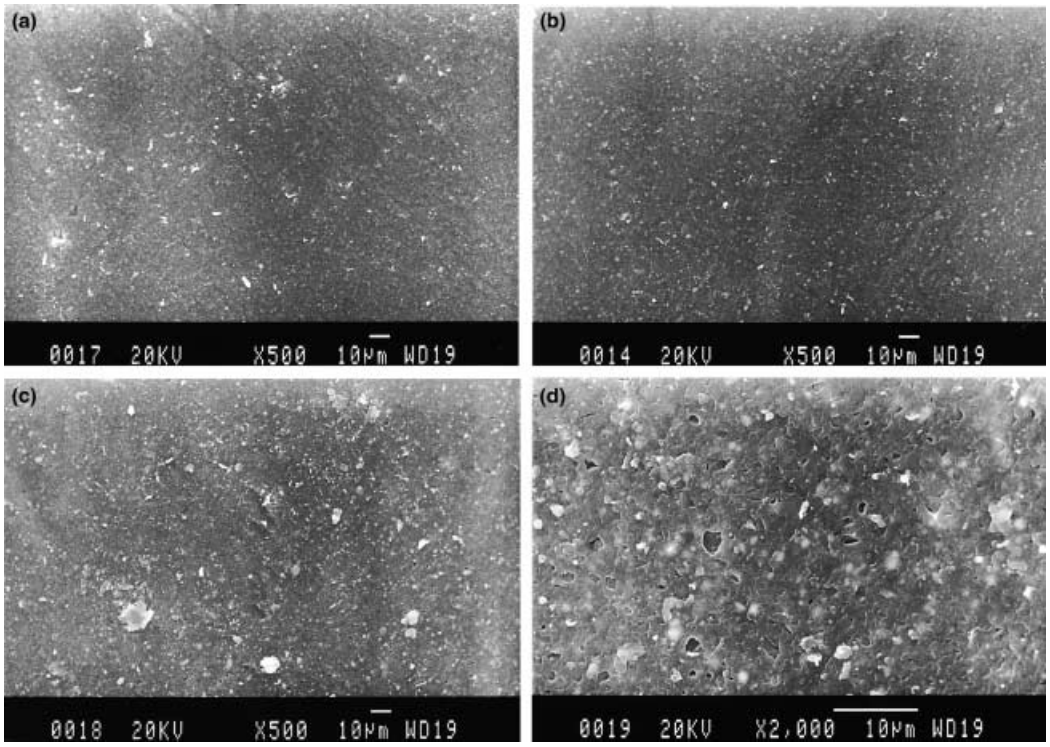

Fig. 3. (a) Dyract control stored in distilled water. (b) Dyract stored in Neutral gel. (c) Dyract stored in APF gel. (d) Dyract stored in APF gel (×2000).

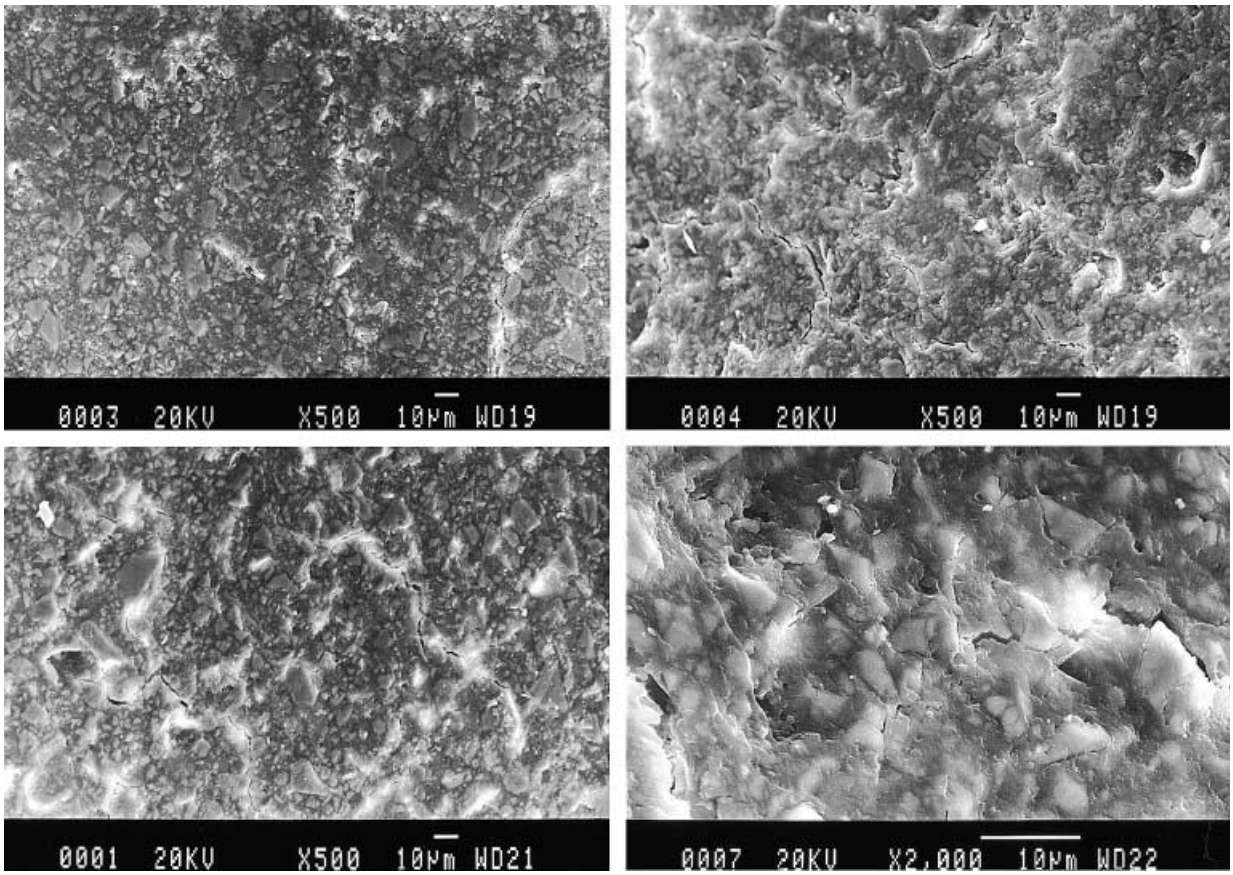

Fig. 4. (a) F-2000 control stored in distilled water. (b) F-2000 stored in Neutral gel. (c) F-2000 stored in APF gel. (d) F-2000 stored in APF gel (×2000).

Table 3. Statistical analysis results (Wilcoxon test)

Material	Fuji II		Vitremer		Dyract		F-2000		Z-100	
	Surface degradation		Surface degradation		Surface degradation		Surface degradation		Surface degradation	
Fluoride gel	Matrix	Particle	Matrix	Particle	Matrix	Particle	Matrix	Particle	Matrix	Particle
Neutral gel	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
APF gel	S	S	S	S	S	S	S	S	S	S

S, significant difference.
NS, no significant difference.

gel was slightly eroded and the surface showed more dehydration cracks than the control (Fig. 4b). Figure 4(c,d) are micrographs of F-2000 specimens treated with APF gel. Small glass particles had been eroded and larger glass particles were etched.

The surface appearance of composite resin Z-100‡ treated with Neutral gel was slightly dissimilar to the control (Fig. 5a,b). After treatment with APF, gel the composite material, the resin matrix remained intact but a large number of particle voids were seen, which indicated significant degradation of the filler particles.

Statistical analysis did reveal some significant differences ($P < 0{\cdot}01$) among the materials in the different storage media. Table 3 summarizes the results of the statistical analysis.

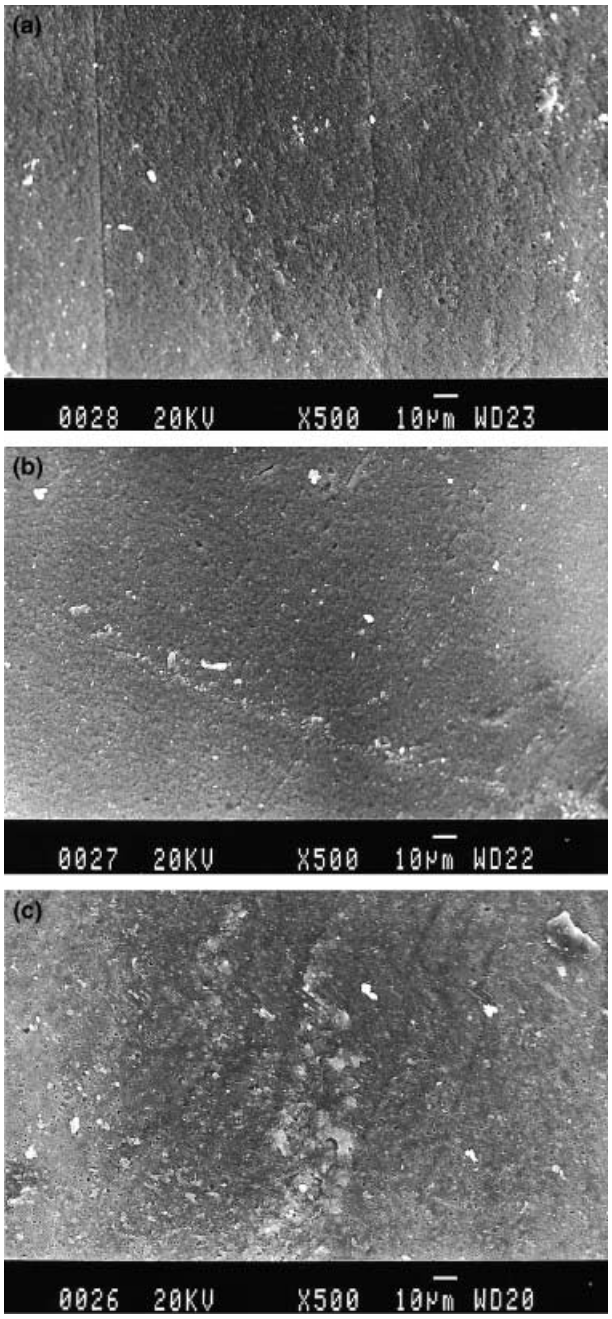

Fig. 5. (a) Z-100 control stored in distilled water. (b) Z-100 stored in Neutral gel. (c) Z-100 stored in APF gel.

Discussion

Immersion of the five restorative materials in Neutral gel had no statistically significant effect on the structure of the surface of the tested materials. Fluoride gel APF contains phosphoric acid and had the most damaging effect of the studied solutions on all experimental materials.

Billington *et al.* (1987) reported no visual disintegration of Fuji II following 24-h immersion in 2·0% neutral sodium flouride (NaF), but they found reduction in hardness values, which is indicative of surface degradation. They attributed this to an increase in alkalinity of the neutral NaF resulting from ion exchange between the cement and the solution.

A swollen matrix appearance was detected in the resin-modified glass–ionomer (Vitremer). This is in agreement with an other study who reported that light-cured glass–ionomers prepared with 2-hydroxyethyl methacrylate (HEMA) copolymers behave like hydrogels and absorb water (Nicholson, Anstice & McLean, 1992). Vitremer tested in this study contained polyacrylic acid and HEMA, a hydrophilic monomer and a polymerizable monomer.

It has been reported that because of the contrasting nature of these liquid components, there is a natural tendency for resin-modified glass–ionomers to undergo phase separation while still liquid and this tendency for phase separation increases as the setting reaction proceeds. Therefore, the set product is expected to contain domains of different phases in its microstructure (Nicholson & Anstice, 1994). Nicholson *et al.* (1992) also reported that light-cured glass–ionomers stored in water showed lower compressive strength, a change in their mode of failure and that weight increase because of water absorption was progressive with time.

It is likely that the swollen appearance detected in this study was an early form of matrix degradation.

The matrix of polyacid-modified composite resins did not show any signs of swelling, which could be the result of the absence of HEMA from its liquid.

This is in agreement with another study which reported that no signs of swelling were detected in the matrix of polyacid-modified composite resins, after exposure in different fluoride gels (El-Badrawy & McComb, 1998).

Immersion of composite resin on APF gel *in vitro* resulted in visually perceptible changes in composite surface reflectivity caused by degradation of filler particles. This is in agreement with other *in vitro* studies (Kula, Thomspon & Nelson, 1983; Kula *et al.*, 1986; El-Badrawy, McComb & Wood, 1993). The degree of

visual change and degradation of filler particles appeared to be related to their composition and size (Kula, Nelson & Thompson, 1983).

Clinically, topical application of APF gel may accelerate the degradation of surface of restorative materials. Altered surfaces may be softened and more readily eroded under intraoral chemical and physical conditions.

The roughened gingival margins of the restorations may allow increased bacterial accumulations that contribute to gingivitis.

Conclusions

Immersion of the specimens in neutral NaF gel had little effect on the surface integrity of all tested materials.

The APF gel has the most damaging effect of the two studied solutions on all experimental materials.

The neutral NaF gel is the preferred home-use fluoride treatment for patients with glass–ionomer, resin modified glass–ionomers, compomers and composite resins. The use of APF fluoride is contraindicated.

References

El-Badrawy, W.A., McComb, D. & Wood, R.E. (1993) Effect of home-use fluoride gels in glass ionomer and composite restorations. *Dental Materials*, **9,** 63.

Billington, R.W., Williams, J.W. & Strang, R. (1987) Effect of neutral sodium fluoride on glass ionomers in vitro. *Journal of Dental Research*, **66,** 844 (Abstract 88).

Crisp Lewis, B.G. & Wilson, A.D. (1980) Characterization of glass ionomer cement. 6. A study of erosion and water absorption in both neutral and acidic media. *Journal of Dentistry*, **8,** 68.

Dionysopoulos, P., Kotsanos, N., Koliniotou-Koulia, E. & Papadogiannis, Y. (1994) Secondary caries formation in vitro around fluoride-releasing restorations. *Operative Dentistry*, **19,** 183.

Earl, M.S.A. & Ibbetson, R.J. (1986) The clinical disintegration of a glass ionomer cement. *British Dental Journal,* **161,** 287.

El-Badrawy, W.A. & McComb, D. (1998) Effect of home-use fluoride gels on resin-modified glass-ionomer cements. *Operative Dentistry*, **23,** 2.

Forss, H. & Seppä, L. (1990) Prevention of enamel demineralization adjacent to glass ionomer filling materials. *Scandinavian Journal of Dental Research*, **98,** 173.

Fukazawa, M., Matsuya, S. & Yamane, M. (1987) Mechanism for erosion of glass ionomer cements in an acidic buffer solution. *Journal of Dental Research*, **66,** 770.

Hicks, M.J., Flaitz, C.M. & Silverstone, L.M. (1986) Secondary caries formation in vitro around glass ionomer restorations. *Quintessence International*, **17,** 527.

Knibbs, P.J., Plant, C.G. & Pearson, G.J. (1986) A clinical assessment of an anhydrous glass ionomer cement. *British Dental Journal*, **161,** 99.

Kramer, K.L., Wolf, M.S., Gale, E.N. & Osborne, J.W. (1986) The effect of fluoride mouth rinses on the solubility of cements. *Journal of Dental Research*, **65,** 777 (Abstract 467).

Kula, K., Nelson, S. & Thompson, V. (1983) In vitro effect of APF gel on three composite resins. *Journal of Dental Research*, **62,** 846.

Kula, K., Thompson, V. & Nelson, S. (1983) Effect of 1.23% APF gel on sealant materials in vitro. *Journal of Dental Research*, **62,** 892.

Kula, K., Nelson, S., Kula, T. & Thompson, V. (1986) In vitro effect of acidulated phosphate fluoride gel on the surface of composite with different filler particles. *Journal of Prosthetic Dentistry*, **56,** 161.

McLean, J.W. & Wilson, A.D. (1977) The clinical development of the glass ionomer cement. III. The erosion lesion. *Australian Dental Journal*, **22,** 190.

Mesue, F.P. (1982) Degradation of luting cements measured in vitro. *Journal of Dental Research*, **61,** 665.

Mount, G.J. (1986) Longevity of glass ionomer cements. *Journal of Prosthetic Dentistry*, **55,** 682.

Musa, A., Pearson, G.L. & Gelbier, M. (1996) In vitro investigation of fluoride ion release from four resin-modified glass polyalkenoate cements. *Biomaterials*, **17,** 1019.

Nicholson, J.W. & Anstice, H.M. (1994) The development of modified glass-ionomer cements for dentistry. *Trends in Polymer Science*, **2,** 272.

Nicholson, J.W., Anstice, H.M. & McLean, J.W. (1992) A preliminary report on the effect of storage in water on the properties of commercial light-cured glass-ionomer cements. *British Dental Journal*, **173,** 98.

Paterson, N. (1984) The longevity of restorations. A study of 200 regular attenders in a regular dental practice. *British Dental Journal*, **157,** 23.

Sidhu, S.K. & Watson, T.F. (1995) Resin-modified glass ionomer materials. A status review for the American Journal of Dentistry. *American Journal of Dentistry*, **8,** 59.

Walls, A.W.G., McCabe, J.F. & Murray, J.J. (1988) The effect of variation in pH of the eroding solution upon the erosion resistance of glass polyalkenoate (ionomer) cements. *British Dental Journal*, **164,** 141.

Wood, R.E., Maxymiw, W.G. & McComb, D. (1993) A clinical comparison of glass ionomer (polyalkenoate) and silver amalgam restorations in the treatment of class 5 caries in xerostomic head and neck cancer patients'. *Operative Dentistry*, **18,** 94.

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