Eur. J. Prosthodont. Rest. Dent., Vol.15, No. 3, pp 98-103
Printed in Great Britain

Effect of selected mouthwashes with and without toothbrushing on the surface hardness of a resin modified glass-ionomer and two compomers.

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Abstract - ***Objectives***. *Physical properties of some restorative dental materials can change as a result of exposure to mouthwashes and toothbrushing. The purpose of this laboratory study was to investigate the possible effects of three commercially available mouthwashes on the surface hardness and weight of a resin modified glass-ionomer and two compomers when used with and without tooth brushing.* ***Methods***. *Specimens of the restorative materials in the study (Vitremer, Compoglass and Dyract) were prepared. Half of the specimens were only exposed to a mouthwash (Plax, Macleans, Listerine, Corsodyl or deionised water as control). The remaining specimens were exposed to one of the mouthwashes in conjunction with tooth brushing. The initial surface hardness and the surface hardness after 24 weeks were assessed using a Wallace hardness testing instrument. The specimens were assessed for possible weight changes between baseline and 24 weeks using a digital balance.* ***Results***. *Mouthwash only: The Wallace hardness values of Vitremer and Compoglass increased in all groups. For Vitremer the increase was significantly higher in Macleans group in comparison with the control, Listerine and Corsodyl groups ($P<0.05$). For Compoglass the increase in Plax and Macleans groups were significantly higher compared with the control group ($P<0.05$). Dyract specimens revealed an increase in Wallace hardness values in all test groups whilst the control group revealed a decrease ($P<0.05$ except for Plax). Mouthwash and toothbrushing. Wallace hardness for all materials increased. The difference was not significant between groups ($P>0.05$). Weighing the specimens of Vitremer revealed that after 24 weeks exposure to mouthwash and toothbrushing some groups had lost weight while an increase in weight was observed in others ($P>0.05$). For Compoglass and Dyract, all groups had lost weight after 24 weeks ($P>0.05$).* ***Significance***. *Exposure of the materials investigated in this study to the mouthwashes and toothbrushing had adverse effects on surface hardness. The adverse effects were more apparent when the mouthwashes were used alone.*

KEY WORDS: Mouthwash; Toothbrushing; Tooth-coloured restorative materials; Surface hardness

INTRODUCTION

Mouthwashes are marketed as breath fresheners, medicaments, antiseptics, and in more recent times as preventive agents [1]. It is well known that there has been an increase in the variety and sales of over the counter mouthwashes in the UK [2].

Many over the counter and prescription mouthwashes contain a high volume percentage of alcohol and a low pH. Studies in the past have revealed that alcohol adversely affects the physical properties of composites and compomers [3-8] and solutions with low pH have been shown to cause considerable softening of conventional and resin modified glass-ionomers and compomers in prolonged exposures [9]. In addition a mouthwash with a low pH can cause erosion and wear of enamel and dentine and this becomes more evident if tooth brushing follows exposure to the solution [10]. Some researchers have recommended that low pH mouth rinses should not be considered for long term or continuous use and never as pre-brushing rinse[6].

In studying physical properties of restorative dental materials, surface hardness is an important property to be considered [11]. The purpose of this study was to investigate the effect of some commercially available mouthwashes on the surface hardness and the weight of a range of hybrid composite resin/ glass ionomer restorative materials.

MATERIALS AND METHODS

The four mouthwashes included in the study were; Colgate Plax, Macleans, Listerine and Corsodyl. The active ingredients and the alcohol content and pH of each of the mouthwashes are given in Table 1. The three different restorative materials investigated included a RMGIC (Vitremer) and two compomers (Compoglass and Dyract) (Table 2).

Twenty five brass dies, each containing two cavities (10mm long× 4mm wide× 2.5mm deep) were prepared for each restorative material. Indentations were placed at the end of the bars to allow identification of the moulds. For Compoglass and Dyract, the cavities were filled directly from the capsules. For Vitremer, the powder and liquid were mixed according to the manufacturer's directions. Each specimen was prepared in two incremental layers of less than 2 mm thickness. Each increment was light cured for 40 seconds. The mould was initially slightly over filled and covered with a clamped glass microscope slide to achieve a smooth flat surface. Each restored brass mould was stored at room temperature (20°C) in a separate, sealed bottle containing deionised water. Twenty five moulds of each material were further subdivided at random into 5 groups. Each group would be exposed to either one of the four mouthwashes or deionised water (control).

Table 1. *Mouthwashes used in this study.*

Mouthwash	*Batch No.*	*Active ingredients*	*Manufacturer*	*pH*	*Alcohol content v/v*
Plax	GBO-163A	Triclosan 0.03%, Sodium fluoride 0.025%	Colgate PalmoliveGuilford, UK.	7.14	8.0%
Listerine	4Y 037	Ethanol, Benzoic acid, Eucalyptol, Menthol, Methylsalysilate, Thymol	Warner Lambert Health Care, Eastleigh, UK.	4.05	29.2%
Macleans	156C	Cetylpyridinium chloride, Sodium fluoride, BP 0.05%, Ethanol	Smithkline Beecham Consumer Brands, Brentford, UK.	5.79	18.5%
Corsodyl	EH 293	0.2% Chlorhexidine-gluconate	Smithkline Beecham Consumer Brands, Brentford, UK.	5.32	7.6%

Table 2. *Restorative materials used in this study.*

Material	*Batch No*	*Manufacturer*
Vitremer	70-2010-0427-5	3M Dental products, St. Paul USA
Compoglass	800647	Vivadent, Schaan, Liechtenstein
Dyract	9602040	Dentsply Detre, Dentsply Ltd. Surrey, UK

One specimen in the mould was exposed to mouthwash only whilst the other was exposed to mouthwash and also brushed. Prior to testing commencing and exposure of the specimens to mouthwashes and toothbrushing they were stored in deionised water at room temperature for 48 hrs.

The restoration in each mould marked for brushing, was brushed with toothpaste (Colgate Great Regular Flavour, Colgate-Palmolive Limited, UK) using an electric toothbrush (Oral-B, UK). To ensure that similar loads were applied to specimens during brushing, loading to the head of the brush was limited to a level just sufficient to maintain contact between the bristles and the specimen surface. Specimens were brushed in random order. Each specimen was brushed for 10s, rinsed under running water for 60s, and then immersed in mouthwash. The immersion time in each mouthwash was determined by the manufacturer's instruction for mouthwash use. The specimens were subjected to the brushing regime and the mouthwashes, as described twice a day for 24 weeks. The samples in the Corsodyl group were exposed to the mouthwash for four weeks and in the following four weeks they were not exposed to the mouthwash, repeating this cycle for 24 weeks, as the manufacturer does not recommend continuous use.

Hardness measurements were taken for all the specimens either exposed to mouthwashes only or to mouthwash and brushing using a Wallace hardness testing instrument (Wallace tester, H.W.Wallace & Co Ltd. Croydon,UK). The measurements were made at the baseline and then at 24 weeks.

The mean hardness for each specimen was taken as the mean from ten readings. The mean hardness value for the group which contained five specimens was therefore the mean of 50 readings.

Alterations in specimens weight following immersion were also assessed. All moulds were weighed prior to mouthwash immersion and tooth brushing, using a digital balance accurate to 5 decimal points (Ohaus, European instruments, Headington, UK). The values obtained were designated as "baseline". Prior to weighing, each specimen was removed from storage and wiped with absorbent paper to remove surface moisture and immediately weighed. After 24 weeks exposure of the specimens of the restorative materials to mouthwash and tooth brushing quantitative investigation of the material lost from the surfaces were made (ΔWeight = Weight at base - Weight at 24 weeks).

Statistical analyses using Scheffe test were carried out as follows:

Changes in hardness values after exposure to the different mouthwashes and the control were compared.

Changes in hardness values for the specimens exposed to mouthwash only were compared with corresponding specimens exposed to mouthwash and brushing.

Changes in hardness values for the specimens of the different materials investigated in this study were compared.

Changes in weight for the test groups were compared with the control group.

Changes in weight for the three materials investigated were compared with each other.

RESULTS

Changes in surface hardness

Exposure to mouthwash only:

The Wallace hardness values for the specimens exposed to mouthwash only are detailed in Table 3.

At 24 weeks, the Wallace values for all Vitremer groups had increased. The greatest increase was observed in specimens exposed to Macleans mouthwash and the lowest increase in the control group. Statistical analysis using Scheffe test

Table 3. *Changes in Wallace hardness values (mm) following exposure to mouthwash only.*

Mouthwash	*Baseline*	*24 Weeks*
	mean s.d.	*mean s.d.*
Vitremer		
Water	0.026 (0.001)	0.030 (0.003)
Plax	0.026 (0.003)	0.037 (0.002)
Listerine	0.023 (0.004)	0.030 (0.004)
Macleans	0.019 (0.001)	0.039 (0.005)
Corsodyl	0.019 (0.002)	0.028 (0.004)
Average	0.023 (0.004)	0.033 (0.006)
Compoglass		
Water	0.027 (0.003)	0.029 (0.002)
Plax	0.022 (0.000)	0.039 (0.003)
Listerine	0.023 (0.002)	0.029 (0.004)
Macleans	0.022 (0.002)	0.038 (0.009)
Corsodyl	0.020 (0.001)	0.032 (0.010)
Average	0.023 (0.003)	0.033 (0.006)
Dyract		
Water	0.026 (0.001)	0.025 (0.001)
Plax	0.025 (0.001)	0.025 (0.001)
Listerine	0.023 (0.002)	0.025 (0.003)
Macleans	0.020 (0.001)	0.029 (0.004)
Corsodyl	0.019 (0.001)	0.031 (0.007)
Average	0.023 (0.003)	0.027 (0.004)

Table 4. *Changes in Wallace hardness values (mm) following exposure to mouthwash and brushing.*

Mouthwash	*Baseline*	*24 Weeks*
	mean s.d.	*mean s.d.*
Vitremer		
Water	0.025 (0.004)	0.034 (0.005)
Plax	0.026 (0.004)	0.039 (0.008)
Listerine	0.022 (0.001)	0.032 (0.005)
Macleans	0.022 (0.002)	0.037 (0.009)
Corsodyl	0.019 (0.001)	0.026 (0.004)
Average	0.023 (0.004)	0.034 (0.008)
Compoglass		
Water	0.022 (0.002)	0.034 (0.005)
Plax	0.023 (0.002)	0.037 (0.011)
Listerine	0.021 (0.001)	0.032 (0.011)
Macleans	0.021 (0.001)	0.042 (0.004)
Corsodyl	0.020 (0.002)	0.029 (0.005)
Average	0.021 (0.002)	0.035 (0.019)
Dyract		
Water	0.025 (0.004)	0.033 (0.003)
Plax	0.022 (0.002)	0.031 (0.005)
Listerine	0.021 (0.002)	0.026 (0.006)
Macleans	0.021 (0.001)	0.031 (0.005)
Corsodyl	0.019 (0.001)	0.027 (0.006)
Average	0.022 (0.003)	0.030 (0.005)

revealed that the increase in the Macleans group was significantly higher than in the control, Listerine and Corsodyl groups ($P<0.05$).

The rank order of the mouthwashes in terms of softening the surface of the specimens of Vitremer was as follows: Macleans > Plax > Corsodyl > Listerine > Water

The Wallace hardness values for all Compoglass groups increased over the test period. The greatest increase was in the Plax group and the control had the smallest increase in hardness values. The statistical analysis, using Scheffe test revealed that the increase in the Plax and Macleans groups was significantly higher than the control ($P<0.05$).

The rank order of the mouthwashes in terms of softening the surface of the specimens of Compoglass was as follows: Plax > Macleans > Corsodyl > Listerine > Water

At 24 weeks the Wallace hardness values for the Dyract control group were reduced while the values for all Dyract test groups had increased. The statistical analysis using Scheffe test revealed that the values for the Corsodyl, Macleans and Listerine groups were significantly different from those for the control group which underwent a decrease in Wallace hardness values in this period ($P<0.05$).

The rank order of the mouthwashes in terms of softening the surface of the specimens of Dyract was as follows: Corsodyl > Macleans > Listerine > Plax > Water

Exposure to mouthwash and tooth brushing:

The Wallace hardness values for the specimens exposed to mouthwash and brushing are detailed in Table 4.

At 24 weeks the Wallace hardness values for all Vitremer groups had increased but there was no significant differences between the groups (Shceffe test, $P>0.05$).

The rank order of the mouthwashes in terms of softening the specimens of Vitremer was:

Macleans > Plax > Water > Listerine > Corsodyl

At 24 weeks the Wallace hardness values for all Compoglass groups had increased. There was no significant difference between the groups (Scheffe test, $P> 0.05$).

The rank order of the mouthwashes in terms of softening the surface of the specimens of Compoglass was as follows: Macleans > Plax > Water > Listerine > Corsodyl

At 24 weeks the Wallace hardness values for all Dyract groups had increased. There was no significant difference between the groups (Scheffe test, $P>0.05$).

The rank order of the mouthwashes in terms of softening the surface of the specimens of Dyract was as follows: Macleans > Plax > Water > Corsodyl > Listerine

For Vitremer and Compoglass, the statistical analysis failed to reveal any significant difference between the specimens exposed to mouthwash and brushing and those exposed to mouthwash only in terms of changes in surface hardness over a 24 week period. However for Dyract the specimens exposed to mouthwash and toothbrushing showed significantly more increase in Wallace hardness values compared to non-brushed specimens in the same period (Scheffe test, $P<0.05$).

Changes in surface hardness, comparison of the three materials:

When the specimens of the restorative materials were exposed to mouthwash only, the Wallace hardness values of the three materials were increased by different amounts. Comparison of hardness values (Wallace value at 24 weeks - Wallace value at base) revealed the following:

ΔWallace Hardness:
C > V >> D overall Scheffe test: (C,V > D, $P<0.05$)

When the specimens of the restorative materials were exposed to mouthwash and tooth brushing , the combined effect resulted in an increase in Wallace hardness values. The hardness values of the three materials investigated were increased by different amounts. Comparison of hardness values revealed the following:

ΔWallace Hardness:
C > V > D overall Scheffe test: (C > D, $P<0.05$)

Weight changes

For Vitremer specimens at 24 weeks the control group gained weight and the Listerine group had the greatest weight loss. There was no significant difference between the groups in terms of weight change ($P>0.05$).

The rank order of the mouthwashes in terms of causing weight loss in the specimens of Vitremer was as follows: Listerine > Plax > Macleans > Corsodyl > Water

For Compoglass, at 24 weeks all groups had lost weight. The least amount of loss was observed in the control group but no significant differences between the groups in terms of weight change ($P>0.05$).

The rank order of the mouthwashes in terms of causing weight loss in the specimens of Compoglass was as follows: Listerine > Macleans > Corsodyl > Plax > Water

For Dyract at 24 weeks all groups had lost weight with the lowest weight loss in the control group, but no significant differences between the groups ($P>0.05$).

The rank order of the mouthwashes in terms of causing weight loss in the specimens of Dyract was: Macleans > Listerine > Corsodyl > Plax > Water

A comparison of the overall amount of material loss at 24 weeks between the specimens of the restorative materials revealed that the rank order of the materials in terms of loosing weight was as follows:

Compoglass > Dyract > Vitremer

The statistical analysis using Scheffe test failed to reveal any significant difference between the materials in terms of weight loss ($P>0.05$). Changes in weight are shown in Table5.

Table 5. *Changes in weight after 24 weeks.*

Mouthwash	*Δ Weight (week 24- baseline)*
Vitremer	
water	-.001 (.002)
Plax	.000 (.000)
Listerine	.000 (.001)
Macleans	-.000 (.001)
Corsodyl	-.001 (.004)
Average	-.000 (.002)
Comoglass	
water	.003 (.003)
Plax	.005 (.004)
Listerine	.006 (.003)
Macleans	.006 (.134)
Corsodyl	.006 (.007)
Average	.005 (.055)
Dyract	
water	.003 (.007)
Plax	.004 (.003)
Listerine	.006 (.016)
Macleans	.007 (.008)
Corsodyl	.005 (.005)
Average	.005 (.008)

DISCUSSION

Resin modified glass ionomer cements (RMGICs) and compomers are hybrids of resin composite and glass ionomer cement systems and can be used as dental restoratives, liners and bases, core build up materials and luting agents. More investigations into properties and performance of these materials in clinical situations are required [12]. The surface of a restorative material can interact with its environment and the surface hardness can change as a result [13]. The present study investigated possible changes in micro-hardness over a relatively short period relative to the anticipated life expectancy of restorations. Furthermore it is acknowledged that there may be materials such as those investigated in the present study over prolonged periods of time in clinical service. The materials investigated in this study were tested at the baseline (48hrs after making and storage in deionised water) and thereafter at 24 weeks exposure to mouthwash and brushing regimes. The specimens may have undergone different patterns of change in surface hardness in the intervals between our testing times. Ellakuria et al [13] revealed in their study that surface hardness of some resin modified and conventional GICs increased in the first several weeks before a decrease in longer term. This phenomenon can be attributed to continuous setting reaction of the materials.

In our study the results of the Wallace surface hardness tests in exposure to mouthwash only showed that all the mouthwashes investigated had a softening effect on the all materials investigated which was greater than that which occurred with water alone. Some workers in the past have reported that the degree of softening of resin composites is in direct relation with the amount of alcohol in the mouthwash [4,5].

McKinney and Wu [14] observed in a study that exposure of composites to alcohol containing liquids for one week caused the polymer matrix to swell and considerable surface damage occurred as a result. Lee et al [15], stated that solvents such as ethanol can penetrate a composite matrix and cause the polymer to expand and the monomer to leach out. Such a theory would explain that the resulting degradation may reduce hardness of these materials. In case of ionic dental materials such as those related to glass-ionomer family, the surface can react with various solutions by ionic exchange and possible damage can occur as a result. The nature of the storage medium is therefore important for these materials [16].

In the present work, it was found that some mouthwashes had a significant softening effect on the specimens of the materials investigated. Although all the mouthwashes investigated in the study contained some alcohol (>7%), no direct relation was observed between alcohol content and the degree of softening. In addition, the degree of softening was not shown to be in direct relation with the level of acidity of the mouthwash. For Compoglass, both Macleans (18.5% alcohol, pH 5.79) and Plax (8% alcohol, pH 7.14) had significantly greater softening effects than water. With Dyract, Macleans and Corsodyl (7.6% alcohol, pH 5.32) both had significantly greater softening effect than water. For Vitremer, Macleans caused significant softening of the specimens compared to other groups. The interesting finding of this study was that Listerine which was the Mouthwash with highest alcohol content and lowest pH did not cause significant softening for any of the materials investigated. This finding corresponds with the results in a study by Gurgan et al [17] who shown that both alcohol-containing and alcohol free mouthrinses can affect the hardness of some light-cured restorative materials.

Our findings are also similar to those of Aliping-McKenzie et al [9] who revealed that when storing specimens of some glass-ionomer and compomers in acidic beverages, the influence of the composition of the storage media on surface hardness was greater than simple consideration of pH values.

The results of the present study suggest that some other components or factors in addition to alcohol and pH or combination of factors might have been responsible in causing softening of the specimens. Further work would be required to investigate effects of such components or factors.

When the specimens of the restorative materials were exposed to mouthwash and brushing, a softening effect was observed in all the groups. However, no significant differences were observed between the test groups or between the test groups and the control group for any material. The reason for these findings might have been that the effect of brushing became the dominant feature by removing softened material from the surface and masked the effects of the mouthwashes. However brushing itself may be associated with a softening effect since, on average the changes in surface hardness of the materials investigated in the specimens exposed to mouthwash and brushing was greater than those exposed to mouthwash only. Comparison between the materials investigated in terms of changes in surface hardness revealed that mouthwashes with or without adjunctive tooth brushing tended to cause less softening for Dyract specimens ($P<0.05$ in mouthwash only specimens) compared with the other two materials. This results were supported by Mante et al [18] were they revealed that a selection of light cured glass ionomers behaved differently when exposed to a variety of test solutions. They attributed the differences in behaviour to different composition and setting reactions of these materials.

Weight changes

Restorative dental materials can take up fluid or dissolve in their environment. Fluid sorption can have both beneficial and detrimental effects [19]. The present study is not specifically designed to assess sorption and solubility of the materials investigated.

However changes in weight of the specimens were investigated in search for possible clues into behaviour of these materials when exposed to mouthwash and brushing regimes and ideas for further research. At 24 weeks the specimens of Vitremer gained weight. The changes in weight for the Compoglass and Dyract specimens indicated loss of material from these specimens. The reason for weight gain in the specimens of Vitremer is considered to have been related to water uptake. All the specimens probably absorbed water, but the uptake by the specimens of Vitremer differed from the uptake by specimens of Compoglass and Dyract in that it exceeded any loss in weight associated with loss of material.

A study by Kanchanavasita et al [19] stated that difference in sorption characteristics of RMGICs was related to the difference in their composition. Also the degree of polymerisation and water sorption was dependent on the proportion of resin component in the cement. In their study restorative RMGICs including Vitremer absorbed more water than the liner/base versions. In comparing their results with those of Braden and Clarke [20], they reported that water uptake of specimens of RMGICs they investigated, was greater than some microfine composites.

In our study, for all the materials investigated, the control group had the least weight loss after 24 weeks although not statistically significant ($P>0.05$), this finding may indicate that mouthwashes investigated in this study possibly contributed to dissolving and loss of material from the specimens. Further studies with more specific methods are required to investigate the mechanism and the amount of substance loss as well as fluid uptake of these materials when exposed to mouthwash and tooth brushing.

CONCLUSION

The findings of the present study indicate that exposure to the mouthwashes investigated in this study may be found to result in softening and loss of substance of some restorative materials.

Given the increasing variety and use of mouthwashes, further research is indicated to better understand the effect of mouthwashes, with and without brushing on the surfaces of different restorative materials.

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