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The Weight Change of Various Light-Cured Restorative Materials Stored in Water

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Abstract

This study investigated weight changes of seven different light-cured composite restorative materials, one polyacid glass ionomer compomer, and one light-cured glass-ionomer cement following short-term and long-term storage in water. Two packable composites, three universal (hybrid) composites, one microglass composite, one polyacid glass ionomer resin composite (compomer), one microhybrid low-viscosity (flowable) composite, and one light cured glass ionomer composite cement were evaluated in this study. The weight changes of these specimens were measured daily (short-term storage), and they were measured after six weeks (long-term storage) using an electronic analytical balance. A significant difference was found in Ionoliner, Dyract AP, Opticor flow, Charisma, and Solitare 2, but no significant difference was found in the others (Filtek Z 250, Filtek P60, TPH Spectrum, and Valux Plus). Weight change showed a tendency to increase with the time of water storage. The greatest weight change occurred in light-cured glass ionomer composite cement (Ionoliner), which is followed in order by the weight changes in Dyract AP, Opticor Flow, Charisma, Solitare 2, Filtek Z250, Filtek P60, TPH Spectrum; Valux Plus had the least amount of change.

Keywords: Weight change, light-cured, glass-ionomer cements, composite, water storage

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Introduction

The attractiveness of tooth-colored restorations has stimulated research in this particular area of operative dentistry during recent years. Patients are increasingly demanding esthetic restorations not only in the anterior region but also for posterior teeth. Various glass ionomer cements and composites have been used clinically because of their beneficial properties, such as adhesion to enamel and dentin[1-3] and fluoride release.[4, 5]

Recently, a new generation of tooth-colored restorative materials such as flowable (low-viscosity) composites, packable composites, compomers, and glass ionomers became available. Flowable composites have lower volumes of filler than the conventional composite resins. As a result, these materials are less viscous which makes them a good choice for pit and fissure restorations. In 1999 packable or condensable composites were introduced to the profession as an amalgam substitute. They contain higher filler content and exhibit a more uniform filler distribution. This results in a stiffer consistency with improved handling characteristics that make it easier to condense into cavity preparations.[6]

However, problems associated with these restorative materials have also been demonstrated. These restorative materials are continually bathed in saliva, and water absorption for some materials is inevitable. Water absorption by a material is the amount of water adsorbed through the exposed surface and into the body of the material. For resin-based composites, water absorption may induce weakening of the resin matrix and breakdown of the resin/filler interface.[7-9] It is also to be expected absorption of water will be accompanied by hygroscopic expansion, which may be able to compensate the effects of polymerization shrinkage and to relieve stress.[10, 11] To overcome such problems, various light-cured glass-ionomer cements and composites have been developed. They are hardened by light-curing, dual curing reactions, and by normal acid-base reactions. It is known water sensitivity of cements appreciably decreases quickly when exposed to light compared with the acid-base reaction of conventional glass-ionomer cements.[1, 12-14] This is also true of composite resins, including those with acid-base setting reactions. Water absorption causes degradation of the physical properties through the dissolution of the components or by hydrolysis of the cement matrix.[5, 15, 16]

The present study investigated weight changes of eight light-cured composites and one light cured glass ionomer cement by short-term and long-term storage in water.

Materials and Methods

The light-cured glass ionomer cement, polyacid glass ionomer resin composite (compomer), and composite resin materials included in the study and their composition according to manufacturers' data are shown in Table 1. The following materials were used in the study:

- Two packable composite resins: Solitare 2 (Group A), Filtek P60 (Group B)
- Three universal composites: Filtek Z250 (Group C), TPH Spectrum (Group D), Valux Plus (Group E)
- One microglass composite: Charisma (Group F)
- One polyacid glass ionomer resin composite (compomer): Dyract AP (Group G)
- One microhybrid low-viscosity composite: Opticor flow (Group H)
- One light cured glass ionomer cements: Ionoliner (Group I)

A specimen from each of the nine restorative materials was placed into a plexiglass mold (6 mm in diameter and 2 mm in depth) and compressed between two polyethylene covered glass slabs to remove voids and excess material. Specimens of each material were made by incrementally placing the material in this mold in 3 stages. They were light-cured for

Table 1. Materials used.

Material (Groups)	Batch	Manufacturer	Shade	Composite Type	Matrix
Solitaire2 (Group A)	030027	Hereaus Kulzer Hanau,Germany	A_3	Packable composite	BaAlF silikatglas, Silissiumdiokcite
Filtek P60 (Group B)	OCB 2003-05	3M, St Paul MN, USA	A_3	Packable composite	BIS-GMA, UDMA BIS-EMA
FiltekZ250 (Group C)	OEL 2003-02	3M, St Paul MN, USA	A_3	Universal composite	BIS-GMA, UDMA BIS-EMA
TPH Spectrum (Group D)	0101061	Dentsplay, Caulk, USA	A_3	Universal composite	BIS-GMA,BIS-EMA
Valux Plus (Group E)	OHL 2003-02	3M, St Paul MN, USA	A_3	Universal composite	BIS-GMA,TEGDMA
Charisma (Group F)	030024	Hereaus Kulzer Hanau,Germany	A_3	Microglass composite	BIS-GMA,BaAlF Glass, Silissiumdiokcite
Dyract AP (Group G)	00622	Dentsply De Tray,Kontanz,UK	A_3	Polyacid glassionomer compomer	UDMA TCB resin
Opticor flow (Group H)	578295	Spofa Dental Frankfurt, Germany	A_3	Microhybrid low-viscosity composite	UDMA,TEGDMA
Ionoliner (Group I)	00659	P_D Dental, Alterwalde, Germany	A_3	Light cured glass ionomer composite cement	BIS-GMA, Diurethane dimethacrilate

40 seconds after each increment by use of a light curing unit (Hilux Expert, Benlioglu Dental, Ankara, Turkey). The light-cured unit was calibrated before polymerizing the composites, and the intensity of the curing light source was 600 Mw/cm^2 as measured by a light meter (Hilux Dental Curing Light Meter, Benlioglu Dental, Ankara, Turkey). The diameter of the light tip was 1 cm. Following light curing, the specimens were removed from the molds and finished with Sof-Lex discs (3M ESPE, St. Paul, MN, USA) coarse through fine. The specimens of each group were immersed in a sealed glass tube filled with 50 mL of distilled water and placed in an incubator at 37°C for six weeks. Every day specimens were removed from the water and weighed after 1 minute. The weights of the specimens were measured using an electronic analytical balance (Metter PE600, Switzerland) every day for six weeks. After weighing, the specimens were transferred to new sealed tubes filled with 50 mL of distilled water.

The results of total weight changes after six weeks (42 days) were analyzed by the Friedman Test, and the differences between restorative materials were analyzed by the Kruskal-Wallis Analysis of Variance. All hypothesis testing was performed with SPSS for Windows software (v11.0, SPSS, Chicago, IL, USA) at a 95% level of confidence.

Results

Table 2 presents the results of the arithmetic means, standard deviations, and minimum and maximum weight of the light-cured restorative materials tested.

The Friedman Test evaluated the changes in time (daily). Table 3 presents the results of the Friedman Test. Significant differences were found in Groups I, G, H, F, and A during the 42 day period ($p<0.05$), but no significant difference was found in Groups C, B, D, and E ($p>0.05$).

The weight change of Group I was the greatest, followed in order by those of Groups G, H, F, and A; Groups C, B, D, and E demonstrated much less change after six weeks water immersion.

Table 2. The results of the arithmetic means, standard deviations (Std D), and minimum and maximum weight (g) of the light cured restorative materials tested.

Groups	N	Mean	Std D.	Minimum	Maximum
A	9	0.20	0.0042	0.19	0.22
B	9	0.20	0.0014	0.19	0.22
C	9	0.19	0.0076	0.18	0.21
D	9	0.20	0.0048	0.19	0.21
E	9	0.20	0.0010	0.20	0.21
F	9	0.19	0.0086	0.18	0.22
G	9	0.20	0.0073	0.16	0.21
H	9	0.17	0.0081	0.16	0.20
I	9	0.16	0.0067	0.15	0.22

Table 3. The results of the Friedman Test.

Groups	Chi-square Xs	P
A	40.522	0.001*
B	21.006	0.178
C	19.116	0.263
D	9.726	0.881
E	10.141	0.859
F	29.339	0.022*
G	42.441	0.001*
H	36.392	0.003*
I	31.825	0.011*

* significant ($p<0.05$)

Figure 1 shows the weight change of specimens after long-term water storage, while Figure 2 shows the rates of weight changes in all of the specimens during the test period.

There were no significant differences noted among the materials ($p>0.05$) according to the Kruskal-Wallis Test. As a result, the difference between the two groups was not compared.

Discussion

Weight change in water was evaluated because saliva is a dilute fluid consisting of 99% water. The concentrations of dissolved solids (organic and inorganic) are characterized by wide variations, both between individuals and within a single individual. Due to this variation, water was used for a test standard.

Water absorption causes the polymer portion of the composite to swell and promotes diffusion and desorption of any unbound monomer. Water potentially plasticizes the composite as well as chemically degrades the matrix into monomer or other derivatives.[17, 18]

The water absorption of glass-ionomer cements is difficult to compare with that of resin composites, since light-cured glass-ionomer cements are hydrophilic materials and water absorption and dehydration occur readily. Therefore, the optimal time for measuring water absorption is difficult to determine. As these cements naturally contain varied amounts of water, water solubility values cannot be determined by weight changes during water immersion alone, and the determination of true water absorption values is extremely difficult. As a result of this phenomenon, there have been few reports concerning water absorption of glass ionomer cements and composite resins.[15, 19-24] In the present study only one glass ionomer cement was used and significant change was found.

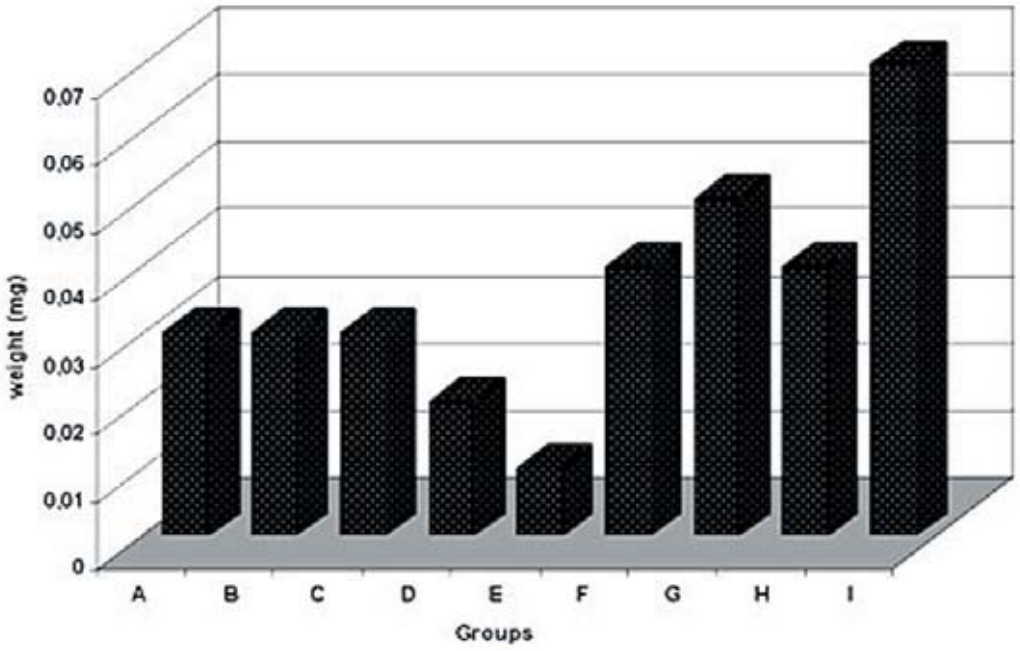


Figure 1. The weight of changes of materials tested after six weeks.

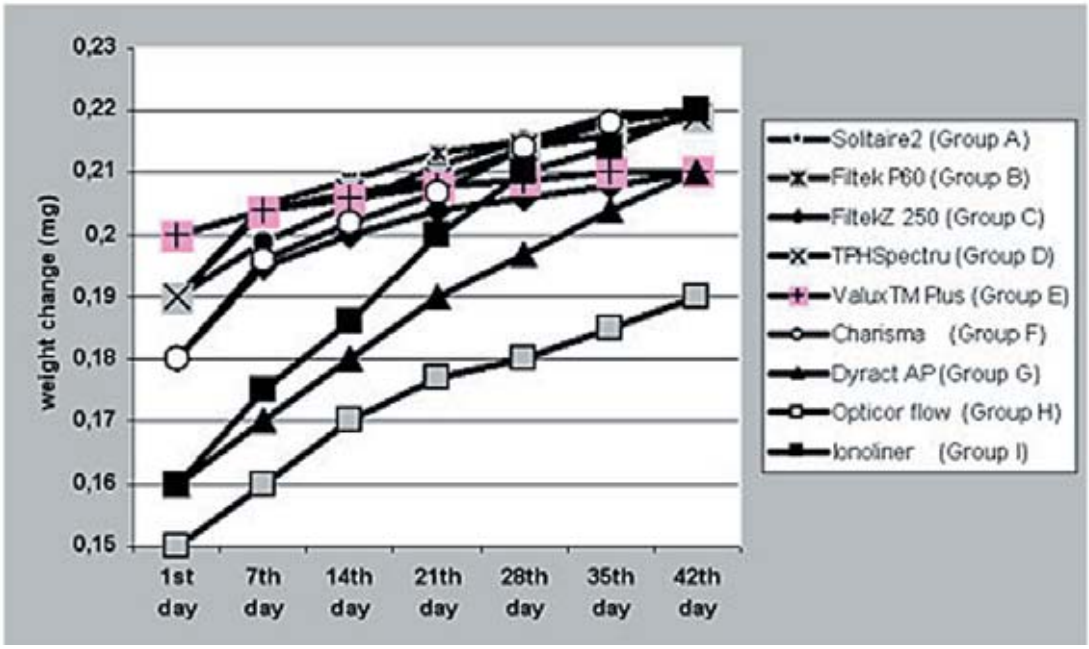
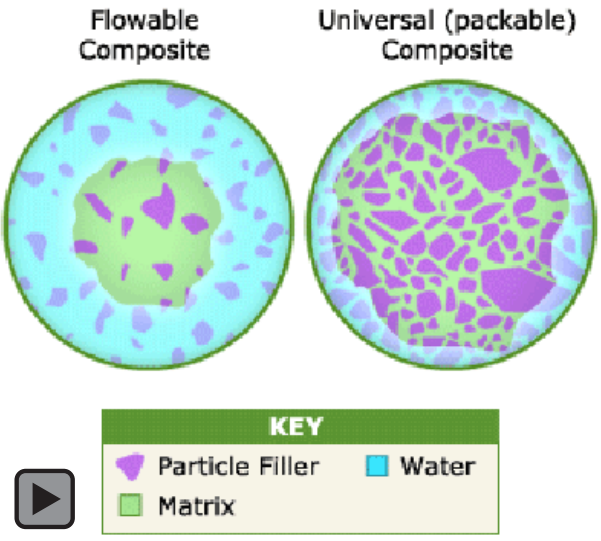


Figure 2. Rate of change in weight according to the first day of every week for six weeks.

In this study the weights of materials were measured everyday for the six weeks. When specimens of each material were immersed in water, increases in these weights by water absorption and decreases in weight by dissolution of the material into water occurred simultaneously. Water absorption is the amount of water that a material absorbs over time per unit of surface area or volume. When a restorative material absorbs water, its properties change and, therefore, its effectiveness as a restorative material is usually diminished. All of the available tooth-colored materials exhibit some water absorption.[20]

Iwami et al.[17] showed the water absorption of resin modified glass ionomers was greater than those of polyacid-modified composite resins. In this study glass ionomer composite cement demonstrated significant weight change. The difference between the first day and the forty-second day was much more than the others ($p<0.05$). Color is known to be related to water absorption.[1, 16] In this study the color of restorative materials remained the same (A3).

Microhybrid composite contains colloidal silico particles as the inorganic filler (35 to 60 wt%). The larger ratio of resin to filler results in greater water absorption, a higher coefficient of thermal expansion, and a decreased modulus of elasticity. Composites consisting of small particle size results in a smooth, polished surface in the finished restoration that is less receptive to plaque or extrinsic staining. However, because of the greater surface area per unit volume of these micro particles, these materials cannot be as heavily filled. Because these types of composites contain considerably less filler than do hybrid composites, some of their physical and mechanical characteristics are somewhat inferior. There are three kinds of filler particles in the universal (hybrid) composite materials in this study. Most modern hybrid fillers consist of colloidal silica and ground particles of glass containing heavy metals; the total filler content being approximately 70 to 77 wt%. The best physical and mechanical properties are identified with this category of composites. With the increased filler content, there is improvement in virtually all properties.[6, 19-21] Materials with higher filler content exhibit lower water absorption values.[20] Thus, one factor related to the water absorption may be related to the particle sizes and filler content of the restorative materials. Flowable composite has an average particle size of 0.04-1.00 μm and less filler than universal composites (48 to 65% wt); universal composite has an average particle size ranging from 0.04 μm to 3 μm and the highest filler component (70 to 77 %wt).[6, 20] In this study universal composites demonstrated the least weight change because this material has a small particle size and it contains the highest filler content.



When a material is selected for clinical use, the amount of water absorption should be considered as well as adhesion to enamel and dentin, fluoride release, and polymerization shrinkage. Ideally, these biomaterials applied in the mouth should not be affected and changed by environmental factors.

Conclusion

In this study water absorption increased steadily for all materials. Weight change showed a tendency to increase with the time of water storage, and it was greatest for light cured glass ionomer composite cement (Ionoliner), followed in order by Dyract AP, Opticor Flow, Charisma, Solitare 2, Filtek Z 250, Filtek P60, TPH Spectrum; Valux Plus showed the least amount of change (Groups I> G> H> F> A> C> B> D> E).

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