Water Sorption and Water Solubility of Various Restorative Materials

FARKLI RESTORATİF MATERYALLERİN SU EMİLİMİ VE ÇÖZÜNÜRLÜĞÜ

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Abstract

Objective: The objective of present study was to evaluate the water sorption and solubility of various restorative dental materials.

Material and Methods: Six commercial restorative materials were selected: One resin-modified glass ionomer cement (Vitremer), one polyacid-modified composite resin (Hytac Aplitip), one conventional glass-ionomer cement (Ionofil), and three light-cured composite resins (Z100, Ecusit System, Filtek A110). All specimens were manipulated according to the manufacturers' instructions and then subjected to water sorption and solubility tests.

Results: Filtek A110 and Hytac Aplitip had the lowest water sorption values, without statistical difference between them. Vitremer followed by Ionofil were the materials with the highest water soption values. Hytac Aplitip showed the lowest water solubility values. Ionofil was the material with the highest mean water solubility value.

Conclusion: It is apparent that the water sorption and solubility of restorative materials are product dependent.

Key Words: Restoratif materials,
water sorption and solubility

Özet

Amaç: Bu çalışmanın amacı farklı restoratif materyallerin su emilimi ve çözünürlüğünü değerlendirmektir.

Gereç ve Yöntemler: Çalışma için, bir rezinle modifiye cam iyonomer siman (Vitremer), bir poliasitle modifiye kompozit rezin (Hytac Aplitip), bir geleneksel cam iyonomer siman (Ionofil) ve üç ışıkla sertleşen kompozit rezin (Z 100, Ecusit System, Filtek A110) olmak üzere toplam altı restoratif materyal seçildi. Tüm örnekler imalatçı firmanın önerilerine göre hazırlanarak su emilimi ve çözünürlük testleri uygulandı.

Bulgular: Filtek A110 ve Hytac Aplitip en düşük su emilimi değerine sahipti ve aralarında istatistiksel olarak bir fark yoktu. Ionofil ve onu takip eden Vitremer ise en yüksek su emilim değerine sahip olan materyallerdi. Hytac Aplitip en düşük çözünürlük değerine sahip materyaldi. Ionofil ise en yüksek çözünürlük değerine sahip materyaldi.

Sonuç: Restoratif materyallerin su emilimi ve çözünürlüğü üretim aşamasındaki farklılıklarla ilgilidir.

Anahtar Kelimeler: Restoratif materyaller,
su emilimi ve çözünürlüğü

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The water sorption and solubility of dental restorative materials are of considerable clinical importance and can not be overemphasized. The solubility of restorative materials influences both their rate of degradation and their biological compatibility due to the nature of eluents.[1]

Glass ionomer cements introduced to the dental profession in 1972 by Wilson and Kent have been used clinically because of their beneficial properties such as adhesion to enamel and dentin and fluoride release.[2-6] However, several problems have also been demonstrated.[7]

To overcome the problems of early low mechanical strengths and moisture sensivity associated with conventional glass ionomer cements, resin modified glass ionomers (RMGIC) and polyacid-modified resins (PMCR) have recently been developed. Although it is thought that the occurrence of the photochemical reaction leads to a reduction of early moisture sensitivity, studies on the effects of storage in water have indicated that the physical properties of these materials change markedly on exposure to moisture.[8] Such changes

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in properties can be brougth about by water sorption or chemical reactions as a consequence of water sorption.[9]

On the other hand, light-polymerized composite resins have much lower solubility, but may present with greater dimensional changes due to polymerization shrinkage or water sorption. Water sorption by composite materials is a diffusion controlled process, and the water uptake occurs largely in the resin matrix.[10] The water sorbed by the polymer matrix could cause filler-matrix debonding or even hydrolytic degredation of the fillers, and may affect composite materials by reducing their mechanical properties.[11,12]

The different mechanisms occur; the first is the uptake of water producing an increased weight and the second is the dissolution of materials in water, leading to a weight reduction of the final conditioned samples.[13]

The objective of present study was to evaluate the water sorption and solubility of various restorative dental materials.

Materials and Methods

As shown in the Table 1, the following materials were evaluated in this study: One resin-modified glass ionomer cement (Vitremer), one polyacid-modified composite resin (Hytac Aplitip), one conventional glass-ionomer cement (Ionofil), and three light-cured composite resins (Z100, Ecusit System, Filtek A110).

Five discs (10 mm in diameter, 2 mm in thickness) of each material were prepared using stainless steel split rings. The mixed material was packed into the ring, pressed between two glass slides. The light-cured materials were irradiated for recommonded exposure time from both sides with a visible-light curing unit (Hilux, Benlioğlu Dental Inc. Ankara/Turkey), while the conventional glass-ionomer cement was left for 5 minutes. This was done until the whole specimen had been irradiated for the recommended exposure time. Immediately after irradiation, the specimens were removed from their moulds and placed in an oven maintained at 37ºC for 15 minutes. The specimens were then taken out from the oven and finishing of periphery was carried out using 1000 grit abrasive paper on a non-rotating grinding table. The specimens were rotated so that only the periphery was abraded. The specimens were transferred to a desiccator maintained at 37 ± 1ºC. After 22 hours the specimens were removed and stored in a desiccator maintained 23 ± 1ºC for 2 h and then weighed to an accuracy. This cycle was repeated until a constant mass (M1) was obtained. The thickness of the specimen at the centre of the specimen and the diameters at four equally spaced points on the circumference was measured. The volume (V) was calculated in cubic milimetres. The specimens were then suspended in water at 37 ± 1ºC for 7 days. The specimens were then removed, washed with water, dried by blotting with absorbent paper and waved in air for 15 s. Specimens were weighed 1 min. after removal from the water. The mass (M2) was recorded. After this weighing, the specimens were reconditioned to a constant mass (M3) in desiccators using the cycle described earlier. The values for water sorption and solubility, Wsp and Wsl respectively, in mg/mm^3, for each of the five specimens were calculated using the following equations:

$$Wsp = \frac{M2-M3}{V} \qquad Wsl = \frac{M1-M3}{V}$$

Table 1. Restorative dental materials evaluated in this study.

Material	Manufacturer
Filtek A110	3M Dental Products, St. Paul, MN, USA.
Ecusit System	DMG, Hamburg, Germany.
Z100	3M Dental Products, St. Paul, MN, USA.
Hytac Aplitip	ESPE, Seefeld, Oberbay, Germany.
Vitremer	3M Dental Products, St. Paul, MN, USA
Ionofil	VOCO, Cuxhaven, Germany.

Results

The mean values for water sorption and solubility for the various product types and usage are presented in Table 2. The data were subjected to one-way ANOVA, Duncan’s test at a 0.05 significance level.

Table 2. Mean water sorption and water solubility values.

Water sorption (mg/mm^3)			Water solubility (mg/mm^3)		
Material	**Mean**	**SD**	**Material**	**Mean**	**SD**
Hytac a	6.0	4.41	Hytac a	0.7	2.78
Filtek a	6.0	3.53	Filtek b	1.1	2.42
Ecusit b	7.4	5.85	Z100 b	1.2	1.52
Z100 c	9.2	1.09	Ecusit c	2.7	5.25
Ionofil d	16.0	9.02	Vitremer d	6.0	1.22
Vitremer e	24.0	3.80	Ionofil e	10.8	1.74

One-way ANOVA showed that water soption was different for tested materials ($F= 9.507$; $p< 0.001$). Filtek A110 and Hytac Aplitip showed the lowest water sorption values, without statistical difference between them, followed by Ecusit System and Z100, with a significant difference between them. Vitremer followed by Ionofil were the materials with the highest water soption values.

Water solubility also showed differences within groups ($F= 9.768$; $p< 0.001$). Hytac Aplitip showed the lowest water solubility values; followed by Filtek A110, Z100 and Ecusit System, without significant differences between Filtek A110 and Z100. Ionofil was the material with the highest mean water solubility value, followed by Vitremer.

Discussion

Several data for water sorption and solubility for restorative materials have been published. However, the water sorption and solubility of glass ionomer cements are difficult to compare with that of resin composites, since conventional and light-cured glass-ionomer cements are hydrophilic materials and water sorption and dehydration occur easily.[14] Generally the amount of water sorption and solubility of glass ionomer cements are greater than that of resin composites and PMCR.[14,15] RMGICs, like conventional glass-ionomer cements, contain water as an integral part of their structures, in addition to resin matrix. The water sorption mainly depends on the resin composition.[16] Hydrophilic constituents such as hydroxyethyl methacrylate (HEMA) clearly increase water sorption values,[17] as observed for Vitremer. In this study, Vitremer and Ionofil were the materials that showed the highest values of water sorption and solubility (Table 2). The method of mixing may generate air voids which may accelerate the water sorption and solubility of this cement.[12,18] This condition may be responsible for the variation of water sorption and solubility of Vitremer when compared to Ionofil.

Hytac was the material showed the lowest values of water sorption and solubility. The explanation for the variable feature of compomers may depend on the degree to which each material has been modified with resin-like components or poly-acid-like components. For instance, the manufacturers could replace only a small percentage of the carboxylic acid groups on the polyacrilic acid with methacrylate groups resulting in a small amount of covalent (resin-like) crosslinking in the polymerization. A material of this type would consist of a matrix largely cross-linked by ionic bonding and would exhibit properties similar to traditional glass ionomer. If a large percentage of carboxylic groups were substituted with methacrylate groups the material would polymerize largely as a resin by formation of free radicals and subsequent crosslinking by formation of covalent bonds.[19] Hytac contains Bis (meth) acrylate. The addition of this resin may be the reason for the behavior of this material being close to resin composites.[20]

Several factors contribute to the process of elution from dental composites: unreacted monomers, chemistry of the solvent and size and chemical composition of the elutable species.[21] The release of these components may influence the initial dimensional change of composite, and the clinical performance.[13] Within the same group of resin system, the water sorption and solubility may depend on the filler content.[16] The interfaces between the filler particles and the polymer matrix accommodate any amounts of water that was absorbed.[22,23] In this study, Filtek A110 microfilled composite resin which has lower filler content showed lower water sorption and solubility when compared to other resin composite specimens. This variation between materials using the BIS-GMA resin as base may be the result of using different proportions of diluent resin.[24] The second possible cause for differences in water sorption and solubility relates to the degree of cure of the polymer network. Inadequate polymerization of dental composite probably increase the solubility and may also increase water sorption, since the network will be less tightly cross-linked.[24] The third factor is the variation in the susceptibility of composite materials to elute elements from filler particles and other degradation products.[25] The dislodgement of filler particles has been corralated to the causes of composite wear.[22]

Conclusions

It is apparent that the water sorption and solubility of restorative materials are product dependent. This may be attributed to the difference in formulations, the generic type of resin and polyacid used. One clinical implication is the importance of observing the powder to liquid ratio.

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