ORIGINAL ARTICLE

SORPTION AND SOLUBILITY OF BIODENTINE NEW RESTORATIVE MATERIAL

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ABSTRACT

Since water sorption of any restorative material can result in expansion of the restoration, which would be detrimental to the restoration, it is important to limit the amount of water absorbed. In addition, solubility of restorative materials is of concern, since inorganic ions can leach into the surrounding environment resulting in breakdown of the restoration. The aim of this study was to measure and compare water sorption and solubility values of Biodentine new direct restorative material with other conventional restorative materials.

Three direct restorative materials were selected for this study: Biodentine (Septodont,France) , composite(master fill), GIC(Kemdent, UK). Ten specimens were prepared from each restorative material (n=10) using a stainless steel mold of 15 mm in inner diameter and 1 mm in thickness. Each restorative material was prepared according to manufacturer's instructions. Water sorption and solubility of each specimen was calculated by weighting the samples before and after immersion in water for 15 days and desiccation. Data were analyzed with one way ANOVA and t-test at (0.05) level of significance.

One way ANOVA that, there were statistically significant differences between the tested groups ($P \leq 0.05$) in both sorption and solubility values.

Within the limit of this study, Biodentine restorative material showed an intermediate sorption and solubility values between Kemdent GIC restorative and Master Fill composite and due to this result the material (Biodentine) is not recommended to be used as a final direct restorative material but recommended to be used as a base only.

Key Word: *biodentine, composite, GIC, solubility, sorption.*

INTRODUCTION

Water sorption by composite materials is a diffusion-controlled process, and the water uptake occurs largely in the resin matrix.[1] The water sorbed by the polymer matrix could cause filler-matrix debonding or even hydrolytic degradation of the fillers[2] and may affect composite materials by reducing their mechanical properties.[3,4] The hydrolytic degradation is a result of either the breaking of chemical bonds in the resin or softening through the plasticizing action of water.[5] When resin samples are immersed in water, some of the components, such as unreacted monomers or filler, dissolve and are leached out of the samples. This results in loss of weight and can be measured as solubility or leaching.[6] 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.[7] The release of these components may influence the initial dimensional change of composite[8], the clinical performance[9], the aesthetic aspect of the restorations[10] and the biocompatibility of the material.[7] Sorption and solubility are affecting composite restorations by two different mechanisms; the first is the uptake of water producing an increased weight and the second is the dissolution of materials (fillers or monomers) in water, leading to a weight reduction of the final conditioned samples.[9]

METHODOLOGY

Three direct restorative materials were selected for sorption and solubility in this study: Biodentine (Sept-

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odont, St. Maurdes-Fossés, France), composite (Master fill, Biodinamica, Portugal), GIC (kemdent, UK) forming three experimental groups (n=10). Each specimen disc was 15 mm in diameter and 1 mm thick and was prepared using a stainless steel mould. The material was prepared in accordance with the manufacturer's instructions, by filling the mold with the material using a plastic spatula to condense, and covering it with a piece of polyester transparent strip which was placed over the mould and finally covered by a glass slide. After specimens setting, they were removed from the mold and any excess material was removed both sides. The specimens were transferred to an air oven (memmert, Gmbh, D-91126 schwabach, Germany) and dried for 2 hours at 37C°. Then the specimens were transferred to the desiccators containing silica gel, freshly dried for 2 hours at 20C°. The specimens were weighed using an analytical balance (Precisa, TYP 205A, made in Switzerland) to an accuracy of ± 0.1 mg. This cycle was repeated until a constant mass (m°) was obtained. The specimens were immersed in distilled water and maintained at 37C° for 15 days. After that time, the specimens were removed, washed with water, surface water blotted away until free from visible moisture, and waved in the air for 15, then finally weighed 1 minute after being removed from the water. This mass (m1) was recorded. The specimens were placed in the desiccator using the same cycle as described above but done at 58C° temperature to obtain (m2). This cycle was repeated until constant mass was obtained. These steps were carried out to evaluate water sorption (A) and water solubility (S) according to Oysaed & Ruyter[11] formula: A=m1−m2/V and S=m°−m2/V, where m° is the sample weight before immersion, m1 is the sample weight after immersion and m2 is the sample weight after immersion and desiccation. V is the volume of the specimen in cubic millimeters. Data were analyzed with one way ANOVA and t-test at (0.05) level of significance.

RESULTS

Mean sorption and solubility values in µg/mm3, standard deviations (SD) of Biodentine, Composite and GIC restorative are presented in Tables 1 and 2 respectively. All the tested materials demonstrated different degree of sorption and solubility. Kemdent GIC restorative material showed the highest means values in sorption and solubility, followed by Biodentine and Master Fill composite which exhibited the least sorption and solubility mean values as shown in Fig 1. One way ANOVA that, there were statistically significant differences between the tested groups ($P \leq 0.05$) in both sorption and solubility values as shown in Tables 3 and 4 respectively. Further analysis of the data was needed to examine the differences between different pairs of groups using the (t-test analysis) and revealed that, there were also statistically significant differences ($P \leq 0.05$) between each pair of groups tested separately in both sorption and solubility values as shown in Tables 5 & 6 respectively.

DISCUSSION

"Biodentine" calcium silicate based product which became a well known dental restorative material in a variety of dental treatments since 2009 and that was specifically designed as a "dentine replacement" material. Biodentine has a wide range of applications including endodontic repair (root perforations, apexification, resorptive lesions, and retrograde filling material in endodontic surgery) and pulp capping and can be used as a dentine replacement material in restorative dentistry. The material is actually formulated using the MTA-based cement technology and the improvement of some properties of these types of cements, such as physical qualities and handling.[12]

ADA Specification No. 27[13] requires that "the water sorption of all materials shall be less than or equal to

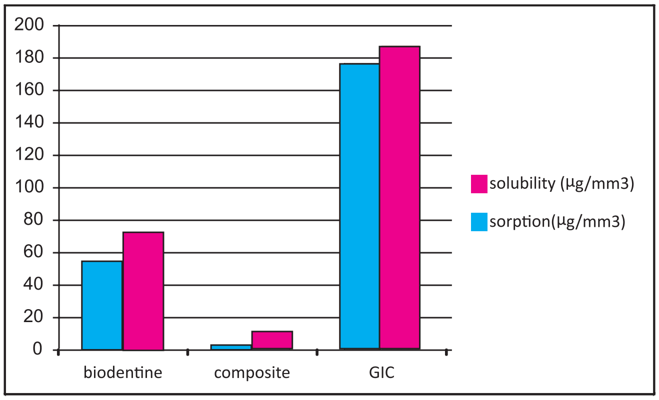

Fig 1: Showing water sorption and water solubility means in µg/mm3

TABLE 1: MEANS AND STANDARD DEVIATIONS OF SORPTION VALUES OF BIODENTINE, COMPOSITE AND GIC RESTORATIVE MATERIAL IN µG/MM3

	N	Mean	Std. Deviation
Biodentine	10	71.9038	24.64229812
Composite	10	10.75718	2.83714002
GIC	10	186.89464	126.0216167

TABLE 2: MEANS AND STANDARD DEVIATIONS OF SOLUBILITY VALUES OF BIODENTINE, COMPOSITE AND GIC RESTORATIVE MATERIAL IN µG/MM3

	N	Mean	Std. Deviation
Biodentine	10	54.011550	35.8175343
Composite	10	2.348250	1.9208487
GIC	10	176.18731	127.2260800

TABLE 3: ONE WAY ANOVA TEST FOR SORPTION VALUES

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	159954.024	2	79977.012	14.544	.000
Within Groups	148470.661	27	5498.913		
Total	308424.685	29			

TABLE 4: ONE WAY ANOVA TEST FOR SOLUBILITY VALUES

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	159386.772	2	79693.386	13.683	.000
Within Groups	157257.548	27	5824.354		
Total	316644.320	29			

TABLE 5: T-TEST OF THE DIFFERENCES BETWEEN DIFFERENT PAIRS OF GROUPS IN SORPTION TEST

		Paired Differences	T	df	Sig. (2-tailed)
		95% Confidence Interval of the Difference			
		Upper			
Pair 1	Biodentine - Composite	79.0060798	7.9828	9	.000
Pair 2	Composite - GIC	-64.4066287-	-4.355	9	.001
Pair 3	GIC - Biodentine	208.3293694	-2.645	9	.027

TABLE 6: T-TEST OF THE DIFFERENCES BETWEEN DIFFERENT PAIRS OF GROUPS IN SOLUBILITY TEST

		Paired Differences	T	df	Sig. (2-tailed)
		95% Confidence Interval of the Difference			
		Upper			
Pair 1	Biodentine - Composite	77.2881530	4.561	9	.001
Pair 2	Composite - GIC	-82.7731578-	-4.318-	9	.002
Pair 3	GIC - Biodentine	223.2859133	2.733	9	.023

40 µg/mm3" and "the solubility of all materials shall be less than or equal to 7.5 µg/mm3 within a seven day period of water storage" Resin composites indicated as restorative materials must also comply with ISO 4049 for a maximum value of 40 µg/mm3 for water sorption and 7.5 µg/mm3 for water solubility within a seven day period of water storage.[14] The water sorption and solubility values obtained in this study for Master Fill composite is remarkably within the limits of ADA and ISO guidelines, even for a 15-day storage time which is double than the recommended time (Fig 1). This could be attributed to its relatively high total inorganic filler volume of 79%. The amount and the type of inorganic filler influence the water sorption and solubility of composites, by decreasing the volume of polymers available for water sorption. Moreover, the composite resins containing filler based on silica or quart are considered inert in water.[15] The solubility behavior of composite resin materials is also affected by the organic matrix and filler types. Organic matrix:diacrylates, bis-GMA, TEGDMA, EGDMA, HEMA; inorganic filler: glass, quartz, ceramic, silica powder (manufacturer's data).

Restorative conventional glass-ionomer cement in this study showed higher values of sorption and solubility than ISO guidelines and this could be from the method of mixing which will increase the solubility and sorption. Another reason is not protecting the cement with hydrophobic isolation after material setting. Cattani-Lorente et al[16] found that deterioration of the physical properties of the cements after long-term storage in an aqueous environment could be related to the water absorption of these materials. Part of the absorbed water acted as a plasticizer, inducing a decrease in strength. Weakening resulted from erosion and plasticizing effect of water. Biodentine sorption and solubility values were in general intermediating between Master Fill composite (lowest values) and Kemdent GIC restorative material (highest values) (Fig 1) but it the values were higher than the ISO guidelines and this might be attributed to the higher release of free calcium ions, higher alkalinizing capability, and the formation of smaller calcium phosphate deposits. Biodentine demonstrates lower apparent porosity, volume of open porosity.

Ion release depends on several factors such as the nature of the network structure and the mineral particles responsible for water sorption and solubility as well the permeability of the material to water diffusion (i.e., porosity). The fast hydration reaction of tricalcium silicate can be correlated with the low solubility and high calcium release at early endpoints.[17]

Biodentine showed to be a biointeractive (ion-releasing) bioactive (apatite-forming) material. Its solubility is interlinked with the pronounced ion-release. The large open pores volume and water sorption provided a high wet biointeractive surface available for the release with the calcium and hydroxyl ions.[18] However, the deposition of substances such as hydroxiapatite on the material surface when in contact with synthetic tissue fluids will compensate for that release. This property is rather favorable as they indicate that the material does not lose particulate matter to result in dimensional unstability.[19]

CONCLUSION

Within the limit of this study, the means of sorption and solubility were in general comparable in relation to the restorable material being tested. Biodentine restorative material showed an intermediate sorption and solubility values between Kemdent GIC restorative and Master Fill composite and due to this result the material (Biodentine) is not recommended to be used as a final direct restorative material but recommended to be used as a base only.

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