Original Study

SOLUBILITY OF ZINC PHOSPHATE, GLASS INOMER AND RESIN MODIFIED GLASS INOMER CEMENT IN ARTIFICIAL SALIVA: IN VITRO STUDY

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ABSTRACT

Aim: The purpose of this study is to evaluate the solubility of three different types of luting cements in artificial saliva.

Materials & Method: Three different zinc phosphate, glass ionomer and resin modified glass ionomer cement was used in this study and twenty disks (8×3 mm) were prepared from each luting cement according to manufactures' instructions. After setting, they were desiccated, weighed and each specimen were immersed in artificial saliva for 96 hours then removed and weighed again and solubility values were calculated from these different measures.

Results: The results shows that the zinc phosphate cements show the highest value of solubility followed by glass ionomer and resin modified glass ionomer shows the lowest value of solubility among three materials tested ($p<0.05$).

Conclusion: The cement type has significant effects on solubility values of the material.

Key words: Artificial saliva, Cement, Glass ionomer, Resin modified glass ionomer, Solubility, Zinc phosphate.

Introduction

Dental luting cements in conjunction with the geometry of the tooth preparation provide the basis for the retention of the casting on the tooth.[1] The clinical success of fixed prosthesis is heavily dependent on the physical properties of the luting cement.[2] Cements in the oral environment are continuously exposed to a variety of acids produced by microorganisms during the breakdown of fermentable carbohydrates. The temperature and pH of the oral cavity fluctuate the luting cements viability.[3] This complexity of the oral environment, coupled with the fact that different cements behave in different ways, has hindered the development of a standard laboratory test to accurately predict the relative resistance to degradation of various cements in vivo.[4] Solubility is an important feature in assessing the clinical durability of luting cements.[5] Consequently, solubility of luting cements has been widely evaluated both in vitro and in vivo.[6] Water sorption and solubility may cause degradation of the cement, leading to de-bonding of the restoration and recurrent decay.[5] Previously, solubility of glass ionomer cements, zinc phosphate cement and polycarboxy-late cement (10×4 mm) after 10 days and revealed solubility were lower in glass ionomer luting cement and polycarboxylate had the highest weight loss.[5]

So, the aim of the current *in vitro* study was to determine solubility of zinc phosphate, glass ionomer and resin modified glass ionomer cement in artificial saliva.

Materials & Method

Sample Preparation

A total of 60 test disks (8×3 mm) were prepared of which 20 samples of each luting cement was prepared for assessing the artificial saliva solubility. These luting cements were grouped as:

(A) Zinc Phosphate,
(B) Glass Ionomer and
(C) Resin Modified Glass Ionomer.

Disks (8×3) were prepared according to manufactures' instructions (as provided in table 1). Diameter and thickness were measured using a digital micrometer. After dry grinding, each specimen was weighed (W1) using an electronic analytical scale with accuracy up to 0.1 mg.[1] After that, the artificial saliva was titrated by the addition of buffers to prepare neutral pH of 6.8. The pH is adjusted by adding buffers and verified at first with pH paper and later with a pH meter. After that, the specimens were immersed in 50 ml of artificial saliva neutral pH 6.8 at 37°C for 96 hours. The specimens were then weighed. The weight thus obtained was termed as W2. The specimens were then dried at 37°C for 24 h in the hot air oven and thereafter transferred to the desiccator. The dried specimens were again weighed on the electronic weight analyzer with readability up to 0.1 mg (W2) and solubility values were calculated from these different measures.[1]

Cements	Manufacture	Batch No.	Powder/Liquid Ratio	Harden Time (sec.)	Activity Time (sec.)	Time for Mix (sec.)
Zinc phosphate	HOFFMANN 'S Germany	6739 Exp. 2021-01; 170529G	1.5/1.0	300-420	180	90
GC GoldLabel Luting and Lining Cement	GC, Tokyo-Japan	EXP. 2020-05; 0301111	1.8/1.0	270	120	20
Fuji II LC	GC, Tokyo-Japan		1/2	20	180	30 – 40

Table 1: Information about the used the luting cements

Statistical Analysis

Weight loss was analyzed by one-way analysis of variance (ANOVA) using SPSS 16.0 for Windows (SPSS, Inc., Chicago, IL, USA). Data is presented as mean ± Sd. For treatment showing a main effect by ANOVA, means compared by Tukey–Kramer test. $p < 0.05$ was considered as significant differences between treatments.

Results

The results of solubility of zinc phosphate, glass ionomer and resin modified glass ionomer cement after 96 hours in artificial saliva is presented in table 2. According to the data, the Zinc phosphate had higher solubility and resin modified glass ionomer, Cement (GIC) had lowest solubility ($p=0.001$, $F=2079.502$).

Specimen No.	Resin Modified GIC	GIC	Zinc Phosphate
1	0.43	1.8	2.1
2	0.43	1.8	2.1
3	0.44	1.7	2.3
4	0.42	1.8	2.4
5	0.41	1.6	2.1
6	0.44	1.5	2.2
7	0.44	1.7	2.4
8	0.41	1.8	2.1
9	0.42	1.6	2.1
10	0.41	1.7	2.3
11	0.43	1.9	2.1
12	0.42	1.8	2.2
13	0.42	1.8	2.1
14	0.41	1.6	2.1
15	0.44	1.8	2.3
16	0.42	1.5	2.2
17	0.44	1.7	2.1
18	0.41	1.8	2.3
19	0.45	1.8	2.2
20	0.41	1.8	2.1
Average Values	**0.42**	**1.725**	**2.085**
GIC: Glass Ionomer Cement			

Table 2: Solubiity of the different luting cements in artificial saliva

According to the figure 1, the zinc phosphate had lowest solubility during the 96 h placement in artificial saliva while GIC and resin modified GIC had higher weight loss ($p<0.05$).

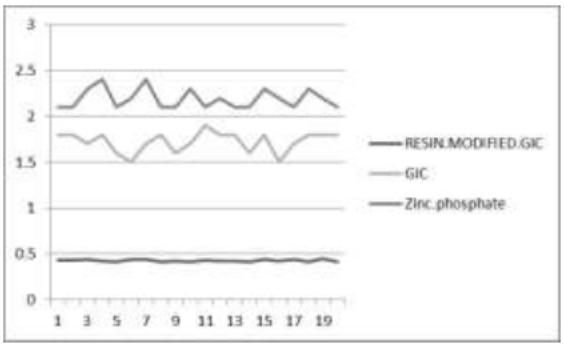

Figure 1: Solubility of the different luting cements in artificial saliva during the time intervals.

As seen in figure 2 and table 3, there was no significant difference between 3 luting cements at the start of the study ($p>0.05$) while zinc phosphate had higher weight loss than GIC and resin modified GIC, respectively.

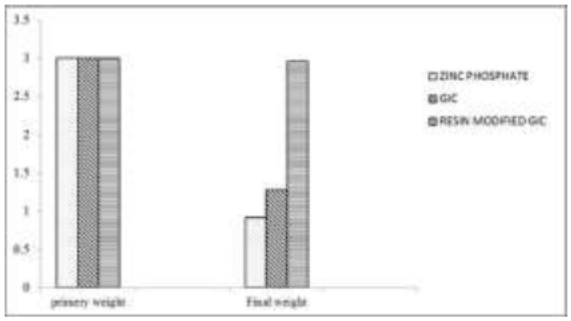

Figure 2: Solubility of the different luting cements in artificial saliva based on their primary and final weight.

		Resin Modified GIC	GIC	Zinc Phosphate
Resin Modified GIC	Pearson Correlation	1	0.054	0.224
	Sig. (2-tailed)		0.822	0.343
GIC	Pearson Correlation	0.054	1	0.022
	Sig. (2-tailed)	0.822		0.927
Zinc Phosphate	Pearson Correlation	0.224	0.022	1
	Sig. (2-tailed)	0.343	0.927	
GIC: Glass Ionomer Cement				

Table 2: Correlation of solubility of the different luting cements in artificial saliva.

Discussion

Solubility of cement components has an importance effect on its structural stability and biocompatibility.[6] The conditions of the test affects rate of dis-solution. However, specimen shape and thickness, powder/liquid ratio of cement, pH, dis-solution time and concentration of the solute affects solubility of cement.[5] As seen, in this study, among 3 luting cements zinc phosphate had higher weight loss than GIC and resin modified GIC, respectively. In a similar study, Hajmiragha *et al*[5] reported glass ionomer luting cement had lower while polycarboxylate had the highest weight loss and observation was similar to previous report by Hersek and Canay[7] and Hajmiragha *et al*.[5] During dissolution, zinc leached from zinc phosphate cements. As well, aluminum and silicon are lost from glass ionomer cement.[8] So, the pH is altered rapidly and tends to inhibit the solution of luting cements over a prolonged storage period.[9] Cattani-Lorente *et al*[10] 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 to erosion and plasticizing effect of water.[11] Zinc phosphate, zinc polycarboxylate, glass ionomer, calcium hidroxide, zinc oxide eugenol and free eugenol cements are used for luting purposes.[12] Due to the limited strength of zinc oxide eugenol and free eugenol cements, they are only accepted for provisional cementation. However, due to implants do not decay, zinc oxide cements may often be used as the definitive cement and permits an easier retrieval of prosthesis, should intermediate or long-term complications result.[12] Glass ionomer cements are sensitive to water erosion. It may probably be due to same hydrolysis of the cement components. This phenomenon is apparently aggravated in oral environment due to the presence of aggressive compounds in the saliva. Clinical success with glass ionomer cements depends on early protection from both hydration and dehydration.[13] Marginal defects around crowns appeared sooner with glass ionomer than with zinc phosphate, possibly because of the greater susceptibility of glass ionomer to contamination by moisture. Contaminated glass ionomer is more susceptible to erosion and glass ionomer aged in water is mechanically weaker.[5]

Zinc polycarboxylate cement is a water-based material that hardens following an acid-base reactions between zinc-rich powder and an aqueous solution of polyacrylic acid.[14] The hydrophilic nature of a polymer is a function of the chemistry of its monomers and polymerization linkages. The presence of hydroxyl, carboxyl and phosphate groups in monomers and their resultant polymer make them more hydrophilic and more prone to water sorption these cements include water in their formulation. Glass ionomer cements are sensitive to water erosion;[15] it may be duo to same hydrolysis of the cement components, this phenomenon is apparently aggravated in oral environment duo to presence of aggressive compounds in saliva. Clinical success of glass ionomer cements depends on early protection from hydration and dehydration; it's weakened by early exposure to moisture, while desiccation on the other hand causes shrinkage and cracks.[12] Deniz *et al* found that higher levels of solubility were associated with earlier exposures of mixed cement to water, and glass ionomer luting cements were highly sensitive to water contact during the first 6 minutes after mixing.[16]

Yanikoglu *et al* uses artificial saliva at different pH values and found that statistically significant differences were found among the specimens stored in acidic, basic and neutral artificial saliva, it was observed that the cements were more soluble in acidic media and more stable at pH 7.[17] The highest solubility found in zinc phosphate followed by zinc polycarboxylate and the least is glass ionomer cement. Keyf *et al* found that the water sorption of zinc poly carboxylate more than zinc phosphate and the two is more than glass ionomer cement, while for solubility he found that glass ionomer has greater solubility than zinc poly carboxylate and the least is zinc phosphate.[12] Nicholson and Amiri studied interaction of zinc phosphate, zinc polycarboxylate, glass-ionomer and resin-modified glass-ionomer cements with aqueous solutions of varying pH and revealed resin modified counterparts, also have the important physicochemical property once set of releasing fluoride which acts to prevent the occurrence of secondary caries.[18] Heshmat *et al* on solubility of the FujiCem resin-modified glass ionomer and G-Cem self-adhesive resin cement in water and acid, reported two cements had no significant difference in water or acid solubility but FujiCem RMGI showed greater water sorption than G-Cem selfadhesive resin cement.[19] Curing and setting of RMGIs are based on acid-base reactions similar to conventional cements and also polymerization of free radicals in the resin part of these materials.[20] In the resin part of Fuji Cem, a considerable amount of hydrophilic groups such as hydroxy ethyl methacrylate are present that act like hydrogen and absorb greater amounts of water.[21] Water sorption and solubility mainly depend on the type of material and the different results yielded by various studies on the same material are usually attributed to the difference in resin matrix compositions.[22] Kanchanvasita *et al* study was totally in accord with ISO 4049 standard and reported higher water sorption and water solubility of RMGIs compared to other resin-based materials which in our study was in agreement to this report and resin based material had lower solubility.[23]

Conclusion

In conclusion the cement type has significant effects on solubility values of the material.

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