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Studies of the Effect of the Chemical Environment on the Solubility of Fixing Cements in Vitro

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Abstract: The paper studies the effect of acidic and alkaline environments, as well as violations of powder and liquid proportions on the solubility of glass ionomer cements for fixing artificial crowns (Glassing, Fuji - 1, I-FIX). The results showed that an acidic environment and an increased liquid content increase the solubility of cements, while an increase in the proportion of powder reduces this indicator. It has been established that proper observance of proportions when mixing cements plays a key role in maintaining their stability and functional properties.

Keywords: Glass ionomer cements, solubility, acidic environment, proportions of powder and liquid, fixation of artificial crowns, chemical resistance, durability.

Introduction. Glass ionomer cements (CC) are widely used in dentistry due to their adhesive properties, biocompatibility, and ability to release fluoride, which reduces the risk of secondary caries [1, 2]. These materials are used both for restorations and for fixing orthopedic structures, including artificial crowns. However, their durability can be significantly affected by operating conditions, such as exposure to acidic and alkaline environments of the oral cavity, as well as the accuracy of the proportions of powder and liquid during mixing [3, 4].

The acidic environment in the oral cavity is formed due to the vital activity of microorganisms, the consumption of acidic drinks and products, which can increase the solubility of cements, reducing their mechanical strength and durability [5]. An alkaline environment, although less common, is also capable of changing the properties of fixing materials. In addition, a violation of the proportions of the components when mixing cements can affect their solubility and mechanical characteristics, which is especially important when fixing structures under high chewing load [6].

The present study is aimed at studying the effect of acidic and alkaline environments, as well as violations of the proportions of powder and liquid on the solubility of glass ionomer cements "Glassing", "Fuji - 1" and "I-FIX". The data obtained will make it possible to clarify the recommendations for the use of these materials and increase the effectiveness of their use in orthopedic dentistry.

Materials and methods: The effect of the pH level on the solubility of cements used for fixing artificial crowns was studied. The following materials were used in the study: glass ionomer fixing cement "Glassing" (Republic of Uzbekistan, Jizzakh region), radiopaque glass ionomer fixing cement GC Fuji PLUS and glass ionomer fixing cement I-FIX (I-Dental, Lithuania). The experiment was carried out using five types of solutions: solution No. 1 was an artificial saliva with a pH of 7.13, based on the recipe of T. Fusayama (1975): 0.42 g/l KCl, 0.4 g/L NaCl, 0.795 g/L CaCl2, 0.69 g/L Na2HPO4, 0.005 g/L Na2S·9H2O, 1 g/l urea and H2O; solution No. 2 contained HCl with pH=1; solution No. 3 — HCl with pH =2; solution No. 4 was a soda solution with pH=9.5; solution No. 5 was a NaOH solution with pH=10.0. Solution No. 1 was used as a control, which was compared with other solutions.

In the second stage of the study, the effect of deviations in the proportions of powder and liquid on the solubility of fixing cements was studied. For this purpose, the medium of solution No. 3 (pH =2) was used. Two samples of each cement were produced with different proportions of components: samples 1, 3, 5 contained an excess amount of powder, and samples 2, 4, 6 — an excess amount of liquid. The weigh-ins were carried out a day later, then the intervals between the weigh-ins increased, as in the first stage of the study. A total of 160 measurements were performed: 110 in the first study and 50 in the second.

Results. Analysis of laboratory research data showed that the solubility of all the cements studied in solution No. 2 (Hco, ph=1) was significantly higher than in other solutions ($p<0.002$). The solubility of Fuji - 1 and Glassing cements in solution No. 4 (soda solution, pH=9) did not differ from their solubility in solution No. 1 (artificial saliva) ($p>0.05$), while the solubility of I-FIX cement in solution No. 4 increased. In solution No. 5 (NaOH, pH=10), an increase in the solubility of "I-FIX" was observed ($p<0.01$), however, the solubility of "Glassing" and "Fuji -1" cements remained unchanged ($p>0.05$).When comparing the solubility of cements in the same solutions, for example, Fuji - 1 in solution No. 1 with Glassing in solution No. 1 and I-FIX in solution No. 1, there were no differences in solubility in solution No. 1. In general, I-FIX cement demonstrated the highest solubility in all solutions, while Glassing cement demonstrated the lowest solubility ($p<0.05$), with the exception of solution No. 2.

Table No. 1. Solubility of cement samples in the pH range from 1 to 10%.

solution number, type of cement.	Day							
	1	2	3	6	7	9	10	15
1 Glazing	1,99	1,99	2,29	2,29	2,44	2,8	3,05	3,5
2 Glazing	15,8	37,6	45,47	51,4	52,81	56,3	58,5	59,2
3 Glazing	1,9	2,0	3,8	3,2	4,1	4,3	4,98	4,7
4 Glazing	1,1	1,2	1,59	1,8	1,98	2,2	2,8	2,93
5 Glassing	0,9	1,05	1,33	1,7	1,9	2,15	3,03	3,53
1 Fuji	2,00	2,01	2,29	2,5	2,8	3,05	3,8	3,9
2 Fuji	13,21	35,2	49,47	51,3	52,9	56,28	57,65	59,7
3 Fuji	1,5	2,4	3,7	3,9	4,9	5,01	5,91	6,15
4 Fuji	1,3	1,4	1,59	1,9	1,99	2,4	2,8	3,03
5 Fuji	0,8	1,0	1,33	1,7	1,93	2,1	2,4	2,9
1 I-FiX	1,8	2,8	2,29	2,6	2,71	2,91	3,21	3,90
2 I-FiX	11,2	35,6	49,47	51,8	52,6	56,3	57,65	58,74
3 I-FiX	1,7	2,8	3,7	3,9	4,4	4,9	5,56	5,95
4 I-FiX	1	1,9	1,8	1,8	1,8	2,01	2,73	3,13
5 I-FiX	0,78	1,6	1,7	1,9	2,3	2,89	3,37	4,53

A study of the effect of a violation of the proportions of powder and liquid on the solubility of cements showed that an increase in the liquid content during kneading leads to an increase in the solubility of cements ($p<0.001$). This effect was observed in all the studied materials. On the contrary, an increase in the powder content contributed to a decrease in their solubility. It is worth noting that the solubility of cements with disturbed proportions changed as follows: during the first day it increased sharply, and then the process slowed down. At the same time, the solubility of the cements mixed according to the instructions initially increased more smoothly. The exception was a solution with pH = 1, where a sharp increase in solubility was immediately observed for all cements. Over time, the solubility values of the cements mixed with both the correct and the wrong proportions gradually leveled off.

Table. 2. The solubility of cement samples in case of violation of the proportions of powder and liquid in %.

Sample number	Cement	Day								
		1	2	3	6	10	11	14	15	16
1	Glassing	3,01	3,7	4,01	4,15	4,26	4,44	4,63	4,7	4,85
2	Glassing	6,81	7,12	7,61	7,91	8,29	8,48	8,54	8,54	8,54
3	Fuji 1	3,14	3,22	3,68	4,25	4,55	4,93	5,02	5,32	5,40
4	Fuji 1	7,15	7,32	8,81	9,12	9,18	9,24	9,32	9,45	9,45
5	I-FiX	3,9	4,19	4,82	4,98	5,26	5,44	5,95	6,02	6,09
6	I-FiX	7,81	8,17	8,89	9,31	9,89	10,09	10,37	10,55	10,45

As can be seen from the table, violations of the proportions of powder and liquid during cement mixing have the least effect on the solubility of Fuji - 1 cement, followed by Glassing, and the greatest effect is observed in I-FIX cement.

Conclusions. Acidic environment and high liquid content significantly accelerate the process of cement degradation, which can negatively affect their durability when fixing artificial crowns in aggressive conditions of the oral cavity. It is especially important to take these factors into account when working with cements such as I-FIX, which exhibit higher solubility. An increase in the proportion of powder, on the contrary, makes the material more stable, which can be useful in conditions of increased load, but it is important to strictly observe the recommended proportions in order to avoid changing the mechanical properties of cement. It should be borne in mind that failure to follow the instructions for mixing can affect not only the solubility, but also the strength of fixation, which requires special supervision by specialists. Optimizing the composition and developing more acid-resistant cements can improve their clinical effectiveness and durability.

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