Release of Fluoride to the Addition of Nanoparticle Zinc Oxide with Glass Ionomer Cements

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Research Article

Release of Fluoride to the Addition of Nanoparticle Zinc Oxide with Glass Ionomer Cements

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ABSTRACT

Background: Glass ionomer cement material has high compressive strength and modulus of elasticity, but low fracture toughness, flexural strength, and wear resistance.
Purpose: The purpose of this study was to determine the release of fluoride due to the addition of zinc oxide nanoparticles to glass ionomer cements.
Methods: The research is experimental laboratories with posttest-only control group design methods using GIC type II samples. The data was analyzed by using one way Anova and Tukey HSD test.
Results: The addition of 1 gram nanoparticle zinc oxide could significantly increase GIC fluoride release. At the same time, the addition of 2 g nanoparticle zinc oxide can't increase the fluoride release of GIC compared with GIC.
Conclusions: That adding 1 gram zinc oxide nanoparticle powder to the glass ionomer cement powder can increase fluoride release in the glass ionomer cement..

Keywords: glass ionomer cement, fluoride release, zinc oxide nanoparticle

INTRODUCTION

Glass ionomer cement was first introduced by Wilson and Kent in 1972 as Alumino-Silicate Polyacrylic Acid (ASPA)[1]. Glass ionomer cement is formed from the cross-linked reaction of the polyacid matrix with glass particles[2]. Glass ionomer cement material has high compressive strength and modulus of elasticity, but low fracture toughness, flexural strength, and wear resistance[3,4]. This makes it a hard but brittle material, so it is rarely used in high pressure areas[5,6]. The addition of nanoparticle-sized 1-100nm material to the glass ionomer cement powder aims to fill the gaps between the particles and strengthen the physical and mechanical properties of the cement[7–9].

Several studies have been conducted in an effort to improve the physical and mechanical properties of glass ionomer cement while trying to maintain its ability to release fluoride[10,11]. The most important function of fluoride is as an anticariogenic substance. It can prevent secondary caries through a mechanism to increase remineralization, prevent demineralization, and prevent microbial growth[12]. Prevention of demineralization is achieved by the reaction of a change in fluoroapatite to hydroxyapatite[13], which is more resistant to acid[14]. Glass ionomer cements contain 10-23 percent fluoride in the matrix. When the powder and solution are mixed, the fluoride ions contained in the powder will be released along with other ions such as calcium, aluminum, and sodium which will build up the cement matrix and cause a setting reaction[15]. There are two mechanisms of fluorine release, namely "early burst" or long-term release[16]. The initial release occurs 24-48 hours after the setting reaction. At that time fluorine compounds will be released in very large quantities and caused by the release of F-ions which are not strongly bonded and are easily released. Fluorine release will decrease continuously after a few weeks or months and is called long-term release.8. This release is influenced by the process of diffusion and formation of the ion matrix during setting reactions. Fluoride compounds will be released little by little and continue for 2-2.5 years thereafter[17].

The fluoride ions contained in glass ionomer cements are more complex in form than the free ion form F-. The process of releasing fluorine into saliva, in addition to the acid-base reaction, also requires F-bonds with other cations, one of which is Zinc (Zn2 +) to make it more stable[18,19]. The cross-linked matrix of glass ionomer cement particles with Zn2 + cations can increase the release of fluorine ions into the saliva and surrounding dental tissue so as to reduce the risk of caries. Based on the background above, it is necessary to conduct research on the release of fluoride in glass ionomer cements added with zinc oxide nanoparticles. The purpose of this study was to determine the release of fluoride due to the addition of zinc oxide nanoparticles to glass ionomer cements.

MATERIAL AND METHOD

This type of research is experimental laboratory research. The design of this study is post-test only control group design[20]. The study was carried out on glass ionomer cements added with zinc oxide nanoparticles at certain ratios. The sample criteria used were not porous, tablet-shaped 6 mm in diameter and 2 mm high. The materials used in this study are type II glass, ionomer cement and zinc oxide nanoparticles, aquades with pH 7, zirconil alizarin reagent, and fluoride standard solution. The tools used in this study are ebonite molds with a diameter of 6 mm with a height of 2 mm, mortar and pastle, digital scales, plastic spatula, glass slab, spectrophotometer, sonde, test tube, incubator and plastic filling.

This study was carried out on type II glass ionomer cement, which has been added zinc oxide nanoparticles with a ratio of 9 gram glass ionomer cement powder plus 1 gram zinc oxide nanoparticle powder mixed with glass ionomer cement liquid and type II 8.5 gram glass ionomer cement powder plus 1.5 gram zinc oxide nanoparticle powder mixed with liquid glass ionomer cement. Glass ionomer cement powder and zinc oxide nanoparticle powder were weighed according to the ratio in the study group. Glass ionomer cement powder is mixed using mortar and paste for 20 minutes at a rate of two revolutions per second until homogeneous. Glass ionomer cement powder and zinc oxide which have been mixed as much as 0.24 grams are stirred with 0.12 grams of liquid glass ionomer cement with plastic spatula above paper for 30 seconds and put into a mold whose top and bottom have been coated with celluloid strips, then glazed the slab and pressed by hand. The specimen can stand for 10 minutes and the excess portion is cleaned with a sonde[17].

Each sample was put into a test tube containing 50ml distilled water and stored in an incubator at 37ºC for 24 hours. The reaction tube containing the sample was removed from the incubator, then, the specimen was removed from the test tube. Specimens are dried with tissue for two minutes and transferred to a new test tube containing 50 ml of distilled water. Each reaction containing specimens in distilled water was measured using fluorine spectrophotometer in ppm units. Each solution in the test tube is replaced every 24 hours and the release of fluorine levels is calculated with a spectrophotometer every day until the day for 15.17 Fluoride release is read with a spectrophotometer (Brand Shimizu UV-1800).

The research data were analyzed by one-way ANOVA to see differences in all sample groups. Data analysis continued with the Tukey-HSD test to see differences between sample groups.

RESULT

Data were obtained by mixing type II glass ionomer cement with zinc oxide nanoparticle powder in a ratio of: 1 gram and 1.5 gram. Samples soaked in distilled water. Observation of fluoride release for 15 days. Fluoride release test was seen with a spectrophotometer (Shimadzu UV-1800 Brand, Japan) with λ = 535nm. The average position of fluoride release in each group can be seen in Figure 1.

Normality and homogeneity tests must be performed as a one-way Anova parametric test requirement. The normality test in this study used the Kolmogorov-Smirnov Test and obtained a normal distribution sample group ($p < 0.05$). Homogeneity test of the five data is done by Levene Test to see the same variance between groups. The test results showed a significance value of more than 0.05 ($p > 0.05$) that is 0.721. It can be concluded that the variance between groups is the same. In the one-way Anova analysis test, the data obtained significance of 0.0005 ($p < 0.05$) showed meaningful results and should be followed by the Tukey HSD test.

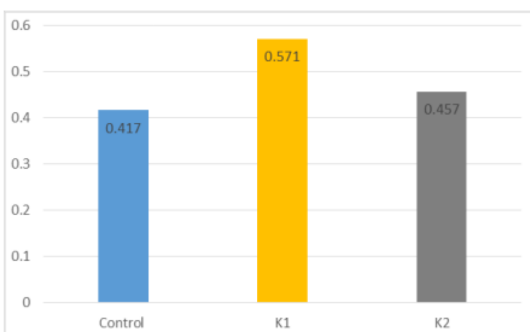

Fig.1: Graph of average yield of fluoride release in type II glass ionomer cements

Table 1: The mean value of fluoride release in type II glass ionomer cements

Group	n	Mean (ppm)	SD
Control	10	0,417	0,133
K1	10	0,571	0,099
K2	10	0,457	0,144

Table 2: Comparison of the fluoride release rates between treatment groups was tested with Tukey HSD

Group	Control	K1	K2
K2	0,675	0,044*	-
K1	0,005*	-	
Control	-		

*Significant

DISCUSSION

The results of statistical analysis show that the addition of zinc oxide nanoparticles to glass ionomer cements at a concentration of 1 gram can increase the release of fluoride ions compared to glass ionomer cements without addition.From Table 1 and Figure 1, it can be seen that in glass type II ionomer cement added 1 gram zinc oxide nanoparticles (Group 1) showed the highest fluoride release compared to glass ionomer cement added with 1.5 gram zinc oxide nanoparticle (Group 2) and control.

In table 2, there was a significant difference between the control group and group 1 which had a ratio of 1 gram of zinc oxide nanoparticle powder and group 1 with group 2 which had a ratio of 1.5 gram of zinc oxide nanoparticle powder. It starts when there is a mixture of powder and liquid glass ionomer cement. The acid will break up glass particles, causing the release of ions including Zn2 + and F- and produce an unreacted core product and ion complex in the form of a cross-linkedpolyacrylate hydrogel matrix bond[18,21].

The result of the glass ionomer cement setting consists of glass particles coated by partially dissolved glass particles in a matrix formed by an acid reaction with a polyvalent. Action[18]. The unreacted zinc oxide core will bond with the salt matrix of glass ionomer cement through the bonding of zinc divalent ions[19]. Ca2+, Al3+, F-, and. Zn2+ ions are released from the cement matrix and form an ion complex in the form of a polyacrylate hydrogel matrix[22].

Initially, fluoride ion particles are inside glass powder particles. After the reaction setting and formation of the cement matrix, fluoride ions will be released evenly in the cement matrix and will be released little by little over a long period of time[17,22]. Fluoride often binds to other cations to be more stable and can be released in complex form to saliva[18]. The result of the Zn2+ cation bond with F- will increase the release of fluoride ions into a solution in distilled water. Samples in Group 2 did not show a significant difference compared to Group 1, probably due to the optimal amount of zinc oxide nanoparticles that they were no longer able to form cross-linked bonds with polyacrylic acid. In Group 2 and control, less fluoride was released than Group 1. This is probably due to the monovalent ionic bond that connects the polymer chain holding it up less than Group 1. This causes smaller water transport in the molecule and less fluoride release[23].

The different result can be because the tools and buffers used in this study are different from other studies. And the volume of more storage media is also likely to affect the amount of fluoride released. The process of releasing fluoride is a complex one, influenced by a variety of factors[24]. The difference in results can be influenced by several things, both experimental and intrinsic variables. Such as research methods, storage media, solubility, porosity of materials, powder and liquid ratios, mixing methods, frequency of media replacement, storage media volume, and specimen size[25,26]. Solubility and exchange between ions is very influential for fluoride release[23], especially in the early days after setting reactions occur.

CONCLUSIONS

The conclusion of this study is that adding 1 gram zinc oxide nanoparticle powder to the glass ionomer cement powder can increase fluoride release in the glass ionomer cement.

CONFLICT OF INTEREST: None

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ETHICAL CLEARANCE

This study was approved by the Universitas Airlangga, Faculty of Dental Medicine Health Research Ethical Clearance Commission

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