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Depth of Porosity of Glass Ionomer Cement with the Addition of Nano-Sized Gourami Scale Powder

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ABSTRACT

Background: Glass ionomer cement (GIC) contains higher porosity than other restorative materials. Porosity can cause the GIC surface to become rough and reduce the material's mechanical properties. Gourami fish scales powder (GFSP) contains hydroxyapatite, which can potentially reduce the porosity of GIC. This research aimed to analyze the porosity depth of conventional GIC by adding 1.5%, 2.5%, and 3.5% GFSP nanoparticles (nGFSP).

Materials and Methods: This type of research is an experimental laboratory with a post-test-only control group design. Twelve samples were disc-shaped diameter of 5 mm and a height of 2 mm which were divided into four groups: G0:GIC, G1: GIC+1,5% nGFSP, G2: GIC +2,5% nGFSP, and G3: GIC+3,5% nGFSP). Samples were cut into two parts and observed by Scanning Electron Microscopy (SEM). The results were analyzed by One Way ANOVA and Least Significant Difference (α = 0,05).

Result: The average value of the porosity depth from the highest to the lowest is G0, G1, G2, G3. There was a significant difference between all sample groups (p = 0.000).

Conclusion: The addition of nanoparticles GFSP reduced the porosity depth of conventional GIC; the addition of 3.5% nanoparticles GFSP showed the shallowest porosity depth.

KEYWORDS: Glass ionomer cement, Gourami Fish Scale Powder, nanoparticles, porosity depth

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I. INTRODUCTION

Glass Ionomer Cement (GIC) has excellent potential in dental applications for its biological, mechanical, and adhesion properties but has disadvantages.[1,2,3] GIC has low fracture and wear resistance, low mechanical properties, brittle, and sensitivity to humid environments during the early stage of setting.[4,5,6] The brittle characteristic indicates that the porosity of GIC is relatively high.[7]

Porosity is the part of the volume of material that is not filled with solid material (cavity or porous state).[8,9] Porosity can form during hardening, where ions (Na^+) and fluoride cannot bond perfectly.[2] Conventional GICs have higher porosity than resin-modified GIC and composite resin.[10] Porosity can cause a decrease in the strength and durability of the material. Deeper porosity causes the restoration surface to become rough so that it becomes a place for plaque and calculus retention that can lead to caries and discoloration of the teeth [5, 7] One of the ways to improve the physical properties of GIC is by adding hydroxyapatite.

Hydroxyapatite can be derived from a variety of sources, both natural and synthetic. One of the natural sources of hydroxyapatite comes from the scales of gourami (*Oshpronemus gouramy*).[11] Fish scales consist of inorganic components, about 7%-25%, including hydroxyapatite and calcium phosphate.[12] Previous studies showed that adding 2.5%, 5%, and 10% GFSP affected the porosity of the GIC. An addition of 2.5% GFSP can reduce the size and level of porosity, but in the addition of 5% and 10% GFSP, there is an increase in the size and level of porosity of the GIC. This is because the size of the particles GFSP added is micro-size. Adding larger particles with smaller surface areas in the GIC/GFSP mixtures reduced the adhesion force between the powder mixtures. Higher viscosity was obtained at concentrations of 5% and 10% due to the difference in particle size and the extremely large amount of added GFSP.[13] A high viscosity causes the inhomogeneous mixing of samples and increases air trapping, thereby causing the pore size and level of porosity to increase.[14]

Therefore, this study was conducted to analyze the porosity depth of conventional GIC that added 1,5%, 2,5%, and 3,5% GFSP nanoparticles. Nanoparticles were used because nano-size particles can penetrate space that micro-size particles cannot reach.

II. MATERIALS AND METHODS

Manufacturing of nanoparticles Gourami Fish Scales Powder

Nano-sized GFSP (nGFSP) was obtained through the method described by Cahyanissa et al. [15]. Furthermore, the pH of nGFSP was measured, and particle size was analyzed using a Particle Size Analyzer (Horiba-SZ 100z, California, US). The pH value obtained is 7.82, and the particle size is 51.77 nm.

Sample Preparation

This study used GIC powder from Fuji IX Gold Label High Strength Posterior Extra, Japan. There are four groups in this study, namely G0: GIC, G1: GIC+1.5% nGFSP, G2: GIC+2.5% nGFSP and G3: GIC+3.5% nGFSP. GIC powder and nGFSP were mixed using a vortex (Labinco L46, Breda, Netherlands). The twelve disc-shaped samples were obtained through the method described by Wulandari et al.[13] The samples were immersed in aquades and put into an incubator (Biobase BJPX-H1232, Karnataka, India) at a temperature of 37ºC for 24 hours. Furthermore, the samples were removed from the incubator and dried using an air spray (Spray Nozzles, Tokyo, Japan). The sample was cut into two parts using a diamond disc, irrigated with sterile aquades, and dried using air spray.

Scanning Electron Microscope Assessment

Sample pieces were put into the Scanning Electron Microscope (SEM) (Hitachi, Tokyo, Japan). Photographs were taken in areas where there was a large porosity formation. The porosity depth is measured from the base of porosity perpendicular to the surface. The deepest porosity was taken. The data were analyzed using One-way ANOVA and post hoc tests with Least Significant Difference (LSD).

Statistical analysis

The data obtained were analyzed using Statistical Package for the Social Sciences (SPSS). One-way analysis of variance and Least Significant Different (LSD) post-hoc tests at a significance level of p=0.05 were used to perform multiple comparison tests.

III. RESULT

Figure 1 shows the SEM photograph of porosity depth GIC with addition of nGFSP. The shallowest porosity depth size was found in G3.

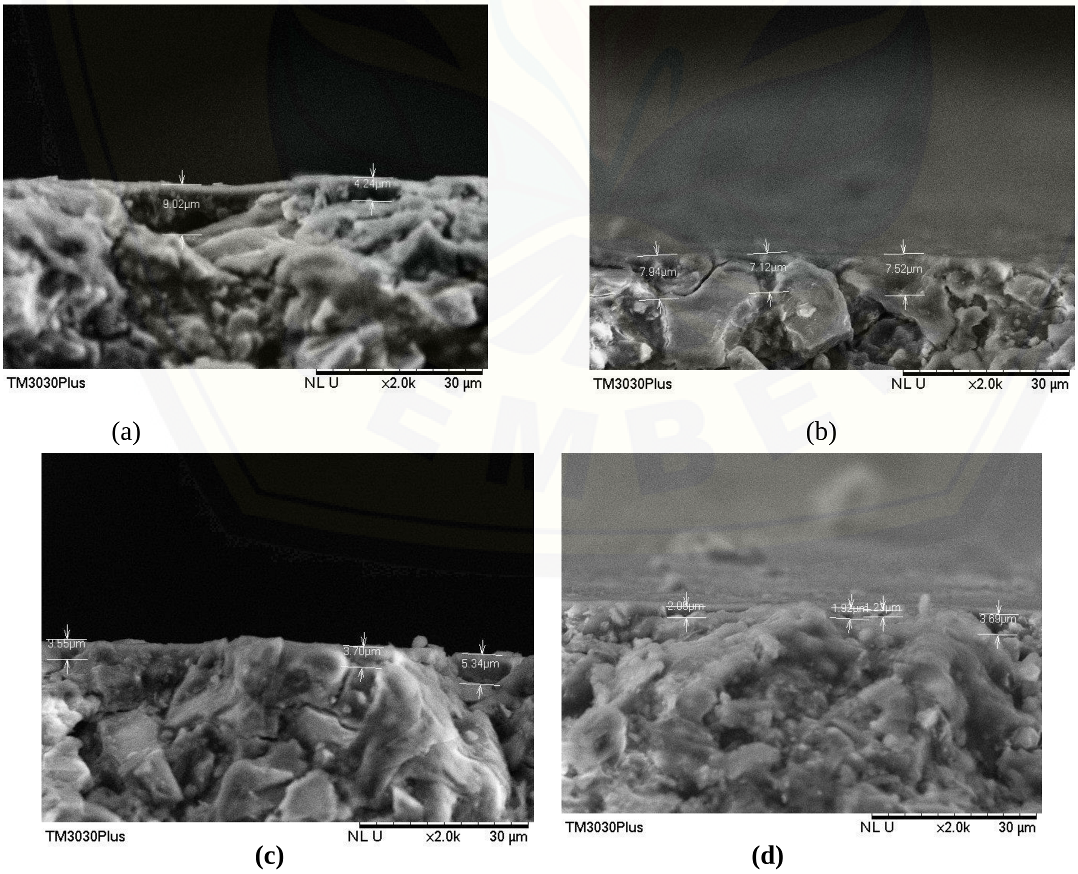

Fig 1. Microscopic image of porosity depth GIC with addition of nGFSP using SEM with 2000x magnification. (a) G0 (GIC), (b) G1 (GIC +1.5% nGFSP), (c) G2 (GIC+2.5% nGFSP), and (d) G3 (GIC+3.5% nGFSP).

Figure 2 illustrates the average porosity depth of GIC with addition of nGFSP. The sequence from deepest to shallowest is G0, G1, G2, G3. There was a significant difference between all sample groups (p = 0.000).

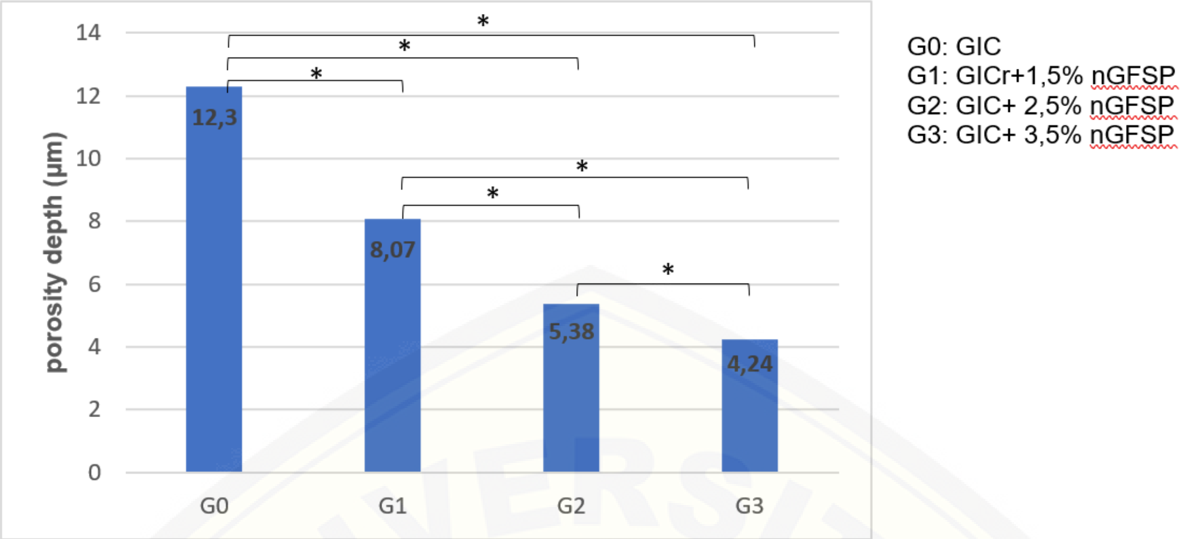

Fig 2. Average porosity depth of GIC with addition of nGFSP and least-significant difference test result between groups. *p < 0.05

IV. DISCUSSION

The results showed that adding 1.5%, 2.5%, and 3.5% nGFSP decreased the value of GIC porosity depth. This can happen because the HA content in nGFSP plays an essential role in the chemical changes that occur during the initial setting phase of GIC. The reaction mechanism between HA and GIC was presumed similar to the adhesion between GIC and tooth structure, which is the substitution reaction between the anion carbonyl group of polyacrylic acid in GIC liquid with hydroxyl groups which is calcium ion and phosphoric acid from HA. [16] HA dissolves in acidic solutions, and its solubility rate increases rapidly at pH below 2.05 after contact with polyacrylic acid (pH 1.23).[17] The nGFSP has base properties (pH is 7.82), which causes it to bind firmly to GIC powder with base properties. This allows for an acid-base reaction between GIC powder added nGFSP with GIC liquid. Therefore, when GIC powder with the addition of nGFSP contact with polyacrylic acid, an adsorption process occurs in which polyacrylate will penetrate the HA surface to release calcium phosphate bonds.[16] This causes calcium ions from HA to be available earlier to react with polyacrylic acid than metal ions from GIC surfaces such as calcium, aluminum, and strontium.[17] Then, the carbonyl anion group of polyacrylic acid will bind to hydroxyapatite's calcium ion.[16]

Adding nGFSP increased calcium binding to GIC, thus allowing more formation of salt bridge structures or cross-linking. This causes an increase in GIC density, and the void or distance between glass particles gets narrower, making the chain structure difficult to break.[16, 18] Therefore, GIC restoration with nGFSP has a shallower porosity depth. Nano-sized hydroxyapatite can penetrate a space that larger particles cannot reach, resulting in better mixing and density. So, minimal porosity is formed.[16,19,20] In this study, the shallowest porosity depth is obtained at an addition of 3.5% nGFSP. The higher the concentration of nGFSP, the higher the HA content, causing an increase in the bond between calcium and polyacrylic acid, forming shallower porosity.[4]

Previous studies showed that adding nGFSP significantly enhances the tensile strength of GIC[15] and the antibacterial activity of GIC against S. aureus and S. mutans.[21] The incorporation of the nano-hydroxyapatite into GIC increased the resulting cement's mechanical characteristics (compressive, diametral tensile, and hardness).[22] The application of nano-sized biomaterials is known to be potentially more useful in dentistry because of greater strength, polishability, and aesthetic value than commercial modifiers.[23]

Gourami fish scale powder also contains organic materials, such as proteins, in the form of type 1 collagen.[24] Type 1 collagen is base so that it can integrate stably with GIC liquid. Collagen acts as a matrix component, and it can strengthen the bonds between silica fillers to improve the mechanical properties of GIC with provision, which is the addition of type 1 collagen, which is not more than 0.01%.[25,26,27] The addition of type 1 collagen that is more than 0.01% can reduce the mechanical properties of GIC because if the amount of collagen is too much, the pH of the matrix will be neutralized, and the ionic reaction will decrease.[25] In this study, it is not known how much collagen is contained in nGFSP, so it is not known precisely the effect of collagen on the chemical reaction of GIC. Therefore, further research is needed regarding the content of nGFSP that affects the mechanical and physical properties of GIC.

V. CONCLUSION

Adding nGFSP reduces the porosity depth of GIC restoration, where adding 3.5% nGFSP produces the shallowest porosity depth.

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