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Effectiveness Of Green Nanochitosaan Addition On Compressive Strength Of Glass Ionomer Cement

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ABSTRACT

Glass ionomer cement is a restorative material that is adhesive, tooth-colored, and has the ability to release fluoride ions which are affected by the degree of acidity (pH). Apart from that, one way to utilize the waste from green mussels is by processing them into chitin and chitosan as materials to strengthen the properties of glass ionomer cement. Glass ionomer cement contains materials such as powderacid soluable calcium fluoraluminosilicate glass and liquidaqueous solution of polyacrylic acid. This can be an alternative as a treatment for dental caries. Objective: This study aims to determine the effectiveness of the addition of green mussel shell (perna viridis) nanochitosan on the compressive strength of glass ionomer cement. Method: This study used a quantitative experimental laboratory study with a True Experimental study design using a post test only control group design. The samples used in this study were divided into 2 groups, namely Group 1 Glass ionomer cement without the addition of Nanochitosan and Group 2 Glass ionomer cement plus 1% Nanochitosan, The total sample used was 10 samples. Analysis of the data used with the Shapiro-Wilk Normality test. The next stage is to do a Test of Homogeneity. Furthermore, the Independent T-test was used to determine whether a group had a significant difference from other groups. Results: The results glass ionomer cement group plus 1% nanochitosan was (0.196) and the normal glass ionomer cement group was (0.109). Conclusion: It can be concluded that 1% green mussel shell nanochitosan (perna viridis) is an effective treatment in affecting the compressive strength of glass ionomer cement.

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1. INTRODUCTION

Caries or cavities is a disease of tooth structure characterized by damage to enamel and dentine caused by metabolic activity of bacteria in plaque, resulting in demineralization through interactions in microorganism products and tooth enamel. Results in 2018 the prevalence of dental caries in Indonesia was 88.8%. in the age group 5-9 years the prevalence of caries is 92.6%, in the age group 10-14 years it is 73.4%, which indicates that the prevalence of dental caries in children is still high, Untreated caries can be a big problem because it can cause pain, abscesses, difficulty speaking, swallowing, and can cause cavities that affect physical and aesthetic health and cause a lack of patient confidence [1]. One of the treatments for tooth decay caused by caries is restoration treatment, namely treatment to restore the anatomy and function of teeth caused by fracture, attrition, abrasion, erosion and caries [2]. Dental materials consisting of amalgam, composite resin, and glass ionomer cement are materials used in dental restoration and rehabilitation to restore chewing ability and aesthetic value [3].

Glass ionomer cement is a restorative material that is adhesive, tooth-colored, and has the ability to release fluoride ions which are affected by the degree of acidity (pH). Glass ionomer cement contains materials including powder acid soluable calcium fluoraluminosilicate glass and liquid aqueous solution of polyacrylic acid. Glass ionomer cements continue to improve several physical and mechanical properties to expand their applications in dentistry. Glass ionomer cement has drawbacks, namely its brittle or breakable nature because it cannot withstand too much chewing load, is susceptible to wear and erosion, has a poor translucency level, easily absorbs water and when used for a long time results in insufficient durability. resistant to fracture, and unable to withstand large stress cycles, so glass ionomer cement requires additional ingredients in the form of chitosan modified in nanoparticle size to strengthen the mechanical properties of glass ionomer cement [4].

Compressive strength is the ability of a material to maintain its integrity under maximum stress in megapascals (MPa) until fracture occurs. The presence of fractures in both the teeth and the fillings is an indicator for assessing mechanical stress on glass ionomer cement fillings [5]. Glass ionomer cement is not used as a high-pressure filling material for permanent teeth because of its low compressive strength. The filling material must withstand the pressure in the mouth, especially in the area of the posterior teeth. Fillers with low compressive strength fracture easily because they cannot withstand masticatory pressure. The compressive strength of glass ionomer cement is considered to be unable to withstand pressure at high loads.

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Several studies have shown that the use of high-molecular chitosan can stimulate the formation of reparative dentine and improve mechanical performance and release of fluoride ions [6]. Chitosan is obtained by deacetylating chitin compounds contained in the shells of arthropods, molluscs, fungi, algae. Chitosan is a long chain polymer consisting of glucosamine monomers with positively charged amine groups. Chitosan can be added to the filler, namely glass ionomer cement. The chitosan form has a high charge density and acts as a cationic polyelectrolyte which interacts very effectively with surface biomolecules and is negatively charged. The addition of chitosan to commercially available glass ionomer cements improves its mechanical performance and acts as a catalyst in the release of fluoride ions.

This effect was explained based on the discovery of polymer networks that bind tightly around inorganic fillers which will result in better bonding [6]. Glass ionomer cement mixed with nanochitosan from mussel shells increased fluoride release and increased resistance to pressure and wear. In addition, adding nanochitosan to glass ionomer cement also increases its resistance to erosion by acids, as well as reduces the surface roughness of glass ionomer cement [7]. One source of chitosan is green mussel shells. Green mussel shells contain 14–35 n of chitin and 20.62% chitosan. Green mussels are one of the fishery resources in Indonesia that are easy to find in nature, and also one of the shells that has been successfully cultivated. Its production produces an abundance of green mussel shells, resulting in the generation of waste that can pollute the surrounding environment [8].

One of the ways to utilize green mussel waste is by processing it into chitin and chitosan as materials to strengthen the properties of glass ionomer cement. The advantages of chitosan from green mussel shells compared to other chitosan, namely having a low water content of 1.02%. The results of the FTIR measurements also showed that the green mussel shell chitosan had a high deacetylation degree value of 77.80% which caused the coagulation process to run effectively. Modification of chitosan can be done physically, including changing the size of chitosan particles or granules into smaller particles up to the size of nanoparticles. The smaller the particle size, the greater the surface area of the particles, thus increasing the ability of chitosan to be absorbent, anti-fungal, antibacterial, as well as its function as a carrier in the body [9]. Based on the description of the background above, it is hoped that through this research the nanochitosan present in Green Mussel Shells can be used as a potential additive for glass ionomer cement restorations. It is hoped that in the future it can be further developed as a dental material.

2. METHOD

This research is a laboratory experimental study with a true experimental study design using a post test only control group design, meaning that research aims to identify the effects caused by observing post-treatment changes. The subject used in this study was green mussel shell nanochitosan with a concentration of 1%. The object used in this study was GC Fuji II LC glass ionomer cement. The samples used in this study were divided into 2 groups, namely Group 1 Glass ionomer cement without the addition of Nanochitosan and Group 2 Glass ionomer cement plus 1% Nanochitosan. The object used in this study was GC Fuji II LC glass ionomer cement and the minimum number of samples was 5 for each treatment group and a total of 10 samples. The research was conducted at the Pharmaceuticals Laboratory, Faculty of Pharmacy, Universitas Muhammadiyah Surakarta. The research procedure is to manufacture nanochitosan by preparing green mussel shells and isolating green mussel shells. Then make the control group sample, make the treatment group sample, test the compressive strength. Analysis of the data used with the *Shapiro-Wilk Normality test.* The next stage is to do a Test of *Homogeneity.* Furthermore, the *Independent T- test* was used to determine whether a group had a significant difference from other groups.

3. RESULTS AND DISCUSSION

Results

The manufacture of nanochitosan from green mussel shells was carried out at the Pharmacy Laboratory of the University Muhammadiyah Surakarta. The prepared nanochitosan consisted of 1 concentration, namely 1% concentration, Chitosan that is said to be successful must have DD characteristics ≥ 70, as evidenced by conducting tests using an FTIR (Fourier Transform Infrared) spectrophotomer. Determination of the characteristics of nanochitosan was also carried out using a Particle size analyzer to determine the resulting particle size. Suitable nanoparticles are in the size of 1-1000 nm [8].

After obtaining the appropriate size of nanochitosan, it is followed by carrying out a compressive strength test using a universal testing machine. The test was divided into 2 treatment groups, with 1 control group (without the addition of nanochitosan) and 1 treatment group (1% nanochitosan concentration).

Table 1. Results of the nanochitosan size test using a universal testing machine

Concentration	Mean	SD
0%	3,17	0,24589
1%	3,45	0,43910

The normality test used in this study is the *Shapiro-Wilk test* because the number of samples is less than 50, so the data is said to have a normal distribution and the requirements for the *Independent T test* have been met if $p > 0.05$.

Table 2. *Shapiro-Wilk Normality Test* Results

Results	*Sig*
1%	0,426
Normal	0,566

The results of the *normality test* indicated that all treatment groups were normally distributed because the results showed p > 0.05. The next step is to carry out *a Test of Homogeneity* of Variance to test whether the samples taken have the same variance.

Table 3. *Levene's Test Homogeneity Test* Results

Levene Statistic	Sig
	0,540

Based on the table above, the *homogeneity test* of variance for significance or probability values shows the result of p> 0.05 so that it can be concluded that the data comes from populations that have the same variance. Furthermore, all of these data were analyzed using the *Independent T test* hypothesis.

Tabel 4. *Independent T test* Results

	Sig.
Results	0,540

The test results obtained a non-significant value (p) of more than 0.05 (p> 0.05) so that it was stated that there was no significant difference between groups.

Discussion

Testing the compressive strength of glass ionomer cement aims to see the ability of a material to withstand fracture or deformation. Compressive strength plays an important role in the mastication process because the chewing force is pressure. The pressure in the mouth must be resisted by the restorative material especially on the posterior teeth. Patching materials with low compressive strength are easy to fracture because they cannot withstand chewing pressure. The compressive strength of GIC is considered unable to withstand occlusal pressure under high loads [7].

The samples tested consisted of 2 treatment groups, group 1 was glass ionomer cement without the addition of nanochitosan, group 2 was glass ionomer cement with 1% nanochitosan concentration. In this study, glass ionomer cement that had been manipulated and added with nanochitosan was immersed in distilled water and adjusted to the temperature conditions of the oral cavity, namely 37oC for 24 hours by storing it in an incubator before testing. This was mentioned in a study 1 which compared the compressive strength of glass ionomer cement immersed in artificial saliva with storage in an incubator for 1 hour and 24 hours [7]. From the results obtained, glass ionomer cement has an effective compressive strength value at 24 hours of soaking and storage. After testing, the results obtained based on table 1, glass ionomer cement without the addition of nanochitosan obtained an average yield of 3.17 MPa, and a concentration of 1%, namely 3.45 MPa. From the test results that have been obtained, the highest average result is at a concentration of 1%, followed by the GIC value with 0% nanochitosan concentration or without the addition of nanochitosan. This shows that there is an effect on the compressive strength of glass ionomer cement added with nanochitosan.

Chitosan is a long-chain polymer consisting of glucosamine monomers that have a positive charge on the amino group. Chitosan can be added to the filling material, namely GIC. Mixing GIC with chitosan increases fluorine release and improves pressure and wear resistance. In addition, mixing nanochitosan into GIC increases resistance to erosion due to acids thereby reducing the surface roughness of GIC. GIC mixed with nanochitosan provides a good antibacterial effect against Streptococcus mutans [10]. This increase in antibacterial effect is related to the increase in fluorine release in nanochitosan modified GIC. Chitosan that is physically modified into nanoparticle sizes can increase the surface area by up to 100 times compared to microparticle chitosan. Nanoparticles can penetrate into spaces that cannot be reached by larger sized particles and also increase solubility thereby increasing the bioavailability of the particles [9]. One of the advantages of nanochitosan is that chitosan nanoparticles have a higher antibacterial effect than regular sized chitosan [7]. Nanochitosan has better sealing ability than calcium hydroxide because it is a polyelectrolyte that can interact with negative surfaces and biomolecules. The amine groups in chitosan can bind to the hydroxyl particles in dentine. The ability of chitosan to form a good seal can prevent contamination of microorganisms from entering the pulp, preventing inflammation and promoting pulp repair. Chitosan has a high level of deacetylation. The high degree of deacetylation will increase the biocompatibility properties of chitosan in the wound healing process, especially in the formation of odontoblast-like cells.

The results of this study are in line with research which stated that the highest compressive strength in GIC was GIC with 1% chitosan added [7]. This is because the more nanochitosan added to GIC, the nanochitosan molecules tend to interact with each other rather than with GIC components so that the mechanical properties of GIC decrease. Nanochitosan has hydroxyl groups and amine groups. It is this amine group that makes nanochitosan have a strong positive partial charge so that nanochitosan can attract molecules with a partial negative charge. The reaction that occurs between the GIC and nanochitosan components is that there is a bond formed between the hydroxyl and acetamide groups of nanochitosan with the hydroxyl groups from SIK powder and the carboxyl groups from polyacrylic acid through hydrogen bonds. Hydrogen bonds bind to GIC components which have a high tension. This reaction lowers the surface tension between the GIC components. The adhesion force between GIC components increases due to decreased surface tension so that the bonds between GIC components become stronger and the mechanical properties of GIC increase [7].

4. Conclusions

Based on the results of research that has been done regarding the effectiveness of adding green mussel shell nanochitosan (*perna viridis*) to the compressive strength of glass ionomer cement, it can be concluded that 1% green mussel shell nanochitosan (*perna viridis*) is an effective treatment in affecting the compressive strength of glass ionomer cement. It is necessary to conduct further research on other nanochitosan such as nanochitosan on red snapper fish scales or nanochitosan on horn beetles to see its comparison in the compressive strength of glass ionomer cement. Further research is needed regarding the comparison of immersion time in an incubator with a combination of nanochitosan levels to determine the most effective treatment.

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