The Effectiveness of Adding Rice Husk Nanosilica to the Flexural Strength of Opaque Porcelain Coatings on Metal Ceramic Dental Crowns

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A B S T R A C T

Background. Failure of dentures that are unable to withstand flexural forces is often a major problem in the use of metal-ceramic crowns. The use of rice husk nano-silica powder has been extensively researched in dentistry because of its ability to improve mechanical properties. This study aims to determine the effectiveness of nano-silica particles from rice husks on the flexural strength of the opaque layer on Co-Cr metal-ceramic crowns. **Methods:** The type of research is experimental laboratories in vitro with posttest only control group design. The research samples were rectangular Co-Cr metal and porcelain plated on top of the metal center totaling 25 samples which were divided into 5 treatment groups. Flexural strength measurement with three-point bending at UTM. Data were analyzed by independent T-test and one-way ANOVA. **Results:** flexural strength of Co-Cr metal ceramic crown with the addition of 0.25% rice husk silica; 0.5%; 0.75%.1% in the opaque layer is 70.431±4.168; 84.093±2.852; 100,672±4,182 and 115,092±3,821, respectively. **Conclusion:** There is an increase in the flexural strength of metal ceramic crowns with the addition of 0.25% silica; 0.5%; 0.75%,1% on opaque coating.

1. Introduction

Loss of teeth can interfere with the function of mastication, swallowing, and speech, if not immediately replaced with dentures will cause health problems. A large number of cases of tooth loss will of course make the demand or desire for artificial teeth increase to restore the function of the missing teeth.[1-3]

One of the dentures that are permanently cemented to the abutment teeth, and cannot be removed by the patient are dentures. Fixed (GTC). This denture consists of a crown and a bridge. Based on the material, GTC is divided into full ceramic and metal-ceramic.

Metal ceramic crowns have several advantages, namely color stability, aesthetics, biocompatibility, and strong resistance to mastication. However, this restorative material also has its drawbacks, namely low flexural strength and brittleness, resulting in fracture, especially when exposed to high pressure on the posterior teeth.[4]

Denture failure that is unable to withstand the flexural force is often a major problem with the wearing of metal ceramic crowns. The fleksural strength of metal ceramics is affected by the thickness of the

ceramic coating. The ceramic layer that covers the metal coping on the metal ceramic crown is called the porcelain layer, which has three layers including an opaque layer, dentin layer and enamel layer.[5] The opaque layer is the first layer of covering the metal coping serves to bind the ceramic layer with a metal coping and give color to the dentures.

The ideal thickness of the opaque layer ranges from 0.2-0.3 mm. At a thickness of 0.15 mm, the opaque layer can be attached with metal coping. The opaque layer attached to the metal cover can seal the oxide on the metal. Good adhesion between the opaque layer and metal is the main key to the success of metal ceramics. The dentin layer is a porcelain layer that covers the metallic color in the number and size of opaque particles, is influenced by the number of dentin pigment particles, and can scatter and reflect light. The enamel layer is a layer that does not have pigments and metal oxides, so it is more translucent than the dentin layer. [6,7]

Porcelain in metal-ceramic crowns is a type of ceramic that is dominated by silica, which is a derivative of 75-81% feldspar minerals, which is three-dimensional bonds three-dimensional atoms whose arrangement is irregular (amorphous), resistant to heating, and can be found in the form of quartz, cristobalite, and tridymite. Silica is hard and stable which makes metal-ceramic crowns resistant to mastication. Silica is a compound resulting from the polymerization of silicic acid which is composed of a tetrahedral SiO_4 and has the general formula SiO_2. Silica can be obtained from natural or synthetic materials. Silica from natural materials can be found in sand, quartz, glass, and so on. Synthetically, silica can be produced from silicate solutions or silane reagents. [8]

The use of rice husk silica powder on a nanoscale has been developed and researched in dentistry because of its ability to improve mechanical properties. A study using the addition of silica in 3 variations, namely 0.25%, 0.5%, 1%, and the results of the study stated that the best flexural and dynamic strength was found in the addition of 0.5% concentration.[9] A study examined the effectiveness of the particles. rice husk

nano-silica as filler in composite resin and compare it with commercial composite Z250. The results showed that the rice husk nano-silica composite had the same hardness as the commercial composite.[10]

2. Methods

This research was an experimental laboratory in vitro with a posttest-only control group design. The research objects in this study were 25 (divided into 5 groups: group without the addition of rice husk silica, application of rice husk silica 0.25%, 0.5%, 0.75%, and 1%) cobalt-chrome metal-ceramic dental crowns. (Co-Cr), wherein CoCr metal is rectangular (25±1) mm ×0(3±0.1) mm × (0.5 ± 0.05) mm. Porcelain (8±0.1) mm × 3 × (1.1±0.1) mm has plated over the metal center. The manufacture of rice husk silica begins with rice husks washed thoroughly with water to remove dissolved particles, dust, or other contamination such as dirt on the material.

The rice husks were then dried overnight in an oven at 110oC. The dried rice husks were then heated in an acid solution (1 M HCl solution in a water bath) 75for 90 minutes to remove metal impurities. The rice husks were then washed several times using ionized water. The rice husk precipitate was then dried overnight with 10% NAOH solution at 90℃ for 1 hour and filtered to obtain Sodium Silicate Solution (SSS).

Nanosilica was obtained by precipitation of Sodium Silicate Solution (SSS) with an organic acid solution with constant stirring until the pH dropped to 8. Before precipitation, 40 ml of propanol was added to Sodium Silicate Solution (SSS). When the pH of the solution dropped to 8, the precipitation process was stopped, then the gel was stirred again for 45 minutes. The gel was then cleaned several times and centrifuged at 4000 rpm for 5 minutes after each cleaning to obtain a solution without acid during the white precipitation process. The white precipitation was calcined at 50 powder with pure silica. Nano silica was added to the opaque layer with 4 variations, namely 0.25%, 0.5%, 0.75% and 1%. With the ultrasonic homogenizer method with a vacuum filtration device for 180 minutes, it produces nano-silica particle sizes. Furthermore, rice husk silica characterization was

carried out with XRF (X-ray fluorescence). Next, the opaque layer of rice husk was applied to the Co-Cr metal, starting with ultrasonic cleaning of the metal coping for 3 minutes. Oxidation of metal coping with temperature 95. Apply an opaque layer of rice husk silica with a thickness of 0.2 mm by burning 2 times at a temperature of 94 in 4 variations: 0.25%, 0.5%, 0.75%, 1%. Condensation with 1 x manual vibration. Apply a layer of dentin with a thickness of 0.7 mm by burning 2 times at a temperature of 93. Apply an enamel layer with a thickness of 0.2 mm at a temperature of 94 glazing with a firing temperature of 92. Furthermore, measurements of flexural strength were carried out with three-point bending at UTM.

Data analysis was carried out with the help of SPSS version 25 software. First, a univariate analysis was carried out which showed the value and level of the test for each variable in the form of mean ± standard deviation. Then, bivariate and multivariate tests were conducted to see the difference in the mean test scores between the treatment groups.

3. Results

Analysis based on X-Ray Fluorescence (XRF) aims to analyze the composition of a compound more accurately. Based on Table 1 and Table 2 shows that the Si element can be seen before refining the percentage of 78.4% and after purification 97.9%. Based on the particle size analysis of nano-silica using an ultrasonic homogenizer, it can be seen that the nanoparticle size is 216.1 nm (Table 3).

Table 1. X-ray fluorescence (XRF) analysis of rice husk silica particles

Composition	Si	P	K	Ca	Cr	Mn	Fe	Ni	Cu	Eu	Yb
Percentage of amount (%)	78.4	3.2	10.1	3.89	0.29	1.1	1,96	0.1	0.31	0.2	0.5

Table 2. X-Ray Fluorescence (XRF) analysis of nanosilica particles from rice husks

Composition	Si	Ca	Ti	Cr	Mn	Fe	Ni	Cu	Ba	Yb
Percentage of amount (%)	97, 9	1,39	0.15	0.077	0.071	0.21	0.02	0.091	0.03	0.06

Table 3. Analysis of nanosilica particle size with an ultrasonic homogenizer

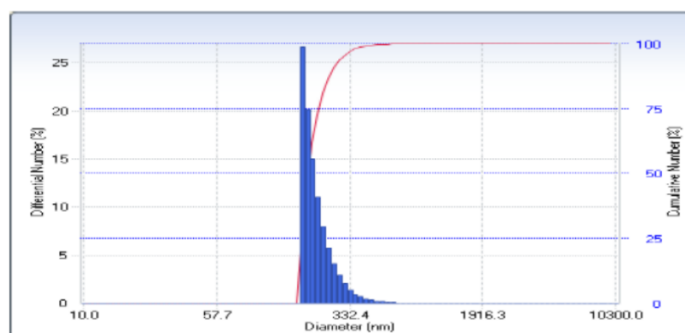| Peak	Diameter (nm)	Std. Dev.
1	216.1	52.3
2	0.0	0.0
3	0.0	0.0
4	0.0	0.0
5	0.0	0.0
Average	216.1	52.3

Figure 1. Analysis of nano-silica particle size with an ultrasonic homogenizer.

There was a significant difference in the effectiveness of the flexural strength of Co-Cr metal-ceramic crowns between without and with the addition of 0.25%, 0.5%, 0.75%, 1% rice husk silica in the opaque layer (p<0.000), the addition of husk silica. rice 0.25% by 0.5%; 0.75%, 1% in the opaque layer (p<0.000), the addition of 0.5% rice husk silica with 0.75%, 1% in the opaque layer (p<0.000), and the addition of 0.75% rice husk silica with 1% (p<0.000).

Table 4. The effectiveness of adding rice husk silica to the opaque layer on the flexural strength of ceramic crowns metal CoCr

Addition of silica	Flexural strength (MPa)		
	Mean	SD	*p-value*
Silica 0%	53,921	3,122	
Silica 0.25%	70,431	4,168	
Silica 0.50%	84,093	2,852	0.000*
Silica 0.75%	100,672	4,182	
Silica 1%	115,092	3,821	

*One-Way ANOVA test, p<0.05

Table 5. Differences in the effectiveness of adding rice husk silica to the opaque layer on the flexural strength of ceramic Co Cr

Addition of silica		Flexural strength (MPa)	
Group		Differences in mean	*p-value*
Silica 0%	Silica 0.25%	16.510	0.000*
	Silica 0.50%	30,172	0.000*
	Silica 0.75%	46,751	0.000*
	Silica 1%	61.173	0.000*
Silica 0.25%	Silica 0.50%	13,662	0.000*
	Silica 0.75%	30,241	0.000*
	Silica 1%	44,662	0.000*
Silica 0,5%	Silica 0.75%	16.579	0.000*
	Silica 1%	31,000	0.000*
Silica 0,75%	Silica 1%	14,421	0.000*

*Post hoc test, Bonferroni, p<0.05

4. Discussion

The results of testing the flexural strength of the Co-Cr metal ceramic crown showed that the sample group without the addition of rice husk silica in the opaque layer had the lowest flexural strength, and the highest in the sample with the addition of 1% rice husk silica in the opaque layer, it can be stated that the more rice husk silica was added. in the opaque layer, the flexural strength of the Co-Cr metal ceramic crown is increasing. This is evidenced by the results of the independentt test that there is a significant difference in the addition of rice husk silica in 0% and 1% opaque layers to the flexural strength of the Co-Cr metal ceramic crown.[11,12]

The difference in the increase in flexural strength was not only seen between the sample groups without the addition of rice husk silica in the opaque layer and the sample group with 1% rice husk silica added in the opaque layer, but also differences were found in all existing groups. In the study using the addition of silica in 3 variations, namely 0.25%, 0.5%, 1% and stated that the higher RHA-Si can increase filler

agglomeration which can reduce the mechanical properties of acrylic resin materials.[13-15]

The results of this study are in line with the theory that the silica content of rice husks can increase the mechanical strength of restorative materials.[16] Supported by other studies which state that the flexural strength of restorative materials is highly dependent on the content of nanosilica particles.[17] The more addition of nanosilica, the higher the flexural strength. The results of this study are also consistent with several other studies that the addition of nanosilica can increase the mechanical strength of composites and hot polymerized acrylic resins. [18-20] The existence of this equation is probably due to the similarity of the restorative material used, namely Co-Cr metal ceramic which has several better mechanical properties than other restorative materials, including higher strength and resistance to heat and lower fracture propagation.[21-25]

5. Conclusion

There was an increase in flexural strength in metal ceramic dental crowns with the addition of 0.25% silica; 0.5%; 0.75%,1% on opaque coating.

6. References

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