World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(Research Article)

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The effect of adding pineapple leaf microfibers (*Ananas comosus* L. Merr) to packable composite resin on flexural strength

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World Journal of Advanced Research and Reviews, 2024, 23(02), 1312–1316

Publication history: Received on 05 July 2024; revised on 13 August 2024; accepted on 16 August 2024

Article DOI: https://doi.org/10.30574/wjarr.2024.23.2.2368

Abstract

Composite resin is a restorative material often used for the aesthetic restoration of anterior and posterior teeth. Packable composite resin is indicated for posterior teeth because its resistance to pressure can reduce the problem of loss of contact. Flexural strength is a combination of compressive stress and tensile stress on the restoration of the teeth in the anterior and posterior areas while functioning in the oral cavity. A restorative material that cannot withstand the flexural force continuously can cause fractures. The addition of microfiber is capable of increasing the strength and mechanical properties, including the flexural strength of packable composite resin. This study aims to determine the influence of the addition of discontinuous microfiber on the flexural strength of packable composite resin. This type of research is a true experimental laboratory study with a post-test only control group design. The study used a total of 16 packable composite samples, divided into two groups: the control group without added discontinuous microfiber from pineapple leaf and the treatment group with the addition of discontinuous microfiber from pineapple leaf.

Keywords: Microfiber; Pineapple Leaf; Composite Resin; Packable; Flexural Strength.

1. Introduction

According to the 2018 Basic Health Research results in Indonesia, dental and oral health is still a problem with a national prevalence of 57.6%. The prevalence of caries in children in Indonesia is 76%, according to recent studies.(1) Restoration is needed to restore the function of the teeth. Dental restoration involves using dental materials to reconstruct the structure of the teeth. Composite resin can modify the shape and color of the teeth and restore their function. Composite resin restorations are the most commonly used materials in dentistry because their use requires simple care and produces good aesthetics.(2) Composite resin is a restorative material for aesthetic restoration of anterior and posterior teeth. Many advantages of choosing composite resin as a restorative material include its more natural appearance and the presence of a micromechanical bond to the tooth structure that can produce a good bond. However, composite resin also has disadvantages, including requiring good insulation to keep the teeth dry, experiencing polymerization shrinkage, being more difficult to apply, and taking a long time.(3)

Amalgam restorations have the advantage of durability over composite resin restorations. The use of amalgam is decreasing due to environmental pollution. Composite resin restorations have aesthetic advantages but they also have the disadvantage that they do not long wear. Failure of composite resin is due to its inability to withstand occlusion loads. Composite resin fillers are small particles that are poorly able to withstand high compression pressures. Fibers in FRCs (fiber-reinforced composites) improve the toughness and other physical properties. The size and distribution of fibers in the composite resin will affect the light scattering. The larger the fiber size will reduce the intensity of the incoming beam because it has a high light spread. (4,5)

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Fiber-reinforced composite resin can be used to replace the metal framework to withstand chewing loads.(6) Composite resin is classified based on manipulation into two types: packable composite and flowable composite. The difference between these composites lies in their content and matrix, determining the viscosity of the material. Packable composite provides an alternative to dental amalgam in Class I and II restorations. This material allows non-adherent condensation during manipulation, similar to dental amalgam.(7,8) Packable composite resin is indicated for posterior teeth because it can withstand chewing loads, thus reducing occlusal tooth wear. As a polymer-based material, composite resin absorbs water and can degrade when exposed to fluids in the oral cavity. Degradation of the resin matrix causes a decrease in the physical properties of the composite resin, such as hardness, flexural strength, and elastic modulus.

Flexural strength is a combination of compressive and tensile stresses on dental restorations in the anterior and posterior areas while functioning in the oral cavity, referred to as flexural stress. Fractures in restorations can occur due to materials that cannot continuously withstand flexural forces, resulting in restoration damage. Adding microfibers can enhance the strength and mechanical properties, including the flexural strength of packable composite resin. A mixture of fibers as a reinforcement with a polymer composite matrix is called fiber-reinforced composite (FRC). The fibers interlock by providing silane bonding to support the load on the composite.(6,9) The mechanical properties of FRC constructions are influenced by adhesion, fiber volume, position, and composition of the fibers.

Pineapple is one of the plants with high economic potential in Indonesia. Kediri Regency is the largest pineapple producer in East Java. Pineapple production in Indonesia increased in 2018.(10) During the harvest season, pineapples produce pineapple leaf waste as a byproduct. Based on microscopic observations, cells in pineapple leaf fibers have an average diameter of about 10 µm. The average cell wall thickness of pineapple leaf fibers is 8.3 µm.(11) The fiber volume fraction should be considered when adding it to composite resin. Pineapple leaf fibers at 30% have the highest flexibility compared to other groups.(12)

The aim of this study is to determine the difference in flexural strength with and without the addition of pineapple leaf microfibers in packable composite resin. The benefits of this study are to provide information about natural materials that can be processed as additives to improve the flexural strength of packable composite resin in dentistry.

2. Material and methods

The research used is the post-test-only control group design approach. The total sample used was 16 samples. The samples were divided into two groups (the treatment group and the control group). Sampling technique using simple random sampling. The alkalised pineapple leaf fiber was cut into small pieces using a blender. The milled fiber was then sieved using a sieve with a size of 100 mesh to get the highest number of fiber sizes available which is 149 micrometers. After sieving, the Pineapple leaf fiber was weighed with a weight of 0.45mg. The test was continued by making an acrylic-based mold with a size of 25 mm x 2 mm x 2 mm.

The packable composite resin was applied 1 mm high to the mold and leveled with a plastic filling instrument on the mold base and then light cured for 20 seconds. Next, pineapple leaf fiber was placed on a glass slide and 1 drop of silane coupling agent was applied, then waited for 60 seconds. Application of Pineapple leaf fiber to the mold. the packable composite resin is layered on top of the fibers to fill the mold and then light-cured for 20 seconds. The sample was immersed in a conical tube filled with 1 ml of distilled water, then the sample was placed in an incubator at 37ºC for 24 hours before the flexural strength test. The sample was dried with absorbent paper then the sample was stored in an airtight place. The flexural strength was measured using a Universal Testing Machine (UTM).

The research data obtained will be analyzed using the Statistical Product and Service Solution (SPSS) to find the difference in flexural strength ratio between the two treatment groups.

3. Results and discussion

This study was to determine the effect of the addition of discontinuous pineapple leaf microfibre to a packable composite resin on flexural strength. The flexural strength test results include the mean and standard deviation presented in the table below.

Table 1 Mean and standard deviation (SD) of flexural strength (MPa) of packable composite resin after adding pineapple leaf fiber

Group	Mean	SD
Control (Without Additional Micro Fiber Pineapple Leaves)	171.57	0.295
Treatment (Pineapple Leaf Microfiber Addition)	173.20	3.798

The highest average flexural strength occurred in the treatment group on average of (173.20 ± 3.798) MPa, and the lowest average in the control group was (171.57 ± 0.295) MPa. Normality data was analyzed with Shapiro.

Table 2 Normality of flexural strength (MPa) of packable composite resin after adding pineapple leaf fiber

Group	***Shapiro-Wilk***		
	Statistic.	df	Sig.
Control (Without Additional Micro Fiber Pineapple Leaves)	0.827	8	0.056
Treatment (Pineapple Leaf Microfiber Addition)	0.512	8	0.000

It was known that the control group had normally distributed data (Sig.> 0,05) while the treatment group had not normally distributed (Sig.< 0.05). The homogeneity test chosen in this study is Levene's test. The homogeneity test data in Table 3, sig. > 0,05. It shows data variations between homogeneous groups.

Table 3 Homogenity of flexural strength (MPa) of packable composite resin after adding pineapple leaf fiber.

Lavene Statistic	df1	df2	Sig.
4.472	1	14	0.053

Samples not normally distributed, the comparative hypothesis test is performed using non-parametric statistical methods using the Mann-Whitney test to determine the effect of adding microfiber leaf Pineapple discontinuously on packable composite resins against flexural strength.

Table 4 Mann Whitney Test of mean difference flexural strength (MPa) of packable composite resin after adding pineapple leaf fiber.

Test	Results
Mann-whitney U	9.000
Wilcoxon W	45.000
Z	-2.446
Asymp. Sig. (2-tailed)	0.014
Exact Sig. [2*(1-*tailed Sig.* 0]	0.015^b

Based on the results of the Mann-Whitney test, the Asymp. Sig. (2-tailed) is < 0.05. According to the decision-making basis of this test, if the sig. < 0.05, there is a difference between the two treatments. Therefore, it can be said that there is a difference between the non-added microfiber of the pineapple leaf and the addition of discontinuous microfiber of the pineapple leaf to the packable composite resin in terms of flexural strength.

Almost all types of natural fibers, especially those from plants (vegetable fibers), abaca, henequen, sisal, jute, pineapple leaves, and sansevieria. The largest chemical composition of fiber content is cellulose, although other elements or substances are also present in the fiber, such as fats and waxes, hemicellulose, lignin, pectin, and coloring matter (pigments) that cause fiber color. The X-ray observations showed that the pineapple leaf fiber had a high degree of crystallinity with a fiber angle of about 150. Treatment with acid and alkali on pineapple leaf fiber showed very high changes in amorphous regions compared to untreated fiber. Treatment is done to improve the absorbency of the liquid. To enhance the adhesion to the composite resin, coating with silane is required. Commercially available silane coupling agents can fulfill the requirements in clinical practice for durable bonds.(13,14)

Another factor that can enhance the flexural strength of packable composite resins is the use of silane as a coupling agent. The cellulose content, such as that found in Pineapple leaf fibers, can bind to silane, as a Coupling Agent, thereby increasing the mechanical strength of the fibers. The matrix and fiber bonding will increase so that the mechanical strength between the composite and the coupling agent is increased. Fibers are divided into two categories: natural fibers and man-made fibers. Therefore, use natural fiber from natural fibers that are easily available and inexpensive as an alternative that can be developed, one of which is pineapple leaf fiber. The advantages of using natural fibers are that they are abundant, have low specific costs, can be recycled and renewable, and do not pollute the environment. Pineapple leaf fiber contains high cellulose, about 86,5 % of its total weight so it can produce good mechanical strength.(15,16)

The average flexural strength value without added pineapple leaf microfiber was 171.57 MPa, while the highest flexural strength value in packable composite resin with added pineapple leaf microfiber was 173.20 MPa. The small difference observed is due to the layer-by-layer sample preparation process. The microfibers were mixed with the composite resin using a cement spatula for 1 minute until homogeneous, ensuring that the microfibers were uniformly distributed throughout the resin in the mold. The flexural strength of pineapple leaf fiber composites decreases as the volume fraction of short (micro) fibers increases. This decrease in flexural strength can be attributed to imperfect bonding between the fibers and the matrix, resulting in voids as the fiber volume increases in the composite. Additionally, short (micro) fibers may not effectively withstand the applied forces in the direction of the working load.

One of the factors that can increase the mechanical strength of fibers is the alkalization process. Alkalization treatment creates mechanical interlocking and bonding on the fiber surface, thereby enhancing adhesion between the fiber and matrix.(17) Additionally, a bonding agent is necessary to bind filler particles with the resin matrix, such as a coupling agent or binder. This serves to improve both the mechanical and physical properties of the resin, and stabilizes hydrolytic degradation by preventing water penetration into the resin filler material.

During the alkalization process, the elasticity of the fiber can change and the fiber diameter may decrease. This alteration increases airflow resistivity and porosity, which can hinder the adhesion of silane to the microfiber.(18) The alkalization process can change the elasticity of the fibers and reduce the fiber diameter, thereby increasing airflow resistivity and decreasing porosity, which can inhibit the attachment of silane to the microfibers. This is why the difference between the treatment and control groups was not significantly different.

4. Conclusion

Based on the results of research on packable composite resins with the addition of discontinuous microfibers of Pineapple leaves, it can be concluded that there is an increase in flexural strength in the packable compound resins plus the microfiber of pineapple leaves (Apineapple comosus (L.) Merr) discontinently. Further research is needed to find out the process of alkalization of pineapple leaf fibers to obtain a good cellulose to be used as a raw material in addition to the strength of packable composite resin. More research is required to know the influence of the addition of micro, macro and nano-sized fiber on flexural strength.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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