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EFFECT OF FLEXURAL STRENGTH NON-DENTAL GLASS FIBER REINFORCED COMPOSITE CONCENTRATION ON ARTIFICIAL SALIVA

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ABSTRACT

Background: Fiber reinforced composite (FRC) provides superior mechanical strength and color stability, as well as resistance to mechanical stress and plaque accumulation. Using cheaper and easily manipulated non-dental glass fiber can enhance the mechanical strength of FRC. This study aims to investigate the effect of FRC with non-dental glass fiber on flexural strength when immersed in artificial saliva, which is important for dental applications.
Method: This study was pre-experimental designs and followed a post-test only control group design. It included 18 specimens, each measuring 25x2x2 mm. The specimens were divided into three groups: the first group consisted of non-dental glass fiber reinforced composite with concentrations of 0%, 1%, and 2%. The data were analyzed using a One-Way ANOVA test followed by Post Hoc testing.
Result: The average flexural strength for the first group of non-dental glass fiber reinforced composite at 0% concentration was 52.496 MPa. For the second group, with a 1% concentration, it was 96.268 MPa. The third group, with a 2% concentration, had an average flexural strength of 134.791 MPa. The One-Way ANOVA results yielded a p-value of 0.000.
Conclusion: The research results indicated that the highest flexural strength was observed in the non-dental glass fiber reinforced composite with a 2% concentration.

BACKGROUND

Fiber reinforced composite (FRC) is a material known for its combination of a polymer matrix and reinforcing fibers.[1] The use of FRC offers benefits in terms of enhanced mechanical properties and its ability to form strong bonds with tooth structures. Key characteristics of FRC include its resistance to mechanical stress, minimal plaque accumulation, and color stability.[2] According to Anzules (2019), this material has optimal flexural strength, making it an ideal choice for prosthetic substructures and the replacement of missing tooth structures.[3] Various types of fibers used in dentistry include carbon, glass fiber, polyethylene, and polyaramid. Glass fiber not only provides good aesthetics due to its translucency but also bonds chemically with the matrix through silane coupling agents offering optimal mechanical properties. Non-dental glass fiber is particularly noted for its potential to enhance mechanical strength.[2]

Non-dental glass fiber is readily available in large quantities and is relatively inexpensive compared to dental glass fiber, which is limited in supply and higher in cost. Non-dental glass fiber offers advantages such as easy manipulation, increased flexural and impact strength, good adaptability, and optimal biocompatibility and aesthetics. However, glass fiber has high density compared to polymers and is not recyclable.[2,4,5]

In dentistry, fiber reinforced composites (FRC) are used for applications such as bridge dentures, splinting treatments for periodontal patients, and temporary fixed dentures after tooth extractions.[4] Flexural strength, or transverse strength, is crucial for the durability of materials, especially in splinting treatments, as good flexural strength helps withstand chewing forces. This study aims to investigate the effect of non-dental glass fiber reinforced composite on flexural strength when immersed in artificial saliva.

METHOD

This study has received ethical approval from the Research Ethics Committee of the Faculty of Dentistry, Sultan Agung Islamic University (FKG Unissula) with the approval number: 486/B.1-KEPK/SA-FKG/IX/2023. This research utilized a pre-experimental laboratory analysis with a post-test only control group design. A total of 18 samples were used, the Federer formula, was used to determine the sample size in a pre-experimental laboratory analysis. The samples were divided into three treatment groups: non-dental glass fiber reinforced composite at concentrations of 0%, 1%, and 2%, all immersed in artificial saliva. The flexural strength of each sample concentration was tested using a Universal Testing Machine. The primary goal of this study was to examine and compare the effects of different concentrations of non-dental glass fiber on flexural strength during immersion in artificial saliva. It was anticipated that the results would provide insights into the impact of non-dental glass fiber reinforced composite concentrations on flexural strength during artificial saliva immersion.

The samples were prepared by manually selecting non-dental glass fibers using tweezers, then separating them according to the required concentrations. The separated fibers were weighed and cut to a specified length of 23 mm to meet the volume concentration criteria of 0%, 1%, and 2%. The sample preparation process continued with filling molds with composite resin. For samples containing fibers, a silane coupling agent was applied to enhance the bond between the fibers and the resin matrix. The non-dental glass fibers treated with the silane coupling agent were placed horizontally in the molds, which were then filled evenly with composite resin. The samples underwent light curing for 20 seconds. The next step was incubation, where the cured samples were placed in an incubator at 37°C for 24 hours. During this period, each sample was immersed in artificial saliva with a pH of 6.8.

After the incubation period, flexural strength testing was conducted on all samples using the Universal Testing Machine. The analysis of the research results was conducted by calculating the sample size, followed by normality testing using the Shapiro-Wilk test and homogeneity testing with Levene's Statistic. The obtained data were analyzed using One Way ANOVA, followed by Post Hoc testing to determine which groups differed significantly from each other.

RESULTS

Based on the research findings, data on the average values of flexural strength of non-dental glass fiber reinforced composite immersed in artificial saliva were obtained from 3 test groups, as presented in the following table:

Table 1. Average Values of Flexural Strength among Non-Dental Glass Fiber Reinforced Composite

Group	Average	Standard Deviation
Non dental glass FRC 0%	52,496	5,297
Non dental glass FRC 1%	96,268	6,130
Non dental glass FRC 2%	134,791	8,793

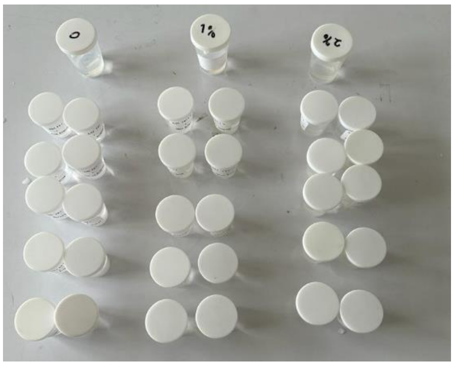

Figure 1. Specimen after being filled with saliva solution according to the concentration

The research findings revealed differences in the average values of flexural strength among non-dental glass fiber reinforced composites. The group with 0% concentration exhibited the lowest flexural strength, with an average value of 52.496 MPa ± 5.297, compared to the other groups. Meanwhile, the group with a concentration of 2% showed the highest flexural strength, with an average value of 134.791 MPa ± 8.793. Subsequently, normality and homogeneity tests were conducted. The normality test, using the Shapiro-Wilk method, yielded the following results for the data from the three groups:

Table 2. Shapiro-Wilk Normality Test Results

Group	Sig.
Non dental glass FRC 0%	0,370
Non dental glass FRC 1%	0,114
Non dental glass FRC 2%	0,269

The Shapiro-Wilk normality test results for all groups indicated $p > 0.05$, indicating that the data in each group were normally distributed.

Table 3. Levene's Test for Homogeneity of Variance Results

Group	Sig.
All Group	0,633

The homogeneity test showed $p > 0.05$, suggesting that the data variances were homogeneous. Consequently, a statistical test was performed using the One-Way ANOVA test to determine if there were significant differences among the groups. The analysis of the statistical data from the flexural strength of non-dental glass fiber reinforced composites with concentrations of 0%, 1%, and 2% showed the following:

Table 4. Analysis of One-Way ANOVA Test Results

	One Way Anova
Sig.	0,000

Based on the results of the One-Way ANOVA test (obtained from the table, $p = 0.000$) ($p < 0.05$), indicating a significant difference in the average results among the three test groups. Subsequently, a post hoc test was conducted to determine the differences between groups.

Table 5. Post Hoc Test Results

Group	Concentration 0%	Concentration 1%	Concentration 2%
Concentration 0%	-	0,000 *	0,000 *
Concentration 1%	0,000 *	-	0,000 *
Concentration 2%	0,000 *	0,000 *	-

The Post Hoc test results indicated that the concentrations of 0%, 1%, and 2% showed $p = 0.000$ ($p < 0.05$), signifying significant differences between all groups compared to each other.

DISCUSSION

The research findings indicate that the flexural strength of non-dental glass fiber reinforced composites increases with the concentration of non-dental glass fiber. According to ISO 4049 standards, the minimum flexural strength required for restoration materials after polymerization with light is 50 Mpa.[6] The flexural strength results for concentrations of non-dental glass fiber at 0%, 1%, and 2% in composite resins fall within normal limits, with an average strength in artificial saliva of 103.82 MPa.

Safitri et al. (2022) demonstrate a significant increase in flexural strength in nanofill composite resin with the addition of non-dental glass fiber, unlike nanofill resin without fiber. This could be attributed to the ability of non-dental glass fibers to evenly distribute pressure across the material layers.[7]

Putri et al. (2016) suggests that adding fibers to composite resins enhances mechanical strength. The addition of fibers improves the resistance of composite resins due to their rigid nature. Without fiber addition, the resin composite lacks uniform load distribution, leading to concentrated forces and an increased risk of fracture. Strong bonding between fibers and composite resin results in even load distribution, with pressure distributed not only to the composite resin but also to the fibers interspersed within the resin.[8,9,10] Mechanical properties of fiber-reinforced composites can be influenced by several factors, including fiber impregnation and bonding with resin, basic properties of fibers and polymer matrix, fiber orientation, quantity, and positioning.

Faizah et al. (2017) state that adding 3% to 5% fiber can decrease strength due to decreased fiber-resin bonding, leading to gaps. These gaps can weaken the bond between fiber and composite resin, resulting in reduced strength. Strong bonding between fiber and composite resin is crucial for strength, as it minimizes gaps between the two materials, thus enhancing strength.[1,11,12]

Flexural strength refers to a material's ability to remain intact before fracturing under pressure and is used to assess a material's resistance to flexibly applied pressure. In the context of non-dental glass fiber, increased flexural strength can be achieved through impregnation using PMMA resin, which plays a crucial role in achieving optimal impregnation of glass fibers.[13,14] Impregnation is a critical step in the wetting process of fibers with resin. The success of impregnation depends heavily on the resin's ability to adhere to the fiber. It's important to note that high viscosity in resin can hinder the impregnation process between resin and fiber. Flexural strength testing can be conducted using a Universal Testing Machine, aiming to determine the maximum load required before specimen fracture. The testing process involves placing the sample on a support base, then applying a load directly to its center until fracture occurs.[15]

Saliva primarily consists of water, accounting for 99% of its total composition. Its organic composition includes bicarbonates, phosphates, calcium, potassium, magnesium, sodium, nitrates, chlorides, thiocyanates, while its inorganic components involve amylase, albumin, amino acids, lactic acid, peroxidase, maltase, proteins, creatinine, mucus, vitamin C, lysozyme, and hormones like cortisol and testosterone. Saliva serves to protect and maintain the health of tooth and mouth hard tissues as a mechanical cleanser by reducing plaque accumulation or by maintaining tooth elements to prevent occlusal wear due to chewing processes. Saliva also regulates pH to control acidity levels, thereby inhibiting the demineralization process. Ion composition is crucial for artificial saliva to resemble normal human saliva. Apart from reducing discomfort, artificial saliva helps maintain tooth integrity.[8,16]

CONCLUSION

The research findings indicate that there was an influence from the addition of concentrations of non-dental glass fiber reinforced at 0%, 1%, and 2% on immersion in artificial saliva. From the flexural strength results in this study, the highest value was observed in the non-dental glass fiber reinforced composite with a concentration of 2%.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest

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