The Effect Of Immersion Duration Of Non-Dental Glass Fiber Reinforced Composite In Artificial Saliva On Tensile Strength

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ABSTRACT

Background: *The type of fiber often used in dentistry is E-glass fiber, which has limited availability and relatively high prices. Non-dental glass fiber can be employed as an alternative in dentistry because its composition is nearly identical to E-glass fiber. Exposure of restorative materials to artificial saliva, designed to mimic the properties of normal human saliva, affects the mechanical properties of non dental glass fiber, including tensile strength. This research aims to determine the effect of immersion duration of non-dental glass fiber reinforced composite in artificial saliva on tensile strength.*
Method: *The research method used is laboratory experimental analytic with a post-test only control group design. Samples are divided into three treatment groups with immersion in artificial saliva for three times (2, 7, and 14 days). Tensile strength is conducted using a Universal Testing Machine (UTM).*
Result: *The research results indicate differences in the average tensile strength values of non-dental glass fiber reinforced composite among the three treatment groups. The tensile strength of non-dental glass fiber + immersion in artificial saliva for 14 days (12.6213 Mpa) is higher compared to immersion in artificial saliva for 7 days (8.1375 Mpa) and 2 days (8.5413 Mpa). The immersion test results show that the longer the immersion duration, the higher the tensile strength.*
Conclusion: *The conclusion drawn from this research is that immersion duration in artificial saliva has a significant effect on tensile strength of non-dental glass fiber reinforced composite. The tensile strength of non-dental glass fiber reinforced composite after immersion for 14 days shows higher results compared to immersion for 7 and 2 days.*

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INTRODUCTION

Fiber Reinforced Composite (FRC) is a composite material strengthened by fibers and is widely applied in clinical fields such as prosthodontics, conservative dentistry, implantology, periodontology, orthodontics, and pediatric dentistry. FRC consists of three components: matrix, fiber, and coupling agent. This material exhibits good resistance to mechanical pressure with low plaque accumulation, excellent color stability, and good physical and flexural strength, making it suitable for prosthetic substructures and for replacing missing tooth structures[3].

The types of fibers used in dentistry include carbon, polyaramid, polyethylene, and glass fibers. Glass fiber is the most commonly used as a restorative and prosthetic material. It is preferred due to its translucency, which provides good aesthetics, its ability to chemically bond with the matrix via a silane coupling agent, and its favorable mechanical properties[16]. The type of fiber frequently used in dentistry is E-glass fiber, which has low density, maintains its properties/strength under various conditions, is not sensitive to moisture, has high water resistance, is resistant to chemicals and heat, has acceptable aesthetics, and bonds well with the matrix through a silane coupling agent[14].

The availability of dental E-glass fiber in Indonesia is quite limited and relatively expensive. However, non-dental glass fiber is abundantly available at a more affordable price. Non-dental glass fiber is typically used in engineering applications such as in the manufacture of gypsum, sculptures, and automotive components. Non-dental glass fiber reinforced composite is not cytotoxic to fibroblast cells[7]. Non-dental glass fiber can be used as an alternative in dentistry because it has a composition nearly identical to E-glass fiber commonly used in dental applications. The high content of SiO2, Al2O3, MgO, and CaO in glass fiber can enhance the strength of FRC[9].

Exposure of restorative materials such as FRC to oral fluids like saliva affects the water absorption and solubility of the material. Water absorption into the polymer gaps can damage the bond between the matrix and fiber, impacting the mechanical properties of FRC, such as tensile strength. Tensile strength is often a critical parameter in engineering applications where resistance to tensile forces is a major concern. The tensile strength of a material is crucial to ensure its reliability and durability against tensile stresses. Understanding material behavior under tensile forces can provide insights into its resistance to breakage or deformation and can be used to predict material performance under different usage conditions[12].

Using artificial saliva as a soaking medium for non-dental glass fiber reinforced composite is appropriate to simulate oral cavity conditions and determine how long the material can withstand exposure to saliva over an extended period. This is important because the material may undergo degradation or performance changes due to long-term exposure to saliva and other environmental factors. These changes can help identify limitations or estimate the lifespan of the material in clinical applications[4].

Previous research using artificial saliva soaking methods for non-dental glass fiber reinforced composite over 7 and 14 days has shown significant differences in water absorption values, resulting

in dimensional changes. On the second day, saliva penetrates the composite matrix, and interaction between the polymer matrix and substances in saliva occurs. Water absorption continues deeper into the composite material by the seventh day, and the absorption process reaches a more stable stage by the fourteenth day. Dimensional changes can occur after 2 days, 7 days, and up to 14 days due to saturation of water absorption occurring by the seventeenth day. The study showed that the longer non-dental glass fiber reinforced composite is soaked in artificial saliva, the greater the dimensional changes[2]. This study aims to investigate the effect of immersion duration of non-dental glass fiber reinforced composite in artificial saliva on tensile strength.

METHODS

The research method used is an analytical experimental laboratory design with a post-test only control group design. A total of 24 samples were divided into three groups: 8 non-dental glass fiber reinforced composites soaked in artificial saliva for 2 days, 8 non-dental glass fiber reinforced composites soaked in artificial saliva for 7 days, and 8 non-dental glass fiber reinforced composites soaked in artificial saliva for 14 days. This study has been approved with an Ethical Clearance (EC) letter numbered 553/B.1-KEPK/SA-FKG/V/2024 from the Research Ethics Committee of the Faculty of Dentistry, Sultan Agung Islamic University, Semarang. The research was conducted at the OSCE Center Laboratory of the Faculty of Dentistry, Sultan Agung Islamic University, Semarang; the Microbiology Laboratory of the Faculty of Medicine, Sultan Agung Islamic University, Semarang; and the Engineering Materials Laboratory, Gadjah Mada University, Yogyakarta.

The study began with the preparation of non-dental glass fibers, which were individually picked up using tweezers to obtain fibrous shapes, cut to a length of 70 mm, and weighed according to a fiber concentration volume of 1%. Packable composite resin Solare X was placed into a mold of dimensions 80 mm x 10 mm x 2 mm, according to the standard for Tensile Strength ASTM D 638 M-84, filling half of the mold, and then light-cured for 20 seconds at a distance of 2 mm. Non-dental glass fibers were wetted with a bonding agent, placed horizontally in the center of the composite resin, and light-cured for 20 seconds. Additional composite resin was then added to fill the mold and light-cured again for 20 seconds. The samples were allowed to rest for 60 minutes after polymerization and then removed from the mold.

Samples were soaked in artificial saliva according to the treatment groups: 2 days, 7 days, and 14 days, at a pH of 6.8 and at 37°C in an incubator. After soaking, the samples were retrieved with tweezers, rinsed with water, and allowed to dry. Tensile strength tests were then conducted using a Universal Testing Machine (UTM). The tensile strength results were analyzed using ANOVA to determine if there were any significant differences in tensile strength among the tested groups, and Post Hoc tests were used to compare the mean differences between groups.

RESULTS

The average tensile strength values of non-dental glass fiber reinforced composites soaked in artificial saliva for 2 days (Group 1), 7 days (Group 2), and 14 days (Group 3) are as follows:

No	Group	Average	± Deviation Standard
1	Group 1	8.5413	1.03291
2	Group 2	8.3175	1.08226
3	Group 3	12.6213	1.59503

Table 1: Average Values and Standard Deviations of Tensile Strength for Non-Dental Glass Fiber Reinforced Composites After Soaking in Artificial Saliva for 2 Days, 7 Days, and 14 Days

Based on Table 1, there are differences in the average tensile strength values among the three treatment groups. The tensile strength of non-dental glass fiber reinforced composites soaked in artificial saliva for 14 days (12.6213 MPa±1.59) is higher compared to the tensile strength of non-dental glass fiber reinforced composites soaked in artificial saliva for 7 days (8.3175 MPa±1.08) and for 2 days (8.5413 MPa±1.03).

Group	Sig	Note
Group 1	0.347	Normal
Group 2	0.100	Normal
Group 3	0.473	Normal

Table 2: Results of the Shapiro-Wilk Normality Test

Based on Table 2, the Shapiro-Wilk test significance values for all three groups indicate that the data is normally distributed, as the significance values are greater than α (0.05). Homogeneity testing was then performed using the Levene Test with the following results:

Levene Test	*p*	Note
1.332	0.285	Homogene

Table 3: Results of the Levene Test for Homogeneity

Based on Table 3, the significance value of 0.285 > 0.05 and with a significance level of α = 0.05, it can be concluded that the variances among the groups are homogeneous. After confirming that the data is normally distributed and homogeneous, an ANOVA test was conducted to determine whether there are any significant differences among the specimen groups, with the following results:

Group	Sig
Group 1	0.000
Group 2	
Group 3	

Table 4: Results of the ANOVA Test

Based on Table 4, the significance column shows a p-value of 0.000 < α = 0.05, indicating that there are significant differences in the tensile strength of non-dental glass fiber reinforced composites soaked in artificial saliva for 2 days, 7 days, and 14 days. Post Hoc testing was then performed to compare the magnitude of the mean differences between each group, with the following results:

(I)Group	(J) Group	*Mean Difference* (I-J)	Sig
Group 1	Group 2	0.22375	0.933
	Group 3	-4.08000	0.000
Group 2	Group 1	-.22375	0.933
	Group 3	-4.30375	0.000
Group 3	Group 1	4.08000	0.000
	Group 2	4.30375	0.000

Table 5: Results of the Post Hoc Test

Based on Table 5, comparisons of the average tensile strength among the three groups are shown. Comparing Group 1 with Group 2 reveals an average difference of 0.22375, which is not statistically significant (p = 0.933). However, the difference between Group 1 and Group 3 is significant (p = 0.000), with an average difference of -4.08000. Similarly, the comparison between Group 2 and Group 3 shows a significant difference (p = 0.000) with an average difference of -4.30375. This indicates that Group 3 has a significantly higher tensile strength compared to Groups 1 and 2.

DISCUSSION

The study results indicate that soaking non-dental glass fiber reinforced composites in artificial saliva affects their tensile strength. The tensile strength of non-dental glass fiber reinforced composites soaked in artificial saliva for 14 days, with an average of 12.6213 MPa, is higher compared to those soaked for 7 days (8.3175 MPa) and 2 days (8.5413 MPa). The minimum standard for tensile strength in packable composite resin is 40-45 Mpa[1]. Based on this, none of the three treatment groups meet the tensile strength standard.

The Post Hoc test results reveal that Groups 1 and 2 show no significant difference in average tensile strength. In contrast, significant differences were observed between Group 1 and Group 3, as well as between Group 2 and Group 3. The lack of significant difference between Groups 1 and 2 indicates minimal variation in tensile strength over these two durations. This could be due to the short-term effect of water exposure on tensile strength within this period or because of inconsistencies in specimen density during molding, leading to different levels of absorption[17]. This results in the non-

significant average differences. The significant differences between Group 1 and Group 3, and between Group 2 and Group 3, indicate that tensile strength increases significantly with longer exposure to artificial saliva.

During the soaking process (Day 2), initial absorption of artificial saliva into the composite matrix occurs. At this point, the process of fluid absorption and initial material reaction to the artificial saliva environment begins. There is an acute release of monomers in the first 24 hours of water absorption in the composite resin. Between Day 1 and Day 3, the monomer release from the composite resin is expected to decrease due to medium saturation, and the initially low pH of the resin increases[6]. The average tensile strength after 2 days of soaking is 8.5413 MPa. According to ISO 4049 standards, composite resins used as materials should meet clinical application standards with 7 days of water soaking[15]. After 7 days, absorption has progressed further. The material begins to adjust its structure to the soaking environment. The average tensile strength after 7 days of soaking is 8.3175 MPa. In this study, the increase in tensile strength on Day 14 reflects a stage where the absorption process has reached equilibrium[10]. The average tensile strength after 14 days of soaking is 12.6213 MPa.

The increase in tensile strength is influenced by the primary component of non-dental glass fiber, which is silicon dioxide (SiO_2), known for its rigidity and effectiveness as a reinforcement. In addition to the non-dental glass fiber content, tensile strength is also affected by the concentration of non-dental glass fiber. This study used a 1% concentration of non-dental glass fiber. A 1% concentration can enhance transverse strength, which combines compression and tensile strength[5]. Additionally, the use of silane is crucial for bonding non-dental glass fiber to the polymer matrix to improve chemical bonding[13]. In this study, non-dental glass fiber was treated with silane to create a strong bond between the matrix and the glass fiber, thereby enhancing the mechanical strength of the FRC, including tensile strength. This aligns with research by Maulida et al. in 2019, which showed that adding silane to non-dental glass fiber reinforced composites could improve flexural strength[8].

In research conducted by Anzules et al. in 2019, dimensional changes in flowable composite resin and non-dental glass fiber after soaking in artificial saliva for 7 and 14 days were observed. Flowable composite resin tends to have lower tensile strength compared to packable composite resin. This is due to its lower filler content and higher viscosity, which may reduce its ability to form a strong bond with non-dental glass fiber, affecting dimensional stability and mechanical strength[2].

Increased water absorption occurred sequentially from Day 2 to Day 14. Other studies have similarly noted that by Day 14, composite resin reaches a saturation point in absorbing artificial saliva, or the material absorbs the maximum amount of substances in the saliva[10]. If the material cannot maintain stable conditions or if there is degradation in the matrix structure or interaction with the fibers, tensile strength may decline. Although tensile strength tends to peak on Day 14, it does not necessarily mean it will continue to increase with prolonged soaking, as equilibrium is reached, and there is no tendency for further change or the material may experience saturation in water absorption[11].

A limitation encountered during the study was the potential for changes in the concentration of certain substances or interactions with components of artificial saliva that could affect the material's tensile strength response if not soaked immediately. To address this issue, soaking of the samples should be carried out immediately after the preparation of artificial saliva is completed.

CONCLUSION

There are significant differences in the tensile strength of non-dental glass fiber reinforced composites after soaking in artificial saliva for 2 days, 7 days, and 14 days. The tensile strength of non-dental glass fiber reinforced composites soaked in artificial saliva for 14 days shows higher results compared to those soaked for 7 days and 2 days.

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