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# Effect of Combination of Flowable and Packable Composite Resins on Restorative Compressive Strength

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Compressive Strength, Short-Fiber Reinforced Composite, Composite Resin, Restoration Base, Fracture.

**ABSTRACT**
Teeth with complex cavities often have a compromised hard tissue structure, making them susceptible to fractures. This necessitates the use of restoration materials capable of effectively replacing the lost tooth structure, particularly when the damage results from caries, trauma, excessive preparation, or root canal treatment. Recent advancements in composite resin materials include flowable and packable composites reinforced with short fibres, which can enhance mechanical properties by improving fracture resistance through fibre reinforcement. This study aims to evaluate the impact of combining flowable composite resins with short fibre-reinforced composites versus combining packable composites with flowable short fibre-reinforced composites on compressive strength. A laboratory experimental approach was employed, involving 48 cylindrical samples divided into 8 groups. Each group was restored with a combination of flowable composite resin and packable composite with a base of short-fibre reinforced composite, polymerized using light curing. Compressive strength was tested using a universal testing machine, and results were analyzed with a 2-way ANOVA statistical test. The analysis revealed a significant difference in compressive strength ($p<0.001$) among the groups. The findings indicate that incorporating short-fibre reinforced composite materials as the restoration base significantly enhances the overall compressive strength of the restoration. This underscores the potential for improved durability and fracture resistance in dental restorations using these advanced composite materials.

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## INTRODUCTION

Care, trauma, cavity access preparation, and root canal preparation during endodontic treatment can lead to weakened tooth structures that are prone to fractures (Tang, Wu, & Smales, 2010). Dental restorations for medium or wide cavities, such as those following endodontic treatment, can be categorized into direct and indirect restorations. Composite resin restorations are commonly used, though they often exhibit lower survival rates and fracture resistance compared to indirect restorations, as noted by Stenhagen et al. (2020). Composite resin restorations are typically indicated for class I and II cavities with small to medium sizes, whereas indirect restorations are preferred for larger cavities (da Veiga et al., 2016; Schenkel & Veitz-Keenan, 2019).

Composite resin is favored due to its aesthetic appeal, strength against chewing forces, and minimal preparation requirements. Advances in restoration material technology have introduced flowable composite resins, which are used for dental restoration after endodontic treatment or as dentin replacements. Flowable composite resins offer advantages such as ease of use, good adaptability to tooth structure, and economic benefits (Cho, Rajan, Farrar, Prentice, & Prusty, 2022; Fugolin & Pfeifer, 2017; Geštakovski, 2019; Murariu et al., 2020). The bonding agents enhance these materials' attachment and adaptation to the tooth structure. Despite ongoing developments, flowable and packable composite resins still face limitations, particularly concerning their mechanical properties and susceptibility to fractures and polymerization shrinkage (Abdulsamee, Elkhadem, & Nagi, 2020; El-Banna, Sherief, & Fawzy, 2019; Kwon, Ferracane, & Lee, 2012; Singh, Kumar, Singh, Kiran, & Kumar, 2015).

To address these issues, composite resins are being reinforced with fibers to create Fiber-Reinforced Composite Resins (FRCRs). This multiphase material combines reinforcing fibers with a polymer matrix, a concept that has been explored since the 1960s and applied in various dental disciplines. Rosatto et al. (2015) further confirm that the combination enhances elasticity and fracture resistance.

A new composite resin material with short-fiber reinforcement in flowable composite preparations was developed, claiming improved fracture resistance due to its ability to absorb pressure and its high modulus of elasticity, which resembles dentin (Özduman, Oglakci, Halacoglu Bagis, Aydogan Temel, & Eliguzeloglu Dalkilic, 2023). The resistance of restorative materials to fractures can be evaluated through parameters such as compressive strength and shear strength, which are crucial for assessing the longevity and effectiveness of these materials in clinical settings (Dinçkal Yanıkoğlu & Sakarya, 2020).

The aim of this research is to evaluate the difference in compressive strength between two composite resin combinations: the combination of packable composite resin with short fibre-reinforced flowable composite resin, and the combination of flowable composite resin with short fibre-reinforced flowable composite resin. This study is motivated by the current scarcity of research comparing the compressive strength of these two material combinations. The specific objectives are to determine whether there is a significant difference in compressive strength between these two combinations and to provide scientific insights into their effects. The research seeks to contribute valuable information to the field of dentistry by enhancing understanding of how these combinations impact compressive strength. Additionally, it aims to offer practical guidance for dental professionals in selecting and managing fibre-reinforced composite-based restoration materials. Ultimately, the findings are intended to benefit the public by ensuring that restorative treatments achieve optimal strength, leading to better patient outcomes.

## METHOD

This type of research is laboratory experimental research. The design of this study uses a parallel group design. Sample preparation, sample treatment and sample compression test are carried out at DMT Core (Dental Material and Testing Center of Research) Faculty of Dentistry, Trisakti University, Jakarta. The research was conducted from January 2022 to June 2022. The sample of this study uses a nanohybrid composite resin flowable combined with composite resin short fibre reinforced flowable and composite resins nano filled packable combined with a short fibre reinforced flowable which is formed with a cylindrical mould according to ISO4049 standards with the calculation of the thickness of the sample diameter area is 2: 1.

### Data Sample

The inclusion criteria for this study sample are composite resin cylinders with a flat surface and free of contamination of other materials such as dust and water with a predetermined thickness. The exclusion criteria for this study sample are composite resin cylinders with poor shapes such as cracks, pores and sizes that are not in accordance with the provisions of the sample. The sample size of this study will be calculated and determined using Federer's formula, based on the calculation above, then the minimum sample size required in this study is 4 samples for each group. In this study, 6 samples will be used for each group, so that the total is 48 samples.

### Data Analysis

Research was conducted to find out the difference in influence combination of flowable composite and Fiber Reinforced Composite with Flowable Short Fiber Reinforced Composite against compressive strength. The compressive strength test data of each group was tested for normality. If the data is normally distributed, the data obtained is then analyzed using two-way ANOVA and Post Hoc Tukey comparative test to compare between groups, with a significance level of $p < 0.05$.

## RESULT AND DISCUSSION

The results of the study on the difference in the influence of the combination of flowable composite and short-fibre reinforced composite with the combination of packable composite and flowable short-fibre reinforced composite on compressive strength began with the calculation of descriptive statistics related to the research data (research variables, normality tests and calculations using ANOVA two ways). The research data comes from primary data in the form of calculation of compressive strength of materials combining flowable composite and short-fibre reinforced composite with a combination of packable composite and flowable short-fibre reinforced composite. This study is an experimental study that is measured after the treatment is carried out. The measurement results are in the form of average results and standard deviations of compressive strength from the combination of composite resin materials shown in the attachment table.

The data normality test was carried out using the Shapiro-Wilk for each group tested. The results of the normality test showed that the data of all groups tested were normally distributed (p-value> 0.005). The next statistical test uses parametric statistical analysis. The next assumption test so that the data meets the parameters of parametric and can be tested differently using the two-way ANOVA test is the homogeneity test, namely the Levene and test Barlete. The results of the homogeneity test showed that the data was homogeneous (p>0.05). Results of two-way ANOVA analysis (appendix table 2) between the composite resin combination groups there was a significant difference in compressive strength (p<0.001). The difference in the thickness of the sample dimension has a significant difference in compressive strength. (P<0.001) between group I and group II. The thickness dimensions and combination of composite resin materials in each group I and group II simultaneously showed no significant difference in compressive strength (p=0.348).

The next statistical data analysis test that is carried out is the post-hoc with the Tukey HSD method to find out the differences between the groups tested. Test results post-hoc To see which combination composite resin group has the greatest compressive strength is found in the Appendix Table 3. Group I and Group II did not show a significant difference in compressive strength (p=0.975). Group I and Group II use the Short-Fiber Reinforced Composite showed that the compressive force was significantly greater than that of the two control groups, namely the 3M packable and groups VOCO flowable. In the control group, 3M packable Significantly (p=0.002) the compressive force is greater than that of the group VOCO flowable.

The results of the post-hoc test to see which combination of composite resin groups and dimensions has the greatest compressive strength are presented in Appendix Table 4. There was no significant difference in compressive strength between IA and IIA groups. The IA and IIA groups were significantly (p<0.001) greater in compressive strength than the VOCO flowable control group. There was no significant difference in compressive strength between the IA and IIA groups and the 3M packable control group. In the IB group, there was no significant difference in compressive strength with the IIB group. There was no significant difference in compressive strength between the IB and IIB groups and the 3M packable control group. The IB and IIB groups were significantly (p<0.001) greater in compressive strength than the VOCO flowable control group. The 3M packable control group with dimensions of 4 mm significantly (p=0.008) had a compressive strength greater than that of the 4 mm flowable VOCO control group. There was no significant difference in compressive strength between the 6 mm packable control group and the 6 mm flowable VOCO.

This study compares the compressive strength of different types of composite resins combined with composite resins with fillers Short Fiber Reinforced in a variety of thickness size dimensions. The material chosen is composite resin EverX flowable, composite resin VOCO Grandioso flowable and composite resin 3M Z350XT packable. The sample thickness dimensions in this study used 4 mm and 6 mm sizes. The determination of the dimension of the thickness of the research sample was adjusted to the depth of the cavity in the original teeth, which was up to 8 mm measured from the tip of the cusp to the bottom of the pulp chamber. The height of the pulp chamber in normal teeth ranges from 1.5 – 2 mm. The height of the depth from the tip of the cusp of a normal tooth to the horn of the pulp roof ranges from 6 mm.30 The process of making sample thickness dimensions using composite resin applied 2 mm to the sample mould incremental and polymerized to obtain the mechanical characteristics of the composite resin material that are sufficiently strong until the dimensional size of the sample thickness is met.

Teeth in an intact condition have better resistance and compressive strength compared to teeth after endodontic treatment. In an in vitro study conducted by Satheesh et al., regarding the effect of the thickness of the adequate dentin wall structure in withholding compressive strength and resistance to fractures in teeth after endodontic treatment, it was found that the minimum thickness of the adequate dentin wall structure in supporting compressive strength was 2.5mm. The compressive strength of the hard tissue structure of the tooth enamel and dentin is natural i.e. enamel ranges from 94 – 450 MPa and dentin ranges from 230 – 370 MPa.26 Teeth with moderate, wide and deep cavities such as teeth after endodontic treatment have weak tooth structures and are prone to failure in the form of fractures in the teeth. Therefore, the dental restoration material used must have mechanical characteristics, one of which is in the form of optimal compressive strength in order to prevent fractures and support the rest of the remaining dental tissue on the tooth.

Conventional composite resins do not have sufficient strength to replace the hard tissue structure of damaged teeth. Composite resin restoration material with short fibre reinforced filler was chosen as the basis for restoration in this study because the function of short fibre reinforced filler has the ability of mechanical characteristics that are able to absorb, distribute and resist crack propagation by reducing the intensity of stress pressure in the restoration so as to create a fracture resistance state of the entire tooth structure. The high fracture resistance to pressure in composite resins with short fibre reinforced fillers is obtained from various factors, namely the aspect of the length-width ratio of the fibre, the number of weight percentages the volume of fibre filler contained and the orientation direction of the fibres in it which form a network called semi-IPN.

Results of in vitro research conducted by Sah et al. regarding fracture resistance in posterior teeth after endodontic treatment using fibre-reinforced composite mesh, short-fibre reinforced composite and conventional composite resin as a restoration base which is compared to its strength against fractures, show that the composite short-fibre reinforced It has the highest fracture resistance compared to the other two materials. Composite resin short-fibre reinforced proven to have resistance to fracture and significantly better bending strength compared to conventional composite resin materials. Micro-sized fibre fibres play a role in distracting the crack propagation so as to create a situation of resistance to pressure that can cause fractures. Minimum fibre fibre size is the best for distributing pressure evenly on the composite short-fibre reinforced which is between 0.5-1.6mm. Orientation of fiber direction on composites short-fibre reinforced plays a role in controlling polymerization shrinkage and microleakage in restored teeth. Effect Reinforcing obtained from fibre fillers on composite resins short-fibre reinforced to the excessive pressure is influenced by the even distribution of pressure from the polymer matrix to the fibre fibres as a crack stopper. In an in-vitro study conducted by Kemaloglu et al., regarding the effect of restoration techniques on fracture resistance in teeth after endodontic treatment, it was found that fillers Short Fiber Reinforced able to improve the overall strength of the tooth structure after endodontic treatment compared to conventional composite resins.

Clinical applications of composite resin restoration materials with short fibre reinforced fillers can be intended as suspension of lost dentin structures with complex cavitations in stress-bearing areas, core build-up, post-core, indirect, Direk and semi-reactor restoration bases. In an in-vitro study by Garlapati et al. on tooth fracture resistance after endodontic treatment using several composite resin materials used for core build-up, the results showed that short-fibre reinforced composite resin showed superior results when used as a core build-up material compared to other core build-up materials. The use of short-fibre reinforced composite resin as a material for post-core manufacturing is easier, faster and has promising results compared to traditional techniques using fibre post.

Composite resins with a high percentage of weight and filler volume have good mechanical characteristics compared to composite resins with a low percentage of weight and filler volume. Selection of composite resins in preparations packable and flowable with nanofiller in this study because composite resin nanofiller has a high filler content due to the size of the filler nanoparticles in it. The high size of nanofillers has the implication of improving the mechanical characteristics of these composite resin materials in terms of tensile dimensional strength, compressive strength and fracture strength when used as a dental restoration material.

The results found in this study show that there is a significant increase in compressive strength in composite resin restoration materials using a short fiber-reinforced composite resin restoration base (Graph 1). Meanwhile, the same restoration thickness dimension with a combination of different types of composite resin materials as capping layers does not affect the significant increase in compressive strength. The increase in compressive strength is influenced by the use of short fibre-reinforced composite resin material as the basis for restoration. In the combination group of flowable nanofilled (VOCO Grandioso) and packable (3M Z350XT) composite resins used as restoration capping layers with short fibre reinforced composite resin bases of 2mm and 4mm thick, it was proven to significantly increase compressive strength compared to the control group that did not use short fibre reinforced composite restoration bases.

In a study conducted by Garoushi et al, the use of composite short-fibre reinforced as a restoration base with varying base thicknesses carried out in direct and indirect restoration showed the use of composite bases short-fibre reinforced The thickest one shows the highest restoration strength against fractures. In the study, all the samples of the research group used a composite base short-fibre reinforced with different thicknesses indicating increased strength against fractures. Another research conducted by Garoushi et al, on restoration Onlay uses composite resin Short Fiber Reinforced and conventional composite resin as a restoration base. The results of his study show that there is a significant increase in compressive strength and fracture resistance in onlay restoration using a restoration base made of composite resin Short Fiber Reinforced compared with conventional composite resins.

## CONCLUSION

Composite resin restoration materials with short fibre reinforced fillers have good compressive mechanical characteristics when used as a base for Direk, indirect and semidirect restorations and in complex tooth cavities. The ability to absorb, distribute and resist crack propagation by reducing the intensity of stress pressure in the restoration, so as to create a fracture resistance state in the entire tooth structure is an advantage of using composite resin restoration materials with short fibre reinforced fillers. The thicker the base of the restoration made of short fibre reinforced composite resin applied, the more the mechanical characteristics of the overall compressive strength of the restoration will increase.

## REFERENCES

Abdulsamee, N., Elkhadem, A., & Nagi, P. (2020). Shrinkage of Dental Composite Resin: Contemporary Understanding its Enigmas and How to Solve? A Review. *EC Dental Science*, 19, 3–17.

Cho, K., Rajan, G., Farrar, P., Prentice, L., & Prusty, B. G. (2022). Dental resin composites: A review on materials to product realizations. *Composites Part B: Engineering*, 230, 109495. Retrieved from https://doi.org/10.1016/j.compositesb.2021.109495

da Veiga, A. M. A., Cunha, A. C., Ferreira, D. M. T. P., da Silva Fidalgo, T. K., Chianca, T. K., Reis, K. R., & Maia, L. C. (2016). Longevity of direct and indirect resin composite restorations in permanent posterior teeth: A systematic review and meta-analysis. *Journal of Dentistry*, 54, 1–12. Retrieved from https://doi.org/10.1016/j.jdent.2016.08.003

Dinçkal Yanıkoğlu, N., & Sakarya, R. E. (2020). Test methods used in the evaluation of the structure features of the restorative materials: a literature review. *Journal of Materials Research and Technology*, 9(5), 9720–9734. Retrieved from https://doi.org/10.1016/j.jmrt.2020.06.049

El-Banna, A., Sherief, D., & Fawzy, A. S. (2019). Resin-based dental composites for tooth filling. In *Advanced Dental Biomaterials* (pp. 127–173). Elsevier. Retrieved from https://doi.org/10.1016/B978-0-08-102476-8.00007-4

Fugolin, A. P. P., & Pfeifer, C. S. (2017). New Resins for Dental Composites. *Journal of Dental Research*, 96(10), 1085–1091. Retrieved from https://doi.org/10.1177/0022034517720658

Geštakovski, D. (2019). The injectable composite resin technique: minimally invasive reconstruction of esthetics and function. *Quintessence Int*, 50(9), 712–720.

Kwon, Y., Ferracane, J., & Lee, I.-B. (2012). Effect of layering methods, composite type, and flowable liner on the polymerization shrinkage stress of light cured composites. *Dental Materials*, 28(7), 801–809. Retrieved from https://doi.org/10.1016/j.dental.2012.04.028

Murariu, A., Dinu, C., Forna, D. A., Stefanescu, V., Topor, G., Forna, N. C., … Iordache, C. (2020). Composite resins-multifunctional restorative material and practical approaches in dental field. *Materiale Plastice*, 57(2), 276–284.

Özduman, Z. C., Oglakci, B., Halacoglu Bagis, D. M., Aydogan Temel, B., & Eliguzeloglu Dalkilic, E. (2023). Comparison of a Nanofiber-Reinforced Composite with Different Types of Composite Resins. *Polymers*, 15(17), 3628. Retrieved from https://doi.org/10.3390/polym15173628

Rosatto, C. M. P., Bicalho, A. A., Veríssimo, C., Bragança, G. F., Rodrigues, M. P., Tantbirojn, D., … Soares, C. J. (2015). Mechanical properties, shrinkage stress, cuspal strain and fracture resistance of molars restored with bulk-fill composites and incremental filling technique. *Journal of Dentistry*, 43(12), 1519–1528. Retrieved from https://doi.org/10.1016/j.jdent.2015.09.007

Schenkel, A. B., & Veitz-Keenan, A. (2019). Dental cavity liners for Class I and Class II resin-based composite restorations. *Cochrane Database of Systematic Reviews*. Retrieved from https://doi.org/10.1002/14651858.CD010526.pub3

Singh, P., Kumar, N., Singh, R., Kiran, K., & Kumar, S. (2015). Overview and recent advances in composite resin: A review. *Int J Sci Stud*, 3(9), 169–172.

Stenhagen, S., Skeie, H., Bårdsen, A., & Laegreid, T. (2020). Influence of the coronal restoration on the outcome of endodontically treated teeth. *Acta Odontologica Scandinavica*, 78(2), 81–86. Retrieved from https://doi.org/10.1080/00016357.2019.1640390

Tang, W., Wu, Y., & Smales, R. J. (2010). Identifying and Reducing Risks for Potential Fractures in Endodontically Treated Teeth. *Journal of Endodontics*, 36(4), 609–617. Retrieved from https://doi.org/10.1016/j.joen.2009.12.002