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EVALUATION OF FLEXURAL STRENGTH OF SINGLE-SHADE NANOFILLED COMPOSITE RESIN

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ABSTRACT

The use of nanofiller in the composite resin improves the mechanical and aesthetic properties and is suitable for anterior and posterior teeth. However, the color-matching procedure is time-consuming and requires professional skills. A single-shade composite resin was developed and claimed to match all tooth colors.To evaluate the flexural strength of single-shade composite resin compared to conventional nanofilled composite resin.This experimental study used specimens measuring 25 x 2 x 2 mm, divided into two groups (n = 10): single-shade composite resin and nanofilled composite resin. Flexural strength was tested using the Universal Testing Machine. The independent t-test was used to analyze the data statistically. The mean value of the flexural strength of single-shade nanofilled composite resin was 110.40 MPa and 106.88 MPa, respectively. Independent t-test results ($p > 0.05$) showed no significant differences between groups.There was no significant difference in flexural strength between single shade composite resin and conventional nanofilled composite resin.

Keywords: flexural strength, nanofilled composite, single shade composite

1. INTRODUCTION

When initially introduced and launched into the market, composite resin was only used for restoring anterior teeth that prioritize aesthetics. Since then, various innovations have been made to enhance the physical and mechanical properties of composite resin.[1,2] Previous researchers have conducted numerous experiments to develop resin matrix that can overcome the weakness of composite resin, which is polymerization shrinkage. However, the most significant evolution has been in the filler particles, including the type, shape, distribution, and size of the filler. Traditional composite resins have large-sized filler particles. The growing interest in the field of nanotechnology has also impacted the field of dentistry, including the use of nanometer-scale fillers in composite resin restorative materials.[3]

The purpose of utilizing nanofillers in composite resin is to create a material suitable for restoring both anterior and posterior teeth, providing satisfactory aesthetics and mechanical properties suitable for areas subjected to significant occlusal loads. One of the most frequently tested mechanical properties of dental restorative materials is flexural strength, deemed crucial for characterizing brittle materials such as composite resin. This flexural strength testing assesses the material's capability to withstand complex forces, including a combination of tensile, compressive, and shear forces.[4] Alzraikat et al. reviewed previous studies examining the flexural strength of various types of composite resin materials and found that the flexural strength of nanofilled composite resin is comparable or even higher than some hybrid composite resins and significantly higher than microfilled composite resins.[3]

Mourouzis et al. evaluated the color matching of three different types of composite resins: microhybrid, microfilled, and nanofilled resins, using a spectrophotometer capable of detecting color differences and simulating clinical conditions. It was found that the color parameters among the three composite resins, when placed on natural teeth, did not differ significantly, and all three were able to closely resemble the color of natural teeth. Furthermore, the researchers stated that the "layering" technique, involving the use of multiple shades or colors of composite resin, would result in better aesthetics.[5] However, this technique requires skill from the operator and a considerable amount of time for implementation. Additionally, dentists need to provide composite resin materials with diverse shades to match the varying tooth colors of individual patients.

Recently, a composite resin has been introduced to the market, developed to simplify the selection of composite shades and claimed to resemble the entire range of tooth colors universally, from A1 to D4, known as single-shade composite resin.[6] Unlike previous composite resins that contained pigments responsible for color perception and wavelength reflection, single-shade composite resin does not contain pigments. Its optical properties and ability to match the color of natural teeth are based on "smart chromatic technology," with a concept of structural color that allows the material to respond to light waves at specific frequencies and reflect certain wavelengths, making it seamlessly blend with the surrounding tooth color.[7,8]

Several previous studies have evaluated the color matching of single-shade composite resin with tooth color. In their research, Dunn K et al. concluded that single-shade composite resin is suitable for enamel shade in Class V restorations.[9] da Silva et al. assessed the color matching of restorations using single-shade composite resin on extracted teeth, and the results were clinically acceptable.[10] Based on the above description, single-shade composite resin may offer a solution to simplify the shade selection procedure compared to conventional nanofilled composite resin. However, there is no research yet comparing the flexural strength between single-shade composite resin and conventional nanofilled composite resin. This study was conducted to evaluate the flexural strength of single-shade composite resin compared to conventional nanofilled composite resin.

2. METHOD

This study is an experimental research conducted at the Dental and Oral Hospital of South Sumatra for the fabrication of composite resin specimens and at the Mechanical Engineering Laboratory of the Sriwijaya State Polytechnic in Palembang for flexural strength testing. The subjects in this study were conventional nanofilled composite resin specimens and single-shade composite resin specimens of rectangular shape measuring 25 x 2 x 2 mm. The research samples consisted of 20 composite resin specimens divided into 2 groups: Group A : Single-shade composite resin; Group B: Conventional nanofilled composite resin.

Single-shade composite resin (Omnichroma, Tokuyama Dental) and conventional nanofilled composite resin (FiltekTM Z350XT, 3M ESPE, USA) were used to create specimens in this study. The specifications of both types of composite resins are presented in Table 1.

Table 1. Specifications of the composite resins tested in this study:

Type of Composite Resin	**Filler**	**Monomer**	Shade
Single Shade Composite Resin (Omnichroma, Tokuyama Dental, Japan)	Contains 79% by weight and 68% by volume spherical silica-zirconia filler with particle size of 260 nm.	UDMA, TEGDMA	Universal
Conventional Nanofilled Composite Resin (FiltekTM Z350 XT, 3M ESPE, USA)	Contains 78.5% by weight and 63.3% by volume combination of zirconia/silica cluster aggregate with an average particle size of 5-20 nm, and nonagglomerated silica filler (20 nm).	Bis-GMA, UDMA, TEGDMA, and Bis-EMA	A3B, body

Sample preparation

An acrylic mold (25 x 2 x 2 mm) is prepared, its interior is coated with Vaseline, and placed on a glass plate. Conventional nanofilled composite resin or single-shade composite resin is taken using a metal plastic instrument and placed into the mold, then compacted using a cement stopper. Celluloid tape is placed on the mold. The surface of the composite resin is smoothed by pressing the celluloid tape with an object glass, and excess resin is removed. The composite resin is cured with a light curing unit for 20 seconds (DTE LUX 1, Woodpecker), with a perpendicular position above the celluloid tape. The composite resin is removed from the mold after curing, then polished with composite polishing kit. The composite resin specimens are measured and meet the sample criteria as follows: non-porous samples, smooth and even surfaces, and unchanged dimensions.

Flexural Strength Testing

The specimen is subjected on the three-point bending test using Universal Testing Machine (UPH 100KN, Tarno Grocki) with the specimen positioned on two supports with a support span of 20 mm. The testing machine is activated, and a continuous load of 5.6 N is applied at a cross-head speed of 0.5 mm/minute until cracks or fractures occur in the specimen. On the monitor, the letter "P" will appear, indicating the maximum pressure that the specimen can withstand. Subsequently, the flexural strength is calculated using a formula.

Statistical Analysis

The obtained data are analyzed using an Independent T-test to determine whether there is a significant difference between the flexural strength of the single-shade composite resin surface and the conventional nanofilled composite resin.

3. RESULTS

The results of the flexural strength measurements for the single-shade composite resin surface and conventional nanofilled composite resin can be observed in Table 2.

Table 2. Flexural Strength Test Results of Universal Single-Shade Composite Resin and Conventional Nanofilled Composite Resin

	Flexural Strength Test (MPa)	
Sample	***Single-shade composite* (Omnichroma)**	**Nanofilled Composite Resin**
1	114,38	120,00
2	99,75	98,62
3	103,13	106,50
4	121,12	100,50
5	118,13	117,25
6	99,38	114,00
7	115,87	99,38
8	107,25	104,25
9	108,75	105,38
10	116,25	102,37
Mean	**110,40**	**106,88**
Standard Deviation	**7,85**	**7,71**

Based on the table above, it is known that the mean of surface flexural strength of single-shade composite resin is greater compared to conventional nanofilled composite resin.

Table 3. Independent T-test

Groups	N	p-value	
***Single-shade composite* (Omnichroma)**			
Nanofilled Composite Resin	**10**	**0,325**	**Not Significant**

Statistical analysis on Table 3 indicates a p-value > 0.05, suggesting that there is no significant difference between the flexural strength values of single shade composite resin and conventional nanofilled composite resin.

4. DISCUSSION

Composite resin is now widely used not only as a material for anterior dental restorations but also for posterior teeth due to improvements in its physical and mechanical properties, as well as clinical appearance influenced by advancing filler technology. However, the use of composite resin still encounters difficulties, particularly in determining the appropriate shade that matches the patient's natural tooth color. This challenge is also influenced by the operator's level of experience and skill. To address this issue, a new type of composite resin has been introduced, namely single shade composite resin (Omnichroma, Tokuyama Dental, Tokyo, Japan), designed without pigments and utilizing structural color technology.[12]

Kobayashi et al. evaluated the color reproduction ability of single shade composite resin compared to multi-shade composite resin. The results showed that single shade composite resin has higher compatibility with various tooth colors, attributed to the filler particles contained in its composition.[12]

The incorporation of fillers to the composite resin matrix aims to enhance aesthetics, optical properties, and mechanical properties of the material. Smaller-sized filler particles can improve mechanical properties, such as flexural strength, as the larger surface area of the particles results in higher surface energy at the matrix-filler interface. Previous studies have demonstrated that composite resins with nano-scale fillers exhibit superior mechanical properties compared to traditional microfiller composite resins.[13] In this study, the composite resin used contains nanofiller particles. The Omnichroma single shade composite resin contains filler particles with precisely the same spherical shape and size, measuring 260 nm. Similarly, Filtek Z350 XT includes a combination of zirconia and silica nanofillers.

In addition to size, the volume of fillers also influences the flexural strength of composite resin. The higher the filler loading in the composite, the higher the flexural strength.[14,15] In this study, the single shade composite resin (Omnichroma, Tokuyama Dental, Japan) with a filler volume of 68% exhibited flexural strength that did not differ significantly from conventional nanofilled composite resin (FiltekTM Z350 XT, 3M ESPE, USA) with a filler volume of 63.3%.

The comparable flexural strength between the two types of composite resins tested in this study can also be attributed to the filler morphology, where both have the same shape, namely a smooth and spherical form. Melander et al. revealed that nanohybrid composite resin Filtek Supreme Plus with spherical-shaped fillers exhibited higher flexural strength compared to other composite resins with irregular or non-uniform fillers. In irregular fillers, mechanical stress tends to concentrate at the corners of the filler particles, creating zones of crack initiation. This phenomenon is not observed in spherical fillers because stress is distributed evenly across the entire particle.[16]

Besides sharing similarities in filler morphology, both the single shade composite resin and the conventional nanofilled composite resin in this study also contain the same types of fillers, namely silica and zirconia. These fillers are commonly used to enhance the mechanical strength of composite resin.[17,18] Siddiqui et al.'s research explains that zirconia, as a filler, has a significant impact on the flexural strength of the tested composite resin.[17] Many composite resin products with zirconia fillers form complexes with silica fillers, which undergo silanization to improve their mechanical properties, including flexural strength.[19]

5. CONCLUSION

Based on the results, it can be concluded that there is no significant difference between the average surface flexural strength values of single shade composite resin and conventional nanofilled composite resin.

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