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Research Article

Diametral Tensile Strength of Microhybrid and Nanohybrid Composite Resins

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nanohybrid filler

ABSTRACT

Introduction: Microhybrid and nanohybrid composite resins are commonly used due to their high diametral tensile strength, which indicates the resistance of a material to chewing in posterior tooth restoration. Both composite resins have been widely produced via various modifications of their composition. **Objectives:** To evaluate the diametral tensile strength of composite resins with microhybrid and nanohybrid fillers. **Methods:** In this experimental laboratory study, microhybrid (DenFilTM) and nanohybrid (DenFilTM N) composite resins were shaped into 10 specimens each in cylindrical molds (6 mm diameter × 3 mm height) by the bulk-fill technique, and the upper layer was flattened using mylar strips and then polymerized using a light-curing unit for 20 s. Then, composite resin samples were immersed in cell culture plates filled with 2.5 mL of artificial saliva in a 37°C incubator for 24 h. Dimensions of the soaked specimens were examined using a digital caliper and tested using a universal testing machine. **Results:** The diametral tensile strength values for microhybrid and nanohybrid composite resins were 41.67 MPa and 45.42 MPa, respectively. **Conclusion:** There was no significant difference in the diametral tensile strength of microhybrid and nanohybrid.

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INTRODUCTION

In 1940, composite resins were first used in conservative dentistry to replace acrylic resins.[1] Composite resins comprise three key components, namely, matrix, filler, and coupling agent, respectively.[2] In 1962, Bowen patented a dental filling material comprising vinyl-silane-treated fused silica and a binder comprising the reaction product of BisGMA.[3] Ethylene glycol dimethacrylate, triethylene glycol dimethacrylate (TEGDMA), methyl methacrylate, or urethane dimethacrylate (UEDMA) is commonly used and mixed with BisGMA.[3] In addition to boron silicate and lithium aluminum silicate, silicon dioxide is the most important filler in composite resins.[3] The matrix and fillers cannot be appropriately bonded without a coupling agent. Gamma methacryloxy propyl trimethoxy silane is the commonly used coupling agent.[4]

Composite resins were first used to restore anterior teeth. However, since the past 50 years, composite resins have been increasingly used as a posterior tooth restoration materials[5,6] because mechanical properties of composite resins support the success of posterior tooth restoration, including fracture toughness, compressive strength, flexural strength, wear resistance, and diametral tensile strength.[7-9] Several researchers utilized diametral tensile strength as a standard for composite resins and it can characterize dental composite restoratives; this property can provide some information regarding the behavior of the brittle dental composite to evaluate its fragility.[9,10] A hybrid composite resin is preferred for posterior teeth restoration.[11]

A hybrid composite resin was developed to maintain the superiority of macrofilled and microfilled composite resins via the combination of fillers with different particle sizes.[12] This hybrid composite resin is divided into two categories, namely, microhybrid and nanohybrid composite resins, respectively.[1,5] With particle sizes of 0.6–0.7 µm, microhybrid composite resins are advantageous as they facilitate easy polishing and easy application, and these resins exhibit excellent mechanical properties. Therefore, such composite resins are still considered for posterior teeth restoration.[11,12] As the second type of composite resins with particle sizes of 40–50 nm, nanohybrid composite resins are advantageous due to their higher wear resistance, as well as easy polishing and application. Nanohybrid is included in nanotechnology, commonly called a nano-composite.[11,13,14,15] A material has advantages and disadvantages. Likewise, with microhybrid and nano-hybrid, the disadvantage of microhybrids lies with its low particle density, whereas nanohybrids have rough surface and are not glossy.[5,11,16]

Moraes et al. concluded that nanohybrid resins exhibit higher values than microhybrid resins, albeit with no significant difference.[5] These results are different from those reported by Jun et al., who concluded that compared to microhybrids, nanohybrids exhibit a significant difference in value.[17] Compared to microhybrid composite resins, nanohybrid composite resins exhibit higher values.[17] Matrix and filler compositions are certainly a differentiating factor for each brand and study; however, the shape and thickness of the examined specimen also affect the diametral tensile strength. Based on the described conditions, the author conducted a comparative study to determine differences in the diametral tensile strength values for two composite resin fillers.

MATERIALS AND METHODS

An experimental laboratory study was conducted with unpaired numerical analytical data. Two composite resins, e.g., microhybrid composite resins (DenFil™, Vericom CO., LTD., Korea) and nanohybrid composite resins (DenFil™N, Vericom CO., LTD., Korea), respectively, were used as specimens (Table 1).

A minimum sample size of three specimens was calculated using the Lemeshow statistic. However, 10 specimens of each composite resin were prepared, affording a total of 20 specimens. According to the American Dental Association Method Specification No. 27 about Direct Filling Resins,[18] specimens were prepared in cylindrical molds (6 mm diameter × 3 mm height) by the bulk-fill technique. In this study, the upper layer of specimens was flattened using mylar strips and subsequently polymerized using a light-curing unit for 20s. Then, the specimens were immersed in 2.5 mL of artificial saliva in cell culture plates before placing in an incubator at 37 ˚C for 24 h.

In this study, microhybrid and nanohybrid composite resins in new condition were imperative for preparing appropriate and solid specimens; hence, a good and an accurate shape can be obtained by utilizing a polymerization time of 20 s per specimen, a cylindrical specimen with a diameter of 6 mm and a height of 3 mm, an immersion temperature of 37ºC in the incubator, and an immersion time of 24 h. This diametral tensile strength test uses a tool, namely the Universal Testing Machine (UTM) (Shimadzu Autograph AGS-5kNX), with a crosshead speed of 0.1 mm/min. The specimen that has been made is loaded vertically on the lateral part of the specimen and produces a tensile strength that passes through the specimen's center.[19]

Table 1. Type and compositions of the resins used in this study

Types	Product	Code	Manufacture	Batch Code and Expire Time	Matrix	Filler Composition
Microhybrid (packable) Color : A3	DenFil™	MH	Vericom Co., LTD., Korea.	DF8O07A3 October 1st, 2021	bis-GMA TEGDMA	• Barium aluminosilic-ate (average particle size ≤ 1 µm). • Fumed silica (average particle size of 0.04 µm). • Weight percentage of total inorganic particles 80%.
Nanohybrid (packable) Color : A3	DenFil™ N	NH	Vericom Co., LTD., Korea.	DN8401A3 April 2nd, 2021	bis-GMA bis-EMA UDMA TEGDMA	• Barium aluminosilic-ate (average particle size ≤ 0,7 µm). • Fumed silica (average particle size 12 nm). • Weight percentage of total inorganic particles 76%.

Statistical Analysis

To evaluate the distribution of research data, the normality test Shapiro–Wilk test was conducted. Owing to the normal distribution of data, analysis was performed by the independent t-test using IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.

RESULTS

The diametral tensile strength of microhybrid and nanohybrid composite resins were summarize in Table 2. The results obtained for the significance value (p) of the Shapiro–Wilk test revealed that $p > 0.05$, which is 0.15; thus, research data are normally distributed. Table 3 summarizes the results obtained from the independent t-test. According to Table 3, the independent t-test utilized equal variances that were not assumed, which were equal to 0.17 ($p > 0.05$). Therefore, the statistical result revealed that the composite resins with microhybrid and nanohybrid fillers do not exhibit significant differences.

Table 2. The average of diametral tensile strength of microhybrid and nanohybrid composite resins

Name Parameters Unit	Test Result of DTS Average	Standard Deviation
Microhybrid	41.67	2.91
Nanohybrid	45.42	7.63

Table 3. Statistical data analysis by the independent t-test

Type	T-test of Equality of Means		
	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Equal variances assumed	0.16	–37.45	25.84
Equal variances not assumed	0.17	–37.45	25.84

DISCUSSION

Based on the diametral tensile strength analysis using a universal testing machine with a crosshead speed of 0.1 mm/min, the average diametral tensile strength values for the microhybrid and nanohybrid composite resins were 41.67 ± 2.91 MPa and 45.42 ± 7.63 MPa, respectively. Compared with those of previous studies, the results of this study were not considerably different, such as that reported by Jun et al., where three brands of composite resins prepared from microhybrid fillers and one brand of composite resins prepared from nanohybrid fillers were used. In their study, the diametral tensile strength values for each composite resin with microhybrid fillers were 47.5 MPa, 47.4 MPa, and 49.2 MPa. In comparison, the diametral tensile strength of the composite resin with nanohybrid fillers was 55.9 MPa, indicating that the

diametral tensile strength values for the composite resins with nanohybrid fillers are greater than those of composite resins with microhybrid fillers, albeit with no significant differences.[17]

Another study reported by Moraes et al., one brand of composite resins with microhybrid fillers and four brands of composite resins with nanohybrid fillers were used. The diametral tensile strength values for the composite resin with four microhybrid fillers are 53.4 MPa, 54.6 MPa, 40.1 MPa, and 38.8 MPa, respectively. In contrast, the diametral tensile strength of composite resins with nanohybrid fillers is 53.7 MPa. From the above-mentioned results, the diametral tensile strength of composite resins with nanohybrid fillers is not always the highest and that of composite resins with microhybrid fillers is not always the lowest, and their comparison revealed that the value also exhibits insignificant differences.[5]

The preparation of this specimen is supported by the composition and color of the composite resin. The matrix affects the diametral tensile strength. According to Bona et al., the diametral tensile strength is strongly affected by matrix components, different sizes of composite resin fillers, and the bond between the matrix and filler (coupling agent).[18,19] In each composite resin, high-viscosity BisGMA is always used as the matrix component, which is typically combined with UEDMA and TEGDMA. This combination is extremely effective for increasing the mechanical properties of composite resins; this matrix can lead to the increase in the degree of conversion, which is closely related to the result of polymerization of the composite resin.[19] The higher the degree of conversion, the stronger the mechanical properties of the composite resin.

In this study, the color of the two composite resins used is A3 because the average color of the posterior teeth is typically darker, which is similar to the A3 color of the composite resin. Polymerization is also affected by the color of the composite resin. The darker the color of the composite resin, the more difficult the absorption of light.[20] Hence, it is crucial to render good polymerization, which subsequently affects the diametral tensile strength. In this study, even though the composite resin is a packable, conventional, or layered type, the bulk-fill technique is employed. The difference between bulk-fill composite resins and layered composite resins is that the layered types must be made one layer at a time with a thickness of 2 mm per layer. In contrast, the bulk-fill type can afford layers with thicknesses reaching greater or equal to 4 mm at once; in this study, the height of the specimen is 3 mm, which is thought to reduce the pressure of shrinkage during polymerization and result in better polymerization depth.[21,22] The bulk-fill technique is selected as it can reduce polymerization shrinkage and the occurrence of microleakage, prevent the formation of gaps in the specimen layer, and save time in preparing specimens.[3,17,23]

The upper layers of the specimens are flattened using mylar strips, which can produce a smooth layer by blocking the contact between the composite resin and air outside the specimen. A smooth layer also can be formed in the final stage of polymerization; termination occurs by joining the two ends of the free radical chains into one tight polymer chain. The specific function of the smooth layer is to reduce the oxygen-inhibited layer because it results from free radicals that are formed during the inhibition of oxygen outside the specimen during polymerization. Hence, the resulting monomer layer in the specimen becomes poorly or not completely polymerized.[24]

The polymerization uses a light-emitting diode light-curing unit, with a light intensity of 1200–2000 mW/cm² and wavelength of 460–480 nm. Still, for the bulk-fill technique, the recommended light intensity is 1000 mW/cm². This light-curing unit is advantageous as it can produce controlled wavelengths and provide minimal heating. Several factors must be considered to achieve complete polymerization, such as the distance (1–1.5 mm) and polymerization time (20s).[25,26] This consideration is related to the degree of conversion and depth of cure, as well as preparing a well-polymerized composite resin.[26] The degree of conversion is the percentage of double carbon chains that are converted into a single chain and form a polymer resin. The depth of cure is the thickness of the resin converted from monomers to polymers under a light-curing unit. Moreover, a polymerization time of exactly 20 s is sufficient to well polymerize a polymer resin composite, starting with the activation of the molecules in the composite resin and the initiation of the propagation process (chain extension) by the generated heat.[26-27]

In this study, artificial saliva was used as the immersion medium to mimic the condition of the mouth in general, with a volume of 2.5 mL/place. There is no specific reason for taking 2.5 mL of artificial saliva, but it was actually used to prevent the overcapacity of the volume in the immersion as cell culture plates with a volume per place of 3.17 cm³ or 3.17 mL were used as the immersion vessel. Still, previous studies have not reported that the amount of artificial saliva affects the diametral tensile strength. Artificial saliva considerably affected the diametral tensile strength because during immersion, , the ions released from the composite resin were less than those released from the composite resin using distilled water as the immersion medium. The matrix elements of the composite resin can dissolve due

to immersion using artificial saliva such as TEGDMA, which is one of the elements that enhances the diametral strength test, in addition to the type of filler.[28]

Immersion in artificial saliva can cause swelling, which can affect the dimensions of the composite resin. Kumar Y et al. reported that after immersing the specimen in artificial saliva for 24 h, the specimen volume should be weighed and measured in advance to determine the change in weight and as a proof to support the hypothesis of the exact volume of water in the specimen that can affect the diametral tensile strength of each specimen.[29]

There are many limitations in this study, such as it should measure the weight after the specimen was made, the room temperature should be conditioned and adjusted for each specimen manufacture, the results before and after soaking the specimen should be weighed to assess the accuracy of the test of the diametral tensile strength, and in this study, the researcher did not use the real tooth.

CONCLUSION

Significant differences in the diametral tensile strength of microhybrid (DenFilTM) and nanohybrid (DenFilTM N) composite resins are not observed. The researcher hope other researcher can use the real tooth so the result of the test of diametral tensile strength can be more accurate.

CONFLICT OF INTEREST

There is no conflict interest in this study.

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