Enhancement of Compressive Strength Following Preheating of Universal Single-Shade Resin Composite

Peningkatan Kekuatan Tekan Komposit Resin U*universal Single-Shade* Pasca *Preheating*

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ABSTRAK
Pengembangan bahan restoratif menghadirkan komposit resin *universal single-shade* yang diklaim cocok untuk semua warna gigi. Selain aspek estetika, komposit resin harus memiliki sifat mekanik yang baik. Faktor suhu memengaruhi polimerisasi, yang akan berdampak pada kekuatan tekan. Tujuan penelitian ini untuk menginvestigasi efek *preheating* terhadap kekuatan tekan dari komposit resin *universal single-shade*. Komposit resin *universal single-shade* digunakan untuk membuat spesimen silinder dengan diameter 4 mm dan ketebalan 6 mm, dibagi menjadi dua kelompok: dengan dan tanpa *preheating* (n=9). Spesimen kelompok *preheating* disiapkan dengan memanaskan komposit resin dalam perangkat pemanas pada suhu 60°C selama 15 menit, kemudian ditempatkan dalam cetakan dan diradiasi menggunakan *light curing unit* dengan intensitas 2300 mW/cm³ selama 6 detik, lalu dipoles menggunakan alat poles komposit. Kekuatan tekan diuji menggunakan *universal testing machine*. Data yang diperoleh dianalisis menggunakan uji t independen. Hasil penelitian menunjukkan nilai rata-rata kekuatan tekan secara signifikan lebih tinggi pada kelompok *preheating* dibandingkan dengan kelompok tanpa *preheating* ($p<0,05$). Simpulan penelitian ini adalah *preheating* dapat meningkatkan kekuatan tekan dari komposit resin *universal single-shade*.
Kata kunci: kekuatan tekan, *preheating*, komposit resin *universal single-shade*

ABSTRACT
The development of restorative materials presents a universal single-shade resin composite claimed to match all tooth colors. In addition to aesthetics, composite resin must have good mechanical properties. The temperature factor affects the polymerization, which will affect the compressive strength. The purpose of study was to investigate the effect of preheating on the compressive strength of single-shade universal resin composite. Universal single-shade resin composite was used to make cylindrical specimens with a diameter of 3 mm and a thickness of 6 mm and divided into two groups: with and without preheating (n=9). Specimens of preheating groups were prepared by heating the resin composite in a heater device at 60^0C for 15 minutes, then placed in the mold and irradiated using a light curing unit with an intensity of 2300 mW/cm³ for 6 seconds and then polished using composite polishing kits. The compressive strength was tested using a universal testing machine. The data obtained were analyzed using an independent t-test. The result of study showed the mean compressive strength values were significantly higher in the preheated group than in the non-preheated group ($p<0.05$). The conclusion of this study was preheating universal single-shade resin composite to 60 degrees Celsius significantly enhances its compressive strength.
Keywords: compressive strength; preheating; universal single-shade composite resin

INTRODUCTION

Over the last two decades, restorative dentistry has seen significant advancements in terms of aesthetics. Manufacturers have developed a wide range of translucent and opaque shades to create restorations that closely mimic the natural tooth structure. Despite these innovations, achieving an ideal shade match remains challenging and time-consuming, as it depends on various factors, including the clinician's skills.[1]

Recently, Tokuyama Dental America launched Omnichroma, a universal single-shade resin composite engineered to simplify shade selection and improve esthetic results. To evaluate newly introduced composite resin restorative materials, it is essential to assess their mechanical properties which are influenced by several factors, including the chemical composition of the resin matrix and variations in filler particles.[2] A previous study investigated the mechanical properties of seven new single-shade resin composites, including Omnichroma. The results showed that Omnichroma had the lowest degree of conversion compared to the others, which was suggested to be attributed to its unique matrix and filler structure.[3]

Preheating, the process of warming resin composites before insertion into the cavity and prior to curing, has been proposed as a technique to improve their handling characteristics and physical properties. Daronch *et al.*[4] reported that preheating composites allows for reduced light exposure time by up to 75%, achieving similar or improved monomer conversion compared to room-temperature composites with standard exposure times.

A study by Calheiros *et al.*[5] showed that raising the composite temperature to 40°C and 60°C before light activation reduces composite viscosity and leads to elevated levels of degree of conversion. Similarly, Imam *et al.*[6] found that preheating treatment at temperatures of 37°C and 60°C effectively enhances the compressive strength of nanohybrid-type composite resin. However, there is currently no available data regarding the effect of preheating on the compressive strength of the new composite, Omnichroma. Therefore, this study aims to compare the compressive strength of universal single shade resin composites cured at room temperature and at 60°C preheating.

RESEARCH METHODS

This was laboratory experimental with the post-test-only control group method. The research was conducted at the Basic Laboratory of Dentistry Study Program, Faculty of Medicine, Universitas Sriwijaya, and the Material Engineering Laboratory, Universitas Sriwijaya in Palembang, Indonesia. In this study, no ethical clearance was obtained because it is a test of material characteristics that does not involve living organisms.

The universal single-shade resin composite (Omnichroma®, Tokuyama Dental) (Fig. 1) was used to make cylindrical specimens with a diameter of 3 mm and a height of 6 mm, following the specifications of the American Dental Association (Fig. 2).[7]

The determination of sample size refers to Lemeshow *et al.*[8] using the formula for testing the hypothesis of the difference between two means (two-sided) with a power test of 90%. The calculation yields a minimum sample size of 8 subjects, with potential dropout rate of 10%. Consequently, the sample size for each treatment group in the study was set at 9.[8]

Fig. 2. Resin composite specimens

A total of 18 samples were prepared and divided into two groups: one without preheating and the other with preheating at 60 degrees Celsius (n=9 in each group). The universal single-shade composite resin was placed using a **composite filling instrument** into a mold made of cylindrical metal with dimensions of 3 mm in diameter and 6 mm in height (Fig. 1). The resin composite was compacted using a cement stopper, and mylar strip was positioned and pressed on top of the surface with a glass slide to remove any excess material.[9]

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In the group without preheating, the tube was kept in room temperature. The resin composite was cured in ambient temperature using a light curing unit (Eighteeth CuringPen, Changzhou Sifary Medical Technology Co., Ltd) with an intensity of 2300 mW/cm^3 for 6 seconds. The light curing unit was positioned perpendicular above the mylar strip. In the preheated group, the composite tube was heated in a composite heater (Azdent Dental Composite Resin Heater Material Soften Warmer 40-70°C, Henan Baistra Industries Corp, China) for 15 minutes at 60ºC (Fig. 3).

Figure 3. The composite tube was heated in the composite heater for 15 min at 60ºC.

Afterward, the tube was removed from the device, and the resin composite was applied immediately to the mold using an instrument and polymerized in the same manner as the group without preheating.[9]

The cured specimens were polished using composite polishing kit and kept at room temperature for 48 hours. The compressive tests were performed using a Universal Testing Machine (TORSEE RAT-30P) at a cross-head speed of 0.05 mm/min. The specimens were placed in a vertical orientation on the base of the testing machine and exposed to a compressive force until they reached the point of failure (Fig. 4).

Figure 4. The specimen was tested for compression strength with a universal testing machine

Compressive strength (MPa) was calculated by dividing failure load (F) in Newton (N) by the cross-sectional area. The collected data was subjected to statistical analysis.[10]

RESULTS

Table 1 presents the compressive strength of universal single-shade composite resin, comparing samples with and without preheating. The results show that the mean compressive strength is higher in the group preheated to 60ºC than non-preheated group.

Table 1. Mean compressive strength of universal single-shade resin composite

	Mean Compressive Strength (Mpa)	
	Group A (Without Preheating)	**Group B (Preheating 60ºC)**
	355,26	359,17
	228,27	427,49
	267,42	398,21
	396,26	366,98
	230,33	388,45
	368,74	409,92
	300,45	365,02
	363,07	376,74
	388,90	427,49
Mean ± StandardDeviation	322,07±66,70	391,05±26,33

Table 2. Independent t-test statistical test

Group	N	p-value
Group A (Without Preheating)	9	**0,011**
Group B (Preheating 60ºC)	9	

Sig. <0.05

The Kolmogorov-Smirnov normality test was performed to examine the data distribution on the mean compressive strength of universal single-shade composite resins ($p>0.05$), the data had normal distribution.

An independent t-test was performed to analyze the data. The results in Table 2 show that preheating treatment significantly affects ($p<0.05$) the compressive strength of universal single-shade composite resin.

DISCUSSION

Numerous innovations and novel techniques have been implemented to improve the longevity and clinical performance of dental restorative materials. One of the suggested approaches to enhance their properties is preheating. This heating procedure can be carried out before insertion to the prepared cavity using specialized equipment, with temperatures commonly ranging from 54-68°C, which is considered a relatively safe temperature range that does not cause harm to the pulp. When preheating, it's important to reach optimal fluidity which typically takes around 15 minutes based on previous research.[11] In the current study, preheating was conducted at 60 degrees Celsius for 15 minutes. A key factor to keep in mind when using preheating is the possibility of causing pulpal irritation due to increased temperatures. To reduce this risk, it is suggested to preheat the composite resin to a temperature below 60°C.[12]

Previous studies have found the improvement of physical and mechanical characteristics of resin-based materials through preheating techniques. Kimyai et al. studied the impact of preheating at 68 degrees on the flexural strength of nanohybrid composite resin, the results showed that the preheated group had higher flexural strength than the group without preheating.[13]

In this research, we investigate the impact of curing Omnichroma universal single-shade resin composites at room temperature versus preheating them to 60°C on their compressive strength. The results show that preheating the universal single-shade composite resin leads to significantly higher mean compressive strength compared to the group without preheating treatment.

Elevated temperatures result in reduced viscosity of the composite resin by increasing the mobility of their monomers. This enhanced radical mobility, promoting increased polymerization processes and higher rates of conversion.[13] However, other studies may present conflicting results. Elkaffass *et al*.[14] observed no significant difference in the tested mechanical properties between non-heated and preheated.

The findings of Lempel *et al*.[15] indicate that preheating can have different effects on resin-based composites (RBCs), depending on their filler content. For resin composites with a high filler content, preheating has a positive impact, increasing the degree of conversion (DC%) at both the top and bottom. Studies have demonstrated a clear correlation between the filler volume fraction and filler load level in resin composites and their material strength. In this research, Omnichroma, which was examined, contains a filler loading of 79% by weight (68% by volume) and features uniformly sized supra-nano spherical filler particles measuring 260 nm in diameter made of SiO2-ZrO2.[16] These spherical-shaped symmetric nano-fillers also play a role in enabling universal single-shade composites to match all tooth colors.[17] This is due to their small diameter which is smaller than the visible wavelength of light, allowing them to enhance the color-matching capability of the resin composite by creating structural color without requiring the addition of pigments.[4]

Ensuring sufficient curing is crucial for achieving optimal properties in dental resin composite restorations. Therefore, clinicians must consider two critical factors related to preheating when using resin composites in clinical settings: Preheated composite resin might cool rapidly after the tube removed from the device, potentially offsetting the

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benefits of preheating. A prior study documented a decrease in the temperature of the composite resin, approximately 50%, within 2 minutes following its removal from the heating device, which had been heated to 60°C.[18] Lousan *et al.*[19] recommended that clinicians place the preheated composite into the cavity as quickly as possible to minimize temperature loss. This recommendation is supported by a previous study that found a significant drop in temperature shortly after the composite was removed from the heating device—around 50% of the initial temperature was lost within 2 minutes, and nearly 90% after 5 minutes. The study also suggested that preheating the compule while already placed in the delivery syringe is more advantageous than preheating the compule separately, as this approach helps retain the composite's temperature during application.[20]

The use of a gun-shaped heater that utilizes compules is also worth considering if composite resin in syringe form needs to be heated repeatedly. Gholizadeh *et al*.[21] assessed color changes following 40 cycles of preheating to 55-60 degrees Celsius and concluded that repeated cycles of preheating have an adverse effect on the color stability of composite resins. However, according to D'Amario's study, the composites tested showed similar behaviour even after undergoing 40 repeated cycles of prewarming to a lower temperature of 39°C. This indicates that there were no significant alterations in mechanical characteristics when compared to the unheated groups.[22]

CONCLUSION

Preheating universal single-shade resin composite to 60 degrees Celsius significantly enhances its compressive strength. It's important to note that this study was conducted in vitro, and further research is needed to better simulate clinical oral cavity conditions.

CONFLICT OF INTEREST

The authors declare no potential conflict of interest

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