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Research Article

Hardness Comparison of Single-Shade vs Multi-Shade Dental Resin Nano-Composite

Ananda Haura Nuradnin[1], Martha Mozartha[2]*, Bebbi Arisya Kesumaputri[2], Danica Anastasia[3]
[1]Faculty of Medicine, Universitas Sriwijaya, Palembang, Indonesia
[2]Department of Biomaterial, Faculty of Medicine, Universitas Sriwijaya, Palembang, Indonesia
[3]Department of Conservative Dentistry, Faculty of Medicine, Universitas Sriwijaya, Palembang, Indonesia

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Abstract

Shade matching of multi-shade dental resin nano-composite is a process that requires time and operator expertise. Single-shade universal composite resin claimed to match all tooth colors to simplify the process. Comprehensive testing, including an assessment of surface hardness, is needed to evaluate the properties of this relatively new single-shade universal composite and to evaluate the surface hardness of single-shade universal composite compared to multi-shade dental resin nano-composite. This experimental study tested two composite restorative materials: single-shade universal composite (Omnichroma, Tokuyama Dental, Japan) and nanofilled composite resin (Filtek™ Z350 XT, 3M/ESPE, USA). Thirty specimens divided into 2 groups (n=15) were fabricated by placing the composites into a stainless steel mold (2 mm thick × 12 mm diameter) and photoactivated for 20 seconds, followed by finishing and polishing. Surface hardness was evaluated using a Vickers hardness testing machine and a diamond indenter with a load of 1000 g applied for 15 seconds. Data were analyzed by using an independent t-test. The mean surface hardness of single-shade universal and multi-shade dental resin nano-composite were 21.04±4,92 and 19.33±5,61 Vickers hardness number (VHN), respectively. Single-shade universal composite showed no significant difference in surface hardness to multi-shade dental resin nano-composite (p-value > 0.05). The surface hardness value of single-shade universal composite resin was comparable to multi-shade dental resin nano-composite.

Keywords: multi-shade dental resin nano-composite; surface hardness; single-shade universal composite; Vickers hardness

INTRODUCTION

The development of restorative materials has progressed significantly, and composite resins are increasingly favored because of their continuous improvements and expanding range of applications. These resins are categorized as hybrid, microhybrid, and microfilled, depending on their filler particle size.[1] The emergence of nanotechnology has paved the way for nanofilled composites, which are now utilized in clinical settings. There are two types of composites with nano-scale fillers: nanofilled and nanohybrid. Nanofilled composites consist entirely of nanometer-sized particles, while nanohybrid composites are a mixture of nanofiller particles and larger-sized particles.[2]

The main goal of adding nanosized fillers to resin composite is to enhance the mechanical characteristics of the materials, thus making them suitable for use in both anterior and posterior teeth and having adequate mechanical properties to function in high-stress-bearing areas.[3] Various laboratory tests have previously been conducted to assess the longevity of restorations in the oral environment,

* Corresponding author, e-mail: marthamozartha@fk.unsri.ac.id

including surface hardness testing.[4] Previous studies showed that the nano-composites had significantly higher hardness values compared to the hybrid and microfilled composites that were tested due to higher filler content, denser filler particles, and resin content.[5,6]

In addition to their excellent mechanical properties, dental nano-composites also offer advantages such as good aesthetics, low surface roughness, and ease of polishing, resulting in a high-gloss finish due to their small particle size.[7] Nevertheless, achieving accurate shade matching remains a significant challenge, even for highly skilled operators. To address this issue, a layering technique is used with multiple resin composite shades to reproduce the natural shade of the tooth, which requires a stock of restorative materials in various opacity levels.[8]

Saegusa et al. assessed the color matching of structural colored resin composites in comparison to conventional multi-shade nano-filled resin composites that contain pigments. The new restorative material, which incorporates smart chromatic technology, has recently been introduced to the market. It is claimed to match all tooth colors. The findings reveal that the structural colored resin composite outperforms traditional resin composites in color matching ability.[9] This is in line with Cruz da Silva et al., who found that the structural colored resin composite, also known as the universal single-shade composite (Omnichroma), demonstrates better color matching compared to multi-shade resins.[10] Previous studies suggest that the use of this single-shade universal composite simplifies the shade-matching procedure and shortens treatment time.[11]

Comprehensive testing is necessary to determine the characteristics and clinical performance of this relatively new single-shade universal composite. The current study was conducted to evaluate the surface hardness of a single-shade composite compared to a multi-shade dental resin nano-composite.

MATERIALS AND METHODS

This in vitro study using the post-test-only control group method was conducted at the Dental Hospital of South Sumatera Province and the Mechanical Engineering Laboratory Universitas Sriwijaya in Palembang, Indonesia. Two different resin-based composites were investigated: a nanofilled (FiltekTM Z-350 XT, 3M Dental Products, St Paul, MN, USA) and a universal single shade composite (Omnichroma®, Tokuyama Dental, Tokyo, Japan). Table 1 provides an overview of the restorative materials examined in the current study.

Table 1. Product information for tested dental composites[12,13]

Brand	Manufacturer	Type	Resin matrix	Fillers
Filtek™ Z-350 XT	3M ESPE (St. Paul, MN, USA).	Multi-shade dental resin nano-composite	Bis-GMA, Bis-EMA, UDMA, TEGDMA, PEGDMA	20 nm nanosilica fillers, 5.00–20.00 nm agglomerates zirconia/silica particles, 0.60–1.40 um clusters particle size (78.5% by weight)
Omnichroma®	Tokuyama Dental, Tokyo, Japan)	Single-shade universal composite	UDMA, TEGDMA, mequinol, dibutilhidroxitolueno e UV absorber	79% by weight (68% by volume) of spherical zirconium silica filler (average particle size 0.3 µm, range 0.2–0.4 µm)

The stainless-steel mold was placed on a mylar strip set on a glass slide. Each sample was created by placing the composite inside the mold and covering it with another mylar strip. A glass sheet was then used to apply pressure, compress the composite resin, and remove any excess material. The LED Light Curing Unit (LUX I, DTE®) was then used to irradiate each specimen from both the top and bottom for 20 seconds without removing the glass sheet, and then the cured specimens were dislodged.

The surface of the specimen was then polished with a composite resin polishing kit using a low-speed handpiece and minimal pressure to remove excess resin. After finishing and polishing, the specimens were re-measured to ensure measurement consistency before polishing. Each sample was placed in a small container and labeled according to its respective group: Group 1 for nanofilled composite and Group 2 for universal single-shade composite (with n=15 samples in each group). Vickers hardness values were measured using a Vickers hardness tester machine (Albert Gnehm, Switzerland) with a 1000 g load applied using a diamond tip at the center of the material for a duration of 15 seconds. A microscope was used to measure the diagonals of the square traces. The collected data were statistically analyzed to assess their hardness values.

RESULT

The result of the Kolmogorov-Smirnov test indicated a normal distribution ($p>0.05$). Assessment of any significant differences between the tested composites was performed using the Independent t-test. The measurement results for the surface hardness of these two types of resin composites are presented in Table 2.

Table 2. Surface Hardness Value

Property	Mean±SD		p-value
	Nanofilled	Single-Shade Universal	
Hardness	19.33 ± 5.61	21.04 ± 4.92	0.384

Table 2 shows that universal single-shade resin composite has greater surface hardness compared to conventional nanofilled resin composite, but the difference was not statistically significant ($p > 0.05$).

DISCUSSION

Surface hardness testing is advantageous in evaluating a material's properties, including wear resistance to the indentation of another harder material. It stands as one of the crucial factors that determine the long-term clinical performance of resin composite restorative materials when functioning in the oral environment. The curing depth of composite resin materials can be determined by measuring surface hardness. Rezaei et al. discussed that the surface hardness of composite resin can be correlated with many factors, including the size, type, and distribution of the fillers, the type and viscosity of monomers, the initiator system, and the light-curing unit device.[14]

In this study, two types of composite resins were tested: Filtek™ Z350 XT, a multi-shade nanofilled composite, and Omnichroma, a universal single-shade composite. Based on the results, the two composites exhibited similar surface hardness values. Independent t-tests showed no statistically significant difference between the two. It can be attributed to the similarity in filler particle characteristics between the two composites. Omnichroma and Filtek™ Z350 XT have a filler loading of 79 wt% and 78.5 wt%, respectively.[15]

Kundie et al. reviewed articles that investigated the influence of the size of the filler on the mechanical properties of composite resins. The findings revealed that filler size plays a role in determining the hardness of composites. Dental composites containing nanoparticles exhibited elevated hardness levels.[16] Omnichroma, which was examined, contains uniformly sized supra-nano spherical filler particles measuring 260 nm in diameter. Similarly, Filtek™ Z350 XT contains nanometer-scale spherical particles in the form of clusters and agglomerates. Furthermore, both of them also contain silica and zirconia filler particles.[12,15] Silica fillers are the most widely used in commercial resin fillings, and zirconium oxide is added to improve the mechanical properties, including hardness. Previous studies have emphasized that incorporating zirconia as a filler in composite materials enhances both strength and toughness, but a decrease occurs when zirconia-silica concentrations are increased. At present, the levels of zirconia-silica concentrations in Omnichroma are not known.[17]

The measurement of the initial Vickers hardness values of the bottom and the top surfaces of the composites can provide insight into the depth of polymerization. A Bottom/Top average ratio approaching 1 indicates adequate light transmission from top to bottom and ensures that the base has adequately been polymerized. However, there is a limitation in this study, where Vickers testing was only conducted on the top surface. Previous research suggests that Vickers hardness values of composites decreased in all the samples after undergoing thermocycling to simulate the oral environment.[18] Further research is required to determine the aging effects on the surface hardness of multi-shade dental resin nano-composite.

CONCLUSION

The universal single-shade composite resin (Omnichroma®) exhibits surface hardness values comparable to that of the multi-shade dental resin nano-composite (FiltekTM Z350 XT).

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