Under-surface hardness of light-cured nanofilled resin composites of different shades

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Abstract. The objective of the this study was to analyze the under-surface hardness of light-cured nanofilled composite resins of different shades. The specimens were resin composites of each light (B1), medium (A3), and dark (C3) shades packed in a cylinder mold and subsequently polymerized. The hardness was tested using a Knoop system. The hardness test results for the bright (B1), medium (A3), and dark (C3) shades were 82.4±1.1, 75.9±1.2 and 65.9±1.9, respectively, and indicated significant differences between the under-surface hardness of each shade. It was concluded that resin composites of darker to brighter shades demonstrated lower to higher under-surface hardness.

1. Introduction

The demand for esthetic restorations, besides strong physicomechanical properties, is a key factor in the placement, and popularity with patients. Some countries that has entirely replaced mercury amalgams, the use of resin-based composites has continued to increase [1,2]. The increase use of light-cured composite resins relates to the availability of various color (shade) that influence their appearance. On the other hand, the natural tooth’s shade varies with the age of the patient, region of the tooth, and whether enamel and/or dentin is exposed. In order to select a composite shade, an understanding of the influence of light on shade is necessary [3,4]. In shade matching to tooth color, one of the commonly used shade guides was the Vitapan Classical Vita [5]. Three main considerations in shade are hue, chroma and value of a material, based on a system. Light absorption, transmission, diffusion, refraction, reflection, and scattering all play a role. Shade variations represent the reflection of pigment impregnated within the material.

Types and amount of pigment affects several mechanical properties of resin composites, of which hardness is being one of them, since it determines the longevity and durability of a restoration [6,7]. Hardness of a resin composite relates with polymerization; uncomplete polymerization of a restoration revealed with low hardness, for which this would cause monomer release [8]. Previous research have shown a relationship between resin composite shades and their hardness [9,10]. A hybrid resin composite (Z250, 3M-ESPE, USA) with bright (A3), medium (A3.5) and dark (C3) shades demonstrated that the medium shade (A3.5) had the highest under-surface hardness [11]. In contrast, another study by Aguiar FHB 2005 showed that the bright (A1), medium (A3.5) dark (C2) shades demonstrated increased under-surface hardness from bright to dark shades; however the differences of the undersurface hardness between shade A1 and A3.5 and also between A3.5 and C2 are insignificant [12]. This led to an assumption that there must be factors that influence under-surface hardness, and that the shade of the restoration could be one of those factors.
Nano-filled resin composites have been the main option for direct anterior restorations, yet there has been little study conducted to evaluate the under-surface hardness in relation to the material shades. The objective of the study, therefore, was to analyze the influence of resin composite shade on their under-surface hardness.

2. Materials and Methods
We chose nano-filled light cured resin composite shades B1, A3 and C3 for the light, medium and dark color, respectively, and were the most widely used shades. The resin composite of each shade was used to prepare the specimen in a 6 mm in diameter and 2 mm in thickness mold. The resin composite in the mold was polymerized by a curing unit (Elipar™ S10, 3M ESPE, USA) with an irradiance of 900 mW/cm² for 20 sec. Ten specimens were prepared for each shade in room temperature of 23±1°C. An interval of 60 seconds between specimen preparation was maintained and after every five polymerizations, the light irradiance was monitored. After removal of the polymerized specimens from the mold, all specimens were stored in an incubator at 37°C for 24 hours. After this period, we measure the hardness at the bottom of the specimen.

The under-surface hardness of the specimen was determined based on ISO 4049:2000 described in a previous work [11,12]. A Knoop tester (Zwick, Kennesaw, GA, USA) with a 25 g load was given on the under-surface of the specimen producing a kite-shaped micro-indentations to calculate the hardness value using the following equation:

\[ KHN = \frac{F}{d^2C_f} \]

in which F is the force, d is the diagonal length of the lesion and C_f is the constant of the indenter relative to the projected area of the indentation and the square of the length of the long diagonal (0.7028). Data were recorded as the average of each set of five readings in each specimen and the value was expressed as Knoop Hardness Number (KHN). One-way analysis of variance (ANOVA) was used to determine whether there were significant differences in the under-surface hardness values among groups that were exposed to different shades with significance of 0.05. We then used the Tukey HSD test to analyze the differences between the groups.

3. Results and Discussion
3.1 Results
Polymerizing the resin composite specimens of the different shades led to results of the under-surface hardness, as given in Figure 1.

![Figure 1](image_url)
In Table 1 the under-surface hardness was presented from resin composite of shades B1, A3 and C3. The under-surface hardness values decreased from 82.4±1.10 KHN of the shade B1 to the lowest value 65.9±1.91 KHN of the shade C3 with a mid-range 75.9±1.22 KHN of shade A3. One-way ANOVA indicated a significant difference (p<0.05) in the under-surface hardness. The Tukey post-hoc test indicated significant differences (p<0.05) between the under-surface hardness of each shade, as showed in Table 1.

|       | B1  | A3  | C3  |
|-------|-----|-----|-----|
| B1    | --- | *   | *   |
| A3    | --- | --- | *   |
| C3    | --- | --- | --- |

*p<0.001.

3.2 Discussion

Different amount of pigment in each composite might be one of the factors that led to the differing results of the undersurface hardness. It is thus possible that results of this study presented a lower hardness obtained of the dark shade C3 than those of the brighter shades A3 and B1. When a resin composite is being polymerized, light from a curing unit is absorbed by a photoinitiator (camphorquinone) and scattered by the pigments and fillers [8]. Absorbed light by the resin composite of bright shade (B1), having low amount of pigment, were able to scatter the absorbed light higher than those of the darker shades. This may have progressed the polymerization process well, thus, revealing high undersurface hardness of the resin composite specimens of bright shade (B1). In contrast, an unfavorable capable of absorbed to be transmitted by darker the shade (C3) was likely to occur. The relatively high amount of pigment, that must have markedly affecting low degree of conversion, thereby, the polymerization process does not progress well resulting in low polymerization of the materials, and consequently, low undersurface hardness. The undersurface hardness of resin composite specimens of the medium shade (A3) lies between both of shades light (B1) and dark (C3).

Results presented in this paper, regarding the increased undersurface hardness of the lightshade resin composites compared to those of the dark shades, confirms the results of a similar study by Aguiar et al. Another study by Jeonget et al. showed results different from the present study. They suggested that the bright shade specimens have the lowest undersurface hardness compared to other resin composites [11]. This different result might be due to difference factors conducted in both studies. For example, the light curing unit, time and length of light curing, specimen thickness, resin composite composition, and the hardness tester used are different.

4. Conclusion

It was concluded that the shade of nano-filled light cured resin composites influence their undersurface hardness. The bright shade (B1) tended to produce higher undersurface hardness than the darker shades (A3 and C3).

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