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ORIGINAL ARTICLE

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Effect of thickness on fluorescence of resin composites and dental substrates

Efeito da espessura sobre a fluorescência de resinas compostas e substratos dentais

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ABSTRACT

Objective: This study evaluated the effect of thickness on fluorescence of resin composites and tooth substrates (enamel and dentin). **Material and methods:** Ninety bovine incisors were used, resulting in 45 dentin and 45 enamel disks (6 mm diameter and 0.5, 1, or 1.5 mm in thickness). Ninety discs of Charisma, Filtek Z350 and IPS Empress Direct (for enamel and dentin) resins at same dimensions were built. Fluorescence measurements were performed using a fluorescence spectrophotometer (RF-5301PC, Shimadzu Corp) with excitation at 365 nm. Data were submitted to 2-way ANOVA and Tukey's post hoc tests ($\alpha = 0.05$). **Results:** The 2-way ANOVA revealed statistically significant differences for all factors, as well as the interaction between them ($p < 0.05$). Dentin specimens (1.5 mm) showed highest fluorescence (128.33 A.U.), while Filtek Z350 (dentin - 1.0 mm) showed the lowest fluorescence (29.84 A.U.). Thickness influenced fluorescence values of enamel substrate. **Conclusion:** The thickness influenced fluorescence of enamel and all resin composite assessed showed fluorescence lower than natural dentin.

KEYWORDS

Dental enamel; Dental resins; Dentin; Spectrometry, Fluorescence.

RESUMO

Objetivo: Este estudo avaliou o efeito da espessura de resinas compostas e substratos dentais (esmalte e dentina) sobre a fluorescência. **Materiais e Métodos:** Noventa incisivos bovinos foram utilizados, resultando em 45 discos de dentina e 45 discos de esmalte (6 mm de diâmetro e 0,5, 1 ou 1,5 mm mm de espessura). Noventa discos das resinas compostas Charisma, Filtek Z350 e IPS Empress Direct (para esmalte e dentina) foram confeccionados com a mesma dimensão. A fluorescência foi analisada por meio de espectrofluorímetro (RF-5301PC, Shimadzu Corp) com excitação de 365nm. Os dados foram submetidos ao teste ANOVA dois fatores e Teste de Tukey ($\alpha = 0,05$). **Resultados:** O teste ANOVA dois fatores revelou diferenças significativas para todos os fatores, bem como para interação entre eles ($p < 0,05$). As amostras de dentina (1,5 mm) apresentaram alta fluorescência (128,33 A.U.), enquanto a resina composta Filtek Z350 (dentina - 1,0 mm) apresentou menor fluorescência (29,84 A.U.). A espessura influenciou os valores de fluorescência para o substrato esmalte. **Conclusão:** A espessura influenciou na fluorescência do esmalte e todas as resinas compostas avaliadas apresentaram uma fluorescência menor do que a dentina natural.

PALAVRAS-CHAVE

Esmalte dental; Resinas dentárias; Dentina; Espectrometria de Fluorescência.

INTRODUCTION

An important optical property of the dental tissues is fluorescence. It can be defined as the property of a substance that absorbs light and then emits spontaneously at a longer wavelength. Natural teeth emit a strong blue fluorescence under the action of ultra-violet light [1].

As a rule, dentin is covered by enamel coating which is highly translucent [2, 3]. In order to mimic color, translucency and fluorescence of natural tooth, manufactures make available on the market several composites to provide the requirements of esthetics dentistry [4, 5].

The predominance of ultraviolet light in the environment may change the appearance of restorations made with composites with different fluorescence presented by the tooth structure. Under these conditions, the restorations may present either lighter or darker than the adjacent tooth structure [6].

To minimize background color effect during building of an aesthetic restoration, the insertion of the resin layers is generally performed [7, 8]. Thickness of composite resin is one of the factors affecting translucency [9]. However, it is not known about the influence of the thickness of resin composites on fluorescence.

Thus, this study aimed to evaluate the fluorescence of composite resins with different opacities, enamel and dentin at different thickness.

The null hypotheses tested were: (1) - there is no difference in fluorescence between the tested materials; (2) – specimen thickness does not affect the fluorescence.

MATERIAL AND METHODS

Specimens Preparation

Teeth

Ninety extracted, non-damaged and intact bovine incisors were stored in 0.1% thymol solution at room temperature until required. A single enamel or dentin specimen, presenting 6 mm in diameter and 0.5, 1 or 1.5 mm high, was obtained from the labial surface of each crown using a trephine mill (F.N. Moraes, São José dos Campos, SP, Brazil) and polishing paper (Extec, Essington, PA, USA).

Resin composite

In this study, the following three commercial resin composites shade A2 (enamel and dentin shades) Filtek Z350, Charisma and IPS Empress Direct were used. Details are listed in Table 1.

Table 1 - Dental composites tested in the study (information provided by the respective manufacturers)

Material	Composition	Manufacturer
Filtek Z350	Bis-GMA, Bis-EMA, UDMA and TEGDMA - Nanofillers of silica (5–20 nm) and nanoclusters of zirconia / silica (0.6 and 1.4 μm) - 78.5 wt%	3M ESPE St. Paul, MN, USA
Charisma	BIS-GMA and TEGDMA - Fillers: Ba-Al-F – 64 wt%	Heraeus Kulzer, South Bend, Ind
IPS Empress Direct	Bis-GMA and UDMA – Fillers: Barium, alumina, fluorosilicate glass, barium glass filler, mixed oxide, and ytterbium trifluoride - 81.2 wt%	Ivoclar Vivadent, Schaan, Liechtenstein Ivoclar Vivadent

Resin composites were packed into standardized circular molds measuring 6 mm diameter and 0.5, 1 or 1.5 mm thickness. The molds and materials were covered with Mylar strips on the top and bottom and placed between two cover glasses. Finger pressure was then applied to extrude excess material and eliminate porosities. The materials were light cured (Radi Cal curing light, SDI, Australia; wavelength, 440-480 nm; intensity, 1200 mW/cm^2) according to manufacturer's instructions. Fifteen specimens were prepared for each material for each thickness. The specimens were stored in distilled water for 24 h at 37 ºC to ensure complete polymerization.

Fluorescence analysis

Fluorescence measurements were performed with the RF-5301 PC (Shimadzu Corp., Kyoto, Japan) spectrofluorophotometer

with excitation wavelength at 365 nm. The emission spectrum (400 to 600 nm) was obtained and the value of emission peak in Fluorescence Units (F.U.) and wavelength were recorded using the "peak pick" tool of specific software (RFPC - Shimadzu).

Statistical Analysis

The data obtained were statistically analyzed using Statistica for Windows (Statsoft, Tulsa, OK, USA). Two-way analysis of variance and Tukey's test were applied at a significant level of 0.05 for fluorescence assessment.

RESULTS

Figure 1 presents Fluorescence results of all experimental conditions. The cross-product substrate versus thickness as well as the factors were statistically significant ($p = 0.001$).

Natural dentin showed the highest values of Fluorescence and the thickness had no influence in this substrate. For the resin composites the thickness also had no influence. However, for natural enamel as more thick the specimens more fluorescent they were.

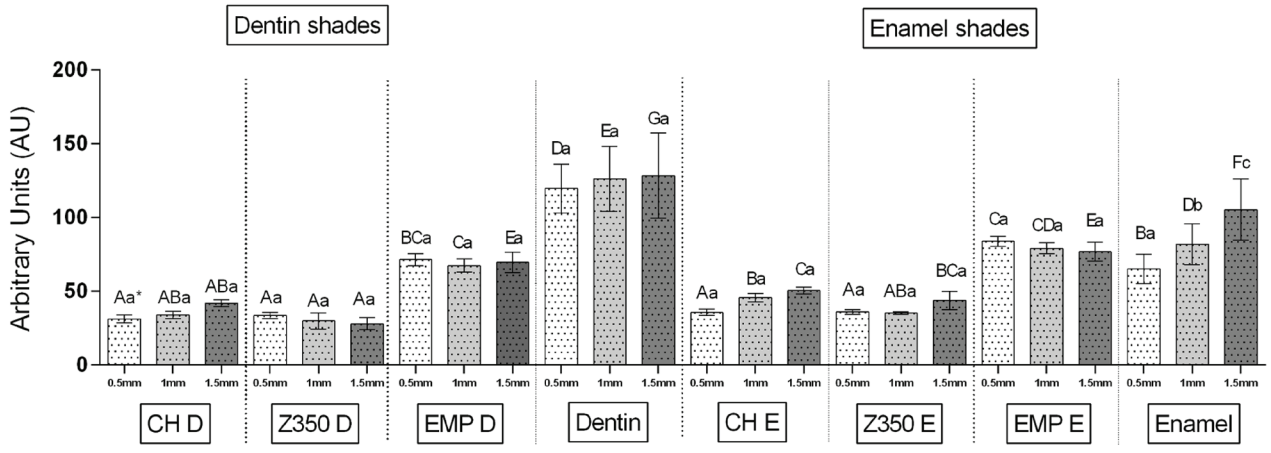
Figures 2 and 3 show Emission Spectra of Fluorescence of all experimental groups. Average wavelength of fluorescence emission was 446.38 nm and 448.96 nm for Dentin and Enamel Shades, respectively.

DISCUSSION

Based on the results of this study, the first null hypothesis tested was rejected, since fluorescence was influenced by the brand of resin composite and tooth substrate. In addition, the second null hypothesis was partially rejected because specimen thickness influenced fluorescence of natural enamel.

Fluorescence, although could be minimally perceptible under normal ambient light conditions, is clinically significant because restorations should match color of the natural teeth not only in daylight but also under different light sources. Fluorescence is important under black light such as in dance clubs. Under these conditions the fluorescence of a restoration is very important to its natural appearance [10].

Previous studies and the present one used fluorescence spectrophotometers to measure the fluorescent emission [1,10-12]. They usually use single wavelength for specimen excitation. It is important because it is possible to choose a specific wavelength and obtain the results of only



* Different capital letters mean significant differences among thicknesses ($p < 0.05$).
Different lowercase letters mean significant differences among resins or substrates ($p < 0.05$).

Figure 1 - Fluorescence of all material and substrates tested.

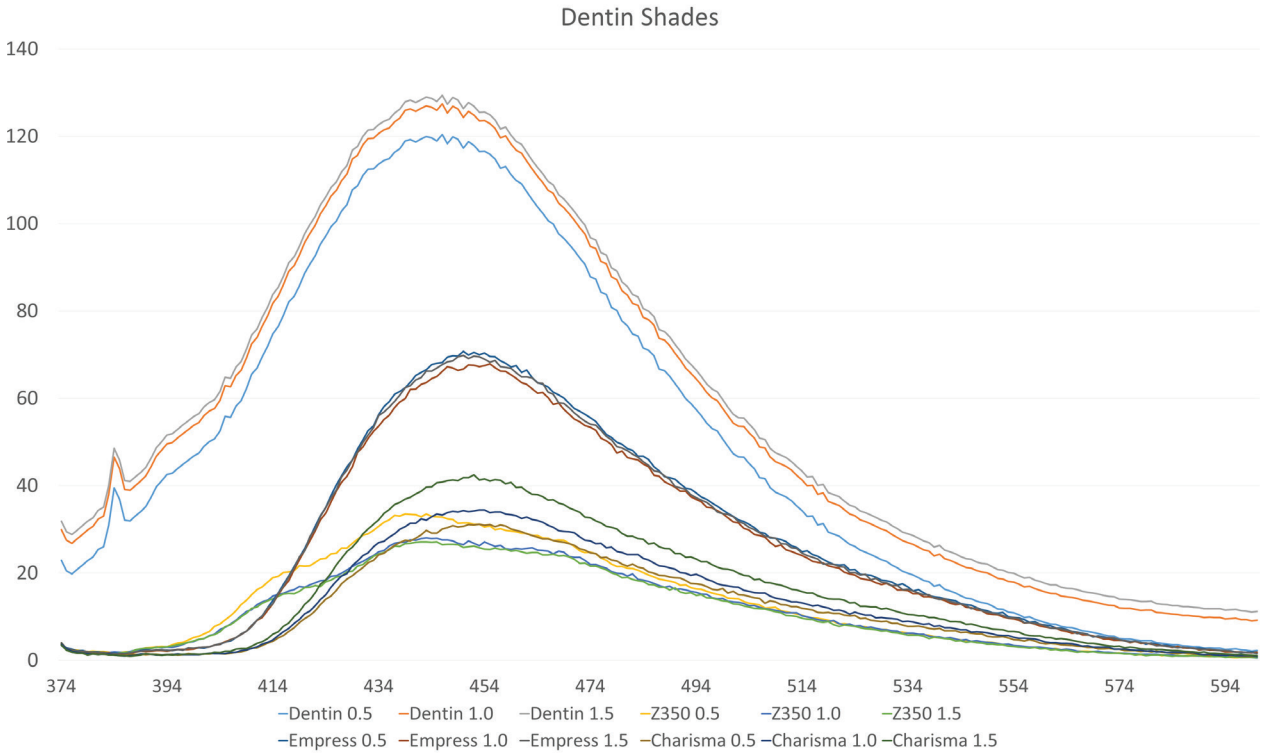


Figure 2 - Fluorescence emission spectra for dentin shades.

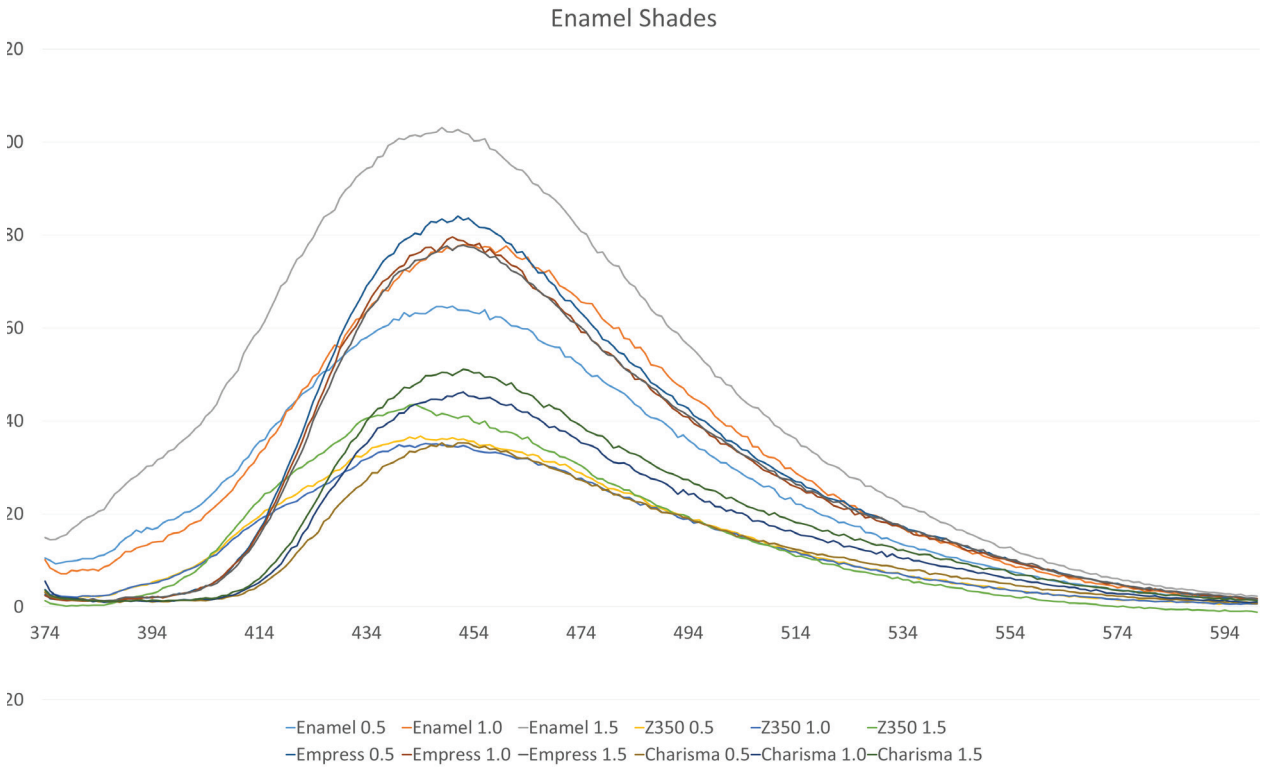


Figure 3 - Fluorescence emission spectra for enamel shades.

fluorescence emission. However, some others studies [13-15] used the UV component of the standard illuminant D65 to excite the specimen. The range of UV component is 330–395 nm. Fluorescence is calculated as the color difference between the inclusion and exclusion of the UV component of the illuminant. According these authors [13], it has clinical relevance because the ambient light is not a monochromatic light. Standard illuminant D65 represents the average daylight with a correlated color temperature of approximately 6500 K. Therefore, the measurement could have measured the fluorescent emission under ambient light condition. In our study we could simulate a condition under UV illumination. We used 365 nm for specimens' excitation. This wavelength, according to Spitzer and Bosch [1], promotes a fluorescent phenomena in dentin, that emits light at 440-450 nm.

Similarly to this investigation, previous studies [12,16] evaluated the fluorescence intensity of composites of dentin and enamel shades. However, authors found that some resin brands showed fluorescence intensities similar to human dentin, in contrast with our results, which all resin composites showed lower fluorescence than the dentin substrate (Figure 1). Although these studies used a direct measurement, the excitation wavelength (380 nm) was different from that used in this present study (365 nm).

Regarding influence of thickness in fluorescence, no information available in the literature was found. According to Vanini [17], the emission of fluorescence is not limited to the superficial layer; it emanates from the inner aspect of the material. The basic components of composite resins do not promote fluorescence, but this property is obtained by incorporating luminescent substances, such as rare earth oxides (europium, terbium, and neodymium) [18]. On the other hand, dental substrates emit fluorescence due presence of amino acids, such as tryptophan, present manly in dentin [19]. Furthermore, as enamel has little amount of organic content, the fluorescence is lower than dentin. This study showed that only for natural enamel, thickness had influence in fluorescence values. The fluorescent substances that promote fluorescence of the tooth and resin composites are different, and they could present different behavior under UV excitation.

CONCLUSION

Within the limitations of the study, it was concluded that:

- The thickness of the materials and type of substrate affected the fluorescence.

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