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Dental fluorescence: Potential forensic use

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ABSTRACT

In cases of identification of bones, skeletal segments or isolated bones, searching for biotypologic diagnostic data to estimate an individual's age enables comparing these data with those of missing individuals. Enamel, dentin and pulp undergo remarkable changes during an individual's life. The enamel becomes more mineralized, smoother and thinner, and deteriorates because of physiological and pathological factors. Dental pulp decreases in volume due to the deposition of secondary dentin; thus, the dentin becomes thicker with time. In natural teeth, the fluorescence phenomenon occurs in dentin and enamel and changes in those tissues may alter the expression of the natural tooth color. The aim of this study was to assess the correlation between age and teeth fluorescence for individuals from different age groups. The sample consisted of 66 randomly selected Brazilians of both genders aged 7–63 years old. They were divided into 6 groups: Group 1 – aged 7–12 years, Group 2 – aged 13–20 years, Group 3 – aged 21–30 years, Group 4 – aged 31–40 years, Group 5 – aged 41–50 years and Group 6 – aged between 51 and 63 years. Upper right or left central incisors were used for the study. Restored and aesthetic rehabilitated teeth were excluded from the sample. The measurement of tooth fluorescence was carried out via computer analysis of digital images using the software ScanWhite DMC/Darwin Systems – Brazil. It was observed that dental fluorescence decreases when comparing the age groups 21–30, 31–40, 41–50 and 51–63 years. The results also showed that there is a statistically significant difference between the groups 41–50 years and 21–30 years ($p = 0.005$) and also among the group 51–63 years and all other groups ($p < 0.005$). It can be concluded that dental fluorescence is correlated with age and has a similar and stable behavior from 7 to 20 years of age. It reaches its maximum expected value at the age of 26.5 years and thereafter decreases.

1. Introduction

Fluorescence is a phenomenon defined as the absorption of UV light (1–400 nm – invisible light) by objects such as natural teeth, and its spontaneous emission in larger wavelengths (430–450 nm – light visible) [1,2]. The hypothesis of age estimation from changes in dental fluorescence has arisen because it is known that the expression of natural tooth color is dynamic and depends on the interaction of enamel, dentin and pulp with light during the phenomena of refraction and reflection [1]. The enamel, dentin and pulp undergo remarkable changes during an individual's life. Enamel becomes more mineralized, smoother and thinner. This increase in the mineral content and thinning of enamel makes it more translucent. The physiological and pathological wear of enamel may also lead to exposed areas of dentin, especially in the incisal region; and exposed dentin absorbs stains, leading to an alteration in the expression of the natural tooth color. The pulp decreases in volume due to the deposition of secondary dentin thus the dentin becomes thicker with time. Furthermore, the dentin becomes less permeable as a result of deposition of peritubular dentin, which increases its chromatic saturation and reduces its opacity [3].

Young people usually have anterior teeth with a large pulp volume, and opaque dentin, completely covered by enamel. The enamel is thicker, translucent, shiny and often presents a milky,

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white chalk color [4]. Individuals aged 70–80 years of age have significantly reduced enamel thickness and surface texture and a significant increase in translucency. Often, there are large areas of dentin exposure at the incisal edges, which usually suffer from severe extrinsic staining. The pulp virtually disappears, while the dentin becomes thicker and more saturated and decreases in opacity [5]. Thus, if the enamel and dentin are responsible for the dental fluorescence phenomenon and teeth undergo significant changes during life, proper investigation of the phenomenon of fluorescence can provide us a method to estimate an individual's age.

There are different methods to measure tooth color, including visual assessment with shade guides, spectrophotometry and computer analysis of digital images. The latter method has been successfully used to assess the effects of dental whitening and color changes through longitudinal studies [6–8]. Therefore, the International Commission of Illumination (ICI) established standards that enable the definition of a certain color. It developed the colorimetric model in which a color is located by three values: the luminance (L), expressed as a percentage – 0 for black to 100 for white; two color ranges a^* and b^*, respectively ranging from green to red, and from blue to yellow, where a^* positive tends toward red and the negative toward green, and b^* positive tends toward yellow and negative toward blue. Consequently, it is possible to describe a set of visible colors. In CIELAB systems the comparison between two colors (ΔE) can be mathematically calculated. The basis for these calculations are the parameters L^* (brightness), a^* (red–green), b^* (blue–yellow) of the two colors [1,8–13].

Studies should be carried out to verify and quantify the change in tooth fluorescence through the lifetime of an individual and establish a new age estimation method, which would be of great value, especially in individuals older than 20 years. The aim of this study was to assess the correlation between age and the change in fluorescence of dental teeth in groups of individuals with different ages The variables assessed in this study were: total fluorescence, L^* (brightness), a^* (red/green), and b^* (yellow/blue).

2. Materials and methods

The research project was appreciated by the Ethics Committee of the University of São Paulo, Brazil, and approved under number 134/2010.

Photographs of the maxillary central incisor tooth (right or left) obtained in an environment illuminated by ultraviolet light (UV), commonly known as "black light" were analyzed. The sample consisted of 66 Brazilians, 25 males and 41 females who were randomly selected in the clinics of graduate courses. The study subjects were aged between 7 and 63 years and were divided into 6 groups: Group 1 – 7–12 years, Group 2 – 13–20 years, Group 3 – 21–30 years, Group 4 – 31–40 years, Group 5 – 41–50 years and Group 6 – 51–63 years. The division of groups was based on a study by Hasegawa et al. [10] who studied the color and translucency of natural teeth in all age groups and established 6 groups where the color and translucency vary throughout life.

The following exclusion criteria were used: presence of restorations or any other rehabilitative or aesthetic procedure (such as tooth whitening), the presence of stains, imperfect amelogenesis, fluorosis and any change on the tooth surfaces where fluorescence was measured, as well as traumatized incisors. There was no cleaning procedure prior to photography, because the central incisor is an easily accessible tooth for hygiene and has a smooth surface. The recorded data were registered in a special form developed for the study.

A box of expanded polystyrene (styrofoam) was manufactured with depth, width and height of 50 cm for each. Two 25 W/127 V Golden® UV lamp bulbs were installed, placed 30 cm apart, with a slot between them through which the photographs were taken. The opposite surface (front) of the box remained open to enable proper positioning of the volunteer. The subject's head position was standardized with the Frankfurt plane (tragus line to the wing of the nose) parallel to the ground. The subject was positioned at a distance of 65 cm from the camera.

The photographs of the selected maxillary central incisor were obtained in a dark environment with the UV lamp bulb as the only light source. A Sony cybershot DSC (Digital Still Camera) camera (Sony USA – Sony Corporation of America) was used set at Macro f/2.8, ISO 400, speed of aperture 30, at a distance of 65 cm from the object. The camera was fixed by a tripod and no flash was used. The images were coded and the differences in the level of fluorescence from each analyzed condition were determined using a digital image processing with the help of software ScanWhite DMC/Darwin Systems software from Brazil, which is able of assessing the level of tooth whitening. This software calculates the parameters L^*, a^*, b^* according to the CIE lab.

For the statistical analysis to compare the different age groups regarding the variables considered in this study, the model analysis of variance was applied with a source of variation. In case of rejection of the hypothesis of equal means in all age groups, these bands were compared in pairs considering the LSD test. To assess the relationship between age and each variable of interest fit regression models were used. To evaluate the error of method the model of variance components and estimation of the intraclass correlation coefficient was considered. p values less than 0.05 were considered statistically significant. The null hypothesis of total fluorescence was tested, L^*, a^* and b^* mean was equal in all age groups versus the alternative hypothesis that at least one age group had mean total fluorescence, L^*, a^* and b^* different from the others. Statistically significant difference was observed in at least one age group. Due to the rejection of the hypothesis of an equal mean in all age groups, these age groups were compared in pairs for each variable.

3. Results

From the experiments the data results observed for the total fluorescence are shown in Table 1 and Fig. 1. At Table 1 it can be seen that some age groups has a statistically significant difference when compared with the age groups studied. Fig. 1 shows a descending dental fluorescence from the age group of 21 to 30 years onwards.

The observed data for the L^* (brightness) are shown in Table 2 and Fig. 2. Table 2 shows that some age group has a statistically significant different fluorescence when compared to all the age groups studied.

From Fig. 2, a decreasing value of L^* can be observed from the age group of 21–30 years onwards. The results enable us to infer that the age where the maximum expected value of L^* is achieved is at the age of 29.2 years, with a maximum expected fluorescence of 53.91.

Table 1
p values for comparisons between the groups of total fluorescence variable.

	Age groups				
	13–20	21–30	31–40	41–50	51–63
Age groups					
7–12	0.959	**0.023**	0.497	0.360	**<0.001**
13–20		**0.027**	0.490	0.407	**<0.001**
21–30			0.118	**0.005**	**<0.001**
31–40				0.146	**<0.001**
41–50					**0.002**

$p < 0.05$ = statistically significant difference.
Bold numbers mean statistically significant difference.