Restorative Dentistry

Spectrophotometric assessment of the effects of 10% carbamide peroxide on enamel translucency

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Abstract: Tooth shade results from the interaction between enamel color, enamel translucency and dentine color. A change in any of these parameters will change a tooth's color. The objective of this study was to evaluate the changes occurring in enamel translucency during a tooth whitening process. Fourteen human tooth enamel fragments, with a mean thickness of 0.96 mm (± 0.3 mm), were subjected to a bleaching agent (10% carbamide peroxide) 8 hours per day for 28 days. The enamel fragment translucency was measured by a computer controlled spectrophotometer before and after the bleaching agent applications in accordance with ANSI Z80.3-1986 – American National Standard for Ophthalmics – nonprescription sunglasses and fashion eyewear-requirements. The measurements were statistically compared by the Mann-Whitney nonparametric test. A decrease was observed in the translucency of all specimens and, consequently, there was a decrease in transmittance values for all samples. It was observed that the bleaching procedure significantly changes the enamel translucency, making it more opaque.

Descriptors: Tooth bleaching; Dental enamel; Spectrophotometry

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Introduction

Nowadays, white, well positioned and outlined teeth not only portray a pattern of beauty, but also indicate health and oral hygiene.[1]

Any tooth discoloration may compromise the beauty of a smile, as the tooth color is an important factor in an attractive smile. Tooth color changes can occur on the enamel surface (extrinsic stain) or inside the tooth structure (intrinsic stain). The former often results from the precipitation of diet pigments on the bacterial plaque or enamel surface.[2] It is important to mention that some structural features and some superficial characteristics of the enamel may contribute to pigment precipitation, such as roughness, porosity, and depression.[3] On the other hand, intrinsic stains may result from several pre-eruptive or post-eruptive factors. In vital teeth, color changes could be natural, physiological or the result of excessive ingestion of some substances (e.g., tetracycline or fluoride). Moreover, in vital teeth, intrinsic discoloration can result from systemic diseases or traumas, which lead to an internal hemorrhage and consequently to change of the tooth color.[1]

In Dentistry several techniques have been indicated to rebuild a smile that has been jeopardized by a change in tooth color. However, tooth whitening has been considered an effective and conservative treatment for achieving harmony between esthetic requirements and tooth color.[4,5] A large number of methods have been developed for this purpose. Different percentages of hydrogen peroxide and carbamide peroxide can be used. In vital teeth, however, carbamide peroxide has been suggested to be the safer alternative.[6]

Enamel color and translucency as well as dentine color determine the color of teeth. Enamel translucency affects the perception of the color, therefore the enamel acts as a light filter for dentine, which works in 2 ways, that is, when light falls on the enamel, it is transmitted to the dentine, which in turn reflects it, so that it returns to the enamel again, and is passed into the environment in the direction of the observer.[7]

The purpose of this *in vitro* research was to assess the effects of a 10% carbamide peroxide agent on enamel translucency.

Materials and Methods

This study was carried out at the Restorative Dentistry Laboratory, School of Dentistry, University of São Paulo, after approval by the Ethics Committee (process 69/05).

Fourteen human tooth enamel fragments from the buccal face of fourteen human molar teeth, which were extracted for several reasons, were evaluated. The dentine was abraded with a low speed hand piece and carbide bur under cooling. The samples – 8.0 mm long, 4 mm wide and 0.96 mm thick (± 0,3 mm) – were made to enable them to be adapted to the spectrometer window (Cintra 10 UV – Visible Spectrometer).

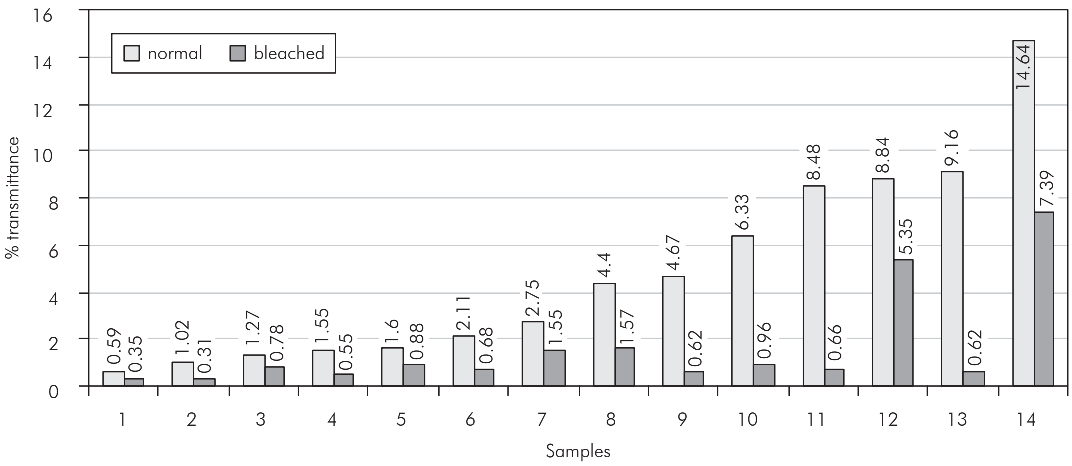
The specimens were kept moistened in distilled water at all times. The whitening agent Sorriso (Colgate-Palmolive, Brazil), 10% carbamide peroxide, was used in accordance with the manufacturer's instructions. Each enamel fragment was positioned so that the external surface, which corresponded to the buccal face, was in contact with the gel. To ensure that the samples were kept moist, wet cotton was placed in contact with the internal surface.

Each of the 14 fragments was conditioned with the gel during 8 hours per day and the translucency of the specimens was evaluated before and after the whitening process. After this period, the samples were washed and kept moistened as described previously. The procedure was repeated during 4 weeks.

In order to measure fragment translucency, each sample was positioned in the spectrometer viewer, so that any fissure between the fragment edge and the spectrometer viewer would be noticed. It is important to mention that during the measurements the samples were kept moist and were placed against a black background.

The ANSI Z80.3-1986, American National Standard for Ophthalmics – nonprescription sunglasses and fashion eyewear – requirements was used in the research. The transmittance values were obtained between 380 and 780 nanometers.

The data were analyzed by a non-parametric test, comparing the situations (normal and bleached). The Mann-Whitney test was performed at a 5% level of significance ($p \leq 0.05$).

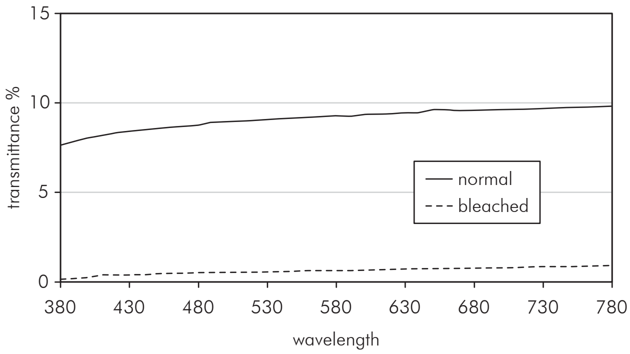


Graph 1 - Transmittance values of all samples before and after bleaching.

Table 1 - Transmittance values (%).

	min	max	Mean	p
Normal	0.59	14.64	4.815	0.003
Bleached	0.31	7.39	1.5907	

p = Mann-Whitney test (significance 5%).



Graph 2 - Transmittance values of sample 10 before and after bleaching.

Results

The results are shown on Table 1. Table 1 shows that there was a statistically significant difference between the groups. There was a decrease in transmittance values for all samples (Graph 1).

An example of the behavior of one specimen for all wavelengths is shown in Graph 2. It was observed that for all emitted wavelengths the transmittance of bleached enamel was lower than that of normal enamel. The same behavior was repeated in all samples.

Discussion

The sense of sight puts people in contact with the environment through light, which provides the visual sensation of the shape, size and color of objects. In other words, one's interaction with the outside world depends on 3 factors: the object, the viewer and the light.[8]

The color of an object is determined by the light it reflects diffusely. For instance, an object is blue because when a white light falls on it, it diffusively reflects the blue light. This relation between the incident light and the reflected light is known as reflectance. Therefore, the color perception of objects relates to their reflectance. However, it must be taken into consideration that there are pigments on the surface of and inside objects, which diffusively reflect part of the incident light. Therefore the color of an object is associated with the reflectance of each of the superficial and internal pigments.[9]

Apart from the light source and the viewer, objects behave differently with regard to light propagation. They can be considered as: transparent, when they allow light propagation and clear visualization of an object through them; translucent, when they allow light propagation, but it is not possible to visualize an object clearly through them; or opaque when the light cannot pass through them. It is also important to consider that once a light falls on an object the specular reflection, diffusive reflection, refraction and absorption phenomena may occur simultaneously.[10]

Taking all the previous information into consideration, it can be said that the color of an opaque object depends on the reflectance of each pigment present on its surface. On the other hand, when an object is transparent or translucent, it is necessary to consider the transmittance, which refers to the relation between the incident light and the amount of the light that passes through it. The color of a translucent or a transparent object will result not only from the reflectance of superficial pigments, but also from the reflectance of internal pigments. In other words, the color of a transparent or a translucent object depends on the quality of the pigments (i.e., blue, red, yellow, etc.) and on the quantity of the pigments (or saturation). Therefore, it can be concluded that in transparent or translucent objects, thickness is an important factor: The thicker the object is, the larger the quantity of pigment it contains.[8]

In addition to thickness, the surface smoothness of the object and the background are important factors to consider, because the interaction between them and the type of the object – opaque, translucent or transparent – may interfere in the process of visualizing an object. A further example is given to explain this interaction: Consider an opaque sample, such as a glossy metal slab. If it were roughened, the slab would still be an opaque object, but it would have less brightness or less luminosity.[9]

Background is also an important aspect to consider when observing an object. If a glass slab were placed against a white background and then the same glass slab were placed against a red background, the observer would have the impression that the slab "became" reddish. This occurs because, in both situations, light falls on the glass slab and it is transmitted to the background. However, while the white background reflects all the incident light, the red background returns only the red light to the observer.[8]

Tooth color is determined by the light reflected diffusively by its crown. However the tooth crown is composed of dentine and enamel, which do not have a uniform thickness and are considered opaque and translucent structures, respectively.[11] This structure will influence the tooth color, because in different regions of the same tooth, the amount of light reflected, absorbed and/or transmitted by dentine and enamel will be different.[12,13] Therefore, when a light illuminates a tooth, part of it is reflected by the enamel surface and part of it passes through the enamel and falls on the dentine. In dentine, the light is either absorbed or reflected back to the enamel, passing through it and affecting the observer.[14] Thus, a change in enamel translucency will modify the optical phenomena described previously, which means that a decrease in enamel translucency, as that observed in this research, leads to a decrease in the incident light on dentine, and, consequently, the influence of dentine color on tooth color will decrease.

In this *in vitro* research there was a decrease in transmittance values of all samples (Graph 1). Since the light source and the observer were kept constant through the entire experience, and there was no change in sample thickness, the variations in transmittance values are believed to be related to the changes in the translucency of the enamel samples.

There are several researches about dental bleaching using spectrophotometry to evaluate the efficacy of treatment.[15-19] However the parameters observed in these studies are the color coordinates of the CieLab System (L*, a* e b*). Therefore it is difficult to compare our results with those of other researches.

Carbamide peroxide, irrespective of its concentration, dissociates into urea and hydrogen peroxide.[6] The latter degrades into free radicals which, by means of an oxi-reduction chemical process, break down big pigmented molecules and transform them into smaller molecules.[20,21] The free radicals are unstable and highly reactive, which make them unable to break down the unsaturated bond of organic molecules and promote a change in the absorption spectrum of the radiant light of these molecules. If there were a change in light absorbed, there would be a change in the transmitted and reflected light, which means that there would be a change in the perception of color and in the transmittance values, respectively.[22]

When light reaches a translucent object, it passes through the object and falls on every pigment in the object, and then the light returns to the observer.

When there is a decrease in the translucency of the object, there will be a decrease in the amount of light that passes through it, and therefore, less light will fall on each pigment. In others words, the object would seem lighter (or less saturated).[8]

The potential change in the enamel surface caused by bleaching agents has been the focus of interest.[23,24] Many researches observed no significant changes in the enamel surface.[6,25-27] However, in some researches the following results were observed: oxidation and loss of the aprismatic layer, exposure and demineralization of enamel prisms, oxidation and, possibly, partial removal of the aprismatic layer.[28]

The increase in surface roughness leads to a rise in diffuse reflection and leads to a decrease in the transmitted light,[29] and consequently, there will be a decrease in the transmittance values. Although this research did not evaluate the surface roughness of specimens before and after the bleaching process, it is possible that the above-mentioned changes occurred, resulting in a decrease in translucency of all specimens.

Conclusion

It was observed that 10% carbamide peroxide affected the enamel translucency by decreasing it in all samples.

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