Surface hardness and color change of dental enamel exposed to cigarette smoke

Abstract

Background: Tooth susceptibility to discoloration can be attributed to defects in enamel and dentin due to pigments penetration into the cracks and tubules present in the dental substrates. Aims & Objectives: This in vitro study was undertaken to evaluate the microhardness and the color change of dental enamel exposed to cigarette smoke. Materials & Methods: Fifteen bovine enamel fragments (25mm2) were submitted to exposure to the equivalent of cigarette smoke from 50 cigarettes over a period of five days. Initial and final readings of microhardness and colorimetric evaluation were performed. The results were analyzed statistically with the one-way ANOVA and Tukey test (p≤0.05). Results: The samples presented a significant color change and a decrease in the values of microhardness. Conclusion: In conclusion, the exposure to cigarette smoke can significantly alter the microhardness of enamel and its coloring.

Key Words: Knoop hardness; Color; cigarette smoke; dental enamel

Introduction

Tooth susceptibility to discoloration can be attributed to defects in enamel and dentin due to pigments penetration into the cracks and tubules present in the dental substrates. Also, these pigments can be incorporated into their organic content. Possible causes for the discoloration of enamel and/or dentin include food or beverages containing pigments, oral therapies that include chlorhexidine, dental caries, the presence of metals such as iron, and high temperatures. In addition, tobacco can usually cause stains on the enamel surface.(1)

Cigarette smoking is a public health problem. Many of the toxic substances present in cigarettes are in the tobacco plant or are produced during burning. Cigarette smoke contains ammonia, formaldehyde, arsenic, carbon monoxide, radioactive polonium, and many other potential disease-causing agents.(2)

In addition to affecting the aesthetics of teeth, cigarette smoke contains various chemical agents that may cause surface alterations or structural changes when in contact to enamel, altering many important mechanical properties of the tooth.(3)

The literature contains only a few studies (4,5) about the effect of cigarette smoke on the optical properties of esthetic restorative materials and dental structures when compared to the numerous studies(6,7) on the effect of coffee, red wine, tea, and other staining agents. Therefore, this study aimed to evaluate the effects of cigarette smoke on the color and enamel Knoop microhardness of the enamel. The hypothesis tested was that exposure to cigarette smoke alters the microhardness of enamel and would cause color changes in the samples during the time period under study.

Materials and Methods

Fifteen bovine incisors were cleaned and disinfected with thymol (Dinâmica, Piracicaba, São Paulo, Brazil) and submitted to an initial polishing with pumice (SS White LTDA; Rio de Janeiro, RJ, Brazil) and water. After separating the coronary portion by means of a double-faced diamond disc (KG Sorensen, Ind. Com. Ltda.; Barueri, SP, Brazil), enamel blocks of 25 mm2 were obtained using a precision saw (Isomet 1000; Buehler, Illinois, USA) and a high-concentration diamond disc (4” x 012 x ½, Buehler, Illinois, USA). The fragments were included, without covering the top with a polystyrene resin, to facilitate handling during planning (8,9) using silicon carbide emery-cloth of decreasing granulation (1200, 600, and 400) and surface polishing with felts with a diamond paste of decreasing granulation (1 and ¼ µm), greased with a specific oil (Arotec, Cotia; SP, Brazil). The samples were then washed for 15 minutes in an ultrasonic tub (Marconi, Piracicaba, São Paulo, Brazil) in order to remove any sludge present on the enamel surface, and then immersed in artificial saliva at 37°C.(10)

Knoop Microhardness analysis: For the Knoop hardness evaluation, the indentations were made on the enamel surface using a Knoop indenter with a static load of 25g for 5 seconds with a microhardness tester (HMV-2000 Shimadzu, Tokyo, Japan).(11) Five consecutive and equidistant indentations were made in the
color and brightness pattern, simulating a clinical situation. (12) The color was measured by placing the sample on a black background with a color and brightness pattern, simulating a clinical condition.(13)

Simulation of the act of smoking: For the smoke cigarette group the study employed the smoking machine developed by Department of Restorative Dentistry, Piracicaba Dental School - 2011 (registered under #01810012043 INPI – National Institute of Industrial Property) and permitted impregnation of pigments contained in cigarette smoke in the specimens of dental structures and restoration materials, in order to reproduce in vitro the smokers mouth cavity conditions. The machine works as it aspires and conducts smoke through glass cannulas aiming to allow it to circulate and deposit the chemical products on the specimen. This cycle is programed within a span of time that simulates smoke aspiration normally performed by a smoker with the duration of 3s. The temporizer permits the ambient air to be inhaled every 10s, simulating smoke exhaustion and afterward smoke elimination.

The standard was the use of one pack of Marlboro (Philip Morris Brazil Ind. e Com. Ltda., Santa Cruz do Sul, RS, Brazil) cigarettes a day for each specimen during the period of 5 day. In the interval between one simulation and the other, the specimens were kept in artificial saliva at a constant temperature of 37°C. Every 24h, the specimens were washed with 250 mL of distilled water and reimmersed in fresh solution of artificial saliva to prevent sedimentation.

After exposure to cigarette smoke, the samples were subjected to a prophylaxis procedure with pumice (SS White LTDA, Rio de Janeiro, Brazil) and water immersion in an ultrasonic tub (Marconi, Piracicaba, SP, Brazil) for 15 minutes.(10)

**Results**

Analysis of the Knoop microhardness: The final reading (T2) significantly differed from the initial reading (T1), which presented the lowest hardness values, as shown in Table 1.

<table>
<thead>
<tr>
<th>Time</th>
<th>Average micro hardness (Pattern Error)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>373.64 (22.99) A</td>
</tr>
<tr>
<td>Final</td>
<td>315.16 (24.45) B</td>
</tr>
</tbody>
</table>

Table 1: Means (SD) of the Knoop microhardness evaluation before and after exposure to smoke

* Means followed by distinct letters differ by Tukey test (p ≤ 0.05).

CIE Lab Colorimetric Analysis: After exposure of the samples to cigarette smoke, the values of color increased, as shown in Table 2.

<table>
<thead>
<tr>
<th>Color change ΔE (Pattern Error)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enamel</td>
</tr>
<tr>
<td>4.4* (1.6)</td>
</tr>
</tbody>
</table>

* Indicates unacceptable value of color change (ΔE ≥ 3.3)

Table 2: Mean (SD) of color change ΔE evaluation before and after exposure to smoke

**Discussion**

In this study, a decrease in enamel microhardness after exposure to cigarette smoke was observed. Researchers have speculated that a change occurs in the spatial arrangement of hydroxyapatite crystals.(14) According to Palamara,(15) heat can modify the structure and morphology of crystals.

During the act of inhaling cigarette smoke, the combustion can generate heat up to 950°C16, and the smoke generated is composed of thousands of toxic substances, such as carbon monoxide, ammonia, nickel, arsenic, and heavy metals,(2) which in addition to altering the color of dental materials and substrates may alter the surface hardness, as shown by the results of this study.

The smoke of a cigarette contains on average 1 to 2μg of cadmium, and it is estimated that 0.1 to 0.2 mg per cigarette is inhaled. This chemical is not present naturally in the human body, so any concentration may be dangerous to one’s health,(14) and perhaps its presence in the oral cavity can alter the ultrastructure of dental tissues, maybe because some type of chemical bonding occurs. This could be an important factor that causes a decrease in the microhardness of enamel.

This research also recorded the color changes in the enamel surface, as measured by the CIE Lab system. This system represents a
uniform color space with equal distances, corresponding to equally perceived color differences. (17) Many authors have reported that values of ΔE in the range of 2 to 3 are noticeable and that the value of 3.3 is critical for visual perception. (3)

For colorimetric evaluation, the samples were subjected to prophylaxis with pumice and water so that no interference occurred in the readings caused by superficial sludge present after the test exposure to cigarette smoke. (10)

In this study, exposure to cigarette smoke promoted a staining of the enamel surface in the range of 4.4 ΔE, which is considered to be a clinically unacceptable color change. These results are consistent with those of other studies, (6,18) which reported that staining by cigarette smoke was higher when compared to other types of pigments. According to Sulieman,(19) the distribution and intensity of staining is dependent on the type, amount, and duration of exposure to a pigments agent. In this study, the exposure of each sample to the smoke of 50 cigarettes over 5 days was sufficient to produce clinically noticeable color changes. Unfortunately, there is a paucity of published data that indicates a protocol for the time and amount of exposure to smoke in order to compare results.

The hypotheses of this study were proven once the enamel surface microhardness was accepted, and a superficial enamel color change was observed after exposure to cigarette smoke.

Conclusions

Cigarette smoke led to a decrease in enamel microhardness and altered the color of the enamel, which was darker than a clinically acceptable condition.

References
15. Palamara I, Phakey PP, Rachinger WA, Orams HJ. The ultrastructure of human dental enamel heat-treated in the temperature range 200 degrees

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