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Effects of the bleaching procedures on enamel micro-hardness: Plasma Arc and diode laser comparison

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Background and aims: One of the major side effects of vital bleaching is the reduction of enamel micro-hardness. The purpose of this study was to evaluate the influence of two different bleaching systems, Plasma Arc and GaAlAs laser, on the enamel micro-hardness.
Materials and methods: 15 freshly extracted human third molars were sectioned to prepare 30 enamel blocks (5×5 mm). These samples were then randomly divided into 2 groups of 15 each (n=15): a plasma arc bleaching group (: 350-700 nm) + 35% Hydrogen Peroxide whitening gel and a laser bleaching group (GaAlAs laser, λ: 810 nm, P: 10 W, CW, Special Tip) + 35% Hydrogen Peroxide whitening gel. Samples were subjected to the Vickers micro-hardness test (VHN) at a load of 50 g for 15s before and after treatment. Data were statistically analyzed by a Mann-Whitney test ($p \leq 0.05$).
Results: In the GaAlAs laser group, the enamel micro-hardness was 618.2 before and was reduced to 544.6 after bleaching procedures. In the plasma arc group, the enamel micro-hardness was 644.8 before and 498.9 after bleaching. Although both techniques significantly reduced VHN, plasma arc bleaching resulted in a 22.62% reduction in VHN for enamel micro-hardness, whereas an 11.89% reduction in VHN was observed for laser bleaching; this difference is statistically significant ($p<0.001$).
Conclusion: Both bleaching techniques reduced enamel micro-hardness, although the reduction is much less significant with the GaAlAs laser than with the plasma arc. Therefore GaAlAs laser bleaching has fewer harmful effects than plasma arc in respect to enamel micro-hardness reduction.

Key words: GaAlAs Laser · Bleaching · plasma arc · micro-hardness

Introduction

Discolored teeth are presently considered a major problem and different approaches have been proposed to solve it. Vital bleaching is becoming increasingly popular and is more favored as an effective solution. It may be classified into 3 groups: office or power bleaching, mass market bleaching and dentist supervised home bleaching. [1)] H_2O_2 was used in bleaching methods for the first time in 1910 [2)] and its concentration for bleaching procedures varies from 20% to 50%. Carbamide Peroxide and Hydrogen Peroxide are combined with light or chemical sources for efficient use and the basic mechanism for removing stains involves the carbon chains breaking in the organic portion of the enamel and dentine. [2, 3, 4)]

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Although saliva can re-mineralize and balance enamel changes, bleaching methods have different specific side effects on the composition of enamel and dentin, such as the mineral loss, which should be taken into consideration. Micro-hardness, shear strength and compressive strength reduction have been reported after bleaching procedures. [5, 6, 7, 8] Different factors can alter the surface texture of enamel during the bleaching process including, among other things, the acidity of the bleaching gels at the time of processing and the amount of interaction heat. [9, 10]

In contrast to such findings, numerous investigations reported no significant change in the micro-hardness of enamel resulting from the application of various bleaching methods.

Hydrogen Peroxide is the major foundation of all bleaching gels and it may be activated by different light energy sources such as lasers, Plasma Arc (PAC), Light Emitting Diodes (LED), and halogen lamps (HL). Decomposition of Hydrogen Peroxide into free radicals such as oxygen and per-hydroxyl is the main mechanism of bleaching. The absence of electrons in the last atomic layer makes the oxygen and per-hydroxyl electrophilic as it diffuses throughout the matrix of enamel and dentine. To reach stability, these attack stain molecules and break their chains into small particles. As essential electrons are absorbed, free radicals stabilize while breaking stain chains, resulting in the bleaching of the teeth therefore making them whiter. [3,11,12,13,14]

In the last couple of years, different kinds of lasers have been used for the bleaching process. Argon lasers were among the first devices used for power bleaching while today diode lasers are the standard method used for bleaching. Diode lasers with powers above 3W have harmful side effects on the pulp chamber and can increase the pulp temperature. However, in the 1-2 W range, they can be the best lasers for bleaching: in fact, several researchers showed that this power range is below the critical threshold for irreversible pulpitis. [6,12,14,15,16] Therefore, to find a safer device with fewer side effects on dental pulp is a topic of ongoing research. [3] The aim of this study was to compare the bleaching effects of diode laser to plasma arc irradiation on enamel micro-hardness.

Materials & Methods

Fifteen freshly extracted third molars were stored in a 0.2% thymol solution before they were used in this study. Samples were mesio-distally sectioned to make 30 lingual and buccal enamel blocks of 5×5×2 mm size each. The blocks were embedded in acrylic resin (Bayer, Barmen, Germany), to realize 30 acrylic blocks of 11×21 mm. The samples were subsequently polished with carborundum discs (1000 grit, water proof silicon carbide paper, Germany) and stored in physiological serum before, during, and after the experiment. Blocks were coded and prepared for hardness determination. Micro-hardness measurements were performed in the center of the specimen, 1 mm right and 1 mm left of the center point. For each test, indentations were made on each specimen by applying 15gr of load for 15s by a Vickers micro-hardness tester (Micrometer, Buhlar company, 1600/6100, Plymouth, USA). The specimens were randomized into 2 groups for experimental treatment.

Group 1: Plasma Arc bleaching (λ : 350-700nm) by using 35% Hydrogen Peroxide (Everbrite gel, Dentamerica, City of industry, California, USA). Samples were covered with a 1 mm thick layer of Everbrite gel and the distance between the tip of the device and the enamel surface was kept constant at 1 mm. The bleaching agent was activated with a plasma arc unit (Remedent Belgium) for 30s and then allowed to rest for 10s. These cycles were repeated 15 times and the whole procedure repeated 4 times following the manufacturer's instructions.

Group 2: laser bleaching by using White 10 gel. Samples were covered with a 1 mm thick layer of 35% Hydrogen Peroxide White 10 gel (Biolase, Irvine, California, USA). The bleaching gel was activated using a 810nm GaAlAs Laser, applied at 10W CW for 15s followed by 1min of rest. This procedure was repeated 7 times in accordance with the manufacturer's instructions. The bleaching substances were carefully removed under running tap water, then bleaching gel was applied to the samples once more and the above cycle repeated 4 times. After these procedures, the micro-hardness of the enamel after the bleaching process was determined using the Vickers tester.

Analysis: The micro-hardness of each sample according to the data obtained with the Vickers tester was calculated as a function of the diagonal length of the indentation and the applied load according to the following formula:

Vickers hardness (VH) =0.47 p/a2

P=applied load

A: half of the diagonal length of indentation

The means of the Vickers hardness measurements from each specimen were analyzed by a Mann-Whitney test. There were significant differences relative to the measured baseline values.

Results

In the laser group, the micro-hardness of the enamel was 618.2 before and 544.6 after the bleaching procedures. In the Plasma Arc group, the micro-hardness of the enamel was 644.8 before and 498.9 after bleaching. Although both techniques reduced VHN significantly, Plasma Arc bleaching resulted in a 22.62% reduction in the VHN for enamel micro-hardness while in comparison; laser bleaching resulted in 11.89% reduction. Therefore, the difference was statistically significant ($p<0.001$). **(Table- 1)**

On the basis of these findings, Plasma Arc bleaching resulted in a significantly higher level of micro-hardness reduction compared to laser bleaching.

Fig. 1 shows the mean Vickers micro-hardness values determined at baseline and for test samples at the end of the experiment.

Discussion

The effects of bleaching agents and their compounds on teeth structure have been widely discussed by researchers. Bleaching agents can penetrate the tooth structure and break the molecules of the stains. However, the effects of this reaction are not restricted only to stains and, unfortunately, enamel and dentin may also be affected. [7, 8, 17, 18] Several studies have shown the effects of exposure to bleaching agents on enamel, these effects including pitting, erosion, increased porosity, surfaces, increased roughness and dissolutions similar to the initial caries. [18, 19, 20] These effects are directly related to the exposure time and to the concentration of the active agent: longer exposure time and higher concentrations may cause greater effects on the oxidation process and on the color change; however, they also result in more side effects. [21]

Demineralization is also related to the viscosity of the bleaching gel: thickening agents cause terminal effects on enamel over the treatment time. [20,22,23,24]

Another factor that can affect enamel structure is the rise in temperature during the bleaching process. [18] As incident photons interact with the bleaching substance, bleaching molecules break down and the photons' energy is converted to heat. This process is the main activation mechanism for all light-assisted bleaching procedures. After increasing light absorption and

Table. 1: Mean enamel microharness before and after Bleaching Process and its changes

Microhardness / Group	Microhardness Before Bleaching	Microhardness After Bleaching	Changes		
			number	percentage	P value
Laser	618.2	544.6	15	11.82	P=0.02
Plasma Arc	644.8	498.9	15	22.62	P=0.012
		Result after two tests	30	—	p<0.001

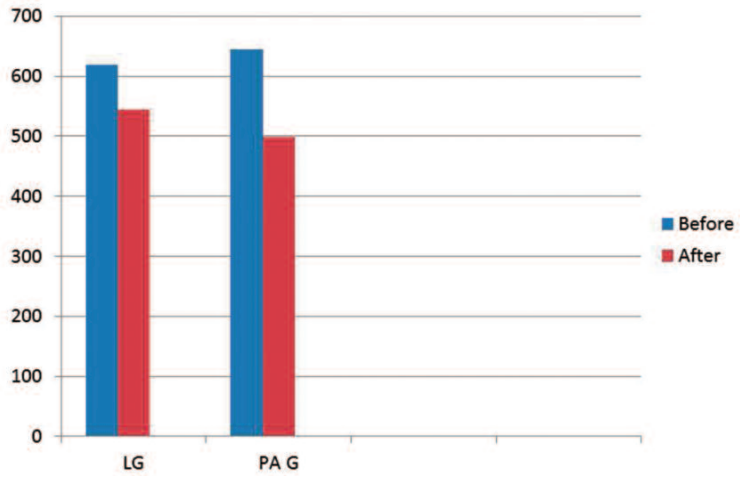

Fig. 1: Mean Vickers hardness values at baseline and after bleaching by laser and Plasma Arc.
LG: Laser Group PA G: Plasma Arc Group

heat conservation, some bleaching substances are mixed with specific colorants, such as carotene, to increase blue light absorption. In the case of infrared light absorption, which is safer, producers add small nanometer size silica particles, which give bluish color to these substances and cause them to absorb red and infrared light. [25)]

In this study we compared the enamel micro-hardness before and after two bleaching methods, laser bleaching and Plasma Arc bleaching. This study was done to find a bleaching method that is more effective and with fewer side effects on tooth structure.

The Plasma Arc method uses a Xenon discharge lamp as its light source, with a wavelength of 380-580 nm after filtering (near UV violet-blue-green). Light generation is the result of recombination of electrons with ionized Xenon atoms, and the power output at exit window is 600-2000 mw/cm^2. [21)]

The laser used in this study was a diode laser operating in continuous wave (CW) mode at a wavelength of 810+/-10 nm. The gel used in the Plasma Arc test was Everbrite and contained 35% Hydrogen Peroxide while Laser Smile gel contains 35% H_2O_2. The H_2O_2 concentrations in both gels were equal, ensuring that variations in H_2O_2 concentration did not bias the results with regard to the effects of bleaching procedures on the micro-hardness of enamel. To accelerate the bleaching process, agent must be heat activated and the source of heat is different in laser and plasma arc bleaching. However, because the temperature does not increase substantially, there is not a significant difference in comparing laser bleaching and plasma arc bleaching methods. There are other important factors such as chair time and duration of exposure to bleaching substances that may lead to unpleasant side effects on enamel structure such as micro-hardness reduction.

According to a total chair time of approximately 8 minutes in laser bleaching method, duration of exposure to agents and laser irradiation in this method is shorter and takes less time. Notably, bleaching agents may cause side effects on enamel structure and so, a longer exposure time can be an important factor and should be taken into consideration.

The wavelength of the diode laser used in this study was 810 +/-10 nm whereas the Plasma Arc wavelength was 380-580 nm. Longer wavelengths have less energy and higher absorption on the surface, which leads to undesired effects in enamel and dentine. These side effects are increased when a Plasma Arc source is used for bleaching.

Today, the use of conservative methods for bleaching has a great importance and Laser is one of the ADA approved methods for bleaching.

However, more studies will be necessary to find an alternative method for tooth bleaching with fewer side effects on enamel and the dentin structure.

Conclusion

Both laser bleaching and Plasma Arc bleaching techniques reduced enamel micro-hardness, although the reduction was much less significant with the laser compared to the Plasma Arc. Therefore, on the basis of this study, bleaching with a diode laser has fewer harmful effects, concerning enamel micro-hardness reduction, than plasma arc irradiation

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