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Case Report

New Possibilities on the Application of Violet Light in Dentistry Combining Aesthetics and Microbiological Control: Report of Two Clinical Cases

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Abstract

Dental bleaching performed in a dental office is considered among the bleaching techniques one of the most safety avoiding damages to the mucous membranes and to the gastrointestinal tract of the patient. The application of violet light appears as an innovative reality in dental bleaching with effective results. The aim of this study was to show the new possibilities of violet LED light (405 nm, 165 mW/cm^2) with liquid peroxide solution used during the dental bleaching in two clinical cases. Dental bleaching was done using a violet LED light source and simultaneous irrigation used hydrogen peroxide liquid on the dental arches with the aim of also promoting oral decontamination in the patient. Based on the results, it was possible to show that violet light has real applicability in tooth whitening and potential to be used in oral decontamination. In addition, the violet light accelerates the whitening process allowing excellent results and minimizing the aggressiveness of this procedure to the patients. Thus, violet light is a new tool for tooth whitening with the advantage of combining the control and prevention of diseases initiated by microorganisms in the oral cavity.

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Keywords

Dental Bleaching; Violet Light; In-Office Bleaching; Light-Activation; Tooth Color; Whitening; Disinfection; Oral Decontamination; Dental Sensitivity

Introduction

Nowadays, dentistry presents great interest on the development new techniques, materials and devices to perform the dental bleaching. Several studies have showed the results of the different techniques, with or more recently without gel, with or without light, at home or in office, or a combination of these procedures [1,2].

The use of light on the dental bleaching has been subjected of great debate. Recently, violet light appears as a new tool for the in-office dental bleaching [1,3]. Moreover, Maclean, et al., and Rhodes, et al., showed that the application of visible light under violet spectrum can also show antimicrobial effect [4,5].

Several infection diseases, such as dental caries, gingivitis, periodontitis, endocarditis, hospital pneumonia, glomerulonephritis, among others are related to microorganisms present in the oral cavity. Such microorganisms, when uncontrolled can lead to a loss of life quality or to death of the patient due to microbial proliferation [6].

Oral infections are often controlled by dental calculus removal procedures, root planning and prophylaxis. Oral decontamination using peroxide solution and light simultaneously with other treatments already established in dentistry can be performed to better control these infections. Recently, the literature has described light therapy associated with photosensitizers. The Photodynamic Inactivation (PDI) shows the antimicrobial effect without creating bacterial resistance [7].

Ultraviolet light, below 350 nm, shows antimicrobial application in literature, but it is not very used in infections due to the possible harmful effect in living tissues of the host, because it causes damage to the deoxyribonucleic acid. The literature also shows the effect of blue light, which is within the visible light spectrum and with longer wavelength than ultraviolet light, less harmful to living tissues and also having antimicrobial effect [8,9].

The violet light under 405 nm, that is safe for use in humans, show higher vibration frequency than blue light and less than ultraviolet light. In this way, violet light is able to deliver greater amount of energy per absorbed photon compared to blue light in soft tissues and on the dental surface. This fact has opened up new possibilities to use violet light in the dental bleaching

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[10]. It was believed that by the physical characteristics the violet light showed to be more effective in dental whitening when associated with peroxides compared to conventional treatments [1].

Peroxides are presented in the literature as antimicrobials [11]. In view of this, hypothetically, the use of violet light associated with the application of peroxide for tooth whitening can also be used with some modifications to obtain oral decontamination effect. The idea in this study is that being more effective in the destruction of pigment molecules, this combination may also promote destruction of the molecular structures that make up the microorganisms.

The aim of this study was to present two clinical cases that received tooth whitening with concomitant use of peroxide solution and to evaluate the effect of oral decontamination in these patients immediately after treatment. Thus, it can be demonstrated that the aesthetic procedure of tooth whitening can be extended to also promote microbiological control.

Case Report

Dental Bleaching Procedure

Two young patients, L. R. P., male, 17-years-old, and B. C. M., female, 21- years-old looking for dental bleaching treatment, because both patients were unsatisfied with the color of their teeth (Fig. 1). The same protocol was proposed for them. Before the beginning of the treatment, the patients signed the informed consent and authorization of the procedure. Who were selected, evaluated and treated in the dental office of the Laboratory of Biophotonics of the Institute of Physics of São Carlos, University of São Paulo (IFSC - USP).

Clinical procedures were performed using a lip retractor. The initial and final colors of the upper teeth were recorded using a shade guide Artiplus to evaluate the color before and after the bleaching procedures. First, a prophylaxis was performed using a Robinson brush at low-speed handpiece and slurry based on pumice and water followed by rinsing and drying. After recording the initial color at the beginning, the evaluation of the dental sensitivity was performed using two tests as follow: for the evaporative test, the dental unit triple syringe, blowing a short blast of room temperature air, being held perpendicular and 2 mm away from tooth surface, whilst shielding the adjacent teeth with fingers or cotton rolls. The sensitivity of the tooth to the tactile test was determined using a clinical probe passed perpendicular to the tooth surface with apical sweeps and the pressure in grams was gradually increased until the subject responded.

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Figure 1: Initial and final registration of the tooth color for both patients (LRP and BCM). A) Case 1 - Before. B) Case 1 - After treatment. C) Case 2 - Before. D) Case 2- After treatment.

The LED device used for dental whitening was the Bright Max Whitening under 405 nm, 350 mW of power output, containing 4 independent LED units, irradiation area of the acrylic tip with 63 x 15 mm equal to 945 mm^2, estimated total power of 1400 mW and irradiance of 165 mW/cm^2. The hydrogen peroxide solution used was liquid hydrogen peroxide under 10 volumes.

The dental bleaching was performed using the violet LED light source and simultaneous irrigation with liquid hydrogen peroxide under 10 volumes over both upper and lower arches at the same time. The light tip of the device was put as close as possible to the surface of the teeth during light irradiation (Fig. 2). The device was turned on for 60 seconds, staying off for a 30 seconds wait time. Irradiation for 60 seconds was repeated 10 times. The total light delivery time was 10 minutes and the total clinical session time was 15 minutes. Irrigation of the dental surface with liquid hydrogen peroxide 10 volumes was performed before the application of violet light and after 5 and 10 minutes of clinical treatment.

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Figure 2: Application of violet light with peroxide solution on the dental surface in both upper and lower arches at the same time.

For both patients, only one session was performed. The results of dental bleaching obtained in these single session can be seen in Fig. 1 and Table 1.

Microbiological Analysis

The evaluation of oral decontamination was performed through collection of saliva before and after the dental bleaching procedure. Two saliva samples from each patient were collected and stored in sterile containers. The saliva samples underwent serial dilutions (1:100000) and 15 μL aliquots were transferred and plated on Brain Heart Infusion agar plates (in triplicate) and then incubated for 48 h at 37°C for further CFU counting. After incubation, the total number of CFUs was determined [9].

Laboratory Analysis

The qualitative analysis of the dental bleaching can be seen in Table 1, which shows the improvement of the teeth color according to the scale used in this study after treatment. It was observed after each clinical session that the initial color of the teeth in both patients was A2 and B2, respectively, becoming A1 at the end of the treatment. The absence of pain sensitivity after treatment can also be seen in Table 1.

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		Shade Guide	Sensibility	
Patients			**Air**	**Dental Probe**
L.R.P.	Initial	A_2	0	0
	Final	A_1	0	0
B.C.M.	Initial	B_2	0	0
	Final	A_1	0	0

Table 1: Comparative analysis of tooth color and sensitivity before and after dental bleaching.

The patients reported no dental sensitivity during and after applications of the violet LED and the decontamination solution. The results of the microbiological analysis are shown in Fig. 3. According to results it was possible to show a reduction of the microorganisms after treatment. Before the application of violet light, the viable number of microorganisms in the saliva was 6.55 log and after treatment, the number of viable cells decreased to 4.81 log.

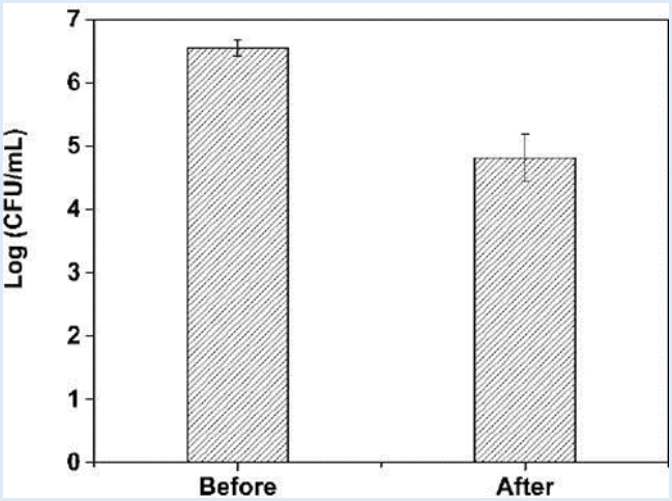

Figure 3: Microorganisms in the saliva samples before and after treatment with violet light in the two clinical cases. Values are the mean and standard deviation.

Discussion

In this study we present a new possibility for the dental bleaching that does not use chemical agents like a gel to provide the tooth bleaching. Only light combined with hydrogen peroxide solution under 10 volume was used. The violet light under 405 nm, promotes the breakdown of the pigmented molecules generating the dental bleaching. Violet light shows a wavelength with photons capable of providing enough energy so that the pigments that stain the dental structure have their molecular chemical bonds changed. These molecular bonds are composed

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of electrons delocalized and highly absorbed by these photons that are responsible by the change on the physic-chemical characteristics of the pigments. Photons that propagate under violet wavelengths have energy that absorbed by the pigment produces an electronic transition or a quantum jump capable of transforming π-type and π*-type bonds into unstable bonds, making the pigment molecule dissociated. This breakdown of the pigment causes that when the white light incident on the tooth reflects the color with a larger component of the blue color, within the compositions of the colors blue, green and red, these proportionally distributed colors make up the white color [10]. This reflection with a larger blue component causes the observer to see the whiter tooth [10].

We find in the literature studies that used the violet light as an energy source capable to break pigments and promoting dental bleaching [3,10]. The violet light (405 nm) shows a wavelength lower than the blue light and with a high vibratory frequency of the photons, which means that the penetration in the living tissues is smaller than the blue light and the delivery of the energy is great on the surface of teeth and soft tissues. This fact can improve the interaction of the photons from violet light with microorganisms adhered to the teeth and soft tissues compared to the blue light [10].

One hypothesis raised in the literature is that bacterial inactivation can occur through exposure to visible light resulting from the photo-excitation of the endogenous porphyrins. Photo-excitation of natural intracellular porphyrins act as endogenous photosensitizers that produce Reactive Oxygen Species (ROS) causing bacterial inactivation [12]. Rhodes, et al., showed the bactericidal effects of visible light (LED), specifically violet light (405 nm) on the eradication of Escherichia coli. An in vitro study showed an approximately 100% reduction in bacterial proliferation after exposure with 67.49 J/cm^2 of energy density [5]. Other study have shown that by the increase of the amount of oxygen over anaerobic bacteria and by the application of violet light, the rate of bacterial inactivation is also significantly increased [4]. In addition, the literature shows that blue-violet light at certain wavelengths (402-420 nm) is effective to inactivate other microorganisms, including MRSA, *P. aeruginosa, A. baumannii, E. faecalis, P. acnes* and *H. pylori*, showing the great antimicrobial potential [12]. It was possible to show with these two case reports, the effectiveness of dental bleaching. In addition, the decontamination of the soft tissue was also showed as seen in Fig. 3.

The literature also shows the use of LED under 405-450 nm for photocoagulation in patients submitted to dental extraction. The application of light shows hemostasis and acceleration of healing of the gingival mucosa. The action of the blue-violet under this wavelength can act as a blood platelet aggregator [11]. Photocoagulation can produce rapid haemostasis and accelerate periodontal regeneration. This is because hemoglobin present in red blood cells has a high light absorption capacity, and wavelengths ranging from violet to blue cover most of the absorption peaks of hemoglobin. Thus, this absorption transforms the irradiation of LED light

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into micro-thermal energy on the surface of the bleed (photocoagulation) eleska-Stevkoska and Koneski reported this effect in their study and observed that the LED irradiation at 410 nm immediately controlled post-extraction bleeding [13,14].
According to the authors, photothermal interaction caused blood to overheat, absorption and dispersion of energy, condensation of the protein's surface and vaporization of bloodstream followed by coagulation. In addition, LED photocoagulation not only produced rapid haemostasis, but also accelerated the healing of periodontal tissue. Thus, the blue-violet LED light shortened post-extraction bleeding time of the tooth and, according to the authors, may be a promising method to control bleeding of patients after dental extraction [13].

According to the literature, it is believed that blue-violet light interacts with the red blood cells of inflamed gingival tissue promoting beneficial changes and improving the appearance of these tissues as observed after oral decontamination in the patients in the case reports presented in this study The reddish and swollen gingival, have your appearance after treatment showed after oral decontamination, to become a lighter pink coloration of the tissue and with a smaller volume of edema, being more compatible with gingival tissue without inflammation (Fig. 4) [13].

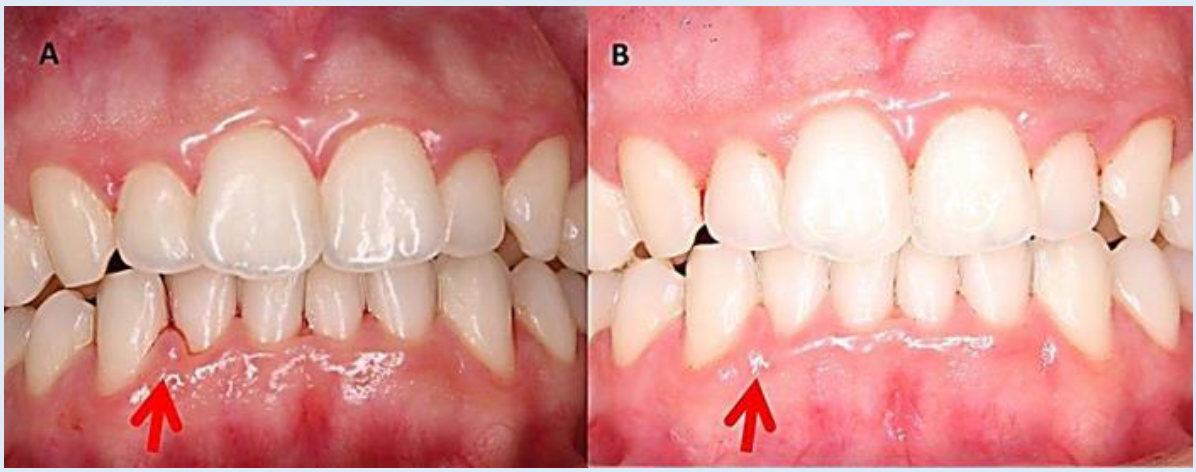

Figure 4: This figure shows with an arrow the decrease of gingival swelling after oral decontamination using violet led. A) Before treatment. B) Immediately after treatment.

The dental bleaching performed only with violet light showed no decalcification of bovine dental enamel and can be considered advantageous in relation to the conventional treatments, since violet light did not provide any changes on the dental surface. Another advantage reported in the literature when violet light is used is the total absence of dental hypersensitivity during and after treatment [10,15,16]. The penetration of the photons in the dental surface can occur and it allows repolarization of the cellular membranes of the nerve terminals in the dentinal tubules. This repolarization has analgesic effect by the decreased excitability threshold of the nerve fibers [10,17].

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The advantages and limitations of the dental bleaching and decontamination using a violet light should be better investigated through other studies such as mainly clinical trials. The evidence announced in this study indicate a new procedure for this light source used to control the infection oral diseases such as gingivitis and maybe others pathologies in the oral cavity.

Conclusion

This case reports showed the ability of violet light to provide whitener teeth and oral decontamination. Randomized clinical trials with a great number of volunteers should be performed to better evaluate the results obtained with this technique. However, these clinical cases announce the first evidence indicating directions to be performed.

Conflict of Interest

The authors report no conflict of interest. The authors alone are responsible for the content and writing of the manuscript.

Acknowledgment

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