

Comparative Evaluation of Colour and Elemental Composition of Enamel Bleached with H₂O₂ and H₂O₂ Assisted by Plasma Microjet:- an In-Vitro Study



Medical Science

KEYWORDS :

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ABSTRACT

Ask the average person how they would most like to improve their smile and the answer would most often be "with whiter and brighter teeth." It is commonly known that people are responded to in a more positive manner when they have a dazzling, healthy smile. The teeth may exhibit either extrinsic or intrinsic discoloration. To evaluate the effect of bleaching on color, morphology and surface roughness of enamel by using SEM, EDX and Profilometer. Analysis for surface roughness showed that there was statistically significant difference in roughness values of both the groups. The samples treated with H₂O₂ assisted with plasma showed lower mean roughness value (0.29) than the samples treated with H₂O₂ (0.83). From the observations of this in vitro study we conclude that using low temperature atmospheric pressure plasma could be supplementary to the conventional method of bleaching because combining the plasma jet and H₂O₂. It improved the bleaching efficacy in terms of whitening effect, with comparatively less morphological and compositional alterations in enamel.

Introduction:

Ask the average person how they would most like to improve their smile and the answer would most often be "with whiter and brighter teeth." It is commonly known that people are responded to in a more positive manner when they have a dazzling, healthy smile.¹ The teeth may exhibit either extrinsic or intrinsic discoloration.¹ The causes for extrinsic discoloration are the factors outside the body, mainly: 1 foods and smoking, foods with tannins, coffee, tea, oranges, and other foods. The causes for intrinsic discoloration are the factors inside the body, mainly: 1 genetics, certain foods, changes in the enamel and the dentin of the tooth, high levels of fluoride, tetracycline, use of antibiotics as a child, developmental disorders, tooth decay, restorations, root canal issues, and trauma. Just as there are several causes for teeth to become discolored, there are number of ways to lighten or brighten them. Tooth whitening is not new. In 1877 Dr. Chapple reported the first tooth whitening technique using Hydrochloric Acid (HCl). Since that time, numerous workers reported tooth whitening with a variety of chemicals, some with the application of heat. For instance, in 1895, Garretson used chlorine as part of tooth whitening treatment. Later, in 1977, Falkenstein used 30% hydrogen peroxide (H₂O₂) with 10% HCl (1 minute acid etch was done first) together with a 100 watt (104 °F) light gun for tetracycline stains.²

This in vitro study was under taken to evaluate color and elemental composition of enamel bleached with H₂O₂ and H₂O₂ assisted with plasma microjet. Scanning electron microscopy (SEM) and energydispersive X-ray spectroscopy (EDX) were used to assess changes in the enamel morphology and elemental composition. Surface roughness was evaluated using profilometer.

Amis and Objectives:

To evaluate the effect of bleaching on color, morphology and surface roughness of enamel by using SEM, EDX and Profilometer. The objectives of the study were: 1. To evaluate comparatively the color, elemental composition and surface roughness of enamel bleached with H₂O₂ and H₂O₂ assisted by plasma

microjet. 2. To analyze the efficacy of plasma microjet during bleaching with H₂O₂. 3. To recommend a safer bleaching technique that will minimize the potential side effects of bleaching like changes in morphology, surface roughness and color of enamel.

Material and Methods:

The given study was conducted in the Department Of Conservative Dentistry and Endodontics, Bharati Vidyapeeth University Dental College and Hospital, Pune. Energy Dispersive X-ray analysis and Scanning electron microscope was done in SVNIT, Surat. Profilometric analysis was done in Praj metallurgical laboratory, Pune.

The plasma device used here comprised of two metal electrodes separated by a dielectric layer of 0.5-mm thickness. The gap between the two electrodes was 1.0 mm. They were completely embedded in the device and powered by an ac power supply. Vacuum chamber was embedded in the handle unit. The electrodes were connected to the base of the vacuum tube separated by a ceramic insulator. The glass tube was covered by PVC insulating tube to prevent the plasma leakage. The end of the glass tube is left exposed to a thin metal tube inserted in a rubber lid covering the top portion of the PVC tube. Effectively the vacuum glass tube is now in contact only with the metal nozzle and insulated all around. Plasma, which is generated in vacuum glass chamber, is now emitted only through the metallic nozzle.

The anatomical root of each incisor, collected for the study was marked with a vertical line to divide it into two equal halves along its long axis. Before conducting the bleaching procedure, the samples were subjected to SEM and EDAX analysis to obtain pre-operative elemental composition of enamel. Shade of the samples was determined with the Vitapan shade guide. Five observers including two dentists were appointed to determine the shade of each sample. The mesial and distal halves of the all samples were divided into two experimental groups (n=10). Group I (all mesial halves): Treated with H₂O₂ only Group II (all distal halves): Treated with H₂O₂ assisted with plasma all the

samples from group I were treated with bleaching gel hydrogen peroxide (H₂O₂) for 20 min. After 20 min the gel was washed off by using air water spray. All the samples from group II were treated in similar manner like in group I except that immediately after application of H₂O₂ gel, the gel was activated by using plasma for 5 minutes. The gel was left on the surface on the samples for remaining 15 minutes. Thus after 20 min the gel was washed off by using air water spray. After completion of the bleaching procedure, all the samples were subjected to SEM and EDAX analysis to obtain post-operative elemental composition of enamel. Shade of the samples was determined with the Vita-pan shade guide. Five observers from which two were dentists did the shade selection. The surface roughness of all the samples was also evaluated by using profilometer.

Results:

Under the limitation of this in-vitro study it was observed that:

1. There was significant color change before and after the treatment protocol, in all the samples.
2. The EDAX analysis showed statistically significant difference in the values of elemental compositions before and after the treatment protocol in both the groups, however post-operative comparison of quantitative analysis showed that the values between two groups were not statistically significant.
3. SEM analysis showed that the photomicrographs of samples treated with H₂O₂ exhibited rougher surface morphology than pre-operative images, whereas the photomicrographs of samples treated with H₂O₂ assisted with plasma exhibited seemingly smoother surface.
4. Analysis for surface roughness showed that there was statistically significant difference in roughness values of both the groups. The samples treated with H₂O₂ assisted with plasma showed lower mean roughness value (0.29) than the samples treated with H₂O₂ (0.83)

- $P < 0.05$ is statistically significant Table no.2 showed that there was statistically significant difference in the mean values of atomic percentage of calcium, phosphate and oxygen, before and after treatment with H₂O₂.
- * $P < 0.05$ is statistically significant Table no.3 showed that there was statistically significant difference in the mean values of atomic percentage of calcium, phosphate and oxygen, before and after treatment with H₂O₂ assisted with plasma.
- * $P < 0.05$ is statistically significant Table no.4 compared the change in elemental composition of both the groups and showed that the mean values of atomic percentage calcium, phosphate and oxygen were not statistically significant in both the groups (H₂O₂ and H₂O₂ assisted with plasma).

Discussion:

Aesthetics of the teeth is of great importance to all. The quest for whiteness has increased in recent years. Patient's interest in whitening and articles on whitening in popular magazines suggest that tooth color is a significant factor in the attractiveness of a smile. An attractive smile plays a major role in the overall perception of physical attractiveness.²⁵ Compared with restorative treatment modalities, whitening, also referred to as bleaching, is the most conservative treatment for discolored teeth. The public demand for a whiter smile and improved aesthetics has made tooth whitening a popular and often-requested dental procedure, since it offers a conservative treatment option for discolored teeth. Whitening often enhances the smile and self-esteem of the patient.²⁵ Successful whitening treatment depends on the correct diagnosis of the type, intensity, and location of the tooth discoloration. It is imperative to determine if the discoloration is extrinsic, which is associated with the absorption of tea, red wine, some medications, iron salts, tobacco, and foods, onto the surface of the enamel and, in particular, the pellicle coating, or intrinsic, as seen in tetracycline staining, fluorosis, amelogenesis and dentinogenesis imperfecta, hypoplasia, erythroblastosis fetalis, and porphyria. Additionally, discoloration results from the aging process. As teeth age, more

secondary dentin is formed and the more translucent enamel layer thins. The combination of less enamel and darker, opaque dentin creates an older-looking, darker tooth.²⁵ There are a number of methods and approaches to successfully improving the color of teeth including whitening toothpastes, professional cleaning to remove stain and tartar, internal bleaching of non-vital teeth, external bleaching of vital teeth, micro abrasion of enamel with abrasives³⁶ and acid, and the placement of crowns and veneers.²⁶ Hence it is necessary to assess the causes of tooth staining carefully for better prediction of the rate and the degree to which bleaching will improve tooth color agents.²⁷ The history of dentistry is comprised of many efforts under taken to achieve an effective tooth-whitening method. Non-vital tooth bleaching began in 1848 with the use of chloride of lime, and in 1864, Truman introduced the most effective technique for bleaching non-vital teeth, a method which used chlorine from a solution of calcium hydrochlorite and acetic acid.²⁷ Vital teeth were also bleached as early as 1868, by means of oxalic acid or Pyrozone and later with hydrogen peroxide. In 1911, the use of concentrated hydrogen peroxide with a heating instrument or a light source was regarded as an acceptable method in dental clinics.²⁷ Finally, the current in-office bleaching technique typically uses different concentrations of hydrogen peroxide (HP), between 15% and 40%, with or without light and in the presence of rubber dam isolation.²⁷ Current bleaching agents contain both active and inactive ingredients. The active ingredients include hydrogen peroxide or carbamide peroxide compounds. However, the major inactive ingredients may include thickening agents, carrier, surfactant and pigment dispersant, preservative, and flavoring.²⁷ The mechanism of bleaching by hydrogen peroxide is not well understood. In-office and home bleaching gels contain hydrogen peroxide or its precursor, carbamide peroxide, as the active ingredient in concentrations ranging from 3% to 40% of hydrogen peroxide equivalent. Hydrogen peroxide bleaching generally proceeds via the perhydroxyl³⁷ anion (HO⁻ O⁻). Other conditions can give rise to free radical formation, for example, by homolytic cleavage of either an O-H bond or the O-O bond in hydrogen peroxide to give H[•] + •OOH and 2. OH (hydroxyl radical), respectively. Under photochemical reactions initiated by light or lasers, the formation of hydroxyl radicals from hydrogen peroxide has been shown to increase.²⁷ Hydrogen peroxide is an oxidizing agent that, as it diffuses into the tooth, dissociates to produce unstable free radicals which are hydroxyl radicals (HO[•]), perhydroxyl radicals (HOO[•]), perhydroxyl anions (HOO⁻), and superoxide anions (OO⁻), which will attack organic pigmented molecules in the spaces between the inorganic salts in tooth enamel by attacking double bonds of chromophore molecules within tooth tissues. The change in double-bond conjugation results in smaller, less heavily pigmented constituents, and there will be a shift in the absorption spectrum of chromophore molecules; thus, bleaching of tooth tissues occurs.²⁷ A number of methods and approaches for whitening of vital as well as non-vital teeth have been described in the literature. For, vital tooth bleaching, there are methods using different whitening agents, concentrations, times of application, product formats, application modes, and light activation methods.²⁵ However, three fundamental bleaching approaches exist; dentist-supervised night guard bleaching, in-office or power bleaching, and bleaching with over-the-counter bleaching products.²⁵

From the observations of analyses of this in vitro study we conclude that using low temperature atmospheric pressure plasma could be complementary to the conventional method of bleaching because combining the plasma jet and H₂O₂ improved the bleaching efficacy in terms of whitening effect, with comparatively less morphological and compositional alterations in enamel. We suggest that the application of low temperature atmospheric pressure plasma may be a novel and efficient therapy for tooth bleaching. However, further studies and more in-depth analysis are needed before we can draw this conclusion with cer-

tainty.

Summary:

Ask the average person how they would most like to improve their smile and the answer would most often be “with whiter and brighter teeth.” It is commonly known that people are responded to in a more positive manner when they have a dazzling, healthy smile.¹ This in vitro study was undertaken to evaluate color and elemental composition of enamel bleached with H₂O₂ and H₂O₂ assisted with plasma microjet. Scanning electron microscopy (SEM) and energydispersive X-ray spectroscopy (EDX) were used to assess changes in the enamel morphology and elemental composition. Surface roughness was evaluated using profilometer. All the samples from group I were treated with bleaching gel hydrogen peroxide (H₂O₂) for 20 min. All the samples from group II were treated in similar manner like in group I except that immediately after application of H₂O₂ gel, the gel was activated by using plasma for 5 minutes. The results of color evaluation were interpreted from the observation of the five observers involved in the study. It was found exhibited lighter shade than pre-operative shade. In our study, in

the group II, plasma must have enhanced . OH generation. Considering that the plasma is a rich source of reactive oxygen species and high energy electrons, it is possible that plasma causes . OH formation by cleaving the O–O bond in H₂O₂. In our study, the samples in the group I before bleaching procedure showed a mean atomic percentage (%) of calcium (Ca), phosphate (P) and 55 oxygen (O) as 35.20, 35.08 and 28.72 respectively whereas the samples in the group II showed a mean atomic percentage (%) calcium, phosphate and oxygen as 35.27, 35.02 and 29.74 respectively. After bleaching protocol for group I the values were found to be 25.72, 25.77 and 48.51 whereas for group II the values were found to be 25.96, 25.72 and 48.37. The seemingly smoother surface in the PMJ + H₂O₂ group might be caused by local acid pickling by nitric acid and nitrate acid created by the air plasma in the aqueous environment. In the present study there was statistically significant difference in the surface roughness values of both the group. From the observations of this in vitro study we conclude that using low temperature atmospheric pressure plasma could be supplementary to the conventional method of bleaching because combining the plasma jet and H₂O₂. It improved the bleaching efficacy in terms of whitening effect, with comparatively less morphological and compositional alterations in enamel.

REFERENCE

- 1) Textbook of Esthetics in Dentistry; Second edition; Volume no: 1; Principles communications treatment methods; Chapter 12 bleaching discolored teeth; page no. 245. 2) Tooth bleaching and tooth whitening: <http://www.docstoc.com/docs/112774730/ToothBleaching-or-ToothWhitening-What-I-hope-to-do-in-this-article-is-reassure-the-profession-and-the-public-that-if-incorrect-patient-assessment-is-carried-out-that-if-the-treatment-is-carr>. 3) High-efficiency tooth bleaching using non-thermal atmospheric pressure plasma with low concentration of hydrogen peroxide; Seoul Hee NAMI, Hyun Woo LEE, Soo Hyun CHO, Jae Koo LEE, Young Chan JEON, Gyo Cheon KIM; Journal of Applied Oral Science; Print version ISSN 1678-7757; vol.21 no.3 Bauru May/June 2013. <http://dx.doi.org/10.1590/1679-775720130016>. 4) Tooth Enamel Evaluation After Tooth Bleaching With Hydrogen Peroxide Assisted by a DC Nonthermal Atmospheric-Pressure Plasma Jet; Jing Wang, Xiaohui Yang, Ke Sun, Peng Sun, Member, IEEE, Jie Pan, Weidong Zhu, Member, IEEE, Kurt H. Becker, Member, IEEE, Jue Zhang, and Jing Fang; IEEE TRANSACTIONS ON PLASMA SCIENCE, VOL. 40, NO. 9, SEPTEMBER 2012. 57 5) Ilana Heling, Alex Parson, Ilan Rotstein; Journal of Endodontics Volume 21, Issue 11, November 1995, Pages 540–542. 6) Rotstein, E. Dankner, A. Goldman, I. Heling, A. Stabholz, M. Zalkind; Journal of Endodontics Volume 22, Issue 1, January 1996, Pages 23–26. 7) S. Gurgan, S. Bolay, R. Alaçam; Journal of Endodontics Volume 22, Issue 7, July 1996, Pages 356–357. 8) Donald J. Horn, M. Lamar Hicks, Janet Bulan-Brady, BS; Journal of Endodontics Volume 24, Issue 12, December 1998, Pages 791–795. 9) Igor Poto nik, Ladislav Kosec, Dominik Gašperšič; Journal of Endodontics Volume 26, Issue 4, April 2000, Pages 203–206. 10) Osman Gökay, Fikret Yılmaz, Sevgi Akin, Meral Tunçbilek, Rahmiye Ertan; Journal of Endodontics Volume 26, Issue 2, February 2000, Pages 92–94. 11) Jun Kaneko, Susumu Kawakami, Hidehiko Sano, (Journal of Endodontics Volume 26, Issue 1, January 2000, Pages 25–28). 12) Yoshifumi Kinomoto, David L. Carnes Jr, Shigeyuki Ebisu, (Journal of Endodontics Volume 27, Issue 9, September 2001, Pages 574–577). 58 13) Hui Kheng Chng, Joseph E.A. Palamara, Harold H. Messer, (Journal of Endodontics Volume 28, Issue 2, February 2002, Pages 62–67). 14) Kohji Kawamoto, Yasuhisa Tsujimoto, (Journal of Endodontics Volume 30, Issue 1, January 2004, Pages 45–50). 15) Daniel Pinto de Oliveira, Brenda Paula Figueiredo de Almeida Gomes, Alexandre Augusto Zaia, Francisco José de SouzaFilho, Caio Cezar Randi Ferraz, (Journal of Endodontics Volume 32, Issue 7, July 2006, Pages 672–674). 16) Massimo Amato, Maria Serena Scaravilli, Mauro Farella, Francesco Riccitiello, (Journal of Endodontics Volume 32, Issue 4, April 2006, Pages 376–378). 17) Ljubisa Markovic, Nebojsa Lakota, Peter Gaengler, (Journal of Endodontics Volume 33, Issue 5, May 2007, Pages 607– 610). 18) Daniel Pinto de Oliveira, Erica Cappelletto Nogueira Teixeira, Caio Cezar Randi Ferraz, Fabricio B. Teixeira, (Journal of Endodontics Volume 33, Issue 4, April 2007, Pages 460–462). 19) Samira Esteves Afonso Camargo, Marcia Carneiro Valera, Carlos Henrique Ribeiro Camargo, Maria Nadir Gasparoto Mancini, Marcia Maciel Menezes, (Journal of Endodontics Volume 33, Issue 9, September 2007, Pages 1074–1077). 20) Leopoldo Forner, Manuel Salmerón-Sánchez, María Palomares, Carmen Llena, José Amengual, (Journal of 59 Endodontics Volume 35, Issue 10, October 2009, Pages 1384– 1386). 21) Hyun Woo Lee, Gon Jun Kim, Jae Moon Kim, Jeong Kil Park, Jae Koo Lee, Gyo Cheon Kim, (Journal of Endodontics Volume 35, Issue 4, April 2009, Pages 587–591). 22) Benjamin Martin-Biedma, Teresa Gonzalez-Gonzalez, Manuela Lopes, Luis Lopes, Rui Vilar, BEng, José Bahillo, Purificación Varela-Patiño, (Journal of Endodontics Volume 36, Issue 2, February 2010, Pages 334–337). 23) Gyo Cheon Kim, Seoul Hee Nam, Hyun Woo Lee and Jae Koo Lee Department of Oral Anatomy, School of Dentistry, Pusan National University, Yangsan, 626-870, Republic of Korea Department of Electronic and Electrical Engineering, Pohang University of Science and Technology, Pohang, 790- 784, Republic of Korea. 24) Peng Sun, Jie Pan, Ye Tian, Na Bai, Haiyan Wu, Lingxuan Wang, Cailan Yu, Jue Zhang, Weidong Zhu, Member, IEEE, Kurt H. Becker, Member, IEEE, and Jing Fang (IEEE transactions on plasma science, vol. 38, no. 8, august 2010). 25) Vital Tooth Whitening Patricia W. Kihn, DDS, MS DENTSPLY International, Inc., Susquehanna Commerce Center, 221 West Philadelphia Street, York, PA 17405-0872, USA Baltimore College of Dental Surgery, University of Maryland, Baltimore, MD, USA; Dent Clin N Am 51 (2007) 319–331. 60 26) A review of tooth colour and whiteness Andrew Joiner, Ian Hopkinson , Yan Deng , Stephen Westland ; journal of dentistry 36s (2008) s2–s7. 27) REVIEW ARTICLE; Tooth-bleaching procedures and their controversial effects: A literature review; Mohammed Q. Alqhatani; King Saud University; The Saudi Dental Journal; www.ksu.edu.sa. 28) Color change of vital teeth exposed to bleaching performed with and without supplementary light; Joe C. Ontiveros; Rade D. Paravina; Journal of Dentistry; 37 (2009) 840-847. 29) The effects of light on bleaching and tooth sensitivity during in-office vital bleaching: A systematic review and metaanalysis; Li-Bang He, Mei-Ying Shao , Ke Tan , Xin Xu , Ji-Yao Li ; Journal of dentistry 40 (2012) 644–653. 30) Atmospheric Non-Thermal Plasma Sources; International Journal of Engineering, Volume (2) : Issue (1).