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Tooth bleaching by plasma jet assisted by hydrogen peroxide and water

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ABSTRACT

In this research non-thermal atmospheric pressure plasma jet, NAPP system has been build for the purpose of teeth bleaching. Extract teeth and dealt outside the mouth were used for the teeth bleaching process. These teeth were classified before and after plasma treatment for different time (3, 5, 10, and15minwith gas flow rate 5 and 2.5ℓ/min)by shade guide. For enhance teeth bleaching process by NAPP jet, water and different concentrations of H_2O_2were used. The effect of NAPPjet on the mechanical properties and teeth suffuse structure were steadied by Vickers hardness tester and SEM. The teeth temperature was measured during bleaching processes by a digital infra-red thermometer. NAPP jet is working on whiteness of the teeth in all circumstances and the best result obtained with the30% H_2O_2concentration where the teeth whiteness transition from 4D to 2E in the shad guide. While theteeth whiteness transition from 1D to 1A in the shad guide by using water at the seam condition. The NAPP treatment did not increase the temperature of the tooth surface above 35ºC.The results show that the plasma has no effect on the mechanical properties and structure of the teeth.it can be conclude that the NAPP can be a useful tooth bleaching device. And it has the ability to replace the conventional light sources that have limitations, such as high temperatures.

Key words: Non-thermal plasma, teeth bleaching, hydrogen peroxide

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INTRODUCTION

Plasma is defined as a gas in which part of the particles are present in ionized form. This is achieved by heating a gas which leads to the dissociation of the molecular bonds and subsequently ionization of the free atoms. Thus, plasma consists of positively and negatively charged ions and negatively charged electrons as well as radicals, neutral and excited atoms and molecules[1,2]. There are two types of plasma: thermal and non-thermal or cold atmospheric plasma. Thermal plasma has electrons and heavy particles (neutral and ions) at the same temperature. Cold Atmospheric Plasma (CAP) is said to be non-thermal because it has electron at a hotter temperature than the heavy particles that are at room temperature. Cold Atmospheric Plasma is a specific type of plasma that is less than 40°c at the point of application [3].tooth bleaching is one of the most commonly applied of discolored pulpless teeth was described in [5], variety of agents such as chloride, sodium hypochlorite, and hydrogenperoxide have been used, either alone or in combination with heat, laser radiation, or UV light [6,7]. In recent years low-temperature ("cold") plasmas at atmospheric pressure in air (or in other gases and gas mixtures) have been shown to provide distinct advantages for tooth bleaching [8], particularly when used in conjunction with hydrogen peroxide [9, 10]. Tooth bleaching has become popular and millions of people have received the treatment during the last two decades, the mechanisms of tooth bleaching remain yet to be fully understood [11,12]. The generally accepted mechanism involved in tooth bleaching is similar to that in textile and paper bleaching: free radicals, produced by H_2O_2, interact with pigment molecules to produce a whitening effect. It is hypothesized that H_2O_2 produces free radicals while diffusing through enamel and dentine, breaking double bonds of pigment molecules and changing the pigment molecule configuration and/or size. Such changes alter the optical properties of tooth structure, creating the perception of a whiter tooth color. in this work anon- thermal, atmospheric pressure, Argon plasma jet NAPP device

assisted by varying concentrations of hydrogen peroxide and water were used for teeth bleaching, the bleaching it had achieve on extracted human teeth.

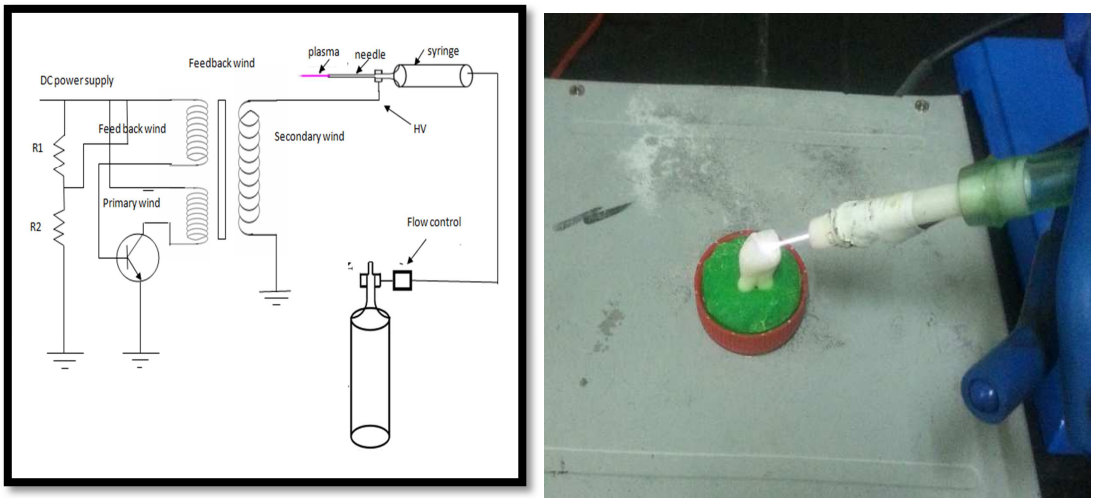
EXPERIMENTAL WORK

Plasma device

Figure (1) illustrates the process for external bleaching using the bleaching using non-thermal atmospheric pressure plasma jet NAPP jet. The hand held NAPP jet is driven by a low frequency 33 kHz high voltage source peak-to-peak 9.6 kV. Argon gas was with a flow rate of 2.5,5 ℓ/min for a safe and stable operation of theNAPP jet.

Teeth bleaching by plasma

Non thermal plasma jet system was used to treat different sample of human teeth that extracted from human. The teeth were classified according to shade guide as shown in Figure (2a). The plasma treatment processes were taken with different H_2O_2 concentrations (25% and 30%), 20µℓ every 1min with plasma power 15Wat different exposure time and different gas flow rate (2.5 and5ℓ/min). The teeth were set on artificial clay as shown in the Figure (2b), and then compare the teeth before and after treatment by shade guide teeth compare classification teeth before and after plasma bleaching for the purpose of determining the outcome of a bleaching.



A B

Figure (1):The process of tooth bleaching using non-thermal atmospheric pressure plasma jet (A)Schematic of the plasma device and (B) photograph of the tooth bleaching experiment

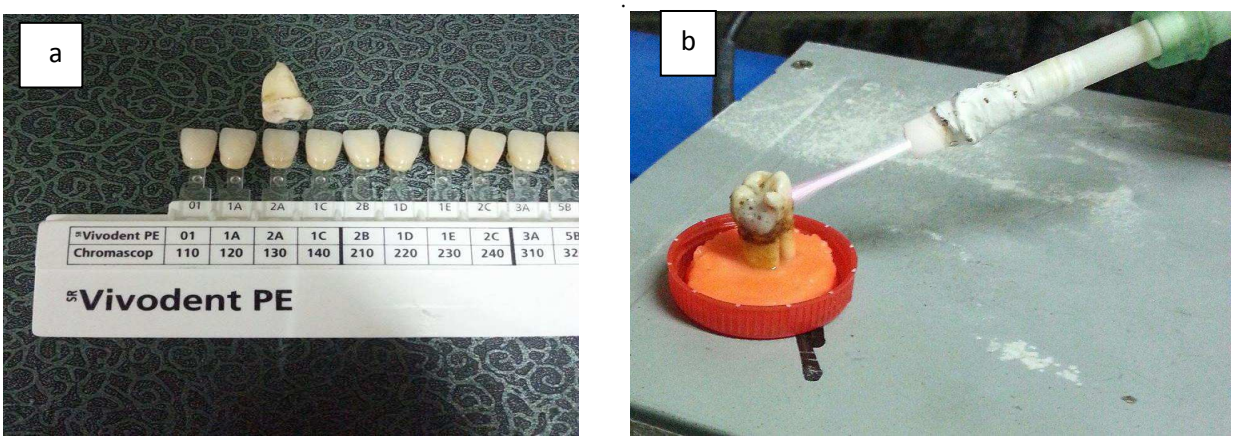


Figure (2):(a) Shade guide for teeth classification before and after bleaching,(b) teeth bleaching process

Teeth temperature measurement

The teeth temperature were measured during bleaching processes by a digital infra-red thermometer model HT-8866, during the temperature measurement the distance between teeth and the plasma tube end fixed at 2 cm .the teeth exposed to plasma jet for different times(3, 5, 10 and 15min)with gas flow rate 2.5 and5ℓ/min.

Micro hardness measurement

To understand the influence of plasma jet on the mechanical properties of human teeth, the teeth hardness were measured before and after plasma jet exposure at 15min with gas flow rate5ℓ/min. The hardness was measured by digital micro Vickers hardness tester TH714.

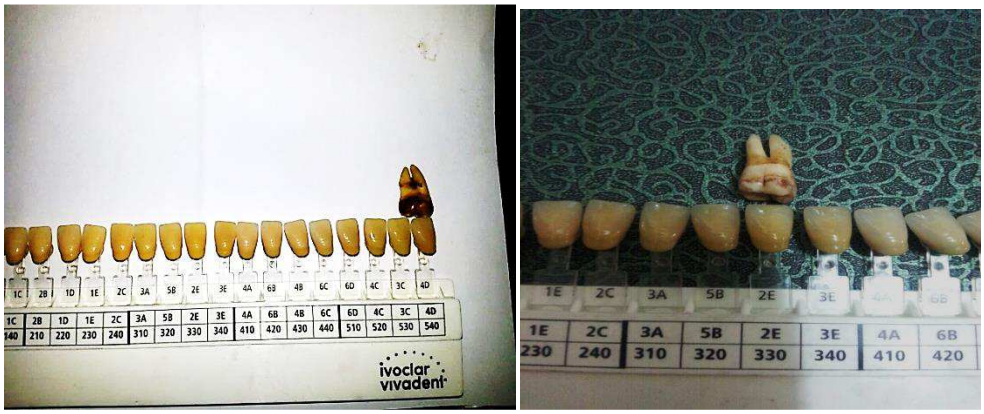
SEM measurement

The effect of plasma jet exposure on the structure of teeth was taken by using scanning electron microscopy measurement of the teeth before and after plasma jet exposure at 15min with gas flow rate 5ℓ/min, to understand the influence of plasma jet on the structure of teeth.

RESULTS AND DISCUSSION

Teeth bleaching

Figure (3)shows the influence of plasma jet on teeth whitening exposed for 15mint where the plasma assisted by 30% H_2O_2andthe argon gas flow rate 5ℓ/min, in addition to teeth classification. Table (1) shows teeth classification before and after treatment by plasma and the circumstances of different treatment. From the table it is clear that teeth bleaching by plasma jet assisted by hydrogen peroxide or by water leads to an increase in the whiteness of the teeth and the degree of whiteness increases with exposure time. Also it can note that the bleaching by plasma jet assisted by hydrogen peroxide, better than that assisted by water under the same circumstances. from table (1)it can see that the argon gas flow rate effect slightly on the bleaching processes, in both cases, enhanced by water and that enhanced by peroxide .also the tooth bleaching efficacy remained essentially independent of the H_2O_2 concentration from 25% to 30%.In plasma teeth bleaching the OH was the key reactive species in tooth bleaching. OH radicals were generated during the plasma treatment. Our observation of an increase in the concentration of hydroxyl radicals with increasing H_2O_2 concentration while the tooth bleaching efficacy remained essentially independent of the H_2O_2 concentration from 25% to 30% suggests that, while hydroxyl radicals are important, they may not be the only radicals that cause tooth bleaching. In low concentration it was speculate that other species such as atomic oxygen (O), the superoxide anion (O_2^-) and singlet molecular oxygen ($^1O_2$) must also play a role in the tooth bleaching process.



Finger (3):Teeth classification (a) before treatment, (b) after treatment byplasma assisted by H_2O_2 (30%), for15min, and gas flow rat 5 (ℓ /min)

Table (1):Teeth classification before and after treatment by plasma and circumstances of different treatment

Classification before treatment	Classification after treatment	Assisted by30% H_2O_2 or H_2O	Processing time(min)	Gas flow rate (ℓ/min)
4D	2E	Assisted by 30% H_2O_2	15	5
3A	1C	Assisted by 30% H_2O_2	10	5
3A	1E	Assisted by H_2O	5	5
5B	1D	Assisted by 30% H_2O_2	5	5
1D	1A	Assisted by H_2O	10	5
2B	1A	Assisted by 30% H_2O_2	5	2.5
2B	2A	Assisted by H_2O	5	2.5
2A	01	Assisted by 30% H_2O_2	3	5
2A	1A	Assisted by H_2O	3	5
2A	2C	Assisted by 25% H_2O_2	10	5

Tooth Surface Temperature

Figure (4) shows the relation between temperature and treatment time for teeth treated by plasm jet for deferent time, the tooth surface temperature increased from 18°C and stabilized near 35°C after 25 minutes treated time. The temperatures of the tooth specimens should be kept low during plasma bleaching because excessive heating can damage pulp, during plasma bleaching the surface temperatures of the teeth did not exceed 40°C during the bleaching treatment, the NAPP treatment did not increase the temperature of the tooth surface above 35°C, indicating that the NAPP does not cause any thermal damage to the tooth, Therefore, the NAPP can be a useful tooth bleaching device. As such, it could replace conventional light sources that have limitations, such high temperatures. This result is obtained because of the NAPP micro plasma and has low temperature.

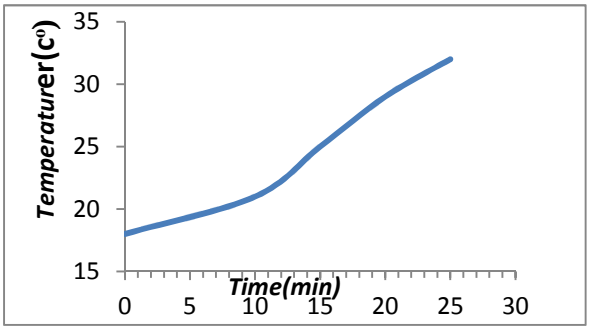


Figure (4): Relation between temperature and treatment time for teeth treated by NAPP

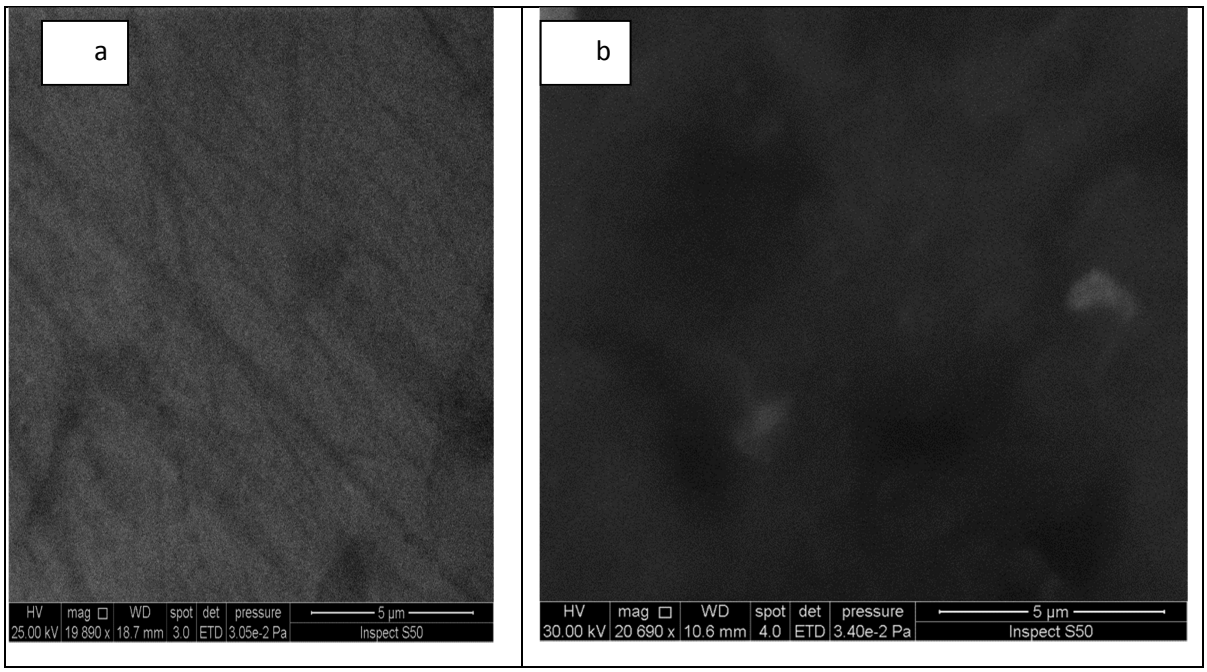


Figure (5): SEM photograph (a) before treatment, (b) after plasma treatment

Microhardness

The extracted human teeth test by digital micro Vickers hardness tester (TH-714),before and after plasma treatment for 20 mints the microhardness of the enamel surface was no significant difference was found in the change in microhardness ,thus, it can be conclude that the change in the microhardness was not significantly affected by the use of30%hydrogen peroxide H_2O_2 concentrations in conjunction with a plasma treatment The micro Vickers hardness values before treatment were HV 233.1 Kg/mm^2 ,and after treatment were HV 210.8 Kg/mm^2.This result is fully compatible with the mechanism of plasma bleaching where plasma working to change the optical properties of the pigments deposited on the tooth without affecting the enamel layer.

SEM Analyses

Figure (5a and b) SEM photograph shows the enamel surface morphology of the tooth before and after treated of 15 min it can be clearly see that enamel surface has no change, this result confirms that the plasma does not affect the structure of the tooth surface. This is consistent with the result of micro hardness test.

CONCLUSION

NAPP good tool for tooth bleaching specially when assisted by H_2O_2 .NAPP treatment did not increase the temperature of the tooth surface above 35ºC, indicating that the NAPP does not cause any thermal damage to the tooth, . The morphological results of tooth bleaching with plasma did not affect mineral composition under scanning electron microscopy (SEM) observations, and no effect on hardness of the tooth. Therefore, the NAPP can be a useful tooth bleaching device that provides a high bleaching effect with hydrogen peroxide, As such; it could replace conventional light sources that have limitations such as bleaching efficacy and high temperatures.

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