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RESEARCH ARTICLE

Plasma in Dentistry

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Abstract Plasma technologies are mostly used in dentistry; our work focuses on Plasma scopes and plasma applications in dentistry. We will directly deliberate about liquid, solid, and gas only without sophisticated about the fourth state (Plasma), which is the most abundant and the most important state and is considered the new technology in dentistry that may create a revolution in this field as a painless free technology in all dental fields. The study results showed that cold atmospheric Plasma could be a new and painless method before the preparation of the cavities. Also, it is very effective in bacterial inactivation, sterilization, oral diseases, root canal treatment, and disordered tissues; therefore, Plasma is used mostly for treating tooth diseases and tooth whitening.

Keywords: Plasma, technology, dental caries, applications, painless.

Introduction

Plasma forms almost 99% of the universe's whole matter, so it's considered the most abundant form, identified and described first by Sir William Crookes (1879). Still, he didn't name it until an American chemist called it (Plasma) in 1929. So Plasma is a term that is used to describe a huge collection of particles, mainly electrons, after being stripped from molecules or atoms; Plasma is naturally energetic since the electron-stripping process requires constant energy. So if there is a dissipation in the energy, the stripped electrons will be re-attached to change from plasma particles to the gas form of matter once by power turning off for make ionization of the particles to produce the gas phase (recombination). The electrons transferring produce the ions neutralization condition by insufficient sustaining power [1]; Plasma can exist in any temperature without changing form. It resembles gas in the fact that its particles haven't determined shape; electric and magnetic fields have a potential effect on Plasma; therefore, Plasma can shape it into the structure [2-4].

The plasma jet dynamics are affected significantly by electric and magnetic fields, which show by a metal ring, at magnetic and electric fields. Depending on how the electric field is made up, the jet will behave differently in a transverse electric field, deflecting, broadening, and shortening. Whether the jet deflects upward or downward in a transverse field depends on the direction of the magnetic field. The jet may be hindered or blocked by a floating metallic ring, but with higher applied DBD voltages, the jet will still pass through the whole tube with little to no change in length or shape [1, 30].

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Many physical processes contribute to energy dissipation and plasma heating. The magnetic energy was converted to plasma flows, energetic particles, and thermal energy. The cascade provides the energy level required for small fluctuations during turbulence [4, 25, 26].

Great efforts and research were made to use cold plasma technology in many dental fields, including surface modifications, dental implants, tooth bleaching, caries treatment, and endodontics. Even though various studies were still in the primary stages, cold Plasma's great value in dental applications was very clear from the start. In order to expand the scope of plasma applications in the practical form, various types of research should be done in cooperation with dental practitioners and dentists

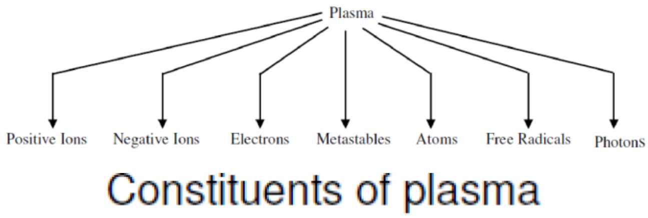

Figure 1. Constituents of Plasma [29]

Generally speaking, Plasma can be divided into two groups: high-temperature Plasma (the fusion plasma) and low temperatures (the gas discharge plasma). The high-temperature Plasma includes all the ions, electrons, and neutral particles in a thermal equilibrium state. Low-temperature Plasma is also subdivided into thermal Plasma; the particles are found in a state of local thermal equilibrium. The other subdivision is non- thermal Plasma, also called cold Plasma or non-equilibrium Plasma [5, 6].

Discussion

Plasma applications in the dental field

A novel plasma technology known as Non-Thermal Atmospheric Plasmas has given rise to dental applications. Because of the existence of electrons and heavy ions at both very high temperatures and normal temperatures, it is known as NTP. Less than 104°F is the temp in the determined site [27].

It may be identified by its low level of ionization, low application point temperature, and lower air conditions. A chemical is converted into a gas to create NTP. Later, the introduction of energy of the laser light, electric current, radiation, and heat causes the gas particle to ionize [28].

Allows for surface preparation at ambient temperature outdoors. A high-tech company specializing in medical equipment for the dental, orthopedic, heart, and blood vessel fields has developed a portable plasma device that dentists may use for many dental clinical purposes. Plasma offers two advantages over other surface-preparation techniques for dental work: it will reduce tissue damage and enhance the surface's suitability for composite adhesion. The prospect of painless, phobia-free dentistry is one of the numerous motivations behind plasma brush research that is presented at conferences for organizations for Biomaterials [7, 8].

1. Disinfection of dental surfaces

Atmospheric plasma jets were used by Rupf *et al*. (2007) in the disinfection process of the organisms that are considered the main cause of tooth caries; the objective of the present work was to test the antimicrobial effect against the oral microorganism, and it was found that the cold plasma jets have another useful effect in dental surface disinfection [7].

2. Composite restorations

The initial data showed that the cold atmospheric Plasma greatly increases the strength of bonding in the interface of dentin-composite by almost 60 percent, and this increase in bonding strength at the interface between composite and dentin improves the performance of composite restoration, longevity, and durability. The clinical practice depends on mechanical bonding, while it should depend more on chemical bonding. Usually, the layer that is responsible for destroying the mechanical bonding is called the smear layer, which is a protein layer that consists mainly of collagen type 1, which forms at the interface between the dentin and the adhesive area to make a surface of the porous which allow the adhesive material to infiltrate so now the preparation technique can etch and also demineralize dentin.

Interaction between the adhesive material and the demineralized dentin will generate the smear layer that can prevent adhesive diffusion on the dentin surface. This layer can be a major part of the reason for the composite restoration failure because it causes weak bonding strength, which forms unprotected and exposed collagen type one at the adhesive-dentin interface, and this will allow the bacteria enzymes to enter the tissue and the interface [9,10]
.

Ritts *et al*. (2010) examined the plasma brush, a cold atmospheric plasma brush used in composite restoration. This study showed that the plasma brush could make surface modifications in dentin and increase the bonding at the adhesive-dentin interface [11]. Yavirach *et al*. (2009) investigated the cold plasma effect on increasing the shear strength bond between the composite resin and the composite posts in the core buildup process. Our results included that the Plasma increases the tensile and shear bond strength between the composite restoration [12].

Lu *et al*. (2009) created a very easy and reliable plasma jet device to form a safe cold plasma inside the root canal and start the disinfection process without causing any pain or burning sensation. And the working gas was a mixture of (He/O_2 20%), the plasma vibrational temperature was 2700 K, and the plasma rotational temperature was about 300 K. while the peak current was almost 10 mA. Initial inactivation test results revealed that cold atmospheric Plasma Kills E. faecalis, which is an important cause of root canal failure [13].

Dr. Wang and his colleagues studied the effects of cold atmospheric Plasma on composite restoration by improving the properties of the interface. The treatment by the plasma brush will make a surface modification of the dentin surface, which in turn increases the adhesive-dentin bond in the interface. This solution helped in introducing a bond that relies on surface chemistry instead of porosity. Dr. Wang found that using plasma etching promises was present in a symposium [14].

3. Root canal disinfection

The treatment of periapical infection of a root canal is very complicated. It is very hard to enter the narrow and irregularly curved root canals and kill the pathogens. That's why failure may happen in the root canal treatment, and infection may reoccur. Lu *et al*. (2009) found that plasma jet generates cold Plasma, which helps in destroying the Enterococcus faecalis and prevents re-infection or treatment failure. Therefore, Plasma can be used to disinfect root canals [13].

Pan *et al*. (2009) studied the possibility of using a non-thermal plasma jet in Enterococcus faecalis biofilms inside infected root canals in vitro. Non- thermal Plasma greatly affects E. faecalis during root therapy [14].

4. Sterilization by eradication of bacteria

The bacterial strain, the driven frequency, and the working gas composition highly affect the sterilization efficiency of cold plasma devices. However, the cold plasma jet devices proved to have a high disinfection ability than most conventional methods like UV sterilization [15, 16].

The sterilization mechanism of a plasma jet usually depends on the abundance of the components of cold Plasma like electrons, ions and reactive oxygen species, electromagnetic fields, and UV [17]. Recently plasma sterilization was utilized in treating dental diseases by Fridman G *et al*. [18, 19], and the threat of the transmission of infection by surgical instruments was a great concern. Plasma is used in surgical instruments and disinfectants. Whittaker *et al*.(2004) found that using gas plasma cleaning is beneficial in decreasing the absolute quantity of proteinaceous materials that can be transferred from one patient to another during root canal treatment by re-using the same dental files during instrumentation [20].

5. Tooth whitening

In their study, Lee *et al.* (2003) revealed that plasma therapy increases tooth bleaching and improves dental whitening results, mainly because it generates in situ p hydrogen peroxide[21].

6. Dental cavities

Zhang *et al*. (2009) presented a study treating the streptococcus mutants bacteria using a dielectric discharge plasma needle that worked at atmospheric pressure. They found that Plasma plumes can inactivate S. mutans considered important bacteria in tooth caries [22].

Using a plasma needle, Raymond E. J. *et al*. (2001) look at how dental tissue interacts with Plasma. Laser or mechanical methods may sterilize and clean infected tissue in the tooth cavity or the root canal. However, even normal tissue may be damaged or heated in any way. Thus, it was determined that the plasma needle is regarded as a reliable source of radicals that can destroy most bacteria [23].

7. In oral diseases

It is used in median rhomboid glossitis, Candida albicans infections, denture stomatitis, and other similar diseases [24].

Limitation of use

Plasma is the future of dental treatment but still has some limitations like cost and availability, care in using it as it is still a new technology.

Conclusion

The plasma brush might be a very useful tool for dentists in underserved areas where people are less likely to access quality dental care. Plasma will bring about a revolution in dental care; procedures without pain, as well as used for teeth whitening without side effects, and painless cavity preparations can change a lot for patients and dentists and may even be a cure for dental phobia, according to numerous studies on this technology and how to get the most out of it.

Conflicts of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper.

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