# "Plasma needle: The future of Dentistry"

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## Abstract:

There is an uncontrolled and unwanted damage to the structure of tooth, whenever any mechanical or a chemical procedure is applied in order to treat a dental cavity or a carious tooth. This led to the development of plasma needle in the field of dentistry. This unique and unprecedented technology, which, though; commonly in use for disinfection and sterilization of medical paraphernalia (instruments etc), as well as undertaking decontamination in biological warfare; has a tremendous potential in the dental field too.

The present article discusses the technology in detail, with special emphasis on its operative details and the useful applications of the same


**Keywords**: plasma, non thermal atmospheric plasma, plasma needle

**Introduction:** Plasma, which is accepted as the fourth state of matter, was initially identified in 1879 by Sir Crooks William. In 1927 Irving Langmuir first described it as an ionized gas containing free moving charge carriers (electrons and ions).The plasma needle was tested first in 2002 by Dr. I.R. Eva Stoffels-Adamowicz at the Eindhoven University of Technology[1]. The plasma has its medical/surgical applications (plasma needle treatment of cells and tissues) and the dental applications (plasma needle treatment of bacteria and biofilms).

**Usefulness of Plasma**: Out of the plethora of applications for plasma technology, it would be very wise to enumerate a few leading ones. This promising technology has established its pivotal role in plasma displays, neon signs,

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fluorescent lamps and lights and integrated circuits Its use in the health care scenario includes its increasing usage in tissue removal, disinfection (sterilization) of medical devices and equipments and decontamination of air, thus improving the air quality .Moreover, plasma has been successfully applied in achieving homeostasis in bleeding wounds and abrasions. Adding another feather to its cap, this technology has proved stupendously beneficial in neutralizing and destroying the biofilms comprising of Streptococcus mutans, Escherichia coli and other microorganisms[2].

**Properties of Plasma:** An intriguing question that arises in our minds is- "*What makes the plasma so active chemically?*" It is said that that it is probably due to the presence of reactive radicals as well as excited molecules; which are considered as a reactive entity[3]. Energy is needed to produce and sustain plasma. This can be done through thermal, electrical or light energy. A discharge in gas is induced electrically to produce plasma. In such conditions, it is possible only by the ions and electrons (which are considered as the charged entities), which can attain energy emanating from the electrical field. This situation is readily achieved under reduced pressure[4].

**Plasma needle** (as shown in Figure 1): The enormous applicability of this plasma technology and its effectiveness, led to its use in dental procedures as the "Plasma Needle". This handheld needle, by producing free radicals efficiently, targets the pathogenic microbes (S.mutans, E.coli etc) with enhanced fineness and precision, along with, maintaining the safety and effectiveness in-vivo[1, 5, 6, 7]. It is a typical atmospheric capacitively coupled radio-frequency (13.56 MHz) micro-discharge created at the tip of a sharp needle. The plasma needle consists of a tungsten wire (0.3 mm diameter) with a sharp tip at the end confined in a Perspex tube (4 mm inner diameter) [5.6.8]. The Perspex tube is filled with a mixture of helium gas & air (1%) via the gas inlet. The supplied flows are low (0.5–2 l/min). As the thermal conductivity of helium is very high (144W/m/K), it is used in the needle as the carrier agent. This assists in maintaining the temperature of the plasma to lower levels. Other advantages of helium include its inertness and it being light in weight. A radio-frequency (RF) voltage of 13.56 MHz is applied to the needle. The signal is produced by a waveform generator and amplified by a RF amplifier. The power that is dissipated is controlled and monitored utilizing a probe. This probe is connected to a power meter via a dual-directional coupler. To optimize the amount of power deposited in the plasma, a matching network is introduced between the power generator and the plasma needle.

**Mechanics of Operation:** The plasma needle is presently used under two functional modes, namely, unipolar mode and the bipolar mode. The former mode is observed when the needle is separated by several millimeters from the ground (Figure 2) while the latter is seen where plasma is sustained between the needle tip and the ground (Figure 3).

**Mechanism of Action[3,4]:**

It is because of the electron impact excitation and dissociation, that the reactive oxygen species (ROS) in non-thermal atmospheric air plasmas are generated. The ROS mainly comprises of free radicals like He, $N_2$, $N_2^+$, $OH^-$ and $O^-$. These active species have a small span of life in gas phase, which have a tendency to dissolve in liquid. After recombination/reaction the radicals are destroyed therefore no radicals remain after plasma exposure. The bacterial cell membranes are made of lipid bilayer made of unsaturated fatty acids and the proteins. These reactive species acts on bacterial cell membranes by cell detachment through breaking cell adhesion molecules (like cadherin or integrin) and finally causing programmed cell death (apoptosis).

**Advantages and Disadvantages:**

There are many advantages of this novel technique. Besides being highly biocompatible, extremely bactericidal and painless, it can be performed at room temperature. Moreover the technique is a safer bet as the chances of thermal damage are miniscule (even none). It cuts with high precision and has good penetration power. It is worth mentioning that, in spite of the advantages cited out above, the plasma needle has some inherent disadvantages too. One of the prime drawbacks of the technique is that it is highly sensitive and does not work well in cases where amalgam restoration is present in the oral cavity. Notwithsatnding, plasma needle technology has a long way to go and shall prove its applicability in the days to come.

**Conclusion:**

Plasma treatment offers the possibility of treating tissues at the cellular level with fineness and precision which can never be thought of while using conventional techniques. Plasma treatment may become a powerful healing technique *in-vivo* in the future and will be a boon to all dental practitioners.

**References:**

1) Stoffels E, Flikweert AJ, Stoffels WW, Kroesen GMW. Plasma needle: a non destructive atmospheric plasma source for fine surface treatment of biomaterials. *Plasma Sources Science*

*and Technology* 2002; 4:383–388.

2) Laroussi M and Lu X. Room-temperature atmospheric pressure plasma plume for biomedical applications. *Applied Physics Letters* 2005*;* 87:113902
3) Halliwell B, Gutteridge, JMC. Free radicals in biology and Medicine. Oxford Univeristy Press, New York, 1999.
4) Laroussi M. Non thermal decontamination of biological media by atmospheric–pressure plasmas: review, analysis and prospects. *IEEE Transactions on plasma science* 2002; 30(4): 1409-1415.
5) Sladek REJ and Stoffels E. Deactivation of Escherichia coli by the plasma needle. *J Phys. D*: *Appl. Phys* 2005*;* 38: 1716–1721.
6) Sladek REJ, Stoffels E, Walrayen R, Tielbeek PJA, Koolhoven RA. Plasma Treatment of Dental Cavities: A Feasibility Study. *IEEE Transactions on Plasma Science* 2004; 32(4): 1540-1543.
7) Van den Bedem LJM, Sladek REJ, Steinbuch M, Adamowicz ES. Plasma treatment of S. mutans biofilms cultured in a simulated dental cavity model. XXVII^th ICPIG, Eindhoven, the Netherlands, 18-22 July, 2005.
8) Stoffels E, Kieft IE, Sladek REJ et.al. Plasma needle for in vivo medical treatment: recent developments and perspectives. *Plasma Sources Sci. Technol* 2006; 15:169–180.

**Figure 1-Plasma Needle**

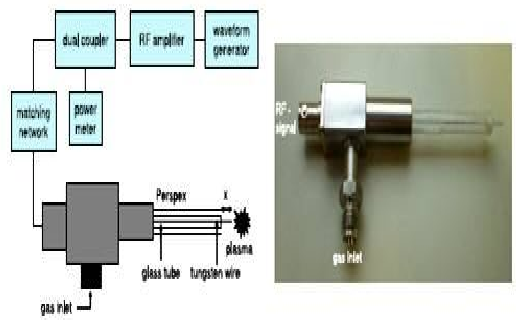


**Figure 2-Unipolar Mode**

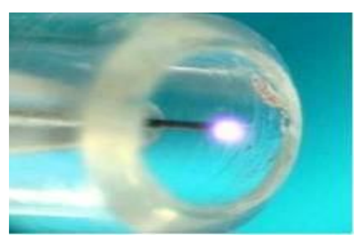

**Figure 3-Bipolar Mode**

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