REVIEW ARTICLE

PLASMA IN DENTISTRY

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INTRODUCTION

Plasma is the fourth state of matter, other than the solids, liquids and gases. It is the stuff of stars, galaxies and northern lights and makes up 99% of visible universe. It consists of charged particles, radicals, and a strong electric field. Plasma has been used for a long time for sterilization of medical equipment, packaging in food industry, implants, blood coagulation etc. This is partly due to their high bactericidal effectiveness and partly due to their easy access into narrow and confirmed spaces.

The plasma is also capable of bacterial inactivation and non-inflammatory tissue modification which makes it an attractive tool for the treatment of dental caries and for composite restorations. However it is problematic to use plasmas because they can damage the dental pulp inside a tooth as their formation usually requires temp of at least 100 ^{o}C. Thus cold plasmas with a temp of about 100 ^{o}F (38 ^{o}C) are made in lab by partially ionizing He gas with pulses of microwaves lasting just millionths of a sec. In recent years, cold atmospheric plasma sources are being developed that provide the possibility to extend plasma treatment to living tissues.

PLASMA GENERATION

Low temp plasmas are generated by supplying electric field to a neutral gas causing the formation of charged carriers. Any volume of neutral gas always contains a few electrons and ions. These free charge carriers are accelerated by the electron field and new charged particles may be created when these charge carriers collide with atoms and molecules in the gas. This leads to an avalanche of charged particles that is eventually balanced by charge carrier losses, so that a steady state plasma develops.

Plasma can exist in a widespread of temp without changing state eg. lightning, neon signs, fluorescent lights. Outside of a container, plasma resembles gas, the particles don't have a definite shape. But unlike gas, magnetic and electric fields can control plasma and shape it into useful, malleable structures. Cold plasma interacts non-thermally with surfaces and is exceptionally suited to treating sensitive objects, including living cells and tissues. Researchers at Eindhoven University of Technology, Netherlands have invented and tested a simple device called Plasma Needle which generates a low power atmospheric discharge by radiofrequency excitation of a mixture of Helium and air. The gas remains at room temp and treatment with this device is non contact and entirely painless.

The plasma needle is a handheld apparatus which is a typical atmospheric capacitive coupled radiofrequency (13.56MHz) micro discharge created at the tip of a sharp needle. It consists of a tungsten wire (0.3mm diameter) with a sharp tip at the end confined in a Perspex tube (4mm inner diameter) which is filled with a mix of *He* gas and air via the gas inlet. As the thermal conductivity of He is very high, it is used in the needle as the carrier agent. This assists in maintaining the temp of plasma to lower levels.

MECHANISM OF ACTION

Action of plasma needle is not based on mechanical injury on thermal ablation but on conveying chemical stimuli to the body's cells which are provided by short living species called radicals. Cold plasma creates these radicals and topically delivers just the right amount, too low to cause oxidative stress but high enough to trigger cell responses. Plasma doesn't cause accidental cell death (Necrosis). Cold plasma, however, offers an attractive alternative tissue treatment without necrosis, inflammation and scarring.

DENTAL APPLICATIONS- have emerged because the Non thermal atmospheric plasma permits surface preparation in open air at room temp. It has the ability to treat irregular surfaces, and work round corners to reach fissures and cracks. This could provide a tissue saving and pain free way to cure dental caries and perform RCT, gingival diseases such as periodontal pockets and mucosal ulcerations, may also be healed.

1. **Tooth preparation for restorations –** Low temp plasma can kill the bacteria, potentially stopping cavities forming in the initial phase, in a pain free manner. For this, a tiny plasma scrub brush has been developed which resembles a white hot flame

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but is cool to touch. It glides across the tooth surface, killing bacteria, and preparing enamel and dentin, and limits the acid etching, mechanical whirring and phobias associated with a drill in mouth. Thus the advantage of plasma here is that it will reduce tissue damage and better prepare the dental surface for composite adhesion. Plasma needle by producing free radicals efficiently targets the pathogenic microbes with enhanced fineness and precision, along with maintaining the safety and effectiveness in vivo. Acc to Dr wang and his colleagues, plasma brush provides improved interface properties, thus modifies dentin surface and thus increases dentin adhesive interfacial bonding. Also it favourably alters tooth surface so that filling material bonds even more effectively.

2. **Use of plasma in composite restorations –** Data has shown that plasma increases the bonding strength at the dentin- composite interface by roughly 60%, thus improved composite performance, durability and longevity.

3. **Use of plasma in Root canal treatment** – Lu et al used a plasma jet device to generate plasma inside the root canal. This plasma can be touched by bare hands and manually directed by the user to place it into the root canal for disinfection.

4. **Plasma in bleaching –** Lee et al conducted a bleaching expt in which they concluded that combining plasma with H2O2 improved the bleaching efficacy by a factor of three compared with using H2O2 alone. This improvement in tooth bleaching was induced by plasma due to the removal of tooth surface proteins and to increase – OH production.

5. **Effect of Plasma on adhesion between Fibre reinforced posts and composite core-** Dantas MCC et al evaluated the fibre post surface after plasma and usual treatments and the adhesion between treated fibre posts and Resin cement. They concluded that plasma treatment favoured the wettability of post surface by modifying it is chemically and also, an improvement in adhesion was also observed. Yavirach et al studied the effect of plasma treatment on shear bond strength between fibre reinforced composite posts and resin composite for core build up. They concluded that plasma treatment appeared to increase the tensile shear bond strength between post and composite.

6. **Plasma cleaning of dental instruments -** Whittaker A.G et al conducted a study in which they concluded that the use of plasma may be extremely beneficial in reducing the absolute amount of proteinaceous materials that may be transferred between patients when endodontic files are reused. As there are no published data on the possible risks of prion disease transmission via such files, the presence of any protein material on these instruments represents a threshold source of iatrogenic CJD transmission.

6. **Other biomedical applications –** include increasing usage in tissue removal, disinfection (sterilization) of medical devices and equipment and decontamination of air, homeostasis in bleeding wounds and abrasions, neutralizing and destroying the biofilms of S. mutans, E.coli and other microorganisms

Advantages – The advantages of this novel technique are that it is painless, noise-free, highly biocompatible and bactericidal. There are no chances of any thermal damage with cold plasma and it can be performed at room temp. It cuts with high precision and has good penetration power.

But despite all these, plasma has some inherent disadvantage that this technique is highly sensitive and doesn't work well in cases where amalgam restoration is present in oral cavity.

CONCLUSION

Plasma treatment offers the possibility of performing the dental procedures without shots and pain and with fineness and precision. Noiseless cavity preparation would be a huge advance in the general consensus dental lasers have attempted to address this concern but have proven expensive and slow.

Thus plasma brush may serve as an extremely valuable tool especially among pedodontists and dentists in less serviced communities where there is an issue of fear or odontophobia and individuals do not readily obtain proper dental care. Plasma treatment may become a powerful healing technique *in-vivo* in the future and will be a boon to all dental practitioners.

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