Evaluation of the relative effectiveness of cold atmospheric helium and argon plasma jets for the elimination of dental smear layers

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The goal of successful and sustainable restorative dentistry and endodontic therapy is the removal of diseased tissue, the eradication of bacteria from canals and dentinal tubules, and the prevention of recontamination post-treatment. These can be accomplished through 3-dimensional obturation; meticulous cleaning, shaping, and disinfection of the root canal system [1]. The chemo-mechanical preparation of the root canal, based on the appropriate use of instruments and irrigating solutions, is one of the most crucial steps during treatment. Mechanical instrumentation invariably creates a smear layer (SL) on the root canal walls that occludes the dentinal tubules and prevent optimal penetration of medicaments, sealers, and root-filling materials into the lateral canals and dentinal tubules. Also, an infected SL containing bacteria and necrotic tissue is the main reason for the multiplication of those bacteria. There has been the use of a variety of chelating agents to remove the SL, but none of them meets the ideal criteria, prompting researchers to explore more in this field.

Cold atmospheric plasma (CAP) jets, also referred to as non-equilibrium plasma jets, have demonstrated significant potential for dental applications due to their ability to produce reactive oxygen and nitrogen species (RONS), radiation, and electromagnetic fields at temperatures close to the environment [2]. CAP has demonstrated significant effectiveness in eradicating planktonic bacteria without damaging living tissues. CAP has the unique ability to penetrate irregular cavities/fissures, like dentinal tubules or apical regions, effectively inactivating bacteria [3]. Plasma has the potential to bring about surface modifications on both artificial and biological materials, which is especially relevant for dental applications.

In this ex-vivo study, the comparative efficiency of bipolar pulsed powered argon and helium CAP jets in removing the smear layer from intra-radicular dentin is investigated, targeting potential applications in Endodontics. The developed cross-field configured CAP jet is a double dielectric barrier discharge (DBD) system which generates plasma through a dielectric material tube having dielectric constant 3.7 in which a copper wire mounted by similar tube acts as the central power electrode and a thin copper material as the outer ring electrode. The central electrode is connected through a bipolar pulsed high-voltage power source, and the outer electrode is grounded [4]. The discharge characteristics of both the CAP jets are compared through electrical and optical characterizations. The collisional–radiative (CR) model coupled with Optical Emission Spectroscopy (OES) is employed to extract the plasma parameters like electron density (n_e) and electron temperature (T_e) and to identify the generated species from the spectra. Seventy mandibular premolars, prepared with ProTaper Universal hand files, are divided into seven groups and treated with Normal saline (control), argon, and helium CAP jets for varying durations. The smear layer removal efficacy is evaluated at coronal, middle, and apical thirds using SEM images, while statistical analysis is performed to analyse the differences among groups. Results demonstrate the smear layer removal capability of both argon and helium CAP jets along with the ability to disinfect the root canal, suggesting their potential as chemical-free alternatives in dentistry with optimized exposure. The obtained comparative results along with certain safety evaluation test results will be presented in details.

References

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