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From Plasma Device Engineering to Clinical Applications in Medicine

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ABSTRACT

Introduction: Cold atmospheric plasma (CAP) has emerged as a promising interdisciplinary technology in medicine, offering novel therapeutic approaches for wound healing and dermatology. However, the lack of standardized engineering parameters and evaluation methods has limited its widespread clinical translation. This work presents an integrated pathway from plasma device engineering to clinical applications, emphasizing standardization, safety, and quantitative assessment.

Materials and Methods: Various CAP systems, including argon and helium plasma jets, floating electrode dielectric barrier discharge, spark plasma, and portable medical plasma devices, were designed and fabricated. Prior to clinical application, comprehensive electrical, optical, chemical, and thermal characterizations were performed. Plasma–tissue interactions were quantitatively evaluated using biometric measurements, ultrasound imaging, hyperspectral imaging, and infrared thermography. The developed systems were subsequently applied in preclinical studies and multiple clinical trials focusing on wound healing, skin rejuvenation, acne treatment, and dermatological disorders.

Results and Discussion: Quantitative diagnostics demonstrated stable plasma operation within safe thermal and ultraviolet exposure limits. Clinical evaluations revealed significant improvements in wound closure rates, reduction of bacterial load, enhanced skin elasticity, hydration, and tissue perfusion. Imaging-based assessments confirmed measurable structural and functional improvements in the skin following plasma treatment. These results highlight the critical role of engineering optimization and quantitative diagnostics in achieving reproducible and safe clinical outcomes.

Conclusion: This study demonstrates that the successful clinical translation of plasma medicine requires a systematic framework that integrated plasma engineering, standardized characterization, and quantitative clinical evaluation. Establishing a national reference laboratory for plasma medicine represents a key step toward harmonizing engineering standards and accelerating the safe adoption of plasma-based therapies in clinical practice.

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Keywords: Clinical, Cold atmospheric plasma, Plasma medicine, Rejuvenation, Wound healing

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