Exploring Channeling Optimized Radiofrequency Energy: a Review of Radiofrequency History and Applications in Esthetic Fields

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ABSTRACT

Introduction: Because of its high efficiency and safety, radiofrequency (RF) energy is widely used in the dermatological field for heating biological tissue in various esthetic applications, including skin tightening, skin lifting, body contouring, and cellulite reduction. This paper reviews the literature on the use of nonablative RF energy in the esthetic field and its scientific background. The purpose of this article is to describe in detail the extensive use of medical devices based on RF technology, the development of these medical devices over the years, and recent developments and trends in RF technology.

Methods: The authors conducted a systematic search of publications that address safety and efficacy issues, technical system specifications, and clinical techniques. Finally, the authors focused on their own clinical experiences with the use of patented Channeling Optimized RF Energy technique and mechanical massage. An in-vivo study was conducted in domestic pigs, with a thermal video camera. Twenty-seven female patients participated in a cellulite and body shaping study. The treatments were conducted according to a three-phase protocol. An additional 16 females participated in a skin tightening case study. All of the patients underwent three treatment sessions at 3-week intervals, each according to a protocol specific to the area being treated.

Results: The review of the literature on RF-based systems revealed that these systems are safe, with low risks for potential side effects, and effective for cellulite, body contouring, and skin tightening procedures. The in-vivo measurements confirmed the theory that the penetration depth of RF is an inverse function of its frequency, and using a vacuum mechanism...
makes an additional contribution to the RF energy penetration. The heating effect of RF was also found to increase blood circulation and to induce collagen remodeling. The results from the cellulite and body shaping treatments showed an overall average improvement of 55% in the appearance of cellulite, with an average circumferential reduction of 3.31 cm in the buttocks, 2.94 cm in the thighs, and 2.14 cm in the abdomen. The results from the skin tightening procedure showed moderate improvement of skin appearance in 50% and significant improvement in 31%. At the follow-up visits the results were found to be sustained without any significant side effects.

**Conclusion:** Of all tissue heating techniques, RF-based technologies appear to be the most established and clinically proven. The design and specifications of the described vacuum-assisted bipolar RF device fall within the range of the specifications currently prescribed for esthetic, nonablative RF systems.

**Keywords:** Body contouring; Cellulite; Radiofrequency; Radiofrequency energy; Skin tightening; Vacuum

**INTRODUCTION**

**Physics of RF Energy**

Radiofrequency (RF) energy is a type of electromagnetic wave which is exponentially attenuated during transition into the target tissue. At high frequencies of electromagnetic wave, power is transferred rapidly close to the surface, attenuating the wave as it is dispersed. At lower frequencies, in the spectrum of RF for example, because the wavelength is greater and therefore the heating cannot be localized to limited areas, the energy penetration is deeper. For this reason, the term “bulk” tissue heating is used [1].

Heat generation by RF energy operates by transfer of energy from the electric field to the charged particles in the target tissue. This transfer can be achieved by three mechanisms of interaction between the electromagnetic field and the charges: (i) orientation of electric dipoles that already exist in the atoms and molecules in the tissue; (ii) polarization of atoms and molecules to produce dipole moments; and (iii) displacement of conduction electrons and ions in the tissue [2]. In the first and second mechanisms, the heat is generated by the energy use involved in the movement of the particles in response to an electric field. In the third mechanism, heat is generated by collisions between the transmission charges and immobile particles. Heat is generated in tissue by both the incident electric and the magnetic field. Since the magnetic field does not transfer any net energy it does not produce any heat [1].

Therefore, the mechanism of tissue heating by electrical current is based on generating joules of heat. Generated heat is described by Joule’s law:

\[ H = \frac{j^2}{\sigma}, \]

where \( j \) is the density of electrical current and \( \sigma \) is electrical conductivity [3]. The opposite of conductivity is called resistance or impedance (R). The parts of the body with high blood content have the highest electrical conductivity. Bone, for example, has very low electrical conductivity, and consequently the electrical current flows around it without penetration. Dry skin also has very low electrical conductivity and must therefore be hydrated to enhance the passage of the current [1].

In general, the electrical conductivity influences the depth to which RF energy penetrates. The RF energy penetration