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Effects of 2.45 GHz Microwave Treatment on Facial Dermal Thickness and Echogenicity. A Case Study

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Abstract

Objective: To evaluate the effects of a 2.45 GHz microwave-based device on facial skin rejuvenation by assessing changes in dermal thickness and echogenicity using ultrasound imaging.

Methods: The clinical case presented involved the central area of the cheeks of a 52-year-old patient. For each cheek, 3 points were identified at the intersection of 4 reference lines, and two different treatment protocols were applied. The left side of the face was treated with protocol 1, while the right side was treated with protocol 2. A single treatment session was performed. Ultrasound examinations were performed at baseline, immediately post-treatment, and after 3, 15, 30, and 45 days. Dermal thickness was measured from ultrasound images, and dermal echogenicity was quantified through a MATLAB-based image-processing algorithm that calculated the percentage of white pixels in thresholder ultrasound images.

Results: Both treatment protocols induced a progressive increase in dermal thickness, with an initial inflammatory response immediately after treatment and a peak effect observed at 30 days. Protocol 2 demonstrated greater efficacy, achieving a 21% increase in dermal thickness compared with 16% for Protocol 1. Improvements remained evident up to 45 days. Echogenicity also increased in both groups, reaching +31% for Protocol 1 and +29% for Protocol 2 at 45 days. Ultrasound images confirmed both dermal thickening and increased brightness, suggesting enhanced tissue density and collagen remodeling.

Conclusion: Microwave treatment improved dermal thickness and echogenicity, supporting its potential as a non-invasive method for facial skin remodeling and collagen regeneration.

Keywords: Microwave-based device; Ultrasound imaging; Facial skin rejuvenation; Echogenicity; Protocol

Introduction

Facial skin aging is a natural phenomenon that can have significant aesthetic impact on an individual. The skin, like the underlying structures, ages chronologically and biologically: alterations in the skin's structure cause laxity, wrinkles, and sagging. The skin's structural stability depends on the integrity of the extracellular matrix: with age, the number of fibroblasts decreases, resulting in reduced collagen and elastin synthesis and thinning and loss of collagen fiber density. This results in a reduction in the thickness of the dermis [1]. There are several commercially available approaches for treating facial aging and skin laxity, including laser therapies. Recently, microwave technology has emerged as a good treatment choice in this field. Microwaves are a very popular technology in contemporary society and is not even new in medical applications. Furthermore, several clinical studies confirmed the efficacy of microwaves on body contouring and skin laxity, facial skin remodeling and cheek skin appearance [2,3].

In our study a microwave-based system with a frequency of 2.45 GHz (ONDA PRO, Deka M.E.L.A., Florence, Italy) was utilized to evaluate the impact of microwaves on skin rejuvenation, assessed by ultrasound measurements (Clarius, Vancouver, Canada). Dermal thickness and echogenicity were selected as the

most suitable parameters to evaluate the effects of the treatment. Dermal thickness has been observed to physiologically decrease with increasing age, in both men and women, in different areas of the body [4]. Measurement of the thickness of the dermis can therefore be used as a parameter to evaluate the effects of an anti-aging treatment. The echogenicity of skin layers has been extensively documented in the literature as a valuable parameter in skin diagnosis. In accordance with the principles of ultrasound imaging, it can be hypothesized that bright or hyperechoic regions signify an increase in tissue density, while dark or hypoechoic areas indicate a decrease. Furthermore, a significant increase in dermal echogenicity has been observed following aesthetic treatment with radiofrequency technology [5].

The clinical case presented involved the central area of the cheeks of a 52-year-old patient. For each cheek, 3 points were identified at the intersection of 4 reference lines, as shown in Figure 1, and two different treatment protocols were applied. The left side of the face was treated with protocol 1, while the right side was treated with protocol 2. A single treatment session was performed. The microwave handpiece was used in a stacking mode, delivering a power density of 21 W/cm^2 for a duration of 0.5 seconds for the protocol 1 and 1 second for the protocol 2. The handpiece was held in position for the entire duration of the emission before moving on to the next point. The two protocols therefore differ in emission duration and, consequently, in the energy density delivered: for the protocol 1, the energy density is 10.5 J/cm^2, while for the protocol 2 it is 21 J/cm^2.

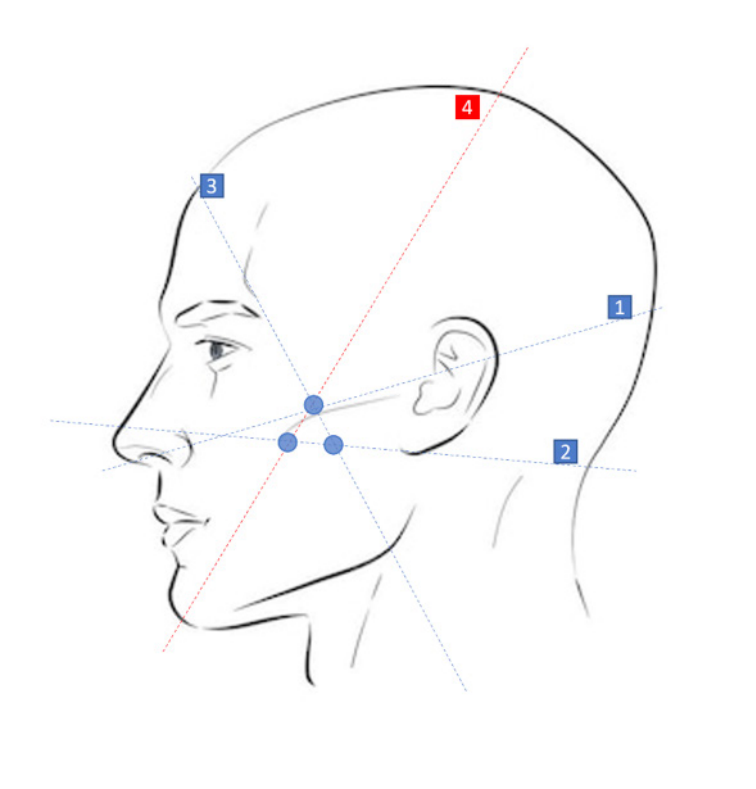

Figure 1: Identification of treatment points (shown as blue circles in the image) by the intersection of four reference lines (dashed lines in the image) that can be identified on both sides of the face.

Ultrasound images were obtained prior to treatment, immediately following treatment, and at 3, 15, 30, and 45 days of follow-up. Using ultrasound images, it was possible to calculate the thickness of the dermis over time for each treated point. The thickness values for the points treated with the protocol 1 were averaged, as were those for protocol 2. An overall analysis revealed an increase in dermal thickness over time, with an immediate inflammatory response to treatment that led to the accumulation of body fluids, and maximum dermal thickness 30 days after treatment for both protocols (Figure 2). The percentage change in dermal thickness at the various follow-ups compared to baseline was calculated for both protocols (Figure 3). An increase in thickness is observed at each follow-up, with a peak at 30 days, which is maintained high up to 45 days of follow-up.

Protocol 2 still appears to have better results, with an increase in dermal thickness 30 days after treatment of 21%, compared to 16% for protocol 1 (Figure 4). Based on the findings from previous observations, an increase in dermal thickness indicates an improvement in skin quality, achieved through localized, superficial heating by microwaves, which causes collagen contraction. The echogenicity of the tissue was calculated

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using the Matlab computing and programming environment (MathWorks, Massachusetts, USA). A script was developed that utilizes dermal ultrasound images as input and implements a thresholding function. This function enables the transition from a grayscale image to a binary image, in which each pixel has a value of 0 (black) or 255 (white).

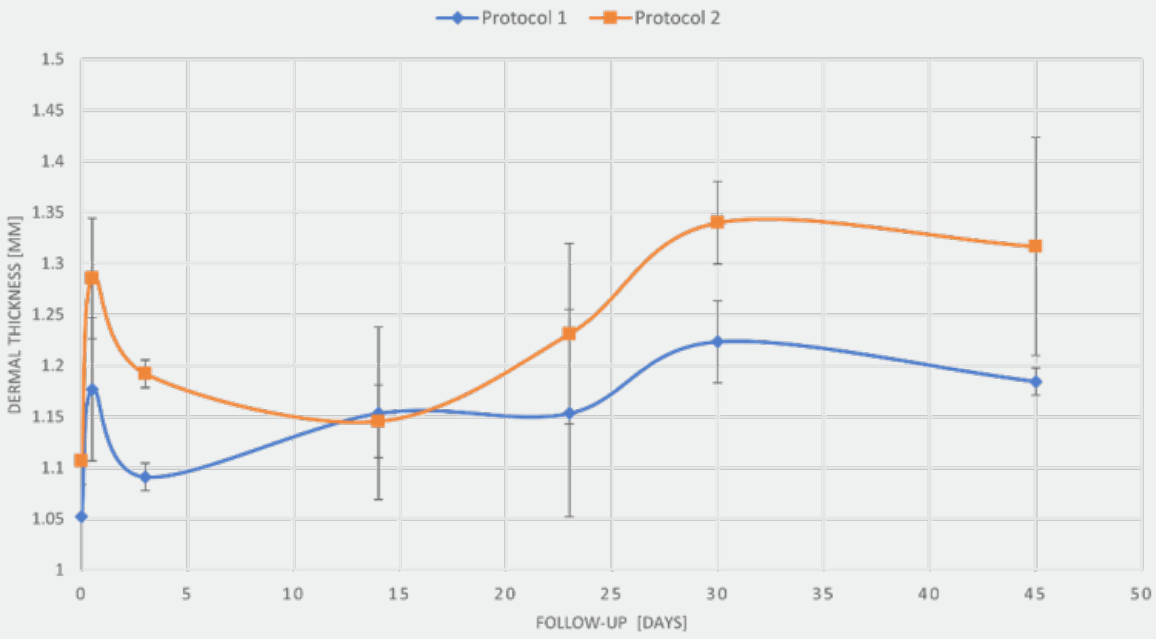

Figure 2: Dermal thickness over time for both protocols.

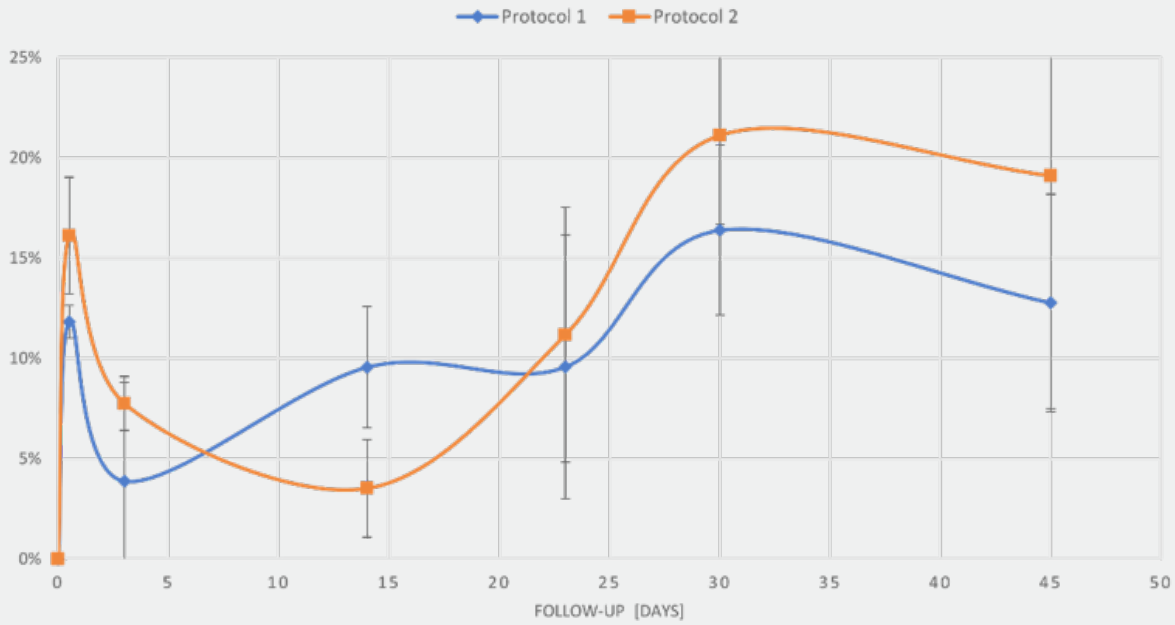

Figure 3: The percentage change in dermal thickness at various follow-up visits compared to baseline shows an increase in dermal thickness over time for both protocols.

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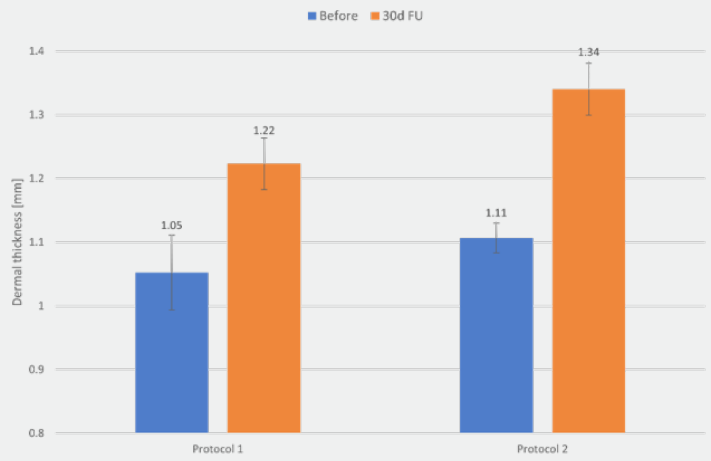

Figure 4: Comparison of dermal thickness at 30 days of follow-up with that prior to treatment for both protocols.

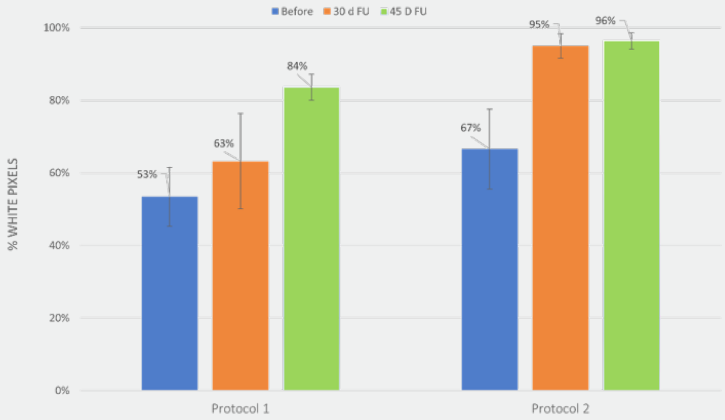

Figure 5: Comparison of dermal echogenicity at 45 and 30 days of follow-up versus pre-treatment for both protocols.

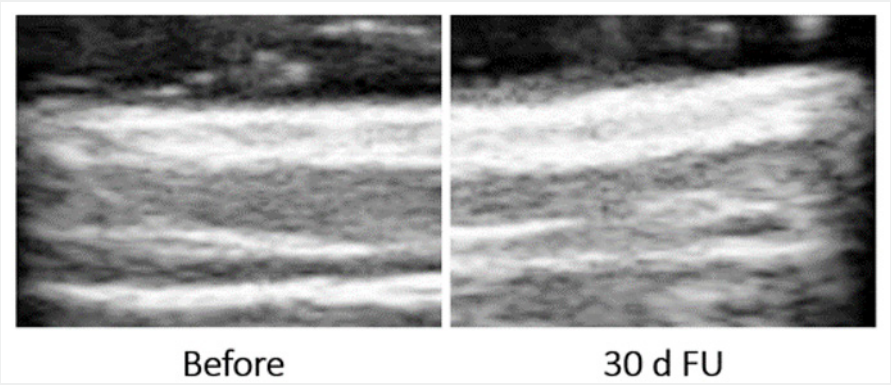

Figure 6: Left: Ultrasound image of the dermis before treatment. Right: Ultrasound image of the dermis at the 30-day follow-up at the same site. Thickening of the dermis is evident.

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This process enables the isolation of white pixels from black pixels, thereby facilitating the calculation of the echogenicity of an image as a percentage of white pixels. A favourable trend was observed for both protocols, with an increase in echogenicity of 31% for the protocol 1 and 29% for the protocol 2 after 45 days (Figure 5). The outcomes were used as an indirect measurement of the increase collagen in the dermis. The findings on the thickness of the dermis and its echogenicity can be directly observed from the ultrasounds. Figure 6 shows an example comparing a point at baseline (on the left) and the same point 30 days after treatment with protocol 2 (on the right). It is possible to notice both a thickening and a greater brightness of the dermis compared to the baseline.

Conclusion

Ultrasound measurements showed positive effects of microwaves on skin rejuvenation for both treatment protocols, with more promising results for protocol 2. These findings suggest that microwave-based treatment can effectively increase dermal thickness and echogenicity, serving as indirect markers of collagen remodeling.

Institutional Review Board Statement

The study was conducted in accordance with the principles of Declaration of Helsinki. No activity was carried out outside the scope of the device intended purpose or that no additional invasive or burdensome procedures were carried out compared to procedure performed under the normal condition of use of the device.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

Data that support the study findings are available on request from the corresponding author (Irene Fusco).

Conflicts of Interest

Authors Jorilda Biba, Irene Fusco and Tiziano Zingoni were employed by El.En. Group. The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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