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Two Treatment Protocol for Skin Laxity Using A 90 Watt Dynamic Monopolar RF Device with Real–Time Impedance Intelligence Monitoring

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ABSTRACT

Multiple devices are currently on the market that employ radiofrequency (RF) to non-invasively treat skin laxity and wrinkle reduction. The study device was a unique monopolar radiofrequency device FDA cleared for the treatment of wrinkles and rhytids. The delivery system allows constant monitoring of the real-time local skin impedance changes, which allows RF energy to be more uniformly dosed over an entire treatment area.

Objective: The objective was to validate effectiveness of a modified treatment protocol for a unique monopolar RF device, which has been engineered with greater power and self-monitoring circuitry.

Methods: Twenty-four female subjects received bilateral monopolar RF treatments to the mid and lower face from the sub malar region to the submentum. Subjects completed 1 and 3 month follow ups with digital imaging. Skin biopsies (on 4 subjects) and ultrasound measurements on 12 subjects were completed.

Results: Assessments demonstrated a reduction in skin laxity of 35%, a reduction in fine lines/wrinkles of 42%, and a reduction in the appearance of global photodamage of 33%. Expert photograding demonstrated 92% of subjects showing at least a mild improvement in skin laxity at three months post treatment. 50MHz ultrasound measurements in 12 subjects showed an increase of 19% in skin density. Histology showed a marked increase in dermal collagen and elastin fibers in two subjects who demonstrated a clinically noticeable reduction in skin laxity and minimal changes in two subjects who demonstrated minimal clinical improvements. There were no significant adverse events reported.

Conclusion: This modified RF device and treatment protocol was well tolerated and produced improvements in the appearance of skin laxity and overall anti-aging effects in the majority of subjects.
Objective measurements including ultrasound and histology help explain the clinical outcome.

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INTRODUCTION

The appearance of the face and neck is profoundly affected in the aging process. There is decreased tissue elasticity coupled with rearrangement of facial volume that is compounded by the effects of gravity.[1] As the appearance of the face and neck is a primary concern of many people, ways in which to tighten the skin are increasingly in demand. One such method to address this concern is radiofrequency (RF) treatment, which produces an electrical current that uses the resistance within the various skin layers to convert the delivered energy into thermal energy.[2] Radiofrequency (RF) creates oscillating electrical current, causing vibration and collisions between charged molecules, thus resulting in the production of heat as described by Belenky, et al.[3] This RF heating occurs regardless of skin chromophores or skin type and is not dependent upon selective photothermolysis but rather heating of water. Thus, hydration of tissues in the RF treatment area is important. There are many different types of RF devices using multiple types of RF energy, temperature ranges, and target depths.[4,5] RF heat has different biological and clinical effects, depending upon the method of delivery and depth of heating. In the dermis, which is comprised of collagen, elastin, and ground substances, RF mediated thermal stimulation of this matrix results in an immediate and temporary change in the helical structure of the collagen.[6] It is also believed that RF thermal stimulation results in a micro-inflammatory stimulation of fibroblasts, which produces new collagen (neocollagenesis) and new elastin (neoelastogenesis), as well as other proteins to enhance dermal structure.[7,8]

To allow a constant and consistent RF energy delivery, there is a need for the power to be maximized and normalized for skin impedance. Some first generation RF skin tightening devices offer skin impedance measurements, but these measurements are not real-time measurements of the target area. Some RF devices use impedance of one sampled area to "average" impedance at the beginning of treatment. This initial one-time impedance measurement is used for the duration of the treatment and does not allow for changing power relative to impedance from one area to the next, thus yielding an uneven thermal energy distribution.

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Without active real-time impedance measurement, some areas of the skin could be treated too intensely (risk of burning, higher in bony areas) while elsewhere the therapeutically optimal temperatures may not be attained.

The monopolar RF device used for the study is a monopolar radiofrequency device (Exilis Elite, BTL Aesthetics) which is FDA cleared for the "primary treatment of dermatologic and general surgical procedures for non-invasive treatment of wrinkles and rhytids". The delivery system allows constant monitoring of the real-time local skin impedance changes during RF skin treatment. This impedance compensation system controls, or tunes, the current supply while the circuitry automatically compensates for impedance changes. Energy flow is controlled and the microprocessor automatically keeps the power output equivalent even in areas of higher/lower impedance allowing the operators to use high power settings without compromising safety. The system design enables the energy be consistently dosed over the entire treatment area.

> "Early equipment designs would continue to put energy through the system even when the contact point was too small, generating a burn or blister in the treated skin. The double grounded electrode ensures that once sufficient contact is lost, no energy is delivered."

These features are highlighted in this system through the following modifications to the original device. First the device has a double grounded electrode that is monitored several times per second and assists in stopping energy flow when sufficient contact is not made with the tissue to be treated. This helps eliminate the previous generation, electro cautery, based issue of arcing when sufficient contact is not made with the tissue. Early equipment designs would continue to put energy through the system even when the contact point was too small, generating a burn or blister in the treated skin. The double grounded electrode ensures that once sufficient contact is lost, no energy is delivered. Next, the hardware/software interface following these measurements allows for even distribution of heat through variable impedance regions as shown on infrared imaging (all treated regions appear to be a uniform temperature despite any impedance differences). These modifications are part of the "Impedance Intelligence" system which is an automatic self-adjusting system, delivering the energy amount based on measured capacitive, inductive and resistive parameters of the skin-applicator borderline. It

consists of impedance measurement circuit connected to the energy delivery system, changing the parameters of the delivered energy according to the impedance measurement.
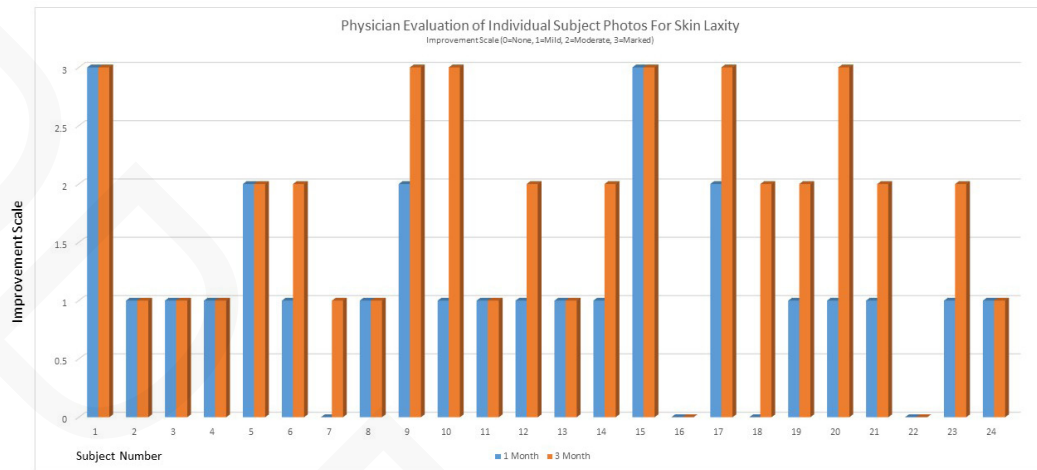
Previous histologic porcine skin studies demonstrated safety of the study device. One study involved 4 serial treatments at one month intervals. Photomicrographs taken from special stained sections were analysed using stereological analysis, which is a computer-based image processing and analysis technique for quantitative analysis of skin structures histological sections. Mean percentage of collagen volume was calculated with results showing that while average baseline collagen volume was 9%, the post four treatments average volume was 23%, an increase in collagen volume of 154%. Histology with temperature measurements also demonstrated that the reported temperature range (42-43C°) can generate this type of tissue response (Data on file, BTL Aesthetics, Framingham, MA).

MATERIALS AND METHODS

Study Design
Our study enrolled 26 female subjects with 24 completed at two investigative sites both under IRB approval. Subjects were between 25 and 65 years of age (average age = 57) who exhibited mild to moderate laxity of the submentum, mid and lower face. Subjects received two (2) treatments 10-14 days apart (+/- 4 days) using the monopolar RF system (Exilis Elite, BTL Aesthetics). The starting settings were 90 Watts and with the device set to emit a continuous wave (CW) of energy (100% duty factor for RF transmission). The power setting (Watts) was titrated based on subjects' verbal response for heat tolerance. The treatment was administered as follows: 1) Treated area from sub malar region to mandible for 6 minutes, 2)Treated submentum from lateral aspect of area to midline for 4 minutes, 3)Returned to sub malar region and treated for 3 minutes. Treated mandible region for 3 minutes, 4) Returned to submentum and treated for 4 minutes, 5) Repeated steps 1-4 on the contralateral side of face. Temperature of the skin was monitored using an external infrared radiometer and maintained at 42-43 C°. Typical total treatment time averaged 40-45 minutes, and no topical anesthetic or oral pain medications were used.

The subjects were consented, had a medical history taken and had assessments for Skin Laxity/Sagging, Erythema, Edema, Fine Lines/Wrinkles and Global Improvement prior to the first treatment, 1 month and 3 months post final treatment. Digital images were also taken using the VECTRA- M3, VISIA CA and Intellistudio (Canfield Scientific, Passaic NJ). Subjects underwent assessment using a 0-3 rating scale (0=Normal, 1=Slight, 2=Moderate, and 3=Severe) at all time points. Ultrasound imaging using the TPM DUB SkinScanner (Taberna Pro Medicum, Germany) on the left lower cheek (within the treatment area) was performed in a series of 3 measurements using a 50MHz scanner head (shallower depth of penetration but higher resolution

FIGURE 1. Improvement in skin laxity.

Physician Evaluation of Individual Subject Photos For Skin Laxity
Improvement Scale (0=None, 1=Mild, 2=Moderate, 3=Marked)

images) This was repeated in the same location at the 1 and 3 month follow up visits. Finally, 4 subjects were selected to have pre and 3 month post final treatment 2mm skin biopsies from the submentum for histological examination. Biopsies were taken a minimum of 1 cm apart to minimize wound healing artifact.

Imaging Methods
Standardized images of the face were captured using 3 different imaging units: the Canfield Intellistudio, VISIA-CA (high resolution/megapixel cameras with a stereotactic head positioning device) and VECTRA-M3. Photographs were taken prior to any treatment (clean and dry face only). No make-up was worn during the photographs, including foundation, blush, eye shadow, lipstick and mascara.

Three ultrasound images (per visit, per scanner frequency) for 12 subjects at a single site were analyzed using the device software for Skin Analysis. Data for each measurement included skin thickness and density. These values were averaged to give individual subject skin thickness and densities for each time point. The subject skin density and thickness measurements for the selected 12 subject subset, were then combined to determine the average effect of the treatment on skin density and thickness for each scanner.

The biopsies were placed in 10% buffered formalin, paraffin embedded and cut into 5 micron sections. Masson Trichrome stain, for visualization of collagen, and Verhoeff stain, for visualization of elastin fibers, was performed on a section for each biopsy subject. The prepared slides were viewed on a Leica-DM IRB inverted microscope fitted with a Nikon Camera system (DS-Fi2 Visible light Camera) and the NIS Imaging Suite was used to form a composite image of the entire section, which was then visually assessed for increased staining of the selected proteins/fibers.

RESULTS
Clinical Observations
On the 0-3 point assessment scale, 35% reduction in skin laxity/sagging (P value < 0.0001), 35% reduction in fine lines/wrinkles (P value < 0.0053), and 33% reduction in the severity of global photodamage (P value < 0.009) was recorded. No edema was observed. An incidental finding was a statistically significant reduction in background erythema (P value = 0.0109) in some subjects.

Photo assessment by blinded expert graders revealed 79% of subjects had mild improvement in each of three categories measured (fine lines/wrinkles, skin laxity and overall skin texture). For skin laxity, 92% of subjects showed a minimum of mild improvement at the 3-month time point (Figure 1). Average improvement from one month to three months achieved statistical significance (as determined by a two-tailed paired T Test) of 38% improvement in fine lines/wrinkles (P value = 0.0011), 64% improvement in skin laxity (P value = 0.0003) and 50% improvement in overall skin texture (P value = 0.0011).

Ultrasound
Ultrasound images from the 50MHz detector revealed an average of 19% increase in skin density at 3 months (Figure 2) and a statistically significant linear increase in skin density over the course of the study ($P < 0.01$; $R^2 = 0.2645$, $P = 0.0014$, respectively). This was calculated using a two-tailed One-Way ANOVA with post-hoc Dunnett's Multiple Comparisons test and test for a linear trend.

Histological Imaging
Histologic examination of the four biopsies showed significant increase in dermal collagen and elastin fibers throughout the dermis in two of the four subjects. Two subject's full thickness images are presented below (Figures 3a, b, and 4a, b). Clinical

FIGURE 2. Average of all subjects density readings at all time points from 50MHz Ultrasound unit in the lower cheek. An increase of 19% in skin density was observed.
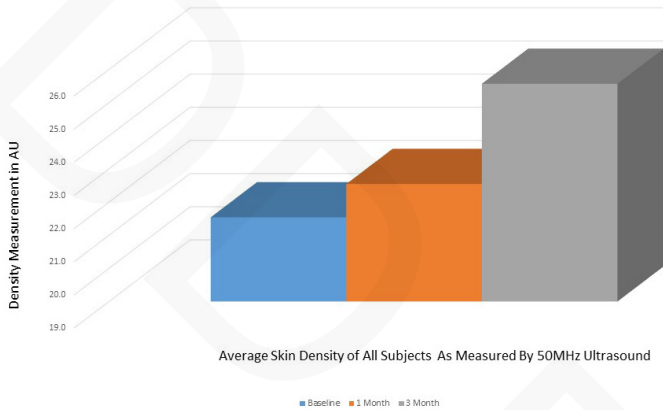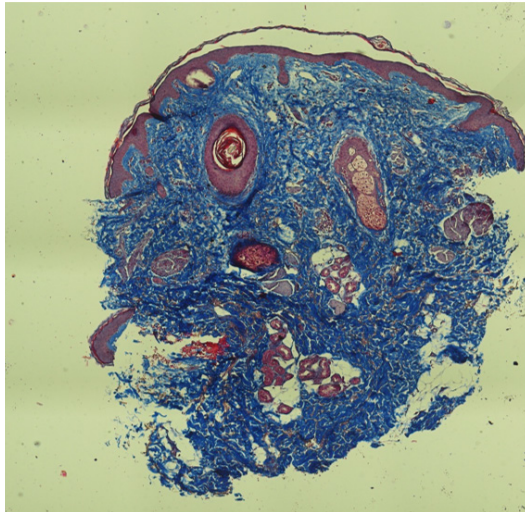

FIGURE 3a. Masson staining in one subject demonstrates increased collagen (blue) at 3 months post treatment.
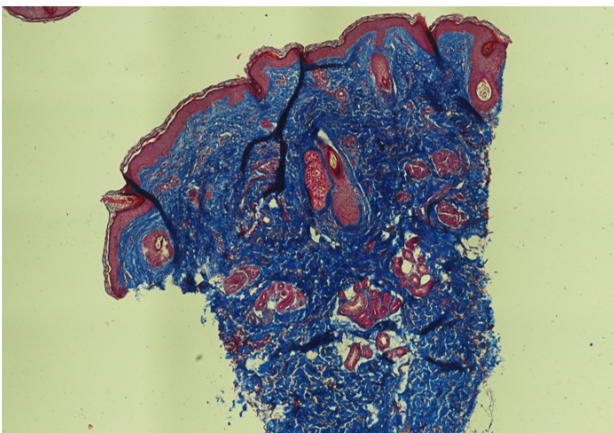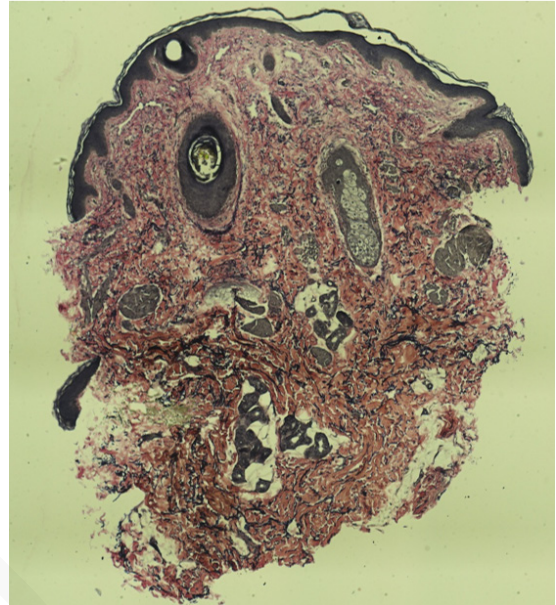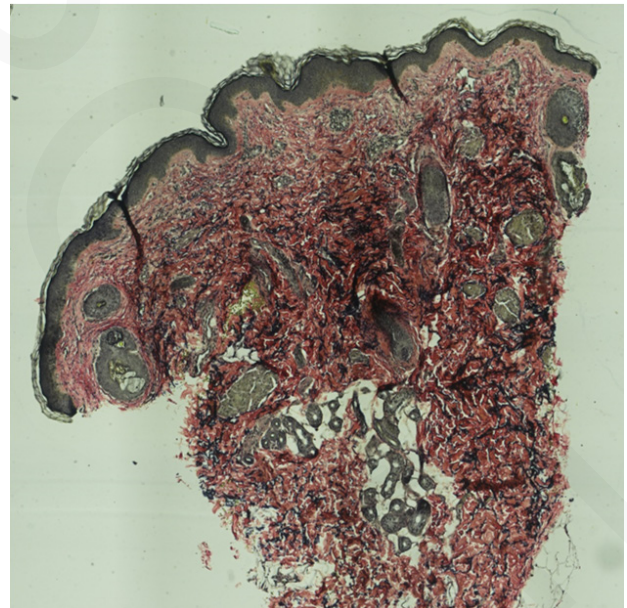
Pre

Post

FIGURE 3b. Verhoeff staining in one subject demonstrates increased elastin fibers (black), with more uniform pattern and distribution at 3 months.

Pre

Post

images of these same subjects demonstrated significant clinical improvement, consistent with the histological findings (Figures 5 and 6). There were minimal changes in the biopsies and clinical grading from the other two subjects. The histology results correlate well with the respective subjects' clinical response (marked improvement for the two with visible collagen and elastin deposition and minimal improvement for the others). Tightening around the jawline, under the chin and neck are clearly demonstrated (Figure 7).

FIGURE 4a. Masson staining in one subject demonstrates increased collagen (blue) at 3 months post treatment.
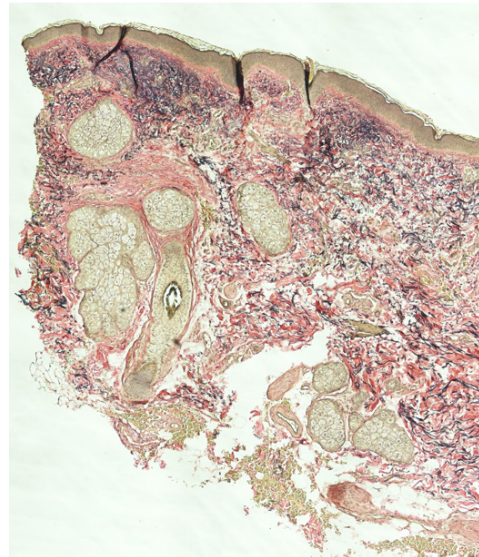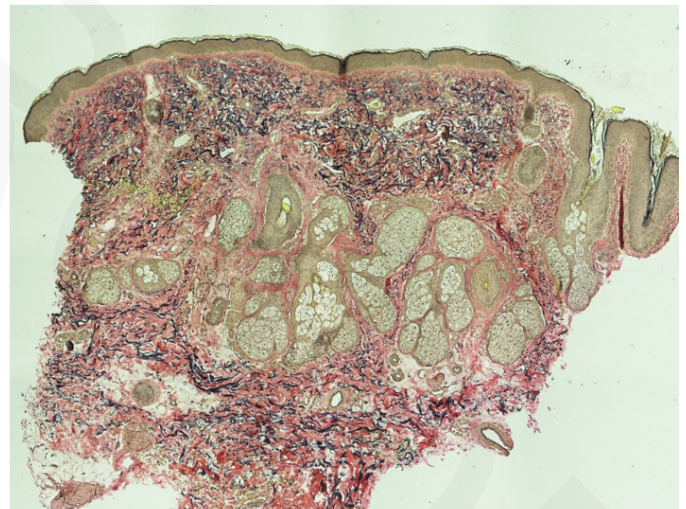
Pre
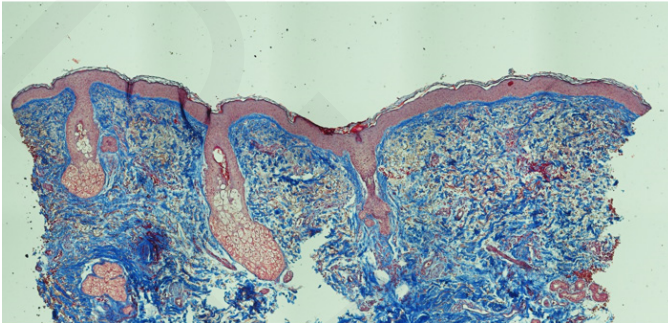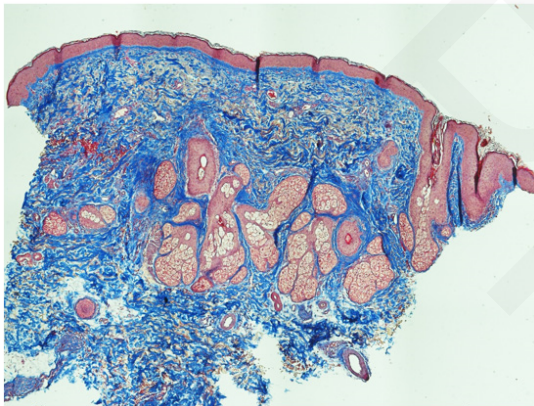
Post

FIGURE 4b. Verhoeff staining in one subject demonstrates increased elastin fibers (black), with more uniform pattern and distribution at 3 months

Pre

Post

CONCLUSION

This study demonstrates that a novel monopolar RF device with increased fluence and continuous impedance monitoring used with a new two treatment protocol achieves measurable clinical benefits. The data supports previous statements that mention by maintaining a lower skin temperature for longer treatment times measurable benefits can be achieved. Thus, it is possible to achieve clinical results without pain and downtime. The study data indicates an increase in overall skin density, collagen and elastin deposition/organization, and some improvement in fine lines/wrinkles as well as overall skin texture in the majority of subjects. There was also an unanticipated decrease in background erythema in many subjects, the mechanism of which is unknown.

The data analysis also revealed other items that warrant further study and discussion. The first is the variation in the results from subject to subject. Each subject was treated using the same standardized protocol such that time on tissue was consistent for every subject. We propose that the cause of variance in the results may be due to the wide age range of the subjects as well as individual heat tolerance. While time on tissue was standardized, the titration of energy was based on tissue response as well as subjects' reported sensation of heat. The subject variation could be addressed in future studies through a tighter selection process as the current subjects were selected from a wide range of potential candidates as this study was designed to mimic broad clinical usage and not to selectively treat subjects that would respond well to the treatment. It is also worth noting that some subjects experienced early results (1 month) but did not improve as expected at 3 months; the reason for this is currently unknown. Future studies that examine the longevity of the results are also warranted. It would be of benefit to follow the subjects for 6 months or longer to determine if repeated treatments are needed as commonly associated with similar types of treatments, or if this device has an additional advantage of increased improvement duration.

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FIGURE 5. Clinical photo of subject at baseline and 3 months following 2 RF treatments.

FIGURE 6. Clinical photo of subject at baseline and 3 months following 2 RF treatments.

FIGURE 7. Clinical photo of subject at baseline and 3 months following 2 RF treatments.

histologic specimens.

DISCLOSURES

[AQ : Please provide full disclosure and any potential conflicts of interest for each author]

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