A NEW APPROACH TO BODY CONTOURING USING CONTROLLED RF HEATING AND HIGH VOLTAGE ULTRA-SHORT ELECTRICAL PULSES

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Introduction

Non-invasive body contouring is one of the fastest growing market segments in aesthetic medicine (1). Non-invasive body contouring technologies have progressed from non-thermal, mechanical rollers and suction systems used in the 1990's, that enhanced lymphatic drainage in cellulite and fat deposits, to thermal based suction devices which combined laser, radio-frequency (RF) and/or infrared energies with or without mechanical massage (2-15). These optical or RF systems, with or without rollers, deliver a thermal stimulus to the superficial adipose tissue to enhance normal lipolysis metabolism and decrease the adipocyte volume (conversion of triglycerides to glycerol and free fatty acids which egress out of the cell), through thermal stimulation of epinephrine mediated lipase. Infrared energy penetrates into the dermis, leading to a modest tightening effect on the skin and some improvement in cellulite, while RF systems can penetrate 5-15mm into the subcutaneous tissue affording the opportunity to have a direct effect on adipose tissue. These thermal RF and optical systems are generally "non-disruptive" in that the adipocyte cell membrane and cellular functions are not damaged. Therefore, the disadvantages of these "non-disruptive" body contour and cellulite systems is the transient effect on adipose tissue and the contour enhancements that may be achieved.

Over the past few years there have been several non-invasive body contouring technologies that have come to the market that do disrupt the adipocyte. They damage and permanently injure the fat cell through: (i) cavitation (the UltraShape focused, high frequency ultrasound), (ii) thermal disruption (Liposonix high frequency focused ultrasound) (iii) freeze the fat cell and induce an adipocyte apoptosis through cryolipolysis (Zeltiq) and (iv) the creation of a temporary "pore" in the adipocyte cell membrane for trigylceride egress (Zerona) (16-30).

The desirable features of a non-invasive body contouring device include:

(i) some energy effect on the adipocyte that destroys the cell permanently, or incapacitates

the cellular function leading to apoptosis (cell death). The final pathway can be thermal (high temperature or vey low temperature), cavitation influences or lipid bi-layer membrane disruption.

(ii) High degree of safety

(iii) Minimal discomfort

(iii) High percentage of adipose tissue impacted

(iv) High degree of efficacy and reproducibility

(v) Disruptive effects on the adipocyte for long lasting body contour and cellulite effects

(vi) Revenue efficient with low disposable costs

We believe that the novel technology described in this current preliminary study represents a new body contouring device that offers many of the ideal body contouring features patients and physicians would prefer.

Material and Methods

The TiteFX device (Invasix Ltd.) combines, in a synergistic fashion, the following therapeutic energy sources:

- Uniform RF heating of the skin and subcutaneous fat with real time monitoring of skin temperature using an infrared thermometer built into the hand piece.
- High-voltage (HV) short RF pulses applied to the subcutaneous fat to deliver irreversible electroporation to the adipocyte leading to delayed apoptosis of the fat cell and secondary minor muscle stimulation.

The TiteFX applicator has a large suction cavity on the undersurface of the hand piece with RF electrodes on each side. The hand piece applies

suction pressure to the soft tissue of the convex contour irregularity, drawing the skin and subcutaneous tissue up into the cavity. Bipolar RF is passed between the two electrodes and through the adipose tissue and skin (Figure 1).

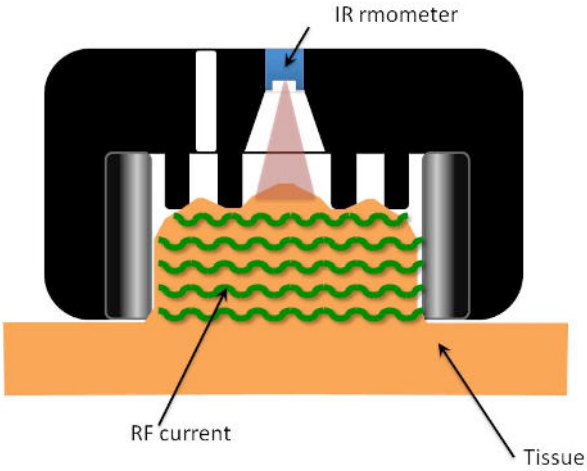

Figure 1 - Hand piece geometry demonstrating RF current passing through the tissue in the suction cavity

As the RF heats the tissue, the surface temperature rises. The TiteFX hand piece displays this measured skin surface temperature on the hand piece. When the temperature gets to an endpoint that is established by the physician (the "trigger temperature") the device will emit a train of High Voltage Pulses (HVPs) directly into the adipose tissue.

The TiteFX allows for very uniform skin heating to a depth of 15mm due to the vacuum suction and electrode placement. Figure 2 shows a thermal image of the skin with uniform temperature distribution. The uniformity of the skin temperature means a target "trigger temperature" of 42˚C can be reached with minimal patient discomfort.

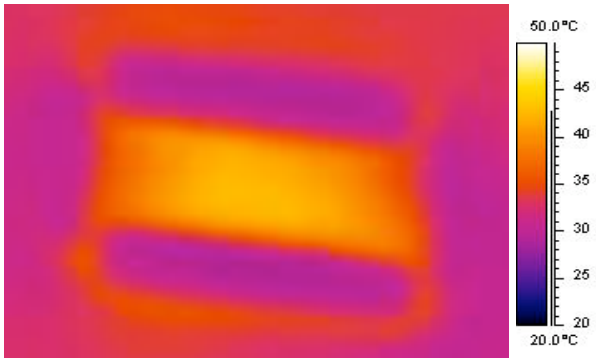

Figure 2 - Uniform temperature distribution on treated skin

Irreversible electroporation is the process of creating pores in cell membranes under an external electrical field, leading to apoptotic death of cells in certain conditions. Preheating of the skin with RF current allows for a significant reduction in the electroporation threshold [9] and target selectively, as the preheated large adipocytes are more sensitive to electrical fields [10]. With the HVP adipocyte apoptosis, the fat cells die and the adipose tissue deflates and loses volume, thereby improving contour. Another benefit of the RF energy and HVP is that the controlled RF energy heats the skin resulting in dermal tightening which enhances the contour as the adipose tissue becomes reduced.

In the current study 20 female and male patients were enrolled. The age range of the patients was 28 to 58 years old, with an average age of 36.5. Patient BMI varied from 18 to 28 and all of patients were interested in focal shape correction, without anticipating any weight reduction. The patients were treated in the abdominal and flanks regions once a week over a period of 6 weeks. Patients were observed for 3 months to determine the long-term adipose tissue effects and body contour changes. Standard photography and circumferential measurements were taken prior to treatment and at 3 months following the last treatment.

The protocol during the treatment involved moving the TiteFX applicator on half of the target zone, heating the soft tissue every three seconds and then moving to the next area, overlapping 10-20% with the previous treatment, rapidly rising the tissue temperature to 41-43^{o}C. Once the trigger temperature of 42^{o}C was achieved, HVP energy was delivered in a pulse of 5-7 seconds with 3-5 passes of High Voltage Pulses completed in each zone. RF power of 40-50W was used and the treatments were completed at an average of 30mins per zone.

Results and Discussion

All patients felt comfortable at tissue temperatures of 42^{o}C and the majority was able to tolerate 43^{o}C. At a skin temperature of 44^{o}C the majority of patients experienced discomfort. No adverse side effects were observed at any of these three temperatures.

Skin erythema, mild edema and a heat sensation were typical following the treatment. The skin

erythema level depended on the final temperature achieved and lasted up to 6 hours.

The average weight of patients was stable over the treatment course without a significant reduction.

Circumferential reduction was obvious for most of patients 3 months following the completion of their 6 treatments. The average circumferential reduction was 28.1mm with range of 15mm to 40mm. There were no non-responders observed in the study.

Our clinical impression is that longer exposure to the predetermined "trigger temperature" and applying more HV pulses provides better results and higher patient satisfaction, but additional clinical studies are underway to refine and optimize the treatment protocols.

Most of patients reported a high satisfaction level and were able to detect visible improvement in their body shape.

Figures 3 to 6 show a female and male patient before and 3 months following the TiteFX treatment program.

Figure 3 - Female before and 3 months following treatment

Figure 4 - Female before and 3 months following treatment

Figure 5 - Female before and 3 months following treatment

Figure 6 - Male before and 3 months following treatment

Conclusion

The pilot study on 20 patients provides convincing evidence that a combination of controlled RF heating and HV pulses offer a long term, non-invasive body contouring solution with adipocyte death and permanent contour enhancements. Synergistic controlled RF heating and HV pulses results in a consistent circumferential reduction that may be result of apoptotic death of adipocytes caused by thermally stimulated Electroporation effect.

The authors believe that the TiteFX technology is effective in its current configuration in delivering a permanent adipocyte apoptotic effect and thus long-term non-invasive body contour enhancements.

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