The Efficacy of a Combination Non-Thermal Focused Ultrasound and Radiofrequency Device for Noninvasive Body Contouring in Asians

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Background and Objective: Several studies have been published on the first generation non-thermal focused ultrasound with an average improvement of 0–3.95 cm reported [1,2]. We aim to investigate the efficacy of the second-generation non-thermal focused ultrasound device with a combined radiofrequency hand piece. With the addition of radiofrequency energy, the temperature of the adipose tissue is raised before focused ultrasound is applied. This facilitates the mechanical disruption of fat cells by focused ultrasound.

Study Design and Methods: Twenty subjects were recruited and underwent three treatments biweekly. Caliper reading, abdominal circumference, and standardized photographs were taken with the Vectra system at all visits. We aim to have the subjects stand and hold the same position and the photograph taken after exhalation. Caliper and circumference measurements carry uncertainty. It is impossible to eliminate all uncertainties but can be improved by having the same trained physician assistant perform the measurement at the same site and taking an average of three readings. Pain score and satisfaction were recorded by means of the visual analogue scale. The efficacy is defined by a statistically significant improvement in circumferential improvement based on intention-to-treat analysis.

Results: Seventeen subjects completed the treatment schedule. Abdominal circumference showed statistically significant improvement at 2 weeks post-second treatment \( (P = 0.023) \) and almost all subsequent follow-ups. Caliper readings were statistically significant at 2 weeks post-second treatment \( (P = 0.013) \) and almost all follow-ups. The mean pain score reported was 2.3 on the visual analog scale and 6% were unsatisfied with the overall treatments. Six incidents of wheal formation appeared immediately after treatment all of which subsided spontaneously within several hours.


Key words: body contouring; focused ultrasound; radiofrequency; UltraShape; adipose tissue; fat

INTRODUCTION

In the past decade, multiple devices and non-invasive technologies such as cryolipolysis, low-level laser therapy, radiofrequency, and high intensity focused ultrasound were launched for improving body contour. This is due to the increased demand for improving body contour and wider social acceptance of cosmetic procedures. A survey published by the American Society for Dermatology Surgery reported that over half of those interested in cosmetic procedures were most interested in “body sculpting” [3]. The idea of undergoing surgery and its surgical complications including infections, scars, visceral perforations, swelling, burns, embolisms, and even death may deter patients from liposuction. Patients seek procedures with little downtime, pain, and adverse effects and are more willing to undergo repeated non-invasive treatments.

Ultrasonic energy can be used to target adipose tissues when emitted to a focal area. Focused ultrasounds concentrated in an area of subcutaneous fat cause adipose cell destruction. In the market, there are two types of ultrasound devices. The thermal effects of high intensity focused ultrasound (HIFU) rapidly raise the temperature of adipose tissue to above 55°C causing thermal coagulative necrosis and secondary mechanical effects due to acoustic pressure. Low frequency focused ultrasound is a non-thermal ultrasound which causes ablation of adipocytes through mechanical disruption. It has been

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demonstrated in porcine models to create small cavitations in subcutaneous adipose tissue [4]. This technology is now FDA cleared for noninvasive reduction of abdominal circumference. The difference of high intensity focused ultrasound is that it uses high-frequency acoustic energy 2 MHz, >1,000 W/cm² causing thermal and mechanical damage, whereas low-intensity nonthermal ultrasound uses 200 kHz, 17.5 W/cm², with a focal point at 1.5 cm deep, causing mechanical damage and cavitation.

In this study, the second-generation focused ultrasound device emits a low frequency focused ultrasound as well as a radiofrequency applicator. The bipolar radiofrequency hand piece creates a conduction field to the skin-fat interface selectively heating up fat due to lower resistance pathway thus increasing the temperature of adipose tissue prior to applying focused ultrasound energy. The aim of the study is to assess the efficacy and satisfaction of this combined device for abdominal circumferential reduction in Asians.

MATERIALS AND METHODS

The study is reviewed and approved by Institutional Review Board Services (Ontario, Canada). This is a prospective study where 20 healthy Chinese subjects between 18 and 60 years of age were recruited. The abdominal thickness measured by a calibrated caliper had to be at least 1.5 cm as the focal point of the device is at 1.5 cm deep, and their body mass index (BMI) between 21 and 28. A normal BMI is required because lipolytic sensitivity is impaired in obese patients, defined by BMI >30. BMI is defined as the body mass divided by the square of the body height, and is universally expressed in units of kg/m². Female subjects cannot be pregnant. Exclusion criteria include any pathological or chronic disease such as hypertension, diabetes mellitus, hepatitis, coagulopathy, hyperlipidaemia, connective tissue disorder; previous liposuction or body contouring procedures in the treatment area of abdomen or flanks; history of skin disease in the treatment area, known tendency to form keloids or poor wound healing; skin laxity; abdominal wall diastasis or hernia; childbirth in the last 12 months or breastfeeding women; unstable weight within the last 6 months, that is, over 3% weight change in the prior 6 months; inability to comply with circumference measurement, for example, inability to hold breath for required duration; participation in another clinical study within 6 months. Upon enrollment, the subjects signed the informed consent form. They were instructed to maintain a healthy lifestyle with no sudden drastic change to their normal routine and diet. The scheduled visits are shown in Figure 1.

Subjects were changed to disposable undergarment then the physician marked the treatment area. Circumferential and caliper measurements, weight, BMI, and standardized photographs were taken at baseline and each visit by trained physician assistant. A special tape measured the abdominal circumference was provided by Syneron² (Syneron² Medical Ltd. Yokneam, Israel), which has a constant tension. The widest part within the defined area for treatment was measured and the height level was recorded. The treatment area, site of caliper reading, and the circumferential measurement level were recorded on the transparent plastic sheet that traced the treatment area with reference to anatomical landmarks. Three consecutive measurements were recorded and the average was taken. The right thigh circumference was used as control. Standardized photographs were taken by the Canfield Vectra¹ system (Canfield Scientific, Inc., Fairfield, NJ). We aimed to achieve the same settings, angles and postures. All these measurements are taken by the same trained physician assistant.

A reusable strap provided by UltraShape¹ system (Syneron¹ Medical Ltd. Yokneam, Israel) was used to gather skin and fat at the area to be treated (Fig. 2). Subject then lied supine under the device real time camera. According to the size of the treatment area, the device will determine the total number of pulses to be delivered during treatment. The treatment area was divided into 2 sub-areas; upper and lower abdomen. At the combined treatment, each sub-area was treated independently using RF first (stacking mode of operation) and ultrasound immediately afterwards (Fig. 2). All RF treatments started with power level 2 and vacuum level 2. It was adjusted according to patient feedback and 5 stacking pulses at each location was applied until a temperature of 43°C was reached. Acoustic gel was used as coupler agent between the RF applicator and skin surface. Castor oil as coupling agent was used between the ultrasonic transducer and the skin surface. The operator treated according to the guidance system. The recommended minimal number of ultrasound pulses to be delivered per subject as a single

![Fig. 1. Study schedule.](image-url)
treatment was defined according to Figure 3. The time required for each treatment is dependent on the size of the area and number of pulses required, an average of 1 hour is to be expected. Each subject received a total of three treatments, 2 weeks apart. The pain score was recorded after each treatment with the visual analog scale. We also asked whether the subject is satisfied with the overall experience. Any adverse effects were evaluated and recorded. Intention-to-treat analysis was performed by using SPSS statistical software. All tests were two-tailed with statistically significant level set at $P \leq 0.05$. The null hypothesis was no difference detected after treatment. For data that did not conform to normality test, Wilcoxon signed rank test for repeated measures hypothesis testing was applied.

**RESULTS**

Seventeen subjects completed the study and the last follow up was at 3 months post-treatment. One subject was lost to follow up, one subject violated the protocol and received other body contouring treatments and one subject withdrew due to personal reasons. All subjects were Asian females with a mean age of 31.7 (range 21–58 years) and mean BMI of 23.5 (range 22.0–25.4). Body weight remained constant throughout the study with no statistical differences at all visits.

After three consecutive treatments, there is statistically significant difference in circumferential reduction at 2 weeks after second treatment ($P = 0.023$), 2 weeks after third treatment ($P = 0.023$), 1 month ($P = 0.004$) and 3 months follow up ($P = 0.002$, Table 1). The most improvement was observed at one-month follow up where a median of 1.0 cm reduction was observed. Baseline median measurement was 88.6 cm and 1-month follow up median measurement was 87.4 cm. The subject that demonstrated

### TABLE 1. Outcome Measurements by Measuring Tape and Caliper

<table>
<thead>
<tr>
<th></th>
<th>$n = 17$</th>
<th>Median (min, max)</th>
<th>$P^*$</th>
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</thead>
<tbody>
<tr>
<td><strong>Tape measurement of the waist (cm)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td></td>
<td>88.6 (80.5, 97.2)</td>
<td>0.061</td>
</tr>
<tr>
<td>Post-1st treatment</td>
<td></td>
<td>88.0 (80.4, 94.9)</td>
<td>0.244</td>
</tr>
<tr>
<td>Post-2nd treatment</td>
<td></td>
<td>88.4 (79.6, 96.4)</td>
<td>0.023</td>
</tr>
<tr>
<td>Post-3rd treatment ($n = 16^a$)</td>
<td></td>
<td>88.0 (79.8, 95.0)</td>
<td>0.023</td>
</tr>
<tr>
<td>1-month follow-up ($n = 16^a$)</td>
<td></td>
<td>87.4 (80.3, 95.2)</td>
<td>0.004</td>
</tr>
<tr>
<td>2-month follow-up</td>
<td></td>
<td>88.4 (79.8, 94.1)</td>
<td>0.118</td>
</tr>
<tr>
<td>3-month follow-up</td>
<td></td>
<td>86.1 (80.0, 94.1)</td>
<td>0.002</td>
</tr>
<tr>
<td><strong>Caliper measurement of the waist (cm)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td></td>
<td>2.7 (1.6, 3.3)</td>
<td>0.013</td>
</tr>
<tr>
<td>Post-1st treatment</td>
<td></td>
<td>2.6 (2.0, 3.3)</td>
<td>0.070</td>
</tr>
<tr>
<td>Post-2nd treatment</td>
<td></td>
<td>2.5 (1.4, 3.0)</td>
<td>0.026</td>
</tr>
<tr>
<td>Post-3rd treatment ($n = 16^a$)</td>
<td></td>
<td>2.5 (1.5, 3.2)</td>
<td>0.024</td>
</tr>
<tr>
<td>1-month follow-up ($n = 16^a$)</td>
<td></td>
<td>2.6 (1.5, 3.2)</td>
<td>0.326</td>
</tr>
<tr>
<td>2-month follow-up</td>
<td></td>
<td>2.6 (1.9, 3.0)</td>
<td>0.049</td>
</tr>
<tr>
<td>3-month follow-up</td>
<td></td>
<td>2.6 (1.5, 3.2)</td>
<td></td>
</tr>
</tbody>
</table>

$^a$Wilcoxon Signed Ranks Test.

$^b$One subject missed “Post-3rd treatment” follow up and one subject missed “1-month follow-up.”
the most circumferential reduction had a 5.5 cm improvement at her 3 month post-treatment follow-up. Caliper measurement showed statistically significant improvement at 2 weeks post-second treatment ($P = 0.013$), 2 weeks post-third treatment ($P = 0.070$), 1-month follow-up ($P = 0.024$), and 3-month follow-up ($P = 0.049$). The two methods of analysis correlated mostly, except at 3-month follow up when caliper reading was not significant. The control site was the right thigh and there was no difference between baseline and all follow-ups.

Vectra® volume analysis showed there was improvement in 37.5%, 35.3%, and 58.8% subjects at 1-, 2-, and 3-month follow-up, respectively (Table 2, Fig. 4).

The procedure was well-tolerated. No severe adverse effects occurred. There were six incidents of wheal formation after treatment all of which subsided spontaneously in a few hours. The mean pain score reported was 2.3 on the visual analogue scale. At all three post-treatment follow-ups, 6% of the subjects were not satisfied.

**DISCUSSION**

The use of focused ultrasound for the destruction of adipose tissue has been well established. It has been demonstrated that low frequency focused ultrasound causes mechanical destruction in subcutaneous adipose tissue. Cavitations were observed in porcine model and histology showed adipocyte lysis and loss of cell viability at the target depth of approximately 1.5 cm depth [4]. Non-thermal focused ultrasound has the advantage of minimal pain experienced during treatment. The mean pain score was 2.3 (out of 10) which correlate with previous studies [1,2].

Several uncontrolled unblended prospective studies for the effect of the first generation, that is, without radio-frequency, non-thermal focused ultrasound for body contouring showed positive results. Moreno-Moraga reported a 2.16 cm reduction in subcutaneous fat thickness and 4.15 cm reduction in abdominal circumference after 3 monthly treatments in a study with 10 subjects [2]. A trial with 25 subjects by Ascher, received three sessions biweekly noted a 3.58 cm reduction in abdominal circumference at 3 months follow up [5]. A multicenter study with 137 subjects in the experimental group reported a 2.3 cm circumferential reduction at 2 weeks post-treatment after a single treatment [6]. Our center carried out a trial in 2009 with the first generation low frequency focused ultrasound and showed no benefit in circumferential reduction [1]. The drop out rate was high with $n = 18$ at last follow-up compared to $n = 58$ at baseline. Recently, a trial in Taiwan using the combined focused ultrasound and radiofrequency device was published. Chang et al. reported a mean circumferential reduction of 3.91 cm in the 32 subjects [7]. Magnetic resonance imaging was used to assess the fat thickness reduction in two subjects and found an average of 21.4% and 25% reduction in the upper and lower abdomen, respectively. Although our result shows a statistically significant improvement, it is not as impressive as the previous published data. Regardless, from our clinical experience, non-invasive procedures are still favored even when the results are subtle. Patients are more willing to

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**TABLE 2. Vectra® Volume Analysis of the Treatment Area**

<table>
<thead>
<tr>
<th></th>
<th>Median (min, max)</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume of treatment area (ml)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>760.2 (242.5, 1804.0)</td>
<td></td>
</tr>
<tr>
<td>1-month follow-up ($n = 16$)</td>
<td>831.1 (262.8, 1994.3)</td>
<td>0.175</td>
</tr>
<tr>
<td>2-month follow-up</td>
<td>771.0 (256.3, 2201.7)</td>
<td>0.378</td>
</tr>
<tr>
<td>3-month follow-up</td>
<td>710.8 (243.3, 1932.8)</td>
<td>0.459</td>
</tr>
</tbody>
</table>

Wilcoxon Signed Ranks Test.

*One subject missed 1-month follow-up.

**Fig. 4.** Plain and 3D photographs showing Vectra® mapping analysis.
undergo non-invasive therapies and may opt for repeated treatments to achieve the desired outcome. Managing patient expectation is the key to patient satisfaction. In this study only one subject (6%) was not satisfied.

Low frequency focused ultrasound is a relatively safe procedure. To date, there are no serious adverse events reported. Known risks include pain, erythema, bruising, blistering, and erosion. Most cases resolve spontaneously. Our previous study reported a case of blistering and erosion at areas near the iliac crest [1]. The modified treatment method can minimize the risk of such incidents by gathering skin and fat with the reusable straps. It is included in the user guideline that areas near bony prominences should be avoided.

Compared to our previous study [1], this second generation device yielded better results. We believe several factors contributed to the improved efficacy including the addition of a radiofrequency applicator, raising the temperature of the adipose tissue and inducing apoptosis. It has been demonstrated that the apoptosis index increases after radiofrequency energy is applied to subcutaneous fat [8,9]. The upgraded software and interface avoids skipping treatment areas due to shifting of images during the procedure. We also aimed to maximize the treatment area as with the aid of the bandages, the procedure can be safely carried out.

CONCLUSION

In conclusion, the second generation focused ultrasound combined with radiofrequency treatment for body contouring showed statistically significant improvement. It was a comfortable procedure with no significant adverse effects. It is known that three-dimensional imaging has its limitations such as respiratory motion, alignment and posture [10]. Such issues are also encountered in radiological procedures such as magnetic resonance imaging. Despite of our best effort to standardize these factors, there are still artifacts.

REFERENCES