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Non-Invasive, External Ultrasonic Lipolysis

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Numerous nonsurgical techniques and devices have sought to reproduce the effectiveness of liposuction. Unfortunately, the vast majority of these has fallen short of adequate results or has been plagued with complications. UltraShape (UltraShape; Yoqneam, Israel) is a device that is able to accomplish the reduction of the subcutaneous fat with a procedure that is both comfortable and leads to good patient satisfaction. Its design of a nonthermal ultrasonic energy is able to produce cavitation leading to fat cell lysis while sparing adjacent blood vessels and nerves. Although the results are not equivalent to surgical results, this device will offer a safe and effective alternative for patients who are apprehensive about undergoing liposuction.
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Liposuction is the most commonly performed esthetic surgical procedure. Developed in Europe in the mid 1970s, it has become the gold standard for the reduction of localized fat deposits. When performed using the tumescent local anesthesia technique, liposuction is quite safe, and most patients are ambulatory within 24 hours.[1-3] Surveys of patient satisfaction indicate that people are usually pleased with the results.[4-5]

Despite the success of liposuction, there has been a great deal of research into nonsurgical devices that might replicate its benefits. This parallels the general trend toward more noninvasive procedures. Despite its potential benefits, many patients inherently do not want surgery. They would prefer a noninvasive method for fat reduction and body contouring that is effective, yet comfortable and safe, with minimal down time.

Mesotherapy, developed in France in 1952, has been promoted over the last decade as a method for reducing fat deposits.[6] This technique involves superficial injections of various medications into the "mesoderm." Most formulas contain phosphatidylcholine. This compound, which is extracted from the soya plant, contains 2 unsaturated fatty acids, linoleic acids, and α-linoleic acids. To be formulated into an injectable form, phosphatidylcholine requires a detergent solvent. The most common solvent used is deoxycholic acid (a gallic acid). Recent studies have indicated that, in fact, the deoxycholic acid may be the actual active ingredient in mesotherapy formulas responsible for reducing fat.[6-7] To date, the effectiveness of mesotherapy on body contouring is not widely supported. Unfortunately, mesotherapy has been plagued by complications including scars, cutaneous granulomas, folliculitis, mycobacterial infections, and ulcerations.[6,8-10] Results have also been unpredictable, leading to significant skin irregularities. More recently, Rotunda et al[7] work on sodium deoxycholate has been well received and suggests that this formulation may possibly be an effective method for reduction of submental fat.

A variety of mechanical devices have also been proposed for localized reduction of fat. None have been impressive, and currently most are viewed as "spa" techniques. Among these is ionithermie that consists of galvanic muscle-electrostimulation combined with algae, seaweed extracts, amino acids, and hops in a thermal clay occlusion. The minimal results reported may be due to temporary mechanical effects from the occlusion. Other mechanical devices include Endermologie (LPG Systems; Valence, France). This is a device that attempts to replicate the mechanical effect of deep tissue massage. This technique is applied to the outer thighs and may give temporary smoothing due to traumatic tissue swelling.[11]

Light based lipolysis includes diode "cold" lasers such as Zerona (Erchonia Medical; McKinney, TX). This 635-nm diode red laser theoretically works by inducing a photochemical cascade directed at adipose cells to cause a transitory pore

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in the fat cell membrane. Ex-vivo studies have showed 99% of the fat released from the adipose cells after treatment.[12] However, clinical results have not been very impressive to date. The manufacturer stresses the need for multiple treatments. Triactive (Cynosure; Westford, MA) combines 6 diode lasers with massage and cooling. Despite years of use, this device has not provided particularly reliable or impressive results. Velasmooth (Syneron Medical; Yoqneam, Israel) combines intense pulsed light, radiofrequency, and suction and is food and drug administration approved for the temporary reduction in the appearance of cellulite. The minimal results seem to be only temporary. Other radiofrequency instruments claiming to reduce fat include Tri-Pollar (Pollogen; Tel Aviv, Israel), Thermage (Solta Medical; Hayward, CA), and Cutera's still to be released adjustable depth selectivity device. So far, none of these instruments have been able to come anywhere near duplicating the excellent clinical results achievable with liposuction. In addition, these devices are not entirely without side effects. For instance, radiofrequency devices can cause burns, scars, and fat atrophy.[13,14]

An intriguing technology for localized reduction of fat is cryolipolysis. This technique involves precisely controlled energy extraction from fat tissue while protecting the dermis. This triggers apoptotic fat cell-death. In pig studies, cryolipolysis has been shown to produce lobular inflammatory infiltrates in the subcutaneous fat, with adipose reduction at 1 week, continuing for up to 2 months without skin damage.[15] Another study has shown 33% fat reduction measured by ultrasound.[16] Questions remain about the potential for sensory nerve injuries.[17]

Ultrasound has been proposed for fat reduction for many years. However, external ultrasound devices, usually based on physical therapy machines, have not proven successful in this regard. Because ultrasonic energy diminishes with the distance from the generator to the target, these nonfocused energy sources affect the skin more than underlying fat. Zocchi[18] pioneered internal ultrasonic devices that have been used in liposuction to directly destroy fat cells.[19] This technology continues to be used today, although internal ultrasonic liposuction has showed a tendency to produce increased complications, such as burns and skin irregularities, without a noticeable difference in results.[20,21] Meanwhile, the idea that a more focused form of ultrasonic energy might be effectively used externally has continued to simmer in the minds of scientists.

Sound waves can be divided into ultrasonic (above the audible range), infrasonic (below the audible range), and audible (20HC-20,000HC). Ultrasonic waves create compression cycles that exert positive pressure and expansion cycles that exert negative pressure. This pushing and pulling effect can lead to rupture of fat cells and eventually cavitation.[22] Focusing this ultrasonic energy into the deeper fat layers can lead to cavities in the fat and theoretically reduction of the overall thickness of the adipose layer.

Currently, there are 2 major external devices being studied that feature focused ultrasound. LipoSonix (Medicis; Scottsdale, AZ) uses high intensity focused ultrasound (HIFU). The transducer focuses to an adjustable subcutaneous depth leading to fat breakdown, macrophage engulfment of lipids and cell debris, and eventually reduced adipose volume. HIFU is used successfully in prostate and other cancer treatments.[23,24] It heats and destroys tissue rapidly and is usually guided by magnetic resonance imaging (MRI) or ultrasound. There is reportedly a 70°C increase in temperature within focal volume during LipoSonix treatments. The energy is focused geometrically, using a lens, or electronically to produce cavitation and heat. Specific claimed advantages of LipoSonix's technology are that it is a highly mobile system based on noninvasive energy delivery. It features adjustable energy and depth settings and a pattern generator for efficient delivery of the pulses. It takes approximately 30-60 minutes to treat an entire abdomen with this device. Side effects have been reported to include significant discomfort during treatment and ecchymoses, perhaps because of the generated heat and its effect on the surrounding nerves and connective tissue.

UltraShape was the first focused ultrasonic device to show noninvasive selective fat cell destruction. The manufacturer, UltraShape, Inc (Yoqneam, Israel), received a CE mark in July 2005 and a health Canada Medical Device license in May 2007 for its Contour I device.[25] The company initiated a US investigational device exemption (IDE) clinical study in August 2008. To date, it is in clinical use in 57 countries, and

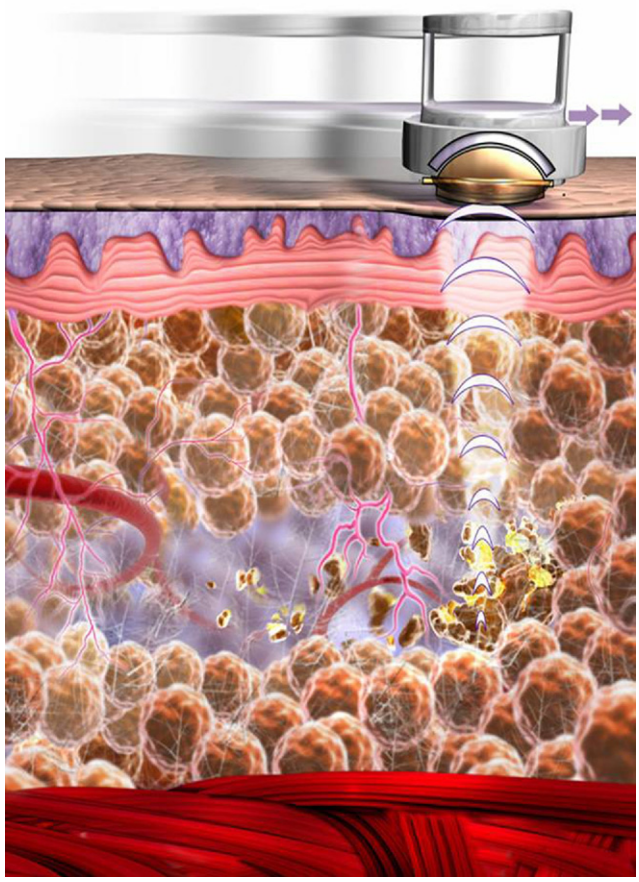

Figure 1 Ultrasound induced cavitation of subcutaneous fat causing fat cell destruction while sparing blood vessels and nerve structures. Courtesy of UltraShape, Inc.

Figure 2 UltraShape device depicting the display and transducer being applied to a patient. Courtesy of UltraShape, Inc.

over 100,000 patient treatments have been performed with an excellent safety profile.

UltraShape features focused ultrasonic energy at a controlled depth using a nonthermal pulsed wave (Fig. 1).[22,26] This is in contrast to LipoSonix that has an adjustable depth and produces heat.[27] The mechanical acoustic effects of UltraShape cause selective fat cell disruption without injury to skin, vessels, nerves, or connective tissue.[22,28] The device relies on a real time tracking and guidance system that allows treatment only within marked treatment areas and assures that each point is treated only once. This tracking system protects against the possibility of overtreatment and insures a uniform coverage of the treatment area. Studies to date indicate a low risk of irregularities.[22,26,28] The manufacturer released its third generation device in September 2008 featuring faster treatments with a 1 second pulse duration. This has provided a 35% reduction in treatment time, so that a typical abdomen would take less than 1 hour to complete. The improved transducer, which contains 36,000 pulses, has also lowered the cost of consumables by 1 of 3.

The Ultrashape Contour I system console houses a power unit, an ultrasound generator, a cooling system, and a computer that orchestrates the overall performance of the system. The stand also contains an illumination system with an integrated video camera, a tracking and guidance system, a system display screen, and a control panel (Fig. 2). The transducer is easy to handle and contains an acoustic feedback mechanism that verifies optimal contact during treatment. It also features temperature sensors. The real time tracking and guiding system relies on a patented mapping algorithm to be certain that each area is treated and treated only once. It guides the operator throughout the treatment signaling the next node to be treated.

The Ultrashape procedure consists of 3 treatments, 2 weeks apart. No anesthesia is required. Most patients are comfortable during the procedure, although they may occasionally complain of modest discomfort. There is no down time, no girdles, and essentially no recovery.[26,28] Ultrashape has been used to treat the abdomen, flanks, and thighs. It has showed success in reducing localized fat deposits, decreasing body circumference, and improving shape and contour.[26,28] Ultrashape has not been studied for the neck or chest areas.

In-vivo porcine studies have showed that Ultrashape achieves fat destruction well below the dermis, consisting of multiple small pores.[22] Histologically, this is confirmed by evidence of fat cell lysis surrounded by intact blood vessels and nerves.[22] In addition, the cell layer that was damaged by focused ultrasound was shown through gross examination and nitroblue tetrazolium chloride staining to be well below the dermis.[22]

After disruption of the fat cells, the contents, primarily triglycerides, are dispersed into interstitial space and then transported through the vascular lymphatic system to the liver. These triglycerides are theoretically absorbed slowly and then metabolized by endogenous lipases to glycerol and free fatty acids. The fatty acids are transported to the liver where they are processed like any other fatty acids. Unmetabolized triglycerides are bound to carrier proteins, or lipoprotein complexes, to become part of the total li-

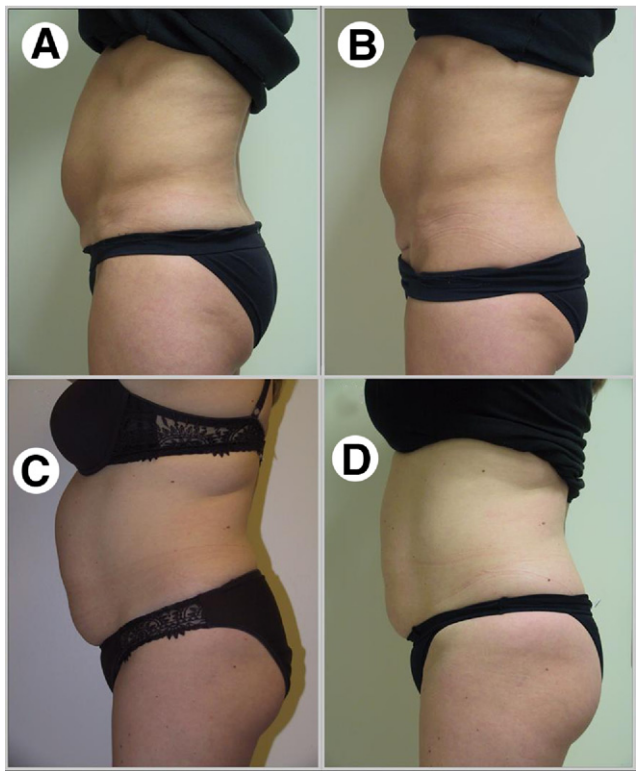

Figure 3 (A) Patient before treatment with UltraShape. (B) Patient A after 3 treatments with UltraShape with a 5.5 cm circumferential reduction. (C) Patient before treatment with UltraShape (D) Patient C after 3 treatments with UltraShape with a 5.4 cm circumferential reduction. Patients treated by Arie Benchetrit, MD.

poprotein pool. To date, there have been no abnormal changes in serum lipids detected in clinical studies of Ultrashape.

The Ultrashape device is not recommended for use over boney areas. Skip nodes can be programmed for these sites. Treatment should also be avoided over tattoos, pigmented lesions, and depressed scars to avoid unpredictable acoustic effects. There are no post treatment recommendations after Ultrashape. Patients can resume daily activities. As with liposuction, those who adhere to a healthier lifestyle of proper nutrition and exercise will likely achieve better results. Current clinical guidelines recommend that patients maintain a negative caloric intake for 4 days after Ultrashape treatment to ensure that the fat released because of the treatment is rapidly metabolized.

Several clinical studies have confirmed the effectiveness of Ultrashape. Teitelbaum et al[26] demonstrated an average waist circumference reduction of 2 cm using a single treatment on 164 patients. Moreno-Moraga et al[28] reported a 3.95 cm average waist circumference reduction in 30 patients. Several not yet published studies have reported similar findings. Representative pre- and post-procedure results can be seen in Figure 3.

The US IDE clinical study of Ultrashape is complete, but the results have not been publicly reported to date. This was a multicenter clinical trial involving 6 sites, 3 of whom were plastic surgeons and 3 dermatologic surgeons. The clinical trial involved the newest generation transducer with reduced pulse duration. One hundred twenty-five patients were treated, including sham groups, using 3 treatments, 2 weeks apart, on the abdomen. All patients were evaluated with pre- and post treatment MRI's and monitored by laboratory work including complete lipid profiles. Patients were also documented using a standardized photographic protocol. Independent and blinded evaluators assessed the results of the MRI's and photography. The primary end point of the Ultrashape US IDE clinical study was MRI measurement of fat thickness reduction. At the time this article was submitted for publication, the study is not formally closed and the data are still being analyzed.

Ultrashape appears to be a promising technology for localized reduction of fat. It primarily differs from the LipoSonix HIFU technology by causing mechanical disruption and cavitation of the fat as opposed to HIFU's thermal effect and necrosis.[22] Ultrashape shows no increase in temperature as opposed to a reported 70°C increase in temperature within focal volume during LipoSonix treatments. The degree of discomfort during treatment also appears to be greater with Liposonix than with UltraShape, perhaps because of the generated heat and its effect on the surrounding nerves and connective tissue. While clinical and histologic evidence seem to show sparing of the blood vessels during UltraShape treatments, this may not be the case with Liposonix where the appearance of post–treatment ecchymoses is apparently common. Ultrashape provides a comfortable procedure with no downtime and a high patient satisfaction rate. If this technology is approved for use in the USA, it promises to become quite popular.

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