

Principles of Ultrasound for Body Contouring: The VASER® System

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Background

Ultrasonic energy has been used for years in a wide array of medical applications - from dentistry to neurosurgery. The introduction of ultrasonic instrumentation for body contouring began in the late 1980s and early 1990s. Researchers began developing the VASER (Vibration Amplification of Sound Energy at Resonance) System in the late 1990s in response to the limitations of traditional liposuction and other energy-based technologies. The VASER System was designed to advance liposuction procedures by improving safety and efficiency, reducing complications and physician fatigue, and allowing for faster patient recovery.

The VASER Lipo System is a minimally invasive body contouring technology that employs mechanical and acoustic forces to emulsify fat within a targeted area, while preserving other important tissue structures. These fat deposits are then removed from the body using proprietary, atraumatic aspiration cannulas, called VentX®, that maximize procedure speed and efficiency while reducing trauma to the surrounding tissue. Although the technology has been available since 2002, new data has shed light on the mechanism of action responsible for the VASER ultrasound effect. This paper discusses the basic principles of ultrasonic energy and how that energy is applied to create an ideal system for efficient fat fragmentation with minimal tissue damage and preservation of fat cell viability.

Basic Ultrasound Terminology and Application

A form of mechanical energy, sound is a vibration or pressure wave that travels through media. Sound travels in waves of higher and lower pressure. The high pressure (compression) and low pressure (rarefaction) regions alternate as the wave travels. Compression causes particles to be pushed closer together, while rarefaction pulls the particles away from one another. This causes the individual particles to vibrate back and forth in place. The amplitude of the wave equals the maximum value of compression and rarefaction (Figure 1). This amplitude can be controlled on the VASER Lipo System for specific body contouring applications.

Sound waves are characterized by their frequency, or the number of times the pressure wave oscillates back and forth per second. The unit of measure is a Hertz (Hz), which is the number of cycles per second. Ultrasound waves are sound waves that vibrate at frequencies greater than what can be detected by human hearing (about 18 kHz and higher.) The VASER System vibrates at a frequency of 36 kHz (36,000 cycles per second).

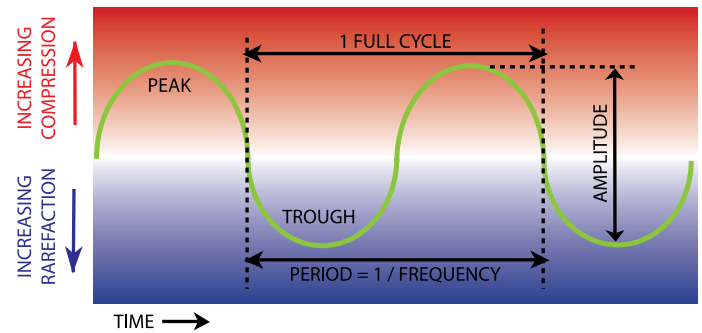


Figure 1: Ultrasonic wave compression and rarefaction cycle

VASER Fragmentation Handpiece and Probes

The VASER Lipo ultrasonic handpiece (Figure 2) converts electrical energy supplied by the VASER ultrasonic amplifier into vibratory energy. As the electrical energy is applied, the handpiece transducer expands and contracts to create longitudinal compression waves. The waves travel down the probe and are reflected back at the tip. The reflection pattern between the two waves produces a "standing wave" that causes specific regions of the probe to have nearly no motion (nodes) and other regions to have the highest motion (anti-nodes). The tip is an anti-node and has the highest level of longitudinal (forward and backward) vibration.

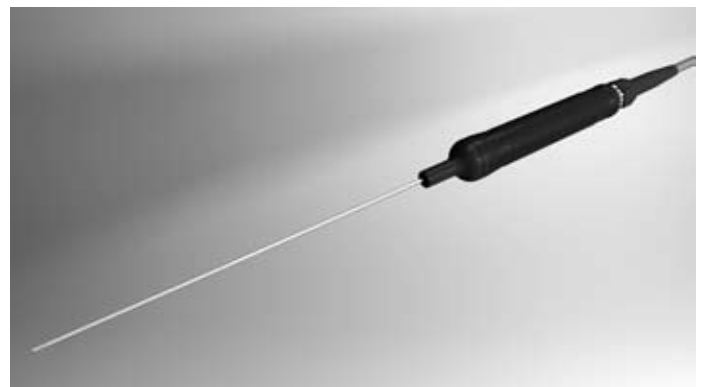


Figure 2: VASER Fragmentation Handpiece and Probe

Principles of Ultrasound for Body Contouring

The forward and backward motion of the probe tip creates a spherically expanding wave of ultrasound energy. As the probe tip moves forward, it compresses the surrounding region. As the probe tip moves backward, rarefaction occurs. The tip excursion is typically about 100 microns and the amplitude of the acoustic field is directly related to this excursion. In other words, the greater the probe tip excursion, the greater the amplitude of the acoustic field. The tip excursion is controlled by the front panel setting on the VASER amplifier.

Fat Morphology

Individual fat cells are contained within larger groups of cells that comprise fatty tissue. Fat cells are part of fat lobules, which are part of fat pearls, which are contained within fat sections, which are within fat compartments. Since fat cells have the ability to change dramatically in size (from 20 to over 200 microns in diameter as a person gains weight), they are bound together relatively loosely compared to muscle, fascia, nerves and blood vessel cells. During body contouring with VASER Lipo, a tumescent fluid is infused throughout the targeted fatty tissue area. The tumescent fluid naturally contains small gas bubbles on the order of 5 to 10 microns. As the fluid is

infused, the microbubbles become dispersed throughout the tissue matrix. Due to the relatively loose packing of the fatty tissue, the tumescent fluid surrounds the fat cells, allowing the gas bubbles to infiltrate between individual cells. In contrast, the tight junctions between cells within blood vessel walls and connective tissues prevent gas bubbles from interspersing among and affecting these tissues.

Ultrasound Effects

The VASER Lipo System delivers ultrasound pressure waves, or alternating regions of higher and lower pressure, at 36 kHz via a titanium probe. These waves produce a push/pull force on the dispersed gas microbubbles. As the pressure wave pulls on the microbubbles, they expand, increasing their surface area and allowing additional gas dissolved in the fluid to enter by diffusion. The pressure wave next pushes on the bubble, compressing it and causing some of the gas in the bubble to diffuse back out. Since the bubble is smaller when compressed by the pressure wave, less gas diffuses out during compression than diffuses in when the bubble is under tension. Thus, with the passage of every ultrasound wave, there is an overall net increase in the volume of the gas bubble (Figure 3). This results

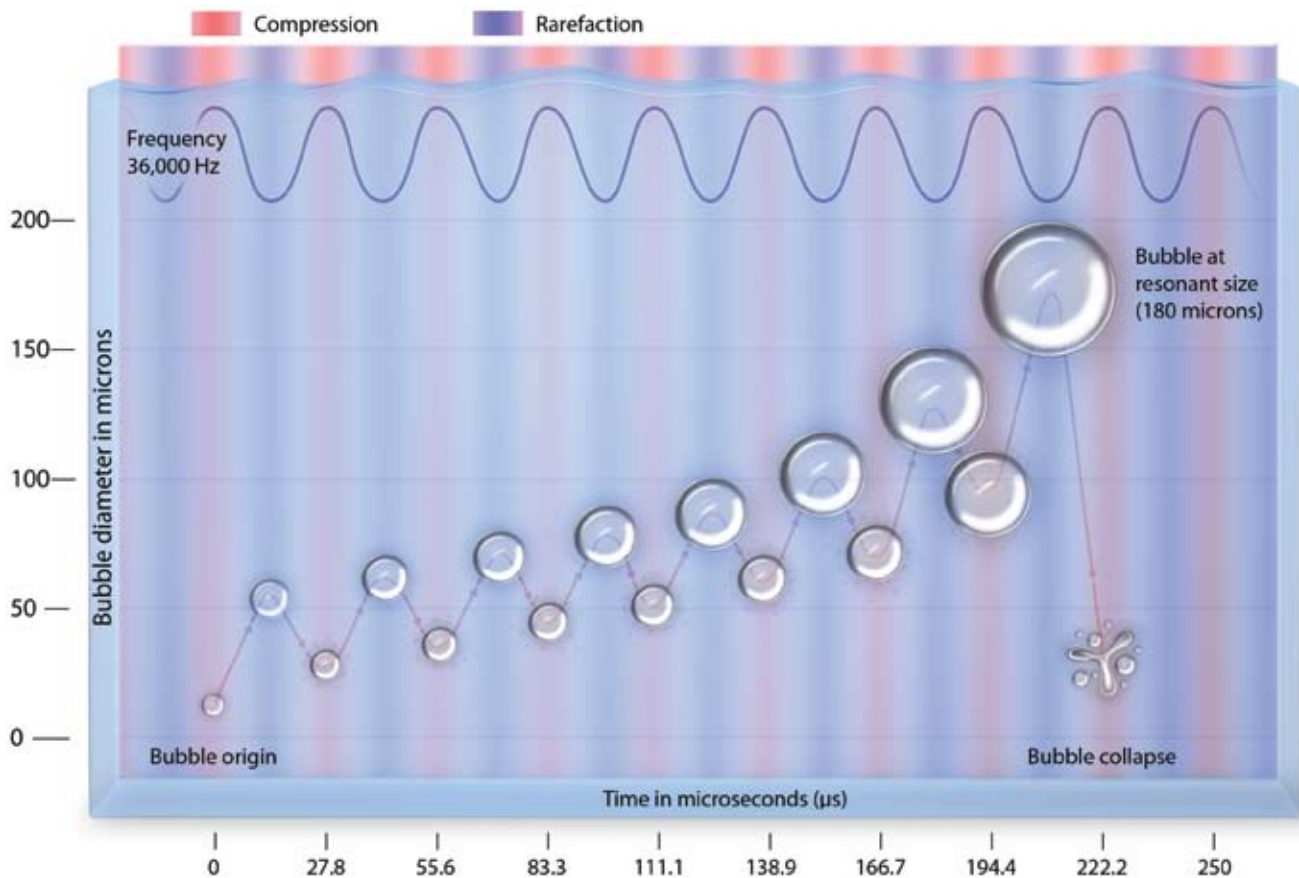


Figure 3: Growth of microbubbles in infusion fluid via compression and rarefaction

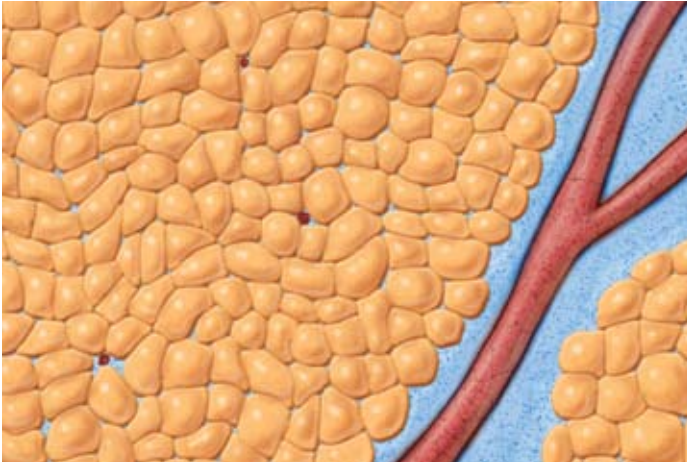


Figure 4: Fat cells surrounded by infusion fluid

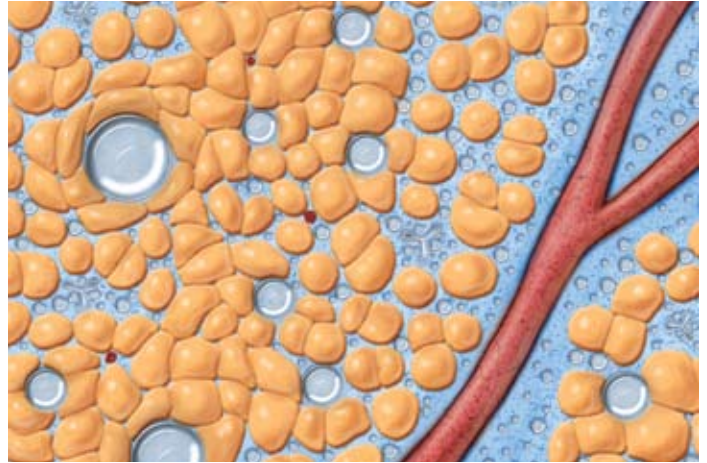


Figure 5: Fat cells being dislodged via stable cavitation

in the microbubbles rapidly expanding from 5 to 10 microns to approximately 180 microns, allowing the bubbles to act as wedges between the fat cells, dislodging the cells from the adipose matrix (Figures 4 & 5). Once the bubbles reach their resonant size, they implode, pulling on and further loosening the fat tissue matrix. The progression then starts over again.

This process of gas bubble action is called stable cavitation. Since adipose cells contain no gas, ultrasound energy does

not cavitate adipose cells. Also, since the bubbles cannot intersperse between the cells of blood vessels, nerves, and other similar tissues, the bubble-mediated cavitation action only acts to dislodge the adipose cells, leaving the other tissues unaffected. This is the source of the natural tissue selectivity of VASER technology. As the fat cells are displaced, they are mixed with the tumescent fluid by a process called acoustic streaming, resulting in a complete emulsion of the fat cells, which are subsequently aspirated (Figure 6).

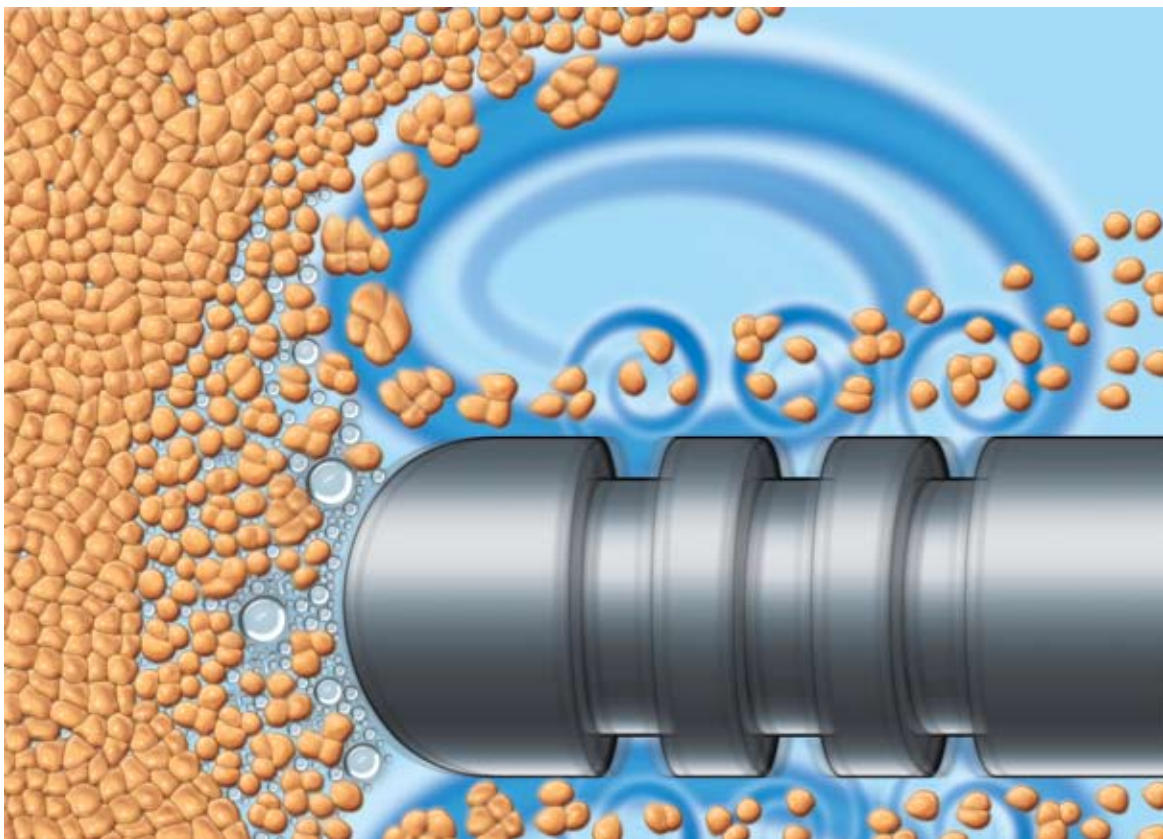


Figure 6: Acoustic streaming

Summary

The use of VASER ultrasonic energy for body contouring has several benefits, including tissue specificity, limited blood loss and patient discomfort, smooth skin retraction, and preservation of fat cell viability. Since individual fat cells remain intact, fat collected during the VASER Lipo procedure may be harvested for autologous fat transfer (AFT). The fat aspirated during VASER Lipo is refined down to small lipocyte packets comprised of 2 to 3 fat cells, which supports growth and vascularization upon reinjection. This is in contrast to the fat aspirated during other liposuction procedures, which may be harvested in large cell packets approximately 50 cells in diameter. These large cell clusters are associated with high rates of cell disruption from shear forces during reinjection, and necrosis at the core after reimplantation due to inadequate blood supply. VASER Lipo utilizes acoustic forces to safely dislodge fat cells while protecting surrounding tissues, ultimately producing a clean, smooth aspirate with excellent cell viability.

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Dr. Schafer is an internationally recognized expert in ultrasonic technology, with over 25 years of design and development experience. He is currently Vice President of the Ultrasonic Industry Association (UIA), Chairman of the National Electrical Manufacturers Association (NEMA) Ultrasound Technical Committee, and serves on the Board of Governors of the American Institute of Ultrasound in Medicine (AIUM). Dr. Schafer holds a Ph.D. in Biomedical Engineering from Drexel University, an M.S. in Acoustics from Pennsylvania State University and a B.S. in Electrical Engineering from the Massachusetts Institute of Technology. He has been published over 40 times and has been issued 13 patents.