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Sculpting the Human Body with VASER Ultrasound-Assisted Liposuction

Abstract—Traditional liposuction methods often involved direct mechanical cutting of the fat or forced suction, which resulted in significant blood loss, pain, and long recovery time. As a response, engineers have invented a new technique called VASER (vibration amplification of sound energy at resonance) ultrasound-assisted liposuction, a fairly recent innovation that is a safer and more effective alternative to the traditional methods of liposuction. Controlled high-powered ultrasonic waves help destroy the subcutaneous fat cells without damaging the surrounding skin, nerves, or muscles. The emulsification containing the fat cells and a tumescent anesthetic solution is then suctioned away to be disposed or deposited in other areas of the body that desire volume. The effectiveness and increased safety of the procedure bring patients and surgeons a superior method of plastic surgery.

Key words/tags: health, medicine, biomedical engineering

Multimedia suggestions: Use a flash animation depicting the cavitation effect inside the fat cells due to an ultrasonic wave, breaking down the fat lobules.

About the author: Taewoo Kim was a sophomore majoring in chemical engineering at USC. He was interested in health and fitness as a hobby, often working out at the gym and practicing acrobatics with friends. As a result, he was interested in innovative ways of weight management in search of a healthier and stronger lifestyle.

Introduction

In 1926, a French surgeon Charles Dujarier performed the first recorded liposuction surgery on a young model who wanted to improve the looks of her legs. The operation was “a disaster” which cost the leg and the future of plastic surgery in France for years to follow [1]. Since then, plastic surgeons continued to develop safer and effective techniques of removing fat to contour the body. The dramatic increase in safety and the effectiveness of the procedure now makes the practice more refined and widely accepted, making liposuction one of the most performed cosmetic surgical procedure in the world [2]. One product of such innovative engineering in is the ultrasound-assisted liposuction technique, which utilizes ultrasonic waves to emulsify fat cells.

Ultrasound-assisted liposuction (UAL) was developed fairly recently with mixed results;

Frequent complications occurred due to the damage to the surrounding tissues from the energy of the waves [3]. In 2001, Sound Surgical Technologies LLC developed and introduced a modified version of the UAL called VASER (vibration amplification of sound energy at resonance) liposuction in response to this problem. This technique releases ultrasonic waves in pulses to precisely deliver energy in smaller amounts than traditional UAL. Still, the use of ultrasound in emulsification of fat for easy removal remains the core concept behind the procedure.

Science

Like all sound waves, ultrasound is a wave of alternating high and low pressure transmitted through a medium. In ultrasound-assisted liposuction, lipolysis (breakdown of lipids such as fat) happens mechanically in what is called the cavitation effect. Ultrasonic waves induce cavitation inside cells the way it is used to kill harmful microorganisms in food products; With high-power ultrasound waves above 10 Watts/square centimeter are used in liquid, the alternating high and low pressure as seen in Fig. 1 causes small vacuum bubbles inside the liquid (i.e. cytoplasm of the cells) [4]. For example, when a part of liquid goes through a rapid change from high to low pressure, a limited amount of liquid in that part expands and a vacuum bubble forms. Immediately afterward, the change from low to high pressure causes the bubble to violently collapse, or implode, causing mechanical disturbance. This continuous formation and implosion of vacuum bubble often induce chemical or physical changes in the medium.

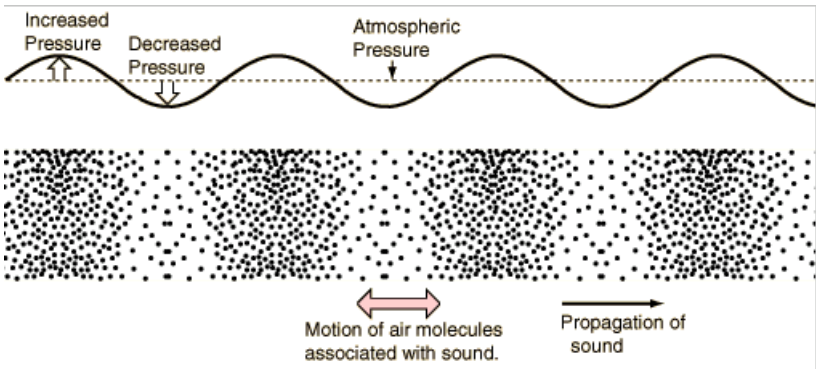

Figure 1: The alternating high and low pressure of a sound wave. Hyperphysics/Georgia State University.

When ultrasonic waves are applied to fatty tissues, the same cavitation effect is induced in tumescent liquid, a dilute anesthetic solution that is injected in the tissues prior to application of ultrasound. Because of the ability of fat cells to dynamically change in size in response to changing body mass—ranging from 20 to 200 micrometers in diameter—the cells are only loosely held together in bundles called fat lobules. The mechanical action of the bubbles inside the tumescent solution forming and imploding inside the lobules as seen in Fig. 2 causes the fat cells to disconnect and scatter, breaking down into smaller droplets. The fat cells are then further broken down by mixing with the tumescent liquid. Other types of cells such as blood, muscles and nerves are too dense for the liquid bubbles to infiltrate, isolating fat cells to be affected by the ultrasonic wave and consequently form an emulsion with the tumescent solution [5].

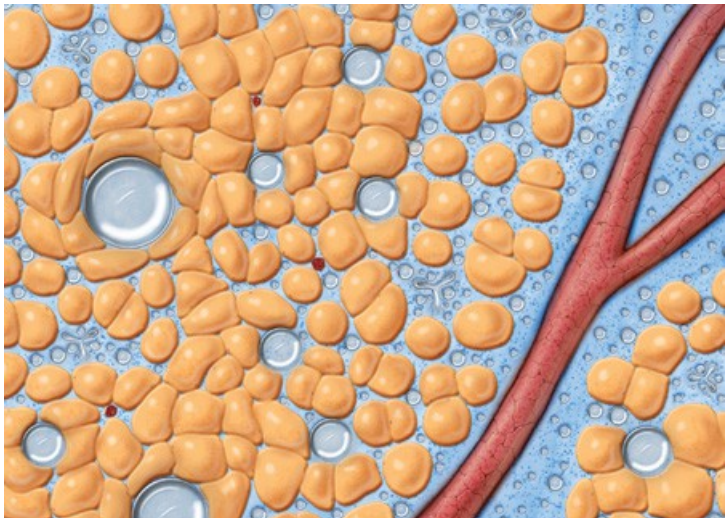

Figure 2: The bubbles inside the tumescent liquid is expanded then collapsed by the ultrasonic waves, causing cavitation. © *Sound Surgical Technologies, Inc.*

Application

In a VASER liposuction, as explained above, a tumescent anesthesia solution is injected until the area becomes swollen, or tumescent, adding small air bubbles between fat tissues to facilitate cavitation. Then a small probe of 2.2 to 4.5 mm, depending on the amount of fat and area of application, is inserted under the skin and a set amount of energy via ultrasound—at about ten burst per second—is focused on the subcutaneous local fat [6]. The resulting emulsion of broken fat cells and the tumescent solution is then suctioned through a small cannula, a hollow medical tube that can be inserted into the body, as the surgeon moves it back and forth under the skin as showin in Fig. 3. This process removes undesired fat tissues without harming the surrounding tissues.

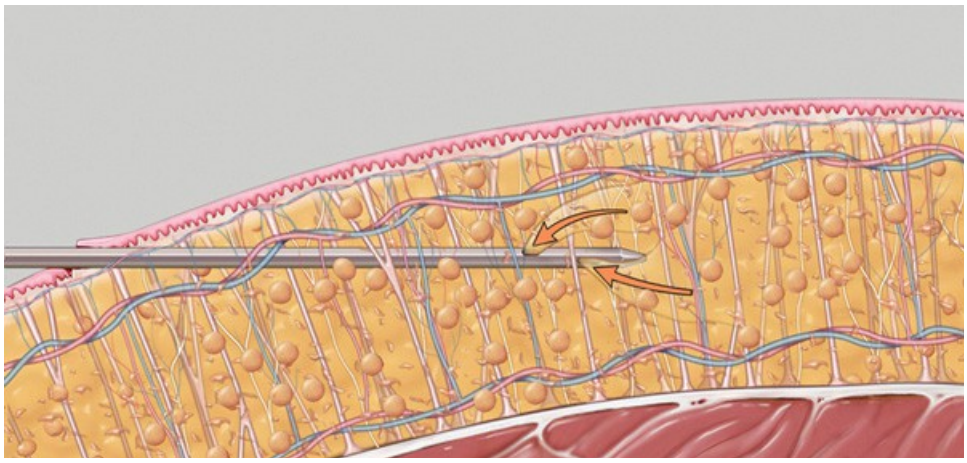

Figure 3: The emulsified fat cells are suctioned through a cannula. © *Sound Surgical Technologies, Inc.*

The emulsified fat in solution then can be re-injected to other areas of the body if desired. This additional contouring of the body by adding volume is a process called high definition lipoplasty; A skilled surgeon can inject fat in a way that essentially resemble "sculpt" the body in high detail. Also, the emulsified fat cells in solution are small enough that when re-injected to another area of the same patient, they can re-organize into stable, healthy fat lobules. Researchers found the fat cells extracted from a VASER ultrasound-assisted liposuction to be functional and metabolically active, possessing about 85% viability [7].

Effectiveness

VASER ultrasound-assisted liposuction, when compared to the earlier methods of liposuction, offers several important benefits regarding performance and safety. The problem with traditional methods of liposuction, which often involve direct mechanical cutting of fat to be suctioned, is the excessive loss of blood and other surrounding tissues such as muscles and nerves that gets caught up and suctioned. Ultrasound-assisted liposuction was developed in order to target only the undesired fat cells for destruction and removal. Additionally, VASER method was invented to avoid damage from the ultrasound itself. According to a comprehensive study of the method, researchers found that compared to the conventional suction-assisted method, VASER ultrasound-assisted method resulted in 26% less

blood loss and 53% statistically significant improvement in skin retraction [8]. When combined with tumescent anesthesia, the procedure can be performed in an office setting and is painless and requires little recovery period and no hospitalization. As mentioned, VASER method also allows use of the extracted fat in additional plastic surgery in body contouring. This is a feature unique to the VASER ultrasound-assisted liposuction that can widen the possibilities of plastic surgery.

Future

Since 1997, the number of liposuction performed in the United States alone has doubled up to over 300,000 in 2012 [9]. The technique of liposuction will continue to improve. For example, some companies are innovating a new technique of ultrasound lipolysis that does not require surgery, breaking down fatty tissues from above the skin and relying on the natural removal of the fat inside the body via lymph system and the liver. As liposuction becomes more common and less intrusive, the obesity epidemic in many developed countries such as the United States will become a non-issue and reduce overall medical costs in the long run in related health issues such as the type 2 diabetes and cardiovascular diseases. At the same time, allowing patients to attain the body that they desire will help achieve a better psychological health. By improving body image, UAL will also further help cure depression as well as obesity, both of which plague many modern societies.

Conclusion

In conclusion, Ultrasound-assisted liposuction technology is a result of an innovative engineering that utilizes physics of ultrasound waves to liquefy and remove fat. Reduced recovery time, minimal blood loss and pain, and effective results means that a successful surgery is able to bring only benefits without interfering with the daily lives of the patients; With the help of a surgeon, one can easily take control of their body in an unconventional way that yields far more immediate results than simple diet and exercise. Changes to eating and exercising habits along with the surgery are still

necessary, however, to insure maximum results from the operation [10]. This procedure will allow those who are dissatisfied with their body will be able to easily restore their self-image and confidence, and to take control of their life towards a healthier lifestyle. VASER ultrasound-assisted liposuction is a significant achievement of modern medicine and biomedical engineering that brings a superior alternative to the traditional methods of plastic surgery.

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