

Ultrasound Technologies for Dermatologic Applications

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Acoustics, the science of sound, originated in the 6th century B.C. with Pythagoras, who detailed the mathematical properties of stringed instruments. Ultrasound is an oscillating sound pressure wave with a frequency that exceeds the upper limit of human hearing, with frequencies above 20 kHz. Applications of ultrasound devices include sonar, imaging, sonication, and biomedical applications, so-called therapeutic ultrasound. A variety of ultrasound technologies are being developed for dermatologic applications, a testament to our field pioneering new methods of device development.

High intensity focused ultrasound (HIFU), also called focused ultrasound surgery (FUS), usually employs frequencies of 250-2000 kHz and has been used to ablate tumors or other tissue. The first ultrasound technology to be approved for aesthetic use, it thermally injures or ablates tissue in a conical distribution up to 4 mm beneath the skin surface. HIFU achieved FDA clearance to lift the eyebrow in 2009, to lift lax submental and neck tissue in 2012, and most recently to improve lines and wrinkles of the decollete (Ulthera, Ulthera Inc, Mesa, AZ).[1,2] HIFU was FDA cleared in 2011 for reducing waist circumference (Liposonix, Solta Medical Inc, Hayward, CA).[3,4] Another ultrasound approach is the use of pulsed nonthermal focused ultrasound. This technology was FDA approved in 2014 for the reduction of abdominal circumference via fat cell destruction (UltraShape, Syneron Inc, Irvine, CA).[5] In contrast to HIFU, which causes thermal damage, pulsed focused ultrasound induces a mechanical effect to destroy fat cells without thermal damage but through cavitation.[1] The advantage to the latter is the sparing of surrounding tissues or organs from thermal damage. The latest ultrasound technology submitted for approval is a high frequency (3 MHz) and low frequency (36-39 kHz) device (Triactive Plus, DEKA Lasers, Calenzano, Italy). The high frequency unfocused ultrasound penetrates to 3 cm deep, whereas the larger spot size of the low frequency handpiece penetrates up to 5 cm.[7,8] The mechanism of action involves cavitation effects, characterized by compression and expansion by the acoustic pressure waves, resulting in microbubble generation and their subsequent rupture. This latest system is being investigated for approval in body contouring (MAA, study in progress). A novel application of ultrasound is in facilitating trans-epidermal delivery of topical agents. A novel acoustic pressure wave technology (Impact, Alma Lasers, Buffalo Gove, IL) is applied following topical application of drug or cosmetic agents, which augments penetration of drug or agent into the skin.[9] Finally, a novel ultrasound technology still under development involves the combination of focused and non-focused, cavitation-based ultrasound in one device to maximize lipolysis and contouring (Accent Ultra, Alma Lasers, Buffalo Grove, IL).[10]

While it has taken over a decade for ultrasound technologies to achieve safety, efficacy, and FDA approval, they have opened up the development of a new generation of therapeutic tools in dermatology.

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