Tissue Restructuring by Energy-Based Surgical Tools

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KEYWORDS

• Tissue restructuring • Energy devices • Noninvasive cosmetic surgery • Radiofrequency • Ultrasound

KEY POINTS

- Advancements in surgical techniques have to the development of many noninvasive concepts or incorporation of existing concepts into plastic surgery armamentarium; stem cells-based therapies, mesotherapy, and energy-based surgical tools such as ultrasonic, radiofrequencies, lasers, cryogenic, hydromechanical, microwave technologies are among the newest developments.
- Clinical outcomes following noninvasive procedures with energy-based devices tend to be much more subtle than those following invasive surgical procedures.
- As with any medical procedure, noninvasive procedures carry some degree of risk of adverse effects as those resulting from non-uniform healing after application of ultrasonic energy, lasers or radiofrequencies in addition to trivial problems such as transient edema, skin erythema, bruises.

OVERVIEW

Various oils, creams, and lotions have been used for skin-quality maintenance and beautification over the centuries. However, the quest for the preservation of youth and beauty has evolved with the introduction of invasive cosmetic plastic surgery procedures, which have been developed and popularized since the beginning of the last century. During the last 2 decades, advancements in surgical techniques have paralleled advancements in dermatologic sciences, leading to the development of many noninvasive concepts (eg, stem cells–based therapies, mesotherapy) and modalities (eg, lasers) and providing new tools for cosmetic surgery and medicine. Energy-based surgical tools, including ultrasonic, radiofrequency (RF), cryogenic, hydromechanical, and microwave technologies with the capability of tissue cutting, sealing, or restructuring, complement these medical concepts well by allowing noninvasive, non–open-access interventions. Energy-based noninvasive surgical tools can be used for ablative bio-stimulation (eg, collagen production) or tissue restructuring functions (eg, tightening or lifting) and they are the subject of this review. Experience with a laser-therapy device for body contouring (1440 nm wavelength laser for soft tissue sculpting), as an example of laser-based technology applied to body contouring, is reviewed in another article of this issue. Additionally, because the focus of this article is tissue restructuring and its applications in aesthetic surgery, hydromechanical tools (eg, water-jet technology used to cut and emulsify soft tissue) are not featured.

THERAPEUTIC OPTIONS

In general, the application of noninvasive energy-based devices for tissue restructuring can lead to results that are less dramatic than those from surgical procedures.[1–4] However, patients find value in the reduced amount of downtime needed to

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recover from noninvasive procedures by energy-based devices. For this reason, the noninvasive energy-based technologies have become popular, even when treatments must be repeated to achieve an optimal result or when approximating the result of an invasive procedure.

The typical 2 tissue-restructuring objectives for currently available energy-based devices are

1. Two-dimensional tissue shrinkage resulting in tissue lifting and/or firming
2. Volume-reducing and body-contouring techniques

Both objectives have energy-based technologies with modalities that are based on controlled thermal damage to the tissue. Therapeutic options for the most common conditions are depicted in **Table 1**. Ultrasound (US), RF, cryolipolysis, laser-assisted therapies, and even soft radiation have found an application in these objectives.

US-BASED DEVICES

US-based devices generate a US beam, which can be focused to a predetermined depth of penetration and placement of energy. After passing innocuously through the skin (or superficial skin layers), focused US waves reach a focal point where alternating waves of compression and rarefaction rapidly heat tissue (ie, thermal coagulation) or mechanically disrupt the target tissue via cavitation. Depending on which tissues are targeted and the degree of tissue disruption, focused US can be used for different purposes. These purposes include the lifting and tightening of the skin and skin-adjacent tissues (ie, microfocused US [MFUS]) or body contouring (ie, high-intensity focused US [HIFUS]).[2–4]

MFUS

MFUS therapy uses US energy (in a low megahertz range) to noninvasively firm, tighten, and shrink the dermis and subdermal tissues producing a lift of soft tissues. There is currently only one commercially available MFUS device approved by the Food and Drug Administration (FDA) (the Ulthera System; Ulthera, Inc, Mesa, Arizona), with another recently available in the Korean market (Doublo System; Hironic Co LTD, Korea), which integrate real-time US imaging with focused US energy. This integration allows the clinician to target the desired treatment depth for the precise delivery of energy below the surface of the skin without affecting the intervening tissues. Multiple removable transducers offer a choice of depths for MFUS penetration (**Fig. 1**). In general, higher-frequency transducers are used for a more superficial tissue effect compared with lower-frequency transducers. For example, a 4-MHz transducer is characterized by a 4.5-mm depth (appropriate for deep dermis or SMAS treatment in facial areas) and a 7-MHz transducer is characterized by a 3.0-mm depth.[3,4] Unlike in focused US ablation therapies (eg, for tumors), which interlace coagulative sonication zones to ensure complete tumor ablation, cosmetic MFUS applications involve

Table 1
Energy-based devices for tissue restructuring: therapeutic options

Technology	Source of Energy	Wavelength or Other Physical Parameter	Tissue Target	Indication
Low-level laser therapy	Red light or near infrared	600–1000 nm	Subcutaneous fat, within a few millimeters range	Desire for focal, noninvasive fat reduction
MFUS	Ultrasound	4–10 MHz	Dermis, SMAS, frontalis, platysma muscles	Excessive skin laxity, need for skin tightening, forehead, brow ptosis
RF	Electromagnetic waves	300 MHz to 3 KHz	Dermis	Excessive skin laxity, mild skin wrinkling
Cryolipolysis	Thermoelectric cooling systems, cold air, contact cold gel panels	−3°C to 7°C	Subcutaneous fat, probably within a few millimeters range	Superficial subcutaneous fat collections, mild tissue ptosis (eg, jowls)
HIFUS	Ultrasound	2 MHz	Subcutaneous fat, up to 30-mm range	Superficial and intermediate fat deposits

Abbreviations: HIFUS, high-intensity focused ultrasound; MFUS, microfocused ultrasound.