Update on Noninvasive Body Contouring Techniques

Alexandra K. Rzepecki, BA; Aaron S. Farberg, MD; Peter W. Hashim, MD; Gary Goldenberg, MD

PRACTICE **POINTS**

- There currently are 4 leading modalities used for noninvasive body contouring: cryolipolysis, radiofrequency, high-intensity focused ultrasound, and laser therapy.
- Devices utilizing these 4 modalities have been found to be safe and effective in reducing subcutaneous fat tissue and improving skin laxity.
- Dermatologists utilizing body contouring treatments need to be familiar with available devices to determine which treatment is appropriate for each patient.

Noninvasive body contouring is the fastest growing area of cosmetic dermatology. It entails the use of specific technology to optimize the definition, smoothness, and shape of the human body in a safe and effective manner. There are currently 4 leading modalities used for noninvasive body contouring: cryolipolysis, radiofrequency, high-intensity focused ultrasound, and laser therapy. This article provides an overview of each modality.

Cutis. 2018;101:285-288.

In today's society there is a ubiquitous pressure to lose weight, reduce fat, and rejuvenate the skin that stems not only from images of idealized bodies in the media but also from our growing knowledge of the detrimental effects of obesity. Along with diet and exercise, it has become popular to use noninvasive devices to attain these goals by means of body contouring—the optimization of the definition, smoothness, and shape of the human physique.[1] In fact, body contouring currently is the fastest-growing area of cosmetic dermatology.[2]

Previously, body contouring primarily involved invasive procedures (eg, liposuction) that are associated with various adverse effects, financial costs, and lengthy downtime.[3] More recently, a growing demand for safer and less painful procedures for adipose tissue reduction and skin tightening have led to the development of several novel modalities for noninvasive body contouring. Although the results achieved using these new technologies may be less dramatic than invasive techniques and are not immediate, they do not carry the risks and adverse effects that are associated with surgical procedures and therefore are increasingly requested by cosmetic patients.[4,5] New noninvasive techniques primarily target the physical properties of fat, resulting in an efflux of triglycerides from fat cells, causing either reduced size, necrosis, or apoptosis of adipocytes.[3,6] Of these modalities, cold-induced adipocyte apoptosis has been commercially available the longest and has been the most researched; however, other noninvasive body contouring techniques have been increasingly explored by researchers since the first reports of human adipose tissue explants exhibiting features of apoptosis after heat injury became available.[7,8]

There currently are 4 leading modalities used for noninvasive body contouring: cryolipolysis, radiofrequency (RF), high-intensity focused ultrasound (HIFU), and laser therapy (Table). Although no procedure has yet been accepted as the gold standard, investigators are working to determine which technique is the most effective.[9] In this article, we provide an overview of these techniques to help dermatologists choose appropriate modalities for their cosmetic patients.

Cryolipolysis

Cryolipolysis is unique in that it employs the principle that lipid-rich adipocytes are more susceptible to freezing than surrounding water-rich cells, allowing selective apoptosis while preserving the adjacent structures. As macrophages digest the apoptotic adipocytes, patients experience a decrease in subcutaneous fat volume over the subsequent 2 to 3 months.[10-13] Cryolipolysis has been gaining popularity since 2010, when it was first approved by the US Food and Drug Administration (FDA) for fat reduction in the flank areas; it was later approved for the abdomen in 2012, thighs in 2014, and submental area in 2015.[14] Most recently, cryolipolysis was approved for fat reduction in the arms, back, and buttocks in 2016.

Ms. Rzepecki is from the Department of Dermatology, University of Michigan Medical School, Ann Arbor. Drs. Farberg and Hashim are from the Department of Dermatology, Icahn School of Medicine at Mount Sinai, New York, New York. Dr. Goldenberg is from Goldenberg Dermatology, PC, New York.

The authors report no conflict of interest.

Correspondence: Gary Goldenberg, MD, Goldenberg Dermatology, PC, 14 E 75th St, New York, NY 10021 (garygoldenbergmd@gmail.com).

Comparison of Modalities for Noninvasive Body Contouring of the Abdomen

Body Contouring Technique	Mechanism of Action	Duration of Treatment Session, min	No. of Treatments Required to See Results	Treatment Frequency	Time to Onset of Treatment Results, wk	Time to Achievement of Optimal Results, wk	Decrease in Abdominal Circumference, cm
Cryolipolysis	Cold-induced apoptosis/ necrosis	60	Varies	Once	8	24	Not evaluated
RF	Heat-induced apoptosis	35–45	4–6	Once every 1–2 wk	1	4–16	1.4–7.4
HIFU	Heat-induced necrosis	45–60	1	Once	4	12	2.1–4.15
Laser therapy	Micropore formation	40	6	3 sessions per wk administered 1–2 d apart	1	2	2.1–2.89

Abbreviations: RF, radiofrequency; HIFU, high-intensity focused ultrasound.

The most popular cryolipolysis device applies suction to the treatment area and vacuums the tissue between 2 cooling panels for 30 to 60 minutes.[9] Clinical studies investigating the safety and efficacy of cryolipolysis have reported a high degree of patient satisfaction with the procedure and only minimal side effects.[4,6,15,16] Common complications of cryolipolysis include erythema, swelling, and sensitivity at the treatment site followed by a lesser incidence of pain, tingling, and bruising, all of which generally resolve within a few weeks of treatment.[6] With the removal of adipocytes, there has been concern regarding elevations in blood lipid levels and liver enzymes; however, these laboratory values have been reported to remain within normal limits during and after cryolipolysis.[17,18] Of note, patients should be advised of the risk of paradoxical adipose hyperplasia, a rare side effect of cryolipolysis in which a large, demarcated, tender fat mass develops at the treatment site 2 to 3 months after treatment, with an estimated incidence of 1 in 20,000.[19] However, the incidence of paradoxical adipose hyperplasia may be underestimated, as a single practice reported an incidence of 0.47% in 422 cryolipolysis treatments.[20] This complication has not been associated with any of the heat-induced fat reduction modalities.

Cryolipolysis has been found to be safe for all skin types with no reported pigmentary changes.[16] It should not be performed in patients with cold-induced conditions (eg, cryoglobulinemia, cold urticaria) or in those with severe varicose veins or atopic dermatitis.[21,22] Patients benefitting most from this procedure are those who require only small or moderate amounts of adipose tissue and cellulite removal with separate fat bulges.[12,17] Interestingly, cryolipolysis also has been used off label to treat pseudogynecomastia in male patients.[23]

Radiofrequency

Radiofrequency has become an important and frequently used modality in cosmetic dermatology.[24] This modality differs from cryolipolysis in that it relies on exploiting the difference in water content and impedance between tissues: the skin has low impedance, whereas fat tissue has high impedance. Radiofrequency induces thermal injury to targeted tissue layers, rather than the cold-induced damage seen in cryolipolysis, through devices that focus thermal energy on tissues with high impedance, inducing apoptosis of cells in the subcutaneous adipose tissue with minimal risk of damaging the epidermis, dermis, and muscle.[9,25] Ultimately, thermal exposure to 43°C to 45°C over several minutes results in a delayed adipocyte death response.[4] In addition to adipocyte death, RF has been shown to cause denaturation of collagen fibrils, leading to subsequent remodeling, neocollagenesis, and skin tightening.[26]

Radiofrequency devices can be broadly classified as monopolar or bipolar.[24,27] Bipolar devices generally require more frequent treatments, whereas monopolar devices tend to require fewer treatment sessions with superior circumference and fat reduction.[28]

Overall, RF devices have a favorable side effect profile. The most common side effects are erythema and edema at the treatment site lasting less than 24 hours after the procedure.[25] The absence of complications such as abdominal discomfort, erythema, and burning during treatment have been reported,[27] with the exception of 1 case of hyperesthesia on the abdomen that lasted for 3 days after a treatment session.[5] Although RF has beneficial effects on circumference reduction in the abdomen and thighs and can improve the appearance of cellulite, an increase in body weight may occur during treatment. When a localized area of fat such as the thigh is targeted for treatment but the remaining fat cells in the body are not affected, the remaining cells can continue to grow and expand; for instance, although fat cells destroyed with RF will not continue to expand, fat cells in untreated areas may continue to grow due to continued weight gain (eg, from excessive eating), leading to overall weight gain. Thus, patients must understand that weight gain is not an indication of treatment failure after RF or any other method of irreversible fat destruction.[5]

High-intensity Focused Ultrasound

High-intensity focused ultrasound recently was introduced as a new treatment modality for body contouring, specifically for skin tightening and rejuvenation.[5] The mechanism of HIFU is similar to that of RF in that it also relies on heat to cause adipocyte apoptosis; however, it utilizes acoustic energy rather than electric energy. High-intensity focused ultrasound devices can deliver energy to the deep dermis, subdermal connective tissue, and fibromuscular layers in precise microcoagulation zones without damage to the epidermis. The focused energy induces a high temperature (>65°C) within 1 to 3 seconds, causing cell protein coagulation in the targeted area. In addition to its thermal effects, HIFU induces a mechanical effect that disrupts cell membranes immediately, which contributes to the coagulation necrosis process, further promoting necrosis and apoptosis. The effects of these devices can be visualized, as there always is a sharp demarcation between the targeted and untargeted tissue.[29] Additionally, microcoagulation is thought to cause gradual skin tightening through collagen contraction and remodeling.[30]

High-intensity focused ultrasound first received FDA approval for eyebrow lifting and has been used safely and effectively to treat facial and neck skin in a variety of skin types as well as to improve the clinical appearance of the abdomen and thighs.[31] This technique is best suited for patients with mild to moderate laxity of the skin or soft tissue who have a body mass index less than 30 kg/m^2 and are seeking mild body contouring.[32] The ideal patient is young with normal wound healing, since the clinical response to treatment is partly dependent on new collagen synthesis.[33] Older patients with extensive photoaging or severe skin laxity are not good candidates for HIFU.

There are a variety of available HIFU devices,[34] which utilize special transducers that direct ultrasound energy to a small focal point in the subcutaneous tissues that harmlessly passes through the skin.[35] By using newly developed transducers with different energy outputs and focal depths, dermatologists can tailor HIFU treatment to meet the unique physical characteristics of each patient.[31]

Adverse effects of HIFU are limited to transient pain in most patients and occasional erythema and ecchymosis in some cases.[31] In general, most adverse effects resolve spontaneously within 4 weeks and all by 12 weeks posttreatment. Studies also have reported hard subcutaneous nodules, discomfort, burning sensation, mild blisters, and one case of purpuric lesions, all at the treatment site.[36-39] There is no evidence that HIFU can cause abnormalities in serum lipids or liver function tests.

Lasers

Laser technology is a rapidly growing modality in noninvasive body contouring. A novel device recently emerged as the first and only FDA-cleared hyperthermic laser for fat reduction and noninvasive body contouring of the abdomen, flanks, back, inner and outer thighs, and submental area.[40,41] The device is a 1060-nm diode laser that uses thermal energy to destroy adipose tissue, leading to permanent reduction in stubborn fat without surgery or downtime through the use of a flat, nonsuction applicator that is designed for consistent, natural-looking results. The device includes a contact cooling system that helps to limit thermal discomfort and prevent damage to the surface of the skin during the procedure. Initial improvement can be seen as quickly as 6 weeks posttreatment, and optimal results usually occur in as few as 12 weeks. This device was found to have an excellent safety profile and was well tolerated among patients, with only mild pain reported.[42,43]

Prior to the development of this new 1060-nm diode laser, the initial application of lasers for noninvasive body contouring involved low-level laser therapy (LLLT), also known as cold laser therapy.[40] One device has 5 rotating diode laser heads that work at a wavelength of 635 nm. Treatment sessions last up to 30 minutes, and 6 to 8 sessions are required to obtain optimal results. Low-level laser therapy is a unique modality that is not based on thermal tissue damage, but rather on producing transient microscopic pores in adipocytes that allow lipids to leak out, leading to fat reduction.[34] Because LLLT causes immediate emptying of targeted adipocytes, results are noticeable as soon as treatment is completed; however, there is no necrosis or apoptosis of adipocytes, so the recurrence of fat deposition is believed to be greater when compared to the other modalities. Because the results are temporary, long-term or permanent results should not be expected with LLLT. Depending on the patient's goals, the temporary nature of the results can be either an advantage or disadvantage: some may prefer immediate results despite gradual diminishment over subsequent months, whereas others may prefer results that progressively increase over time and are more permanent, as seen with cryolipolysis, HIFU, and RF.[3]

Complications of LLLT generally are fewer and more mild than with all other body contouring procedures, with several studies reporting no adverse effects.[44-48] Others reported swelling or erythema at the treatment area, pain or tingling during treatment, and increased urination, all of which were temporary and resolved spontaneously.[49] Additionally, although the lipids released from treatment are cleared through the lymphatic system, LLLT has not been shown to increase serum lipid levels.[50]

Conclusion

The field of noninvasive body contouring is undoubtedly growing and will likely continue to rise in popularity as the efficacy and safety of these treatments improve. Although the available technologies vary by mechanism and side effect profiles, several devices have been revealed to be safe and effective in reducing subcutaneous fat tissue and improving skin laxity.[1] However, additional studies are needed to evaluate these devices in a standardized manner, especially considering the high costs associated with treatment.[32] Current studies investigating these devices vary in treatment protocol, treatment area, number and timing of follow-up sessions, and outcome measures, making it challenging to compare the results objectively.[3] Dermatologists offering

body contouring treatments need to be intimately familiar with the available devices and determine which treatment is appropriate for each patient in order to provide the highest quality care. Most importantly, patients and physicians must discuss individual goals when choosing a body-contouring method in order to maximize patient satisfaction.

REFERENCES

1. Jalian HR, Avram MM. Body contouring: the skinny on noninvasive fat removal. *Semin Cutan Med Surg*. 2012;31:121-125.
2. Ho D, Jagdeo J. A systematic review of paradoxical adipose hyperplasia (PAH) post-cryolipolysis. *J Drugs Dermatol*. 2017;16:62-67.
3. Kennedy J, Verne S, Griffith R, et al. Non-invasive subcutaneous fat reduction: a review. *J Eur Acad Dermatol Venereol*. 2015;29:1679-1688.
4. Krueger N, Mai SV, Luebberding S, et al. Cryolipolysis for noninvasive body contouring: clinical efficacy and patient satisfaction. *Clin Cosmet Investig Dermatol*. 2014;7:201-205.
5. Suh DH, Kim CM, Lee SJ, et al. Safety and efficacy of a non-contact radiofrequency device for body contouring in Asians. *J Cosmet Laser Ther*. 2017;19:89-92.
6. Ingargiola MJ, Motakef S, Chung MT, et al. Cryolipolysis for fat reduction and body contouring: safety and efficacy of current treatment paradigms. *Plast Reconstr Surg*. 2015;135:1581-1590.
7. Prins JB, Walker NI, Winterford CM, et al. Apoptosis of human adipocytes in vitro. *Biochem Biophys Res Commun*. 1994;201:500-507.
8. Sorisky A, Magun R, Gagnon AM. Adipose cell apoptosis: death in the energy depot. *Int J Obes Relat Metab Disord*. 2000;24(suppl 4):S3-S7.
9. Chilukuri S, Mueller G. "Hands-free" noninvasive body contouring devices: review of effectiveness and patient satisfaction. *J Drugs Dermatol*. 2016;15:1402-1406.
10. Manstein D, Laubach H, Watanabe K, et al. Selective cryolysis: a novel method of non-invasive fat removal. *Lasers Surg Med*. 2008;40:595-604.
11. Zelickson B, Egbert BM, Preciado J, et al. Cryolipolysis for noninvasive fat cell destruction: initial results from a pig model. *Dermatol Surg*. 2009;35:1462-1470.
12. Nelson AA, Wasserman D, Avram MM. Cryolipolysis for reduction of excess adipose tissue. *Semin Cutan Med Surg*. 2009;28:244-249.
13. Avram MM, Harry RS. Cryolipolysis for subcutaneous fat layer reduction. *Lasers Surg Med*. 2009;41:703-708.
14. Klein KB, Bachelor EP, Becker EV, et al. Multiple same day cryolipolysis treatments for the reduction of subcutaneous fat are safe and do not affect serum lipid levels or liver function tests. *Lasers Surg Med*. 2017;49:640-644.
15. Dierickx CC, Mazer JM, Sand M, et al. Safety, tolerance, and patient satisfaction with noninvasive cryolipolysis. *Dermatol Surg*. 2013;39:1209-1216.
16. Stevens WG, Pietrzak LK, Spring MA. Broad overview of a clinical and commercial experience with CoolSculpting. *Aesthet Surg J*. 2013;33:835-846.
17. Ferraro GA, De Francesco F, Cataldo C, et al. Synergistic effects of cryolipolysis and shock waves for noninvasive body contouring. *Aesthetic Plast Surg*. 2012;36:666-679.
18. Lee KR. Clinical efficacy of fat reduction on the thigh of Korean women through cryolipolysis. *J Obes Weight Loss Ther*. 2013;3:203.
19. Jalian HR, Avram MM, Garibyan L, et al. Paradoxical adipose hyperplasia after cryolipolysis. *JAMA Dermatol*. 2014;150:317-319.
20. Singh SM, Geddes ER, Boutrous SG, et al. Paradoxical adipose hyperplasia secondary to cryolipolysis: an underreported entity? *Lasers Surg Med*. 2015;47:476-478.
21. Pinto H, Arredondo E, Ricart-Jane D. Evaluation of adipocytic changes after a simil-lipocryolysis stimulus. *Cryo Letters*. 2013;34:100-105.
22. Pinto HR, Garcia-Cruz E, Melamed GE. A study to evaluate the action of lipocryolysis. *Cryo Letters*. 2012;33:177-181.
23. Singh B, Keaney T, Rossi AM. Male body contouring. *J Drugs Dermatol*. 2015;14:1052-1059.
24. Beasley KL, Weiss RA. Radiofrequency in cosmetic dermatology. *Dermatol Clin*. 2014;32:79-90.
25. Weiss R, Weiss M, Beasley K, et al. Operator independent focused high frequency ISM band for fat reduction: porcine model. *Lasers Surg Med*. 2013;45:235-239.
26. Hantash BM, Ubeid AA, Chang H, et al. Bipolar fractional radiofrequency treatment induces neoelastogenesis and neocollagenesis. *Lasers Surg Med*. 2009;41:1-9.
27. Harth Y. Painless, safe, and efficacious noninvasive skin tightening, body contouring, and cellulite reduction using multisource 3DEEP radiofrequency. *J Cosmet Dermatol*. 2015;14:70-75.
28. Nassab R. The evidence behind noninvasive body contouring devices. *Aesthet Surg J*. 2015;35:279-293.
29. Luo W, Zhou X, Gong X, et al. Study of sequential histopathologic changes, apoptosis, and cell proliferation in rabbit livers after high-intensity focused ultrasound ablation. *J Ultrasound Med*. 2007; 26:477-485.
30. Minkis K, Alam M. Ultrasound skin tightening. *Dermatol Clin*. 2014; 32:71-77.
31. Ko EJ, Hong JY, Kwon TR, et al. Efficacy and safety of non-invasive body tightening with high-intensity focused ultrasound (HIFU). *Skin Res Technol*. 2017;23:558-562.
32. Sklar LR, El Tal AK, Kerwin LY. Use of transcutaneous ultrasound for lipolysis and skin tightening: a review. *Aesthetic Plast Surg*. 2014; 38:429-441.
33. MacGregor JL, Tanzi EL. Microfocused ultrasound for skin tightening. *Semin Cutan Med Surg*. 2013;32:18-25.
34. Alizadeh Z, Halabchi F, Mazaheri R, et al. Review of the mechanisms and effects of noninvasive body contouring devices on cellulite and subcutaneous fat. *Int J Endocrinol Metab*. 2016;14:E36727 .
35. Fabi SG. Noninvasive skin tightening: focus on new ultrasound techniques. *Clin Cosmet Investig Dermatol*. 2015;8:47-52.
36. Fatemi A. High-intensity focused ultrasound effectively reduces adipose tissue. *Semin Cutan Med Surg*. 2009;28:257-262.
37. Teitelbaum SA, Burns JL, Kubota J, et al. Noninvasive body contouring by focused ultrasound: safety and efficacy of the Contour I device in a multicenter, controlled, clinical study. *Plast Reconstr Surg*. 2007;120:779-789.
38. Hotta TA. Nonsurgical body contouring with focused ultrasound. *Plast Surg Nurs*. 2010;30:77-82; quiz 83-84.
39. Fatemi A, Kane MA. High-intensity focused ultrasound effectively reduces waist circumference by ablating adipose tissue from the abdomen and flanks: a retrospective case series. *Aesthetic Plast Surg*. 2010; 34:577-582.
40. Schilling L, Saedi N, Weiss R. 1060 nm diode hyperthermic laser lipolysis: the latest in non-invasive body contouring. *J Drugs Dermatol*. 2017;16:48-52.
41. Body contouring. CynoSure website. https://www.cynosure.com /treatment/body-contouring/SculpSure. Accessed March 28, 2018.
42. Decorato JW, Chen B, Sierra R. Subcutaneous adipose tissue response to a non-invasive hyperthermic treatment using a 1,060 nm laser. *Lasers Surg Med*. 2017;49:480-489.
43. Weiss R, McDaniel D, Doherty S. Clinical evaluation of fat reduction treatment of the flanks and abdomen with a non-invasive 1060 nm diode laser: a multicenter study. Paper presented at: 2016 Annual American Society for Laser Medicine and Surgery Conference; March 30–April 3, 2016; Boston, MA.
44. Caruso-Davis MK, Guillot TS, Podichetty VK, et al. Efficacy of low-level laser therapy for body contouring and spot fat reduction. *Obes Surg*. 2011;21:722-729.
45. McRae E, Boris J. Independent evaluation of low-level laser therapy at 635 nm for non-invasive body contouring of the waist, hips, and thighs. *Lasers Surg Med*. 2013;45:1-7.
46. Nestor MS, Newburger J, Zarraga MB. Body contouring using 635-nm low level laser therapy. *Semin Cutan Med Surg*. 2013;32:35-40.
47. Jackson RF, Stern FA, Neira R, et al. Application of low-level laser therapy for noninvasive body contouring. *Lasers Surg Med*. 2012;44:211-217.
48. Jackson RF, Dedo DD, Roche GC, et al. Low-level laser therapy as a non-invasive approach for body contouring: a randomized, controlled study. *Lasers Surg Med*. 2009;41:799-809.
49. Gold MH, Khatri KA, Hails K, et al. Reduction in thigh circumference and improvement in the appearance of cellulite with dual-wavelength, low-level laser energy and massage. *J Cosmet Laser Ther*. 2011;13:13-20.
50. Avci P, Nyame TT, Gupta GK, et al. Low-level laser therapy for fat layer reduction: a comprehensive review. *Lasers Surg Med*. 2013;45:349-357.