Review Article

Noninvasive Arm Fat Reduction

Logan William Thomas, Margit Juhasz, Lance Chapman, Michele Van Hal, Ruzica Conic[1], Ashley Magovern[2], Natasha Mesinkovska

Department of Dermatology, University of California, Irvine, [2]Manhattan Dermatology, Manhattan Beach, CA, [1]Department of Dermatology, Case Western Reserve University, Cleveland, OH, USA

Abstract

The demand for new approaches for noninvasive procedures of the upper arm is increasing. This review will present the most recent literature addressing modalities for arm fat reduction. Thirteen papers met inclusion criteria. The greatest arm circumference reduction (2.75 cm) is accomplished with the combination of cryolipolysis and shock therapy. Limited side effects are noted with each treatment modality. The most painful treatment is cryolipolysis. Physicians should be aware of the most common treatment modalities, new advances in devices, and possible side effects that may occur. There is a need to design and implement a universal patient satisfaction scale, such as the Global Aesthetic Improvement Scale. We recommend a standard approach to fat reduction measurement using three-dimensional imaging and suggest using US at a standardized location such as the midpoint between the olecranon and acromion processes. Although preliminary research suggests that noninvasive contouring of the upper arm is successful with limited adverse events, further research in this field will need to be completed to determine the long-term safety.

Keywords: Arm contouring, cryolipolysis, high intensity focused ultrasound, low-level laser therapy, radiofrequency

Introduction

Societal views on the perfect body aesthetic have associated slimness with beauty; arm fat impacts how individuals perceive self-beauty and negatively impacts self-confidence.[1] Traditional approaches to arm fat refractory lifestyle modifications include invasive surgical procedures such as liposuction [Figure 1], carrying risks such as postanesthesia adverse events, hospitalization, and prolonged postoperative recovery;[2] the incidence of minor wound complications is 6.3%, and major morbidity is 6.8% 30 days after liposuction.[3]

Noninvasive approaches to body contouring have become popular, with the development of novel devices and protocols. In a plastic surgery report from 2015, cosmetic surgical procedures have decreased by 10% since 2000, while minimally invasive procedures have increased by 158%.[4] Minimally invasive approaches have reduced concern for severe side effects and complications such as scarring, decreased procedural discomfort and allowed faster recovery.

Arm contouring is currently in demand with many approaches having been studied, and devices yielding promising results in the reduction of adipose tissue. In this review, we discuss evidence of noninvasive devices for arm contouring, including low level laser therapy (LLLT), high-intensity focused ultrasound (HIFU), radiofrequency (RF), and cryolipolysis.

Arm anatomy

The brachial plexus, brachial artery, cephalic vein, and basilic vein are delicate structures in the arm [Figure 2]. Surgical and invasive interventions may lead to complications such as hematoma, infection, and rarely wound dehiscence. Reports of structural damage to the arm have been rare during noninvasive procedures.[5] However, the median nerve, medial cutaneous nerve, and ulnar nerve may be in danger given their superficial locations. There are reported cases of ulnar and/or median nerve palsy with associated paresthesia during RF and cryolipolysis; fortunately, these symptoms spontaneously resolve shortly after treatment.[6,7]

Address for correspondence: Dr. Logan William Thomas, Department of Dermatology, University of California, 118 Medical Surge I, Irvine 92697, CA, USA.
E-mail: lwthomas@uci.edu

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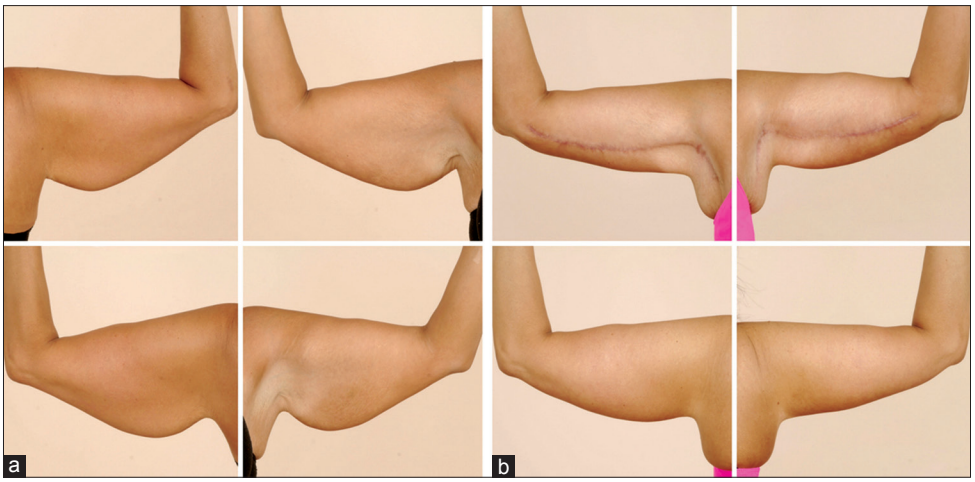

Figure 1: Invasive brachioplasty. A 42-year-old female with massive weight loss following bariatric surgery presents with (a) excess skin laxity desiring brachioplasty, and (b) 6 months' postprocedure

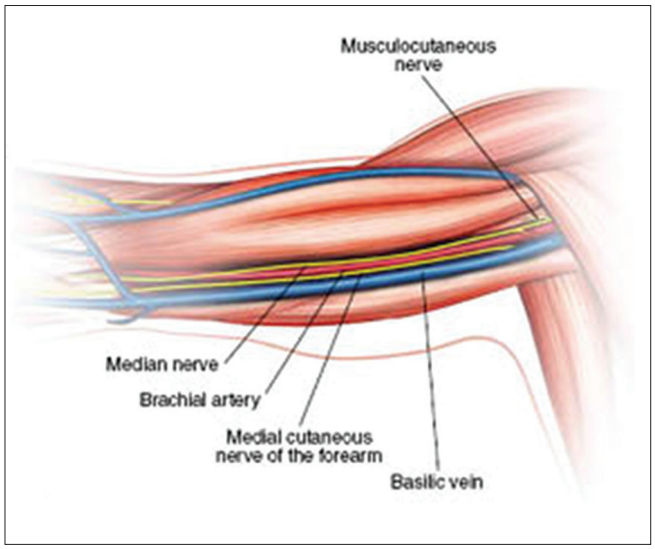

Figure 2: Important anatomical structures within the arm. Important structures (nerves, arteries, veins) reside on the medial and lateral sides of the arm. Care must be taken to avoid the cephalic vein on the anterior aspect of the arm. The posterior aspect is the ideal area for treatment. (Faringer P. Modern Brachioplasty. Plastic Surgery Pulse News, Volume 7, Number 1. St. Louis: Quality Medical Publishing, 2015)

Using the search phrase, "LLLT OR high intensity frequency ultrasound (US) OR RF OR cryolipolysis AND arm" in PubMed allowed for the identification of articles discussing arm contouring using one of four noninvasive methods. Articles were reviewed by title and included if they dealt with human subjects, were published in English, and used one of the identified methods. Additional articles for review were identified from the references of included papers

Results

The primary literature search returned 258 results; 13 articles met inclusion criteria. Study designs included: One double-blinded, controlled, randomized trial; one single-site, single-blinded, split-arm, randomized controlled trial; one prospective open-label clinical trial; one nonrandomized clinical trial; one retrospective, nonrandomized, noncontrolled study; and eight other articles that did not clearly identify their study design.

Low level laser therapy

LLLT applies low-irradiancy laser light (1–5000 mW/cm^2) to achieve therapeutic results without photothermal or photoacoustic effects.[8] Although LLLT's mechanism of action is unclear, proposed mechanisms involve modifying lipid metabolism,[9] or reducing oxidative stress in adipose tissue, increasing adiponectin secretion and decreasing insulin resistance.[8] Other hypothesized mechanisms include laser-induced "pores" in the adipocyte membrane causing disruption and triglyceride (TG) leakage; released TG travel through the lymphatic system to lymph nodes where they are hydrolyzed by lysosomal acid lipase generating nonesterified-free fatty acids (FFA) ready for catabolism.[10,11] Recent studies have shown that a 635 nm diode laser is capable of releasing 80% of fat with 4 min of exposure, and as much as 99% of fat with 6 min.[12] It is important to note that after treatment, there are no macroscopic changes in tissue structure.[13]

Jackson *et al.* described LLLT treatment of 632 patients each receiving six, 40-min treatments over a period of 2 weeks at the waist, hips, and thighs. Despite not receiving direct treatment, a 0.813 cm circumference reduction 1-week postprocedure was measured at the arm.[9] Nestor *et al.* described LLLT treatment of 40 patients each receiving six, 20-min treatments to the arm over a period of 2 weeks with a circumference reduction of 3.7 cm 1-week after the last session [Table 1].[14]

A laser device similar to LLLT is Scultpsure® (Cyanosure, Inc., Westford, MA, USA). This 1060 nm laser is described as a "hyperthermic laser" because tissue is heated during the treatment (as opposed to LLLT, a "cold laser"). The energy delivered by this laser creates movement of particles within the tissue, causing transformation of mechanical to

Table 1: Low level laser therapy

Author	*n*	Treatment goal	Therapy	Frequency	Outcome measures	Clinical outcomes	Patient satisfaction	Adverse effects	Level of evidence
Jackson *et al*., 2012[9]	632	Circumference reduction including: Waist, hips, thighs, arms, knees, neck, chest	635 nm LLLT	6, 40 min treatments over 2 weeks Areas treated: Waist, hips, thighs	Areas measured: Waist, hips, thighs, arms, knees, neck, chest	Untreated arm circumference reduction/body reduction 0.813 cm reduction in untreated arm with treatment of other areas 8.306 cm total body circumference reduction including both treated and untreated	Not reported	Not reported	4
Nestor *et al*., 2013[14]	40	Arm circumference reduction	635 nm LLLT	Total energy delivered to the skin per treatment: 3.94 J/cm^2 6, 20 min treatments, treatments over 2 weeks	Circumference of upper arm measured using tape measure at 3 points between elbow and shoulder	Arm circumference reduction Treatment group reduction of 3.7 cm versus control group reduction of 0.2 cm	Treatment group satisfied with results: Satisfied treated group (n_T=16 vs. satisfied control group n_C=6; P<0.05) Appearance of upper arms improved (n_T=18 vs. n_C=7; P<0.005) Procedure exceeded their expectations (n_T=10 vs. n_C=5; P<0.05)	Not reported	1C

LLT: Low-level laser therapy

thermal energy; maintaining a temperature of 42°C–47°C causes loss of adipocyte membrane integrity and cell death.[15] The 1060 nm adequately penetrates the epidermis, spares the dermis, and specifically targets adipocytes;[16] clinical results are apparent at 6 weeks with optimal results at 12 weeks. The 1060 nm laser is only FDA-approved for contouring the abdomen and flanks,[16] but studies have shown significant thigh and back fat reduction.[17] Decorato *et al*. report a 24% adipose thickness reduction of the flank at 3 months, and 21% fat volume reduction 6 months using this laser; further long-term studies are warranted to determine longevity of fat reduction.[18] Currently, there is no literature using the 1060 nm laser for arm contouring and further studies are needed to determine its utility.

High-intensity frequency ultrasound

HIFU uses ultrasonic waves and negative acoustic pressure to achieve results. Focusing acoustic energy at a singular point causes cell membrane disruption, cavitation bubbles, and acoustic energy is transformed into heat with temperatures >57°C.[19,20] Maintaining temperatures at a specific tissue depth, leads to adipose cell death and coagulative necrosis.[21] Histopathology demonstrates fat necrosis with multicellular inflammatory infiltrates and foreign body giant cells; 4–5-month posttreatment 95% of adipocytes are destroyed.[19,20] Fortunately, surrounding tissue is unaffected. After adipocyte death, FFAs, inflammatory markers, and chemotactic factors are released, recruiting macrophages 3–4-day posttreatment; after 14–20 days, macrophages engulf and metabolize remaining cellular components. Inflammation and healing may take up to 90 days, with a clear reduction in subcutaneous fat on histology.[21-23]

Three papers were identified using HIFU to tighten arm and/or elbow skin [Table 2]. Choi *et al*. describe the Ultraformer® III, Shurink (Classys Inc., Seoul, Korea) on six females, Asian patients. Using a Global Aesthetic Improvement Scale (GAIS) (-3–3 with-3 = very much worse and 3 = very much improved) investigators and individuals rated 100% "improvement" and at least an "improved," respectively, 4 weeks' posttreatment. Pain was ranked 5.17 ± 2.48 out of 10 (with 10 being the worst) immediately postprocedure; no pain was noted at follow-up.[24] Rokhsar *et al*. demonstrate HIFU tightening skin over the elbow in 20 female patients. Physicians and patients noted a 94% and 81% improvement at follow-up, respectively. The mean pain score was 5.7 out of 10.[25] Alster *et al*. treat 18 female patients with Ulthera® (Merz Aesthetics, Mesa, AZ). Masked assessors gave a Global Assessment Score (GAS – 0–4 with 0 = no improvement, 1 = 1%–25% improvement, 2 = 25%–50% improvement, 3 = 51%–75% improvement, and 4= >75% improvement) score of 2.05 for single plane treatment, and 2.25 for double plane treatment. About 81% of patients were highly satisfied with the procedure, reporting mild-to-moderate discomfort.[26]

Radiofrequency

RF relies on a controlled electrical field to preferentially target and heat the subdermal layer to 43°C–45°C, resulting in dermal

Table 2: High-intensity frequency ultrasound

Author	*n*	Treatment goal	Therapy	Frequency	Outcome measures	Clinical outcomes	Patient satisfaction	Adverse effects	Level of evidence
Choi *et al*., 2016[24]	6	Arm tightening	HIFU	One 7.5 cm × 7.5 cm treatment area, treatment time of 50-60 min with pulse duration 25-40 ms Operated the powers with 1.0-1.5 J at each transducer 1.7 MHz at 1.5 mm focal depth 2. 2 MHz at 3.0 mm 3. 2 MHz at 4.5 mm 4. 2 MHz at 6.0 mm 5. 2 MHz at 9.0 mm	Investigator GAIS by blinded independent dermatologist −3=very much worse −2=much worse −1=worse 0=no change 1=improved 2=much improved 3=very much improved Skin elasticity using cutometer Subject assessment of improvement (SGAIS) Pain VAS	GAIS: 100% score of 1- "improved" Skin elasticity: Increased 0.6→0.68	SGAIS: At least 1- "improved" VAS Score: Pain 5.17±2.48 (mild-to-moderate pain) immediately after treatment but none reported at 1+4 weeks	Right upper arm edema (*n*=1)	4
Rokhsar *et al*., 2015[25]	20	Elbow tightening	HIFU/ MFU-V	Grid of 6-2.5 cm × 2.5 cm area applied to back of arm above elbow 4.4 MHz, 4.5 mm focal depth or 7 MHz, 4.5 mm focal depth transducer. Then 7 MHz, focal depth of 3.0 mm Deliver 120 lines of MFU to each treatment area or 240 lines per elbow	PGAIS Masked nonbiased dermatologist shown before and after photos of treated elbows SGAIS Satisfaction Questionnaire Pain scale from 0 to 10 with: 0=no pain; 10=worst pain	PGAIS 94% improvement at 90 and 180-day follow-up Blinded nonbiased dermatologist 56% (*n*=9) showed improvement 25% (*n*=4) no change	SGAIS 83% improvement at 90 days 81% improvement at 180 days Satisfaction questionnaire 72% satisfied/28% dissatisfied at 90 days. 50% satisfied/50% dissatisfied at 180 days Pain scale Mean pain score with 4 MHz, 4.5 mm transducer: 5.7 Mean pain score with 7 MHz, 3.0 mm transducer: 5.0	Not reported	4
Alster *et al*., 2012[26]	18	Arm tightening	HIFU	One arm: 4.0 MHz, 4.5 mm focal depth transducer (single-plane treatment) Contralateral arm: 4.0 MHz, 4.5 mm focal depth transducer and 7.0 MHz, 3.0 mm focal depth transducer (dual-plane treatment) Area treated with 1.2 J per pulse until the entire region covered	GAS by two independent masked assessors 0=no improvement 1=1%-25% improvement 2=25%-50% improvement 3=51%-75% improvement 4≥75% improvement Patient assessment	GAS: Single plane (3 month) GAS score 1.83; 6-month GAS score 2.05 Double plane (3 month) GAS score of 1.92; 6-month GAS score 2.25	Patient assessment Mild-to-moderate discomfort (analgesia was achieved with administration of 5-10 mg of oral diazepam and intramuscular injection of 50 mg meperidine 20-30 min before treatment). 81% highly satisfied with procedure	Erythema (*n*=18) Warmth (*n*=18) Focal bruising (*n*=2) Skin tenderness (most patients)	4

HIFU: High intensity focused ultrasound, GAIS: Global Aesthetic Improvement Scale, PGAIS: Physician GAIS, SGAIS: Subject GAIS, VAS: Visual analog score, MFU-V: Microfocused ultrasound with visualization, GAS: Global Assessment Score

tissue remodeling, disruption of collagen cross-linking bonds, denaturation of old collagen fibers, and fibroblast-initiated neocollagenesis.[16,27,28] Neocollagenesis is further aided by increased dermal vascular flow secondary to thermal heating.[29]

Table 3: Radiofrequency

Author	*n*	Treatment goal	Therapy	Frequency	Outcome measures	Clinical outcomes	Patient satisfaction	Adverse effects	Level of evidence
Blyumin-Karasik *et al*., 2011[31]	20	Arm tightening	RF	140-147 cm^2 from 38-40 J/cm^2, pulses from 95-127. 3 passes. 2 treatments 1 month apart	Circumference reduction Length from olecranon process to axillary vault times width of axillary vault Nonblinded clinical investigator skin laxity improvement evaluation 0=no improvement 1=1%-25% improvement 2=25%-50% improvement 3=51%-75% improvement 4≥75% improvement Skin laxity grade scale 0=no improvement 1=1%-25% improvement 2=25%-50% improvement 3=51%-75% improvement 4≥75% improvement Cosmetrics skin collagen index assessment: Uses Cosmetrics Siascopet to measure collagen amount Histologic evaluation of elastic fibers and dermal collagen Patient satisfaction questionnaire and pain scale	Mean circumference reduction: 0.38 cm Skin laxity improvement evaluation: 90% improvement after 1st treatment. 2 months after final treatment 58%-no change and 32%-minimal improvement Blinded dermatologist assessors: No statistically significant improvement in appearance Cosmetics skin collagen index assessment: No change Histology: No change. Mild RBC extravasation and perivascular lymphocytic and neutrophilic infiltrate	Patient Satisfaction Questionnaire and Pain Scale: Ease of treatment: 100%. No discomfort: 79% versus discomfort: 21%. Treatment mildly to very useful: 58%. Pain score of 1.25/10 after first treatment, 0.5/10 after second treatment	Skin dermatitis (*n*=1) Paresthesia (*n*=1) Erythema (*n*=1)	2B

Contd...

Table 3: Contd...

Author	*n*	Treatment goal	Therapy	Frequency	Outcome measures	Clinical outcomes	Patient satisfaction	Adverse effects	Level of evidence
Beasley *et al*., 2012[32]	20	Arm circumference reduction	RF	80-90 W applied to posterior arm Treated for 6 mins followed by 3 min 2nd pass for superficial treatment	Arm volume measured using vectra 3D imaging Arm circumference measured with tape measure Patient self-assessment	Arm fat layer and volume reduction: 0.02 cm posterior fat layer reduction in control versus 0.57 cm reduction in treatment. Reduction of 45 cc of arm volume Arm circumference reduction: Not significant	2 nonresponders and no reduction in posterior arm fat	Not reported	3B
Manuskiatti *et al*., 2009[34]	19	Arm cellulite treatment and circumference reduction	RF	20 and 28.5 W of TriPollar RF electrode, 1 MHz Temp increased to 40-42°C, maintained for 2 min One 40-min treatment per week for 8 weeks	Arm circumference reduction: 15 cm proximal from olecranon process with tape measure Cutometer skin elasticity measurement	Arm circumference reduction 0.17±0.98 cm (P<0.461). 4 weeks after treatment 0.72%±1.15% increase 4 weeks after treatment (P<0.05) Cutometer skin elasticity R2 (0.01, P=0.093) and R7 (0.01, P=0.059)	Not reported	Erythema (n=19) including erythematous papules, papular urticaria, primary degree burn, blisters, and bruising Sensation of mild heating with occasional pinching (n=1)	2B
Brightman *et al*., 2009[35]	19	Arm circumference reduction	RF IR, bipolar RF, vacuum and mechanical massage	50 W bipolar RF, 20 W IR (700-1500 nm) and 200 mbar vacuum (750 mmHg negative pressure) Temp of 40-42°C. Maintained for 5 min Treated with 2 passes, once per week for 5 weeks	Arm circumference reduction after treatment and follow-up Measure widest point of upper arm and distance from distal point of elbow Histology results from punch biopsy of treatment area versus control Subject satisfaction assessment	Circumference reduction: 0.625 cm. At 1- and 3-month follow-ups, mean loss was 0.71 and 0.597 cm respectively Histology results: Increased cellular components of extracellular matrix of papillary dermis, likely fibroblasts, with increased composition of collagen fibers	Subject satisfaction assessment: Not satisfied (n=10), slightly satisfied (n=5), satisfied (n=3), very satisfied (n=1)	Erythema (n=19) Ecchymosis	4

Contd...

Table 3: Contd...

Author	*n*	Treatment goal	Therapy	Frequency	Outcome measures	Clinical outcomes	Patient satisfaction	Adverse effects	Level of evidence
McKnight *et al*., 2015[36]	12	Arm circumference reduction and skin tightening	Tripollar RF	1 MHZ at 37.5 W with applicator of 1.7 cm^2 Raise temp to 40-42°C within 2 min of treatment Each area treated for 6 min for a total of 24 min, one time/week for 8 weeks	Arm circumference reduction Blinded investigator 5-point assessment 1=worse 2=no improvement 3=moderate improvement 4=good improvement 5=great Improvement Subject 5-point assessment	Arm circumference reduction: 1.99±0.94 cm (*P*=0.001) Blinded investigator 5- point assessment: Arm reduction size score: 3.33 Arm tightness score: 3.33 Overall appearance score: 3.41	Patient assessment: Arm size reduction score: 3.33. Arm tightness score: 3.33. Arm overall appearance score: 3.58. 83% improvement after 1-3 weeks of treatment. Improvement in 4-6 weeks	Erythema (*n*=12) Edema (*n*=12)	4

RF: Radiofrequency, RBC: Red blood cell, 3D: Three-dimensional, IR: Including infrared

Targeting the subcutaneous adipose tissue creates adipocyte thermolysis, release of TGs and FFAs, inflammatory cascade initiation, and destruction of adipose tissue.[30]

Five papers using RF were identified for inclusion in this review with a total of 89 patients [Table 3].[31-35] Arm circumference reduction ranged from 0.17 ± 0.98 cm with Regen™ (Pollogen Ltd, Tel Aviv, Israel)[33] to 1.99 ± 0.94 cm with Tripolar RF.[35] Beasley *et al*. used three-dimensional US to quantitatively measure a 0.57 cm reduction in posterior arm adipose tissue depth, and an estimated 45 cc reduction in adipose volume.[32] No papers were found using ThermiSmooth® (Almirall, S. A., Irving, Texas, USA) for the specific purpose of arm contouring.

Cryolipolysis

Cryolipolysis exploits the higher freezing point of adipose tissue; by cooling subcutaneous fat to 4°C, cryolipolysis spares skin, nerves, vessels, and muscles.[36] Combining with vacuum suction, reduces blood flow and allows for rapid crystallization of adipose tissue. Cellular edema occurs as intracellular water freezes, causing cell lysis. Numerous theories on the mechanism of adipocyte apoptosis after cryolipolysis exist including a decrease in the sodium-potassium-adenosine triphosphatase (ATPase) pump activity and available ATP, increase in lactic acid, and release of mitochondrial-free radicals. After treatment, immediate postischemic reperfusion injury with production of reactive oxygen species causes increase in intracellular calcium and activation of caspases within the apoptotic pathways.[36-38]

CoolScultping® (Zeltiq Aesthetics, Inc., Pleasanton, CA, USA) has been approved for contouring of the submental area, thigh, abdomen, flank, bra, and back, and as of January 2017, was approved by the FDA for treatment of the upper arm. Currently, cryolipolysis is the only treatment approved for fat reduction of the arm.[39] Three papers using cryolipolysis, with a total of 24 patients, were identified for inclusion [Table 4].[6,40,41] These studies report arm circumference reduction ranging from 0.72 cm using CoolSculpting® alone[40] to 2.75 cm using ProShock Ice™ (PromoItalia Group S. p. A, Naples, Italy).[41] Sang *et al*. demonstrate a 0.203 cm fat layer reduction by combining CoolSculpting® with adjuvant US.[6] While this paper was being submitted Carruthers *et al*. published the safety and efficacy of a prototype CoolCup applicator specifically for the upper arm. Thirty patients were treated for 35 min at -11°C resulting in a mean fat layer reduction of 0.32 cm with a standard deviation of 0.27 cm. Four patients experienced numbness in the treatment area which subsequently resolved.[42]

Discussion

Results for noninvasive arm contouring have been promising with studies reporting a significant decrease in arm circumference. Although most clinicians treat the posterior arm,[14,15,24,26,31-34,41] others treat the lateral arm to avoid nerve damage,[40] or treat both anterior and posterior arms.[35] Considering arm anatomy, the best treatment area is the middle posterior arm because it contains the most subcutaneous adipose tissue without concern for structural damage.

The greatest arm circumference reduction, 2.75 cm, was obtained with combination cryolipolysis and shock therapy.[41,44] Studies report a 0.813 cm circumference reduction with LLLT,[9] and 1.99 ± 0.94 cm with RF.[35] Patients report noticeable changes in arm appearance and are satisfied with overall esthetic results.[6,15,24-26,31,35,40,41] Unfortunately, patients with weight gain in the posttreatment period demonstrate no response.[32]

A delicate balance exists between minimal treatment with decreased results and side effects versus maximal treatment

Table 4: Cryolipolysis

Author	*n*	Treatment goal	Therapy	Frequency	Outcome measures	Clinical outcomes	Patient satisfaction	Adverse effects	Level of evidence
Lee *et al*., 2016[6]	7	Reduce upper arm fat	Cryolipolysis	CIF of 41.6 (72.9 mW/cm^2) for one 60-min treatment	SonoAce 6000 ultrasound used to assess fat layer at baseline and 8-week posttreatment Physician assessment: "Excellent," "good," "fair," and "poor" Subjective measure by patients: "Excellent," "good," "satisfied," and "unsatisfied"	Fat layer reduction: 0.203 cm fat layer reduction of the distal and proximal arm (P=0.001) Physician assessment Excellent (n=1, 16.7%) Good (n=4, 66.7%) Fair (n=1, 16.7%)	Patient assessment Excellent (n=2, 33.3%) Good (n=3, 50%) Satisfactory (n=5, 83.3%) Unsatisfactory (n=1, 16.7%)	Paresthesia (n=7) Erythema (n=7) Bruising (n=7) Swelling (n=7) Mild pain (n=2)	3B
Wanitphakdeedecha *et al*., 2015[40]	10	Arm circumference reduction	Cryolipolysis	CIF of 41.6 60 min treatment on the lateral side of arm followed by 2 min manual massage	Arm circumference reduction: Circumference measured with tape measure Patient satisfaction survey −1=worse 0=no improvement 1=1%-24% improvement 2=25%-49% improvement 3=50%-74% improvement 4=75%-100% improvement Patient pain visual analog scale	Arm circumference reduction: 0.41 cm at 3 months (P=0.017). 0.72 cm at 6 months (P=0.017). Mean circumference reduction includes both arm and waist measurements	Patient satisfaction survey Satisfied individuals - 76.5% at 3 months' follow-up, 64.7% at 6 months' follow-up Dissatisfied individuals - 23.5% at 3-month follow-up, 35.3% at 6-month follow-up Most subjects rated to have 1%-25% improvement at 3 and 6 months' follow-up Patient Pain Scale: Intra- and post-procedural pain: mild-to-moderate. Mean pain: 7. 1 patient dropped out of study due to pain from treatment	Erythema (n=10) Pain (n=10) Dysesthesia (n=10) Purpura (n=10)	4
Ferraro *et al*., 2012[43]	8	Arm circumference reduction	Cryolipolysis	Sliding mode, with a temperature range 0-−5°C, for a 30-min The "shock probe" was used with a conductive gel for 10-15 min One treatment every 15 days over the course of 8 weeks for a mean 3.73 treatments	Pinch test and arm circumference reduction Patient satisfaction scale from 0=5 with: 0=unsatisfied; 5=very satisfied	Pinch test and arm circumference reduction: 2.10 cm fat layer reduction using the pinch test. 2.75 cm arm circumference reduction	Patient evaluation: Mean: 4.5	Erythema (n=8) Mild elevation of total cholesterol and triglycerides compared to patients' baseline, remained within normal limits (n=8)	4

CIF: Cooling intensity factor

associated with greater results, but also increased the risk of severe adverse events. Given variable rating systems in each study, it is difficult to determine which modality was most efficacious and satisfying for patients. A universally applied assessment scale such as GAIS could allow for better comparison between modalities. Although the majority of the studied patient population has been female, with the rise in male cosmetic procedures further studies are needed to thoroughly evaluate arm contouring techniques.

There was no report of side effects with the use of LLLT.[9,14] HIFU results in mild edema,[24] erythema, bruising, and skin tenderness,[26] all spontaneously resolving within 1 week. Patients rate pain during HIFU as 5.17–5.7 on a 0–10 pain scale.[24,25] RF treatment results in erythema resolving after 1–3 h; other adverse events such as dermatitis, ecchymosis, blisters, and burns took up to 1 week for resolution.[31,33-35] On a 0–10 pain scale, RF was reported at 1.25.[31] Cryolipolysis causes erythema, neuropathy, numbness, and bruising, with resolution occurring in approximately 2 weeks.[6,40,41] This technique is the most painful rated as 7 on 0–10 pain scale; one subject withdrew from a study due to the inability to tolerate procedural pain.[40] Further studies are warranted to compare the adverse event profile of the various modalities and determine long-term safety after arm contouring.

Most studies included are small and have not been reproduced on larger scale. Limitations comparing studies include a lack of systematic approach to the measurement of arm circumference, as well as variability among modalities of treatment, treatment course, follow-up, adverse events, and overall patient satisfaction. Although most studies use total reduction of arm circumference as a measure of treatment outcome,[9,14,31,33-35,40,41] results were measured differently for each device. Multiple studies recorded arm circumference using a retractable tape measure[9,14,31-35,40,41] and standardized measurements by various means including circumferential measurements at a specific distance from the olecranon,[14,31,33,40] placing a grid over a specified area,[25] or using transparent vinyl superimposed on body landmarks such as nevi or scars.[6] Unfortunately, some studies did not even describe how the initial treatment area was identified or accurately measured.

Studies relying on the three-dimensional US to assess adipose tissue reduction,[6,32] yielded reliable, quantitative results by directly measuring the subcutaneous layer. The use of three-dimensional imaging is superior when measuring subtle reductions in adipose tissue compared to a measuring tape, thus reducing the number of patients needed to adequately power a study.[44,45] US allows investigators to focus solely on the treatment area, excluding confounding anatomic features; furthermore, US measures not only adipose tissue depth but also volume.[32] To standardize evaluation of adipose tissue, measurements were taken from the area of the arm with the greatest subcutaneous fat,[9,34] or at a specified distance from the olecranon.[14,31,33,40]

Conclusions

Noninvasive arm contouring using LLLT, HIFU, RF, and cryolipolysis is successful in reducing arm circumference by decreasing subcutaneous adipose tissue deposits. Studies demonstrate that patients are satisfied with results and adverse events are minimal. This review highlights the need for a universal approach to arm measurement and patient satisfaction scale such as GAIS; standardization of treatment evaluation is needed to enable comparison between different modalities. Currently, the most technologically advanced approach to measuring adipose reduction after noninvasive contouring is the three-dimensional US. We suggest standardizing the location of posttreatment evaluation using the midpoint between the olecranon process and acromion process with the arm fully extended. To validate the promising results of noninvasive methods for arm contouring, further research will need to be completed.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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