Cryolipolysis (CoolSculpting System, ZELTIQ Aesthetics, Pleasanton, CA) has been safely and effectively used to non-surgically reduce subcutaneous fat. This noninvasive fat reduction technique is based upon the inherent sensitivity of adipocytes to cold injury. Clinical observations have been published in research literature describing adipose tissue sensitivity to cold. First described in 1902, firm nodules under the chins of children were reported in response to acute cold injury.1 Subsequent reports of cold-induced panniculitis in young children, teenagers, and adults were published.2-6 In 1970, “popsicle panniculitis” was reported in the case of an infant that developed a red, indurated nodule and subsequent fat loss in the cheek after sucking on a popsicle.7

Based upon these clinical observations, Manstein and Anderson recognized the potential for cold therapy to selectively target undesirable adipose tissue and thus invented cryolipolysis. The proof of concept porcine study was published in 2009 showing that significant fat layer reduction could be achieved by noninvasive application of cold without injury to the skin or significant change in

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serum lipids levels or liver function tests. These results were confirmed in a subsequent porcine study using longer treatment durations and colder temperatures. Thereafter, clinical studies demonstrated safety and efficacy in human subjects.

Cryolipolysis received US Food and Drug Administration clearance for fat reduction for the flanks in 2010, for the abdomen in 2012, for the thighs in 2014, for the submental area in 2015, the back, bra fat, and beneath the buttocks in 2016, and for the arms in 2016.

This study investigated a reconstructive rather than aesthetic application of cryolipolysis. For post-mastectomy patients with unwanted residual fat in the lateral chest wall, cryolipolysis was investigated for nonsurgical fat reduction.

**METHODS**

This was a multicenter, prospective, open label, non-randomized interventional cohort study. From two clinical sites, 31 patients were enrolled and completed treatment between May 2013 and November 2015.

Eligible subjects were female post-mastectomy patients with clearly visible subcutaneous fat in the lateral chest wall under the arm. The fat in the intended treatment area was examined to ensure it was soft, pliable, and readily drawn into a cryolipolysis vacuum applicator. All subjects had undergone mastectomy but had never received cryolipolysis or any surgical procedures to reduce lateral chest wall fat. Study subjects would be considered for lipectomy but desired a novel approach, had completed oncologic treatment and now had additional reconstructive treatment planned, had two sides with excess lateral chest wall fat to compare treatment efficacy, and would be willing to return for study follow-up visits. Study exclusion criteria included prior surgical procedures, invasive fat reduction procedures, and noninvasive fat reduction procedures in the intended treatment area, as well as cold sensitivity conditions including cryoglobulinemia, cold urticaria, paroxysmal cold hemoglobinuria, and Raynaud’s disease. Written informed consent was obtained and the principles of the Declaration of Helsinki were followed to ensure ethical medical research involving human study subjects. Subjects received study treatments free of charge and for the duration of the study, were instructed to avoid implementing major diet or exercise changes in order to maintain their weight within 5% of baseline measurement.

Efficacy data was generated by independent photo review. Any subjects that had weight change in excess of ±5% of baseline were excluded from treatment efficacy analysis by photo review. The photo review panel consisted of independent physicians that had previously participated in blinded photo review panels. The reviewers completed their assessments separately and the responses were combined for the overall independent review correct identification rate.

Pre-treatment and post-treatment photograph pairs of each subject in standardized views were randomized using an automated randomization algorithm (RandBetween[0,1] function, Microsoft Excel software, Microsoft Corp., Redmond, WA) and then reviewers were asked to determine which image was the pre-treatment image. Statistical significance of the independent photo review was evaluated by a one-sided exact binomial test. Subject survey data was collected by a written questionnaire at the treatment and follow-up visits in a consultation room in the physician’s office (blank copies of the pre-treatment and post-treatment surveys are available as Supplementary Material at [www.aestheticsurgeryjournal.com](http://www.aestheticsurgeryjournal.com)). The questionnaire was developed by one of the authors (J.L.H.) and subjects were identified only by their study identification number. Safety was monitored by documentation of adverse events and clinical assessment of the treatment site. Subjects were assessed throughout the study for adverse events.

The cryolipolysis treatment was delivered using commercially available devices and treatment parameters. The contoured vacuum applicator (CoolCurve+) was used to treat post-mastectomy patients in the lateral chest wall. A protective gelpad was applied to the skin, the contoured vacuum applicator was positioned in the center of the treatment area, and vacuum suction was initiated. The vacuum adhered the applicator to the treatment area and the subject was comfortably positioned on a treatment bed with pillows to support the applicator throughout the cryolipolysis procedure.

Treatments were delivered at Cooling Intensity Factor 41.6, equivalent to −10°C for 60 minutes, followed by 2 minutes of manual massage, and then an additional 60-minute treatment followed by massage directly thereafter. This “stacking” method delivered two cryolipolysis cycles to each treatment site. Follow-up visits occurred two months’ post-treatment.

Four subjects were treated bilaterally while all other subjects had unilateral treatments with untreated contralateral controls. Optional equalization treatments on the untreated sides were provided at the conclusion of the study.

**RESULTS**

From two clinical sites, 31 subjects participated in the study. Twenty-one subjects were enrolled at the study site near Minneapolis, MN and 10 subjects were enrolled at the study site in Charlotte, NC. All subjects completed the study visits; no subjects were lost to follow-up. The subject ages ranged from 41 to 71 years (mean, 50.4 years). Body mass index (BMI) ranged from 21.8 to 31.6 kg/m² (mean, 26.6 kg/m²). Weight change from baseline ranged from 1 lb. lost to 10 lbs. gained (mean, 1.5 lbs. gained). One subject gained 6% since her baseline visit and was...
excluded from treatment efficacy analysis for exceeding the allowed ±5% weight change limit. All other study subjects remained within the weight change limit. While all 31 subjects completed their patient surveys, some failed to complete certain questions; therefore, the responses are presented as percentages and fractional values for clarity.

Pre-treatment surveys showed that all patients had undergone mastectomy, 32% (10/31) had breast reconstruction surgery, and 3% (1/31) had scar revision surgery. Twenty-three percent (7/31) of the patients had undergone radiation and 58% (18/31) had undergone chemotherapy (Figure 1).

None of the patients had previous experience with cryolipolysis for noninvasive fat reduction. The pre-treatment surveys revealed that patients had considered several treatments to improve their lateral chest wall appearance, as shown in Table 1. The questionnaires also demonstrated that since their mastectomies, patients had altered their clothing, altered their activities, and experienced skin irritation or pain in the lateral chest wall.

Post-treatment surveys were conducted to assess cryolipolysis efficacy. As shown in Table 2, some patients reported improved bra and clothing fit and visible tissue reduction following cryolipolysis.

Measurable quality of life improvements post-treatment were revealed by the questionnaires. Prior to receiving the study treatment, 61% (19/31) of subjects reported pain in the lateral wall; these 61% were comprised of patients that reported pain either always (1/31), sometimes (8/31), or rarely (10/31). When queried post-treatment, only 13% (4/31) reported pain; these 13% were comprised of patients that reported pain either sometimes (1/31) or rarely (3/31); the remaining 87% (27/31) reported no lateral wall pain post-treatment (Figure 2). Prior to treatment, 29% (9/31) of subjects reported sores and rashes from the arm chafing against the residual adipose bulge in the lateral wall. Post-treatment, this decreased to 19% (6/31), as shown in Figure 3.

Post-treatment surveys (Table 2) found that most patients felt cryolipolysis met their expectations and would choose to have the nonsurgical procedure again. While there was improved body contour, few patients reported increased range of motion or increased activity level following treatment.

Treatment efficacy was evaluated by review of clinical photographs by three independent, blinded physicians. The physicians were two board-certified plastic surgeons and one board-certified dermatologist. All 3 physicians were independent, had participated in previous blinded photographic review panels, and had no involvement in the current research study. Basic reviewer demographics were two males and one female, mean age 52.3 with range 45 to 57 years.

For the independent photo review, the subjects’ photographs were reviewed in randomized pairs. The reviewers correctly identified 84% of the baseline photographs ($P < 0.00000001$), demonstrating treatment efficacy. Ninety percent of the baseline photos were correctly identified by Reviewer A, 86% by Reviewer B, and 76% by Reviewer B.
Clinical assessment of the treatment sites was performed immediately post-treatment and at the 2-month follow-up visit. All subjects were evaluated for side effects at the treatment sites and assessed for any adverse events. Immediately post-treatment, the most common effects within the treatment area were erythema, edema, and numbness. These side effects were mild and typical for the cryolipolysis procedure. By the follow-up visit, all side effects had resolved without intervention; no additional office visits or pain management were required. There were no device- or procedure-related serious adverse events and no unanticipated adverse device effects occurred during the study. No study-related complications and long-term adverse events were reported.

There were four subjects treated bilaterally; the remaining subjects had unilateral treatments with untreated contralateral controls. At the conclusion of the study, the subjects were given the option to receive equalization treatments on the untreated sides. Except for equalization procedures, none of the study subjects underwent additional cryolipolysis treatments in the lateral chest wall. One subject completed her unilateral treatment, but found the cryolipolysis procedure uncomfortable and declined the contralateral equalization treatment. She subsequently opted for liposuction to remove the residual contralateral fat. There were no other reports of procedural discomfort from the remaining 30 subjects.

**DISCUSSION**

Breast cancer is the most common cancer affecting women. Over 290,000 cases are diagnosed annually in the United States and 36% of diagnosed patients have mastectomy surgery. Many patients have reconstructive breast surgery with subsequent refinement procedures to improve aesthetics and function.

The lateral chest wall has been addressed as a separate aesthetic unit that merits special attention in breast surgery. In a retrospective review of patients that had aesthetic or reconstructive breast surgery, lateral chest wall deformity was identified in 39% of the patients; deficiency of soft tissue was identified in 8% and excess skin and/or fat was identified in 31%. The authors found that not all patients with lateral chest wall deformities chose to have it addressed, which may result in suboptimal outcomes, even with excellent breast surgery results. Lateral wall deformity may be caused by discrepancy between the size of the reconstructed breast and the residual tissue left in the lateral thoracic fold. The reconstructed breast is often smaller and the appearance of lateral fat becomes more apparent. Reconstruction does not necessarily replace the lateral tail of excised breast tissue and patients may be left with redundant tissue in this region.
Disharmony can be created between the newly reconstructed breast, the lateral mammary fold, and the lateral thoracic compartment.\textsuperscript{32}

Corrective modalities include liposuction, simple excision, and lateral thoracic dermolipectomy to improve aesthetic appearance and enhance function by reducing compression and rubbing against the inner arm.\textsuperscript{32} These chest wall refinements can be addressed during revision surgery to enhance aesthetic results of breast reconstruction. But some patients do not wish to undergo further surgery and are willing to explore nonsurgical options to minimize the unwanted bulge in the lateral chest wall.

This study was initially conceived as a reconstructive rather than aesthetic application of cryolipolysis, a popular nonsurgical procedure for fat reduction in the abdomen, flanks, and thighs. It is also used for reducing fat in the submental area, arms, and back. For post-mastectomy patients with unwanted residual fat in the lateral chest wall, cryolipolysis was investigated for reconstructive nonsurgical fat reduction.

**Figure 4.** (A) Baseline and (B) 8-week post-treatment photographs of lateral chest wall treatment for a 51-year-old woman. Oval eye guides indicate the treatment area.

**Figure 5.** (A) Baseline and (B) 8-week post-treatment photographs of lateral chest wall treatment for a 50-year-old woman. Oval eye guides indicate the treatment area.
As anticipated, cryolipolysis safely and effectively reduced the unwanted subcutaneous fat in the treated site. Efficacy was demonstrated by 84% correct identification of baseline photographs by independent physician reviewers and questionnaires that revealed 84% of subjects reported noticeable reduction in fat thickness. The reduced fat thickness also resulted in 74% noting improved clothing fit and 85% reporting better bra fit.

Since the quality of soft tissue may change following radiation therapy, treatment effect was examined for the patients that did and did not have a history of radiation. Comparison of blinded photo review results and patient satisfaction data did not show a statistically significant difference; safety and efficacy were not affected by prior radiation therapy. Stratified analysis was also performed on patients with BMI in the normal, overweight, and obese ranges. Stratified analysis was carried out for blinded photo review data and satisfaction survey data. The efficacy data showed there was not a statistically significant difference between the three BMI groups.

Patient histories were examined further with respect to radiation history, reconstruction surgery, and time following mastectomy or reconstruction. For patients that had undergone radiation therapy as part of breast conservation treatment, the duration from completion of radiation until the initiation of cryolipolysis ranged from 6 months to 7 years. For patients that underwent reconstruction surgery, tissue expanders and breast implants were used. Where indicated, patients had sentinel nodes and lymph node dissection. Skin sparing mastectomies and nipple sparing techniques were employed. From the Minneapolis series, the time between completion of mastectomy or reconstruction to cryolipolysis treatment ranged from 6 months to 19 years; only 3 of these 21 patients participated in the cryolipolysis study within the first year following surgery. For the Charlotte series, the time ranged from 7 to 17 months. Further study is needed to establish a safe, stable guideline for post-surgery duration prior to cryolipolysis, but the authors suggest a minimum of 6 months.

While the fat reduction may appear modest to a plastic surgeon, the surveys revealed significant improvement from the patients’ perspectives. The surveys showed that 87% of subjects reported cryolipolysis met their expectations. The satisfaction rate is consistent with results reported in other cryolipolysis prospective clinical study publications in a variety of treatment sites; submental area 83%, flanks 82%, outer thighs 86%, and inner thighs 93%. It is unknown whether this satisfaction rate would have differed had the patients been charged for their post-mastectomy lateral chest wall cryolipolysis treatments, but the results are likely to be within the range for retrospective studies. A retrospective study of n = 518 patients that received commercial cryolipolysis treatments reported 73% satisfaction. An online survey of patients that had undergone commercial cryolipolysis treatments showed 87% felt the procedure was “worth it” based upon n = 860 patient ratings within the previous 12 months.

In addition to the anticipated reduction in subcutaneous fat, there were also unanticipated reports of pain reduction. Prior to the study, 61% of subjects reported pain in the lateral wall either always (3%), sometimes (26%), or rarely (32%); when queried post-treatment, only 13% reported pain either sometimes (3%) or rarely (10%). Thus, 87% reported no lateral wall pain post-treatment.

![Figure 6. (A) Baseline and (B) 8-week post-treatment photographs of lateral chest wall treatment for a 60-year-old woman. Oval eye guides indicate the treatment area.](image-url)
The pain reduction provided an unexpected benefit to these post-mastectomy study subjects with unwanted residual lateral thoracic fat.

This is a first of its kind study to use nonsurgical technology to reduce residual lateral chest wall fat. Providing a nonsurgical treatment option to post-mastectomy patients contributes to the reconstructive surgery knowledge base and benefits patients that are unwilling to undergo additional surgery. This pilot study provides encouraging results on nonsurgical cryolipolysis as a reconstructive option for patients and plastic surgeons.

It is a small pilot study, however, and there were limitations. The study would have benefited from efficacy analysis that quantified the fat reduction using ultrasound or caliper measurements. The subject questionnaire was not validated since its intended use was a small pilot study. Photographic review was conducted to determine baseline photos, but the photos were not graded to quantify improvement; thus, change may have been visible but minor. A follow-up study should be conducted to explore cryolipolysis for lateral chest wall fat reduction in a larger patient population with quantified efficacy data for the treated and untreated contralateral controls in all patients. A larger patient group will allow investigators to look more closely into patient response and which characteristics may predict a favorable clinical outcome for residual lateral chest wall fat.

Further study is needed to explore why post-mastectomy patients in this study reported a reduction in pain following cryolipolysis. While the reduction in adipose tissue volume in the lateral chest wall resulted in less skin irritation from rubbing against the inner arm, it is unknown why pain decreased post-treatment. A dedicated, controlled study on pain reduction in post-mastectomy patients is warranted to further explore the pain reduction observed in this pilot study.

There have been two earlier published studies which reported on sensory nerve alterations following cryolipolysis. An earlier study of cryolipolysis and its effects on peripheral nerves found that transient reduction in sensation occurred but returned to normal by an average of 3.6 weeks; no lasting sensory alterations were observed. The patients in the current study reported pain reduction at 2 months’ post-treatment, which is beyond the expected duration of transient sensation reduction.

A study of sensory nerve function following cryolipolysis found that cryolipolysis produced a marked decrease in mechanical and thermal pain sensitivity. The study findings suggest that cryolipolysis has the potential to provide long-term lasting relief of cutaneous pain. Additional study should be conducted on patients with post-mastectomy pain to understand the duration and degree of pain reduction following cryolipolysis.

In this pilot study of cryolipolysis for post-mastectomy fat reduction in the lateral chest wall, nonsurgical adipose tissue reduction was achieved along with reduction in skin irritation, reduction in pain, and improvement in clothing and bra fit.

**CONCLUSION**

Results from this pilot study indicate that cryolipolysis leads to nonsurgical fat reduction and may reduce discomfort from residual lateral chest wall fat in post-mastectomy patients. Cryolipolysis is a safe and effective nonsurgical reconstructive procedure to reduce undesirable fat. This study presents a unique application in which cryolipolysis is utilized to non-surgically reduce fat in post-mastectomy patients that are reluctant and unwilling to undergo further surgery. Patient surveys reveal reduced pain and skin irritation in the lateral chest wall, improved bra and clothing fit, and visible improvement by nonsurgical refinement of the lateral chest wall post-mastectomy.

**Supplementary Material**

This article contains supplementary material located online at www.aestheticsurgeryjournal.com.

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