



# A Prospective Study Determining Patient Satisfaction with Combined Cryolipolysis and Shockwave Therapy Treatment for Noninvasive Body Contouring



Alain Michon<sup>1,2,3</sup>

Received: 25 November 2020 / Accepted: 10 January 2021 / Published online: 29 January 2021

© Springer Science+Business Media, LLC, part of Springer Nature and International Society of Aesthetic Plastic Surgery 2021

## Abstract

**Background** With an increased interest in nonsurgical and minimally invasive body fat reduction and body contouring procedures with limited side effects and downtime, cryolipolysis has emerged as a compelling and safe alternative to surgical fat removal methods. A massage of the treated areas generally follows cryolipolysis treatment to improve blood circulation and increase apoptotic fat cells' removal. In this study, following cryolipolysis, we used shockwave therapy instead of massage to enhance the results of the body contouring treatment and improve the patient's comfort. We then assessed patients' comfort and satisfaction using the combination of cryolipolysis and shockwave therapy in reducing fat volume.

**Methods** We conducted a prospective study of 30 patients who underwent at least one cryolipolysis therapy cycle followed by shockwave treatment. Subjects were given a posttreatment questionnaire to assess the patient's comfort and satisfaction degree with the combination of cryolipolysis and shockwave therapy for fat reduction. Answers were recorded on a five-point Likert-style scale, entered into a database and were analyzed.

**Results** We found an overall high satisfaction rate for most patients when treated with shockwave therapy after cryolipolysis treatment. The majority of patients described the

discomfort associated with treatment as minimal or tolerable (76.7%) and were prepared to recommend cryolipolysis treatment followed by shockwave therapy to friends (68.9%). Overall, 76.7% of patients found the combination therapy comfortable, 68.3% were satisfied with the results, 57.7% said the results met their expectations.

**Conclusion** The most important aspects of body contouring methods is a patient's safety, comfort, satisfaction and self-image improvement. In this study, we report a high level of patient satisfaction when using a combination of fat reduction procedures of cryolipolysis followed by shockwave therapy. The majority of cases report being satisfied or extremely satisfied with the treatment and found this body contouring combination method comfortable. Cryolipolysis combined with shockwave treatment appears to be a safe and efficient way of reducing the size of localized and stubborn fat deposits for subjects who desire nonsurgical localized fat reduction.

**Level of Evidence IV** This journal requires that authors assign a level of evidence to each article. For a full description of these Evidence-Based Medicine ratings, please refer to Table of Contents or the online Instructions to Authors [www.springer.com/00266](http://www.springer.com/00266).

**Keywords** Noninvasive body contouring · Cryolipolysis · Shockwave therapy · Fat reduction · Aesthetics · Patient satisfaction

✉ Alain Michon  
drmichon@ottawaskinclinic.ca

<sup>1</sup> The Ottawa Skin Clinic, 349 St Laurent Blvd, Ottawa, ON K1K 2Z7, Canada

<sup>2</sup> Department of Emergency Medicine, University of Ottawa, Ottawa, Ontario, Canada

<sup>3</sup> Institut du Savoir Montfort, Montfort Hospital, Ottawa, Ontario, Canada

## Introduction

Body contouring improves the body's appearance by removal, transfer or lipolysis of the body fat. In 2018, the global body contouring market size reached US\$ 6.1 billion. It is estimated that the body fat reduction market

surpasses \$16.5 billion by 2025 [1]. So far, liposuction has been the most popular procedure for efficient fat removal. However, there are some risks and post-procedural adverse effects associated with liposuction, including body scarring, infection, irregularities, complications from anesthesia and, in rare cases, death. Liposuction surgery also requires downtime for recovery [2]. In addition to removing adipose tissue mass by liposuction, fat tissue volume can also be reduced by cryolipolysis. With the emergence of approved non-surgical fat reduction technologies such as radio frequencies, ultrasound, carbon dioxide, laser and cold-induced lipolysis, and rising interest for non-invasive procedures that are minimally painful and requires no downtime, the global market for fat reduction procedures have shifted [3–5]. Cryolipolysis, laser lipolysis and ultrasound are noninvasive fat reduction procedures that can reduce fat deposits, localized adiposities and stubborn fat without surgery and scarring. Other techniques using radio frequencies and carbon dioxide have been studied as noninvasive body contouring [5]. Ice-Shock Lipolysis is another noninvasive procedure for reducing subcutaneous fat volume and fibrous cellulite in areas that previously would be treated by liposuction [3]. CoolSculpting, an FDA-approved noninvasive fat reduction method, has been used for the localized destruction of subcutaneous adipocytes without inducing lipid or liver marker levels in the blood serum [6, 7]. This technique has shown to be safe for repeated applications and different skin types [8]. An animal study of the cryolipolysis technique in the pig model showed cutaneous cooling-induced adipocyte apoptosis, triggering a selective delayed lobular panniculitis and reduction in subcutaneous fat [9]. Cryolipolysis delivers cold to the tissues, as fat cells are more sensitive to cold, the membrane of adipocytes is damaged, and the apoptosis process is triggered. Cold-induced apoptosis leads to an inflammatory reaction, macrophage recruitment and stimulation of the lipolytic process. Lipid droplets vary in size (from 20 nm up to 100  $\mu$ m), and larger ones might take few months to break, be digested and cleared from the body [10].

To enhance the clinical outcome and efficacy of cryolipolysis while maintaining the treatment's safety, a posttreatment manual massage was added to the original treatment protocol [11]. The safety and efficacy of cryolipolysis have been extensively reported in the literature, and most people who have used cryolipolysis for localized fat reduction report being satisfied with the results [12, 13]. The results, however, would generally take a few months to appear. Other techniques have been used in combination with cryolipolysis to improve clinical outcomes, including massage therapy. Massage therapy seems to induce mechanical destruction of adipocytes primed to undergo apoptosis from temperature cooling. However, it is difficult

to measure or control variabilities in the manual massage's quality and intensity. A previous study has shown that shockwave therapy, when combined with cryolipolysis, improved the treatment result. To minimize variability in the quality when the patient was treated with manual massage, instead of manual massage, we used shockwave therapy immediately after cryolipolysis treatment to enhance the result of fat reduction treatment and improve the patient's comfort and satisfaction.

Shockwave therapy was initially used to treat renal calculi and musculoskeletal disorders, cellulite-afflicted skin and acute and chronic soft tissue wounds [14, 15]. High-energy radial shockwaves appear to impact collagen structure, skin and connective tissue, increasing blood circulation and stimulating collagen regeneration, which helps improve skin firmness and elasticity. A previous study using a combination of cryolipolysis and shockwave therapy has shown a significant fat thickness reduction by programmed cell death, which was confirmed by histologic and immunohistochemical analysis [3]. The combination of the two procedures appears to cause the programmed death and slow resorption of destroyed adipocytes. Although the majority of patients reported they experienced minimal or no discomfort during or after the procedures, so far, patient satisfaction and self-image improvement with the combined treatment have not been studied. In this study, we did a comprehensive assessment of tolerance and patient satisfaction level when we used a combination of the noninvasive body contouring technique, cryolipolysis and shockwave therapy.

## Materials and Methods

### Population Study

We conducted a prospective study of patients treated with a combination of therapy of cryolipolysis (CoolSculpting® System, Allergan) and shockwave therapy. All patients treated with at least one cycle of CoolSculpting and subsequent shockwave therapy between January 1, 2018, and December 31, 2018 (64 patients) were considered for this study and were contacted via phone or e-mail. Their full treatment process may have begun in 2017 or have ended in 2019. Patients excluded from this study included (1) patients with metabolic, neurological or oncological diseases, (2) patients who did not complete the recommended rounds of cycles, or (3) did not return for a follow-up that could establish a mutual agreement of completion, or (4) were treated only in the off-label areas, or (5) their treatment charts lacked essential information, or (6) patients who have had CoolSculpting treatment on the same body part at another clinic before coming to our clinic, or (7)

patients who had only CoolSculpting treatment without shockwave therapy, or (8) who did not complete the questionnaire. Patients were included in the study based on completing the number of treatment sessions, as quoted during their initial visit. If the cycles and rounds were not completed as recommended, the patient would still be considered as long as the patient and medical team mutually agreed that further treatment was unnecessary or no longer therapeutic. Forty-eight subjects who fit the inclusion criteria were reached by either telephone or e-mail, 15 patients completed the survey over the phone with a nurse investigator, and 15 patients completed the questionnaire online. In total, 30 patients who fit the above criteria, agreed to be part of the study and completed the Likert survey were included in this study (Fig. 1). Eligible subjects were male (10%) or female (90%) and between 24 and 60. All cases had visible and palpable subcutaneous fat on physical examination. Before treatment and at a minimum of 12-week post-final follow-up visits, clinical assessments and photographs were obtained. The consent form was sent to the patient for review before the phone survey via e-mail.

The consent form was sent to the patient for review before the phone or e-mail survey via e-mail. If they agreed to participate in the study, a recorded verbal informed consent was obtained before the phone or e-mail survey. This study was conducted following good clinical practice and regional laws and regulations and adhered to the Declaration of Helsinki principles.

### Cryolipolysis System

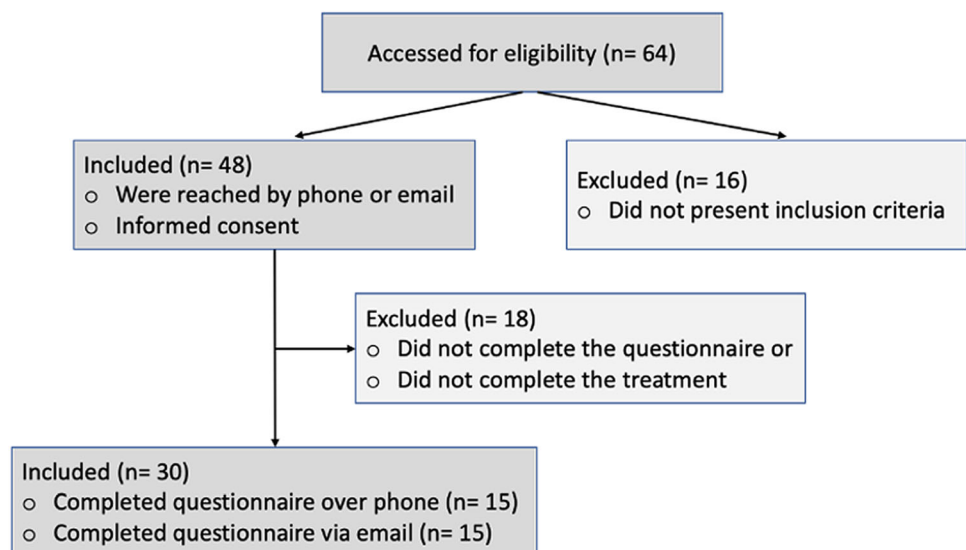
We used CoolSculpting, an FDA-approved cryolipolysis system, in our study (CoolSculpting® System, Allergan).

The first CoolSculpting device was purchased in 2015 and the second device in 2016. In most cases, the CoolSculpting Advantages applicators (CoolAdvantage) were used. The older version of CoolSculpting applicators was used for a few cases as it provided a better fit and seal of the treatment areas. A previous study has shown that the two types of applicators were equivalent in safety and efficacy [16]. CoolSculpting reduces fat volume and thickness by inducing adipocyte apoptosis through cold-assisted lipolysis. The CoolSculpting® procedure is increasingly used to treat visible fat bulges in the submental and submandibular areas, thigh, abdomen and flank, bra fat, back fat, underneath the buttocks and upper arm. Similar to other medical devices, approved indications for the use of CoolSculpting vary in different countries. CoolSculpting is a noninvasive cooling system that induces lipolysis of adipose tissue, breaking down fat cells without damaging nerve cells or other tissues [17]. The destroyed fat cells at the treated area will stimulate an inflammatory process. They will be engulfed and digested by the body's immune system and then cleared through the lymphatic system [13]. The procedure gradually leads to reduced fat layers in the treated areas.

### Shockwave Therapy

Shockwave therapy is primarily used to treat various chronic musculoskeletal disorders and acute and chronic soft tissue wounds. High-energy radial shockwaves appear to impact collagen structure, skin and the connective tissue, improving blood circulation and stimulating collagen regeneration. Also, the treatment appears to decrease the discomfort associated with cryolipolysis treatment and cold-induced lipolysis. Shockwave therapy equipment used

**Fig. 1** Flowchart for Constitution of Study Group. The charts of patients treated during this study were reviewed, and patients who fit the inclusion criteria were contacted. In total, 64 subjects were accessed for eligibility and 30 subjects who presented the inclusion criteria, completed the treatment and responded to the questionnaire were included in this study



in this study was ZWave<sup>Pr</sup> (Zimmer Medizin Systems). The Shockwave system was applied with an electromagnetic generator as a projectile accelerator at 120 MJ, 15 Hz, and 2500 pulses, as recommended by the instrument's manufacturer (Zimmer Medizin Systems).

### Treatment Protocol

The CoolSculpting system was used as per the manufacturer's direction [18]. Based on protocol, subjects received CoolSculpting treatment for each area, followed by shockwave therapy instead of recommended massage to improve the clinical outcome. The skin was cleansed and a transparent gel applied to the selected area before treatment, and then the vacuum applicator was covered with the gel trap. Subjects underwent a single or multiple 35-, 45- or 75-min cycle(s) as recommended by the manufacturer (Advantage, Advantage Plus and CoolMini, or CoolSmooth Pro applicator, respectively) of cryolipolysis treatment per area with a maximum cooling temperature of  $-11\text{ }^{\circ}\text{C}$  to the selected area using the CoolSculpting System, followed by a 3-min shockwave therapy (ZWave<sup>Pr</sup>, Zimmer Medizin Systems). The number of treatment cycles was determined based on the physical examination of the treatment area and the patient's overall expected outcome. Twelve weeks after treatment, each patient was assessed to determine whether an additional session(s) was warranted. The Shockwave system was applied with an electromagnetic generator as a projectile accelerator at 120 MJ, 15 Hz and 2500 pulses. Based on the CoolSculpting treatment guidelines and medical team determination, treatment cycles were performed 6 to 12 weeks apart. Treated areas included submental, abdomen, flanks, inner thighs, outer thighs, triceps area, armpit, arms,

back and axilla. All treatments were performed before the initiation of this study.

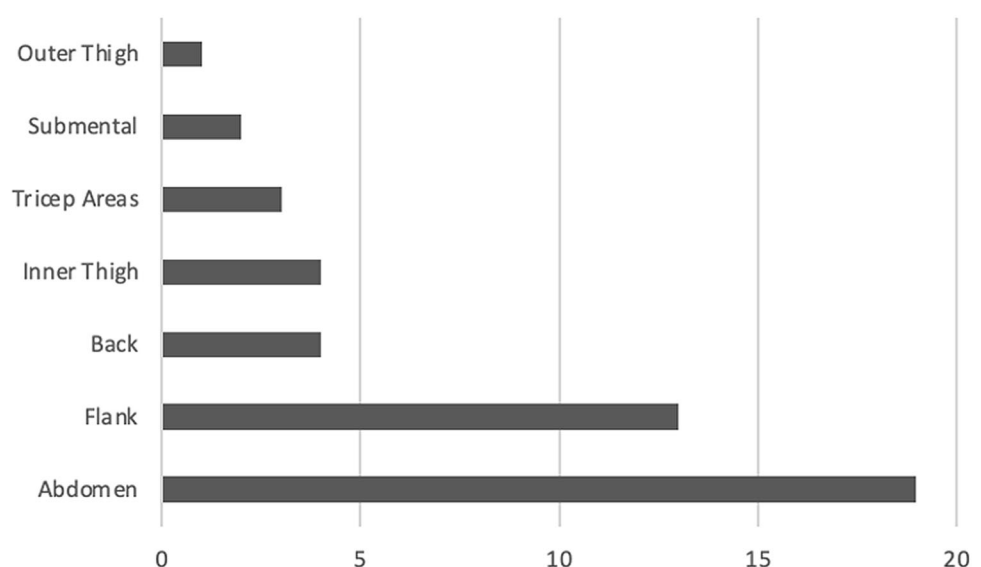
### Statistical Analysis

The five-point Likert scale questionnaire scoring was tabulated and calculated using Microsoft Excel. The results were recorded in a database, and their answers were coded from 1 (strongly agree) to 5 (strongly disagree). For each question, the percentage was calculated for each answer. The five-point Likert scale questionnaire (Q) was also divided into four main categories as follows: the degree of comfort during and after treatment (Q2, Q3, Q12); overall satisfaction with the treatments (Q4, Q13); body image improvement and expectation (Q5, Q6, Q7); and if they would recommend the combination treatment to others (Q8, Q9, Q10). An average score, in percentage, for each category was then calculated and recorded.

### Results

We conducted a prospective patient satisfaction study of patients treated for the combination therapy (CoolSculpting and shockwave therapy). A total of 30 patients met our inclusion criteria and were enrolled in this study. The majority of cases had been treated for the abdomen (63.0%) and flank (43.0%) areas. Other treated areas were back (13.0%), inner thigh (13.0%), triceps (10.0%), submental (6.6%) and outer thigh (3.3%) (Fig. 2). The minimum number of treatment cycles was 2, and up to a max of 37 cycles if multiple body areas were treated. After treatment and at a minimum of 12-week follow-up, patients were asked to complete a five-point Likert-style scale

**Fig. 2** Treatment areas. The majority of cases were treated for the abdomen (63.0%) and flank (43.0%), followed by back and inner thigh areas



questionnaire to evaluate their level of satisfaction with the treatment. The results were recorded in a database, and their answers were coded from 1 to 5 from “strongly

agree” to “strongly disagree.” In total, 83.3% of patients found CoolSculpting treatment to be comfortable and 50.0% found shockwave therapy following CoolSculpting

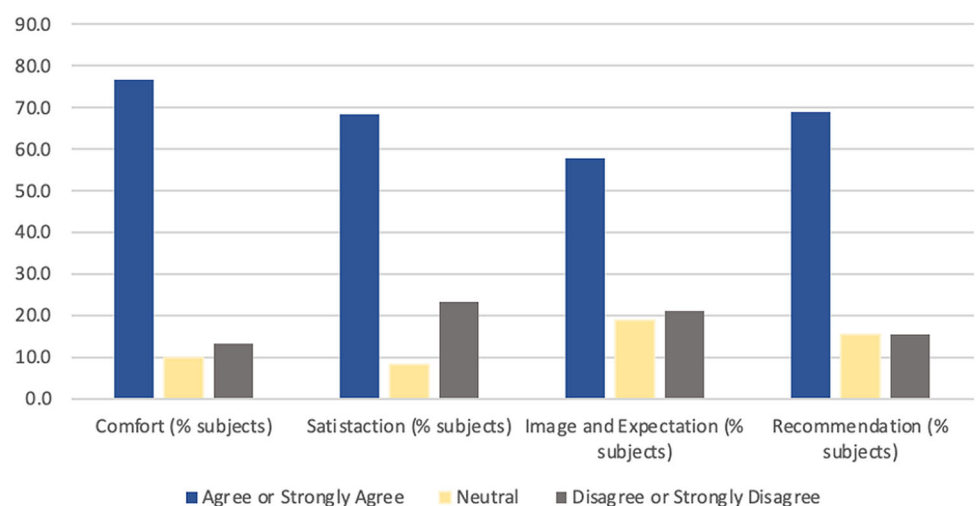
**Table 1** A five-point Likert-style scale questionnaire was used to study the degree of patients’ satisfaction and comfort level with the combination of CoolSculpting and shockwave treatment

Questionnaire	Strongly agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Strongly disagree (%)
Q2 You found CoolSculpting to be a comfortable treatment overall	36.7	46.7	10.0	6.7	0.0
Q3 You found shockwave therapy following CoolSculpting treatment to be comfortable	13.3	36.7	20.0	23.3	6.7
Q4 Your results following CoolSculpting were satisfactory	16.7	50.0	10.0	20.0	3.3
Q5 Did CoolSculpting including shockwave therapy meet your expectations	20.0	40.0	16.7	6.7	16.7
Q6 Your self-esteem has improved since your treatment	20.0	30.0	26.7	13.3	10.0
Q7 CoolSculpting and shockwave therapy have had a positive impact in your life	20.0	43.3	13.3	6.7	16.7
Q8 You are likely to treat additional areas with CoolSculpting and shockwave therapy	20.0	33.3	20.0	16.7	10.0
Q9 You would recommend CoolSculpting with shockwave therapy to a friend	26.7	40.0	16.7	6.7	10.0
Q10 You found your technician to be well informed	73.3	13.3	10.0	0.0	3.3
Q12 You found your environment to be comforting throughout your treatment	73.3	23.3	0.0	0.0	3.3
Q13 You are satisfied with your CoolSculpting treatment combined with shockwave therapy overall	43.3	26.7	6.7	10.0	13.3

**Table 2** The five-point Likert scale questionnaire was also divided into four main categories as follows: the degree of comfort during and after treatment; overall satisfaction with the treatments; body image improvement and expectation; and if they would recommend the combination treatment to others

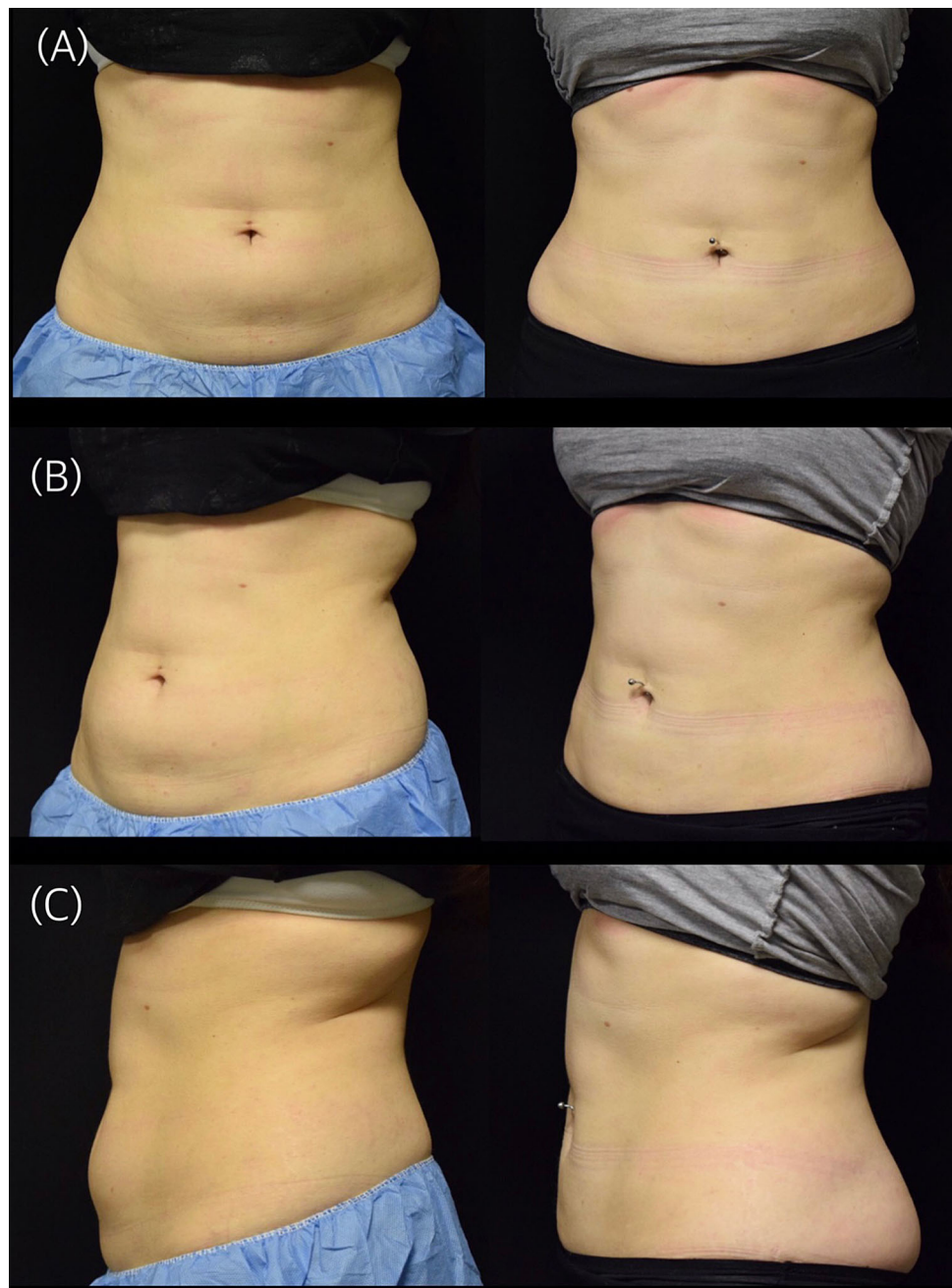
	Comfort (%)	Satisfaction (%)	Image and expectation (%)	Recommendation (%)
Agree or strongly agree	76.7	68.4	57.7	68.9
Neutral	10.0	8.4	18.9	15.6
Disagree or strongly disagree	13.3	23.3	21.1	15.6

**Fig. 3** Overall satisfaction. In our study, 76.7% of patients found the combination therapy (CoolSculpting and shockwave therapy) comfortable, 68.3% were satisfied with the procedures, and the majority of patients (68.9%) described the discomfort associated with treatment as minimal or tolerable and were prepared to recommend CoolSculpting treatment followed by shockwave therapy to friends





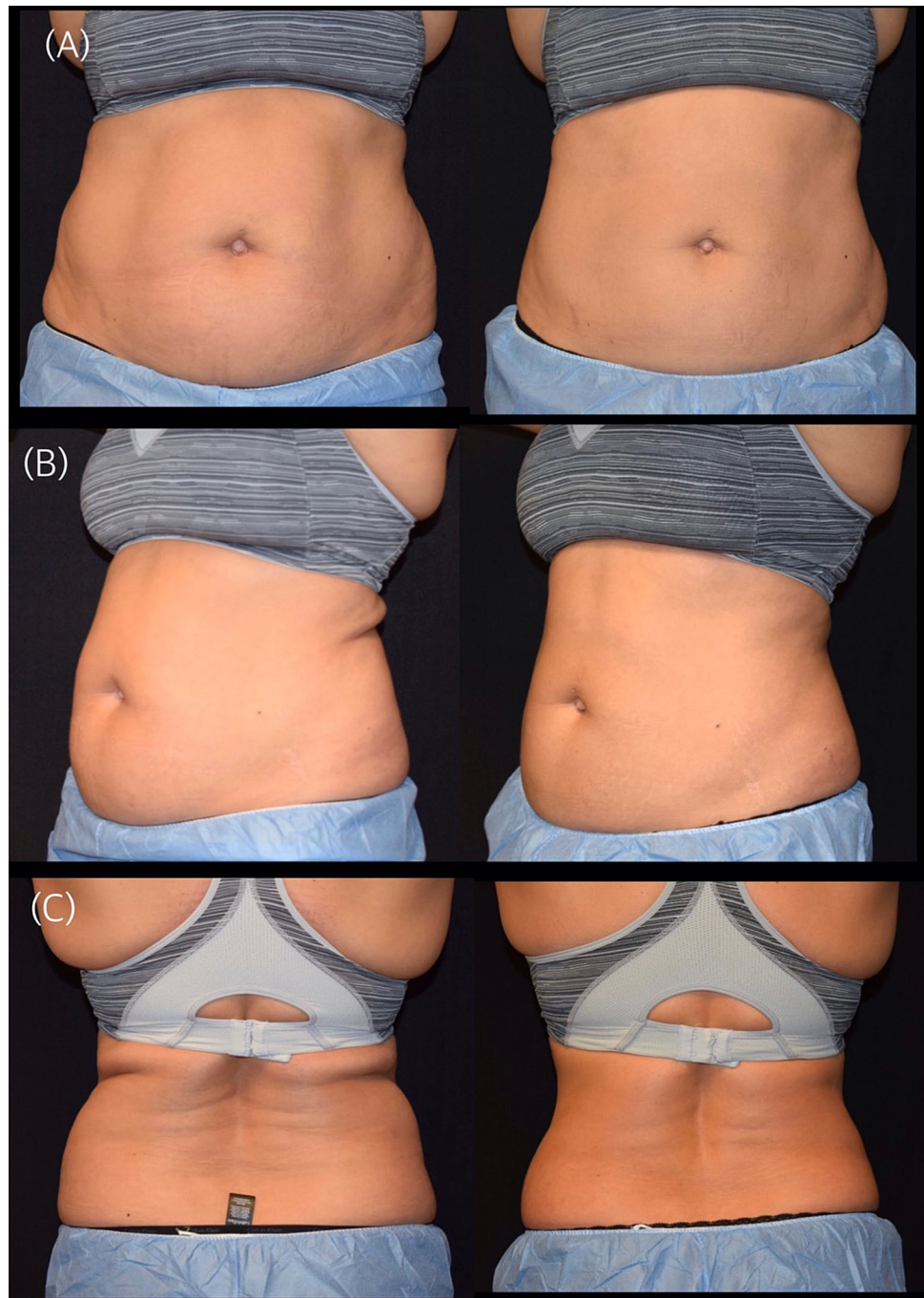
**Fig. 4** Patient No 1. **a** Frontal view, **b** left oblique view, **c** left lateral view. Pre- and post-images of a 41-year-old female that received one cryolipolysis session followed by shockwave therapy. During her session, she received two treatment cycles on her lower abdomen. Clinical photographs **a**, **b**, and **c** show subcutaneous fat reduction between baseline (left) and 3 months posttreatment (right)



to be comfortable. Sixty-seven percent of the patients found the results of CoolSculpting satisfactory, and 60.0% said the results of the combination therapy met their expectations. Sixty-three percent of patients said the combination therapy positively impacted their lives, and 66.7% would recommend the combination therapy to their family and friends. Overall, 70.0% of patients were satisfied or strongly satisfied with the results of the combination of CoolSculpting and shockwave therapy (Table 1). The five-point Likert scale questionnaire (Q) was also divided into four main categories as follows: the degree of comfort during and after treatment (Q2, Q3, Q12); overall

satisfaction with the treatments (Q4, Q13); body image improvement and expectation (Q5, Q6, Q7); and if they would recommend the combination treatment to others (Q8, Q9, Q10). An average score for each category was then calculated and recorded (Table 2). Overall, 76.7% of patients found the combination therapy comfortable, 68.4% were satisfied with the results, 57.7% said the results met their expectations (Fig. 3). The majority of patients (68.9%) described the discomfort associated with treatment as minimal or tolerable and were prepared to recommend CoolSculpting treatment followed by shockwave therapy to friends (Figs. 4, 5, 6).

**Fig. 5** Patient No 2. **a** Frontal view, **b** left oblique, **c** posterior view. Pre- and post-images of a 47-year-old female that received one cryolipolysis session followed by shockwave therapy. During treatment, she received two treatment cycles on her upper abdomen, one cycle on lower abdomen, two cycles on bra fat, and two cycles on flanks. Clinical photographs **a**, **b** and **c** show reduction of fat from baseline (left) and 3 months posttreatment (right)



## Discussion

The most important aspects of body contouring methods are patient safety, comfort, satisfaction and self-image improvement. With an increased number of noninvasive fat reduction and body contouring techniques and advances in these technologies, and high interest in noninvasive fat reduction methods, cryolipolysis popularity has significantly increased [4]. Clinical studies have shown noninvasive controlled cold treatment induces selective

destruction of fat cells and selectively damages subcutaneous fat without harming the overlying skin or any changes in serum lipid levels [19–21]. Lipid-rich fat cells are more susceptible to apoptosis induced by cold than other types of cells. Previous studies have shown cryolipolysis to be safe and efficient in removing up to 25% of the fat layer in the treated areas with a high level of patient satisfaction [19, 22]. However, it takes between 4 to 8 weeks before damaged fat cells are digested by macrophages, adsorbed or eliminated from the body and





**Fig. 6** Patient No 3. Posterior view of a patient's arms before and after treatment. Pre- and post-images of a 35-year-old female that received one cryolipolysis treatment followed by shockwave therapy. During her session, she received two treatment cycles per arm. Clinical photographs **a** depict subcutaneous fat reduction between baseline (top) and three months posttreatment (bottom)

noticeable changes in subcutaneous fat are observed. Also, it may take up to 12 weeks to visualize the final results. To increase the fat removal process's efficiency, decrease tissue swelling around the treated areas and eliminate variability in manual massages, we used shockwave therapy immediately after cryolipolysis treatment. Shockwave therapy has been shown to activate the biological response in treated areas and improve tissue regeneration and healing by increasing proliferation factors. It also increases collagen production and reduces the inflammatory phase and wound infection risk [23, 24]. Shockwave therapy has also been shown to relieve pain around treated areas and wound [14, 25–27]. Mechanical movement and pressure produced by shockwave therapy increase cell membrane permeability and metabolism within treated areas and lead to increased circulation and faster removal of the damaged fat cells after cryolipolysis treatment [28].

## Conclusion

A previous study has shown a combination of cryolipolysis and shockwave therapy induces a substantial fat thickness reduction [3, 29]. It might also lead to a reduction of pain in patients treated with cryolipolysis. One of the patients who had received CoolSculpting combined with manual massage therapy before reported better and faster results with less posttreatment discomfort when treated with our new protocol, where we used shockwave therapy after CoolSculpting treatment. In this study, we found an overall high satisfaction rate for most of our patients when treated

with a combination of CoolSculpting and shockwave therapy. Therefore, we recommend shockwave therapy, following cryolipolysis treatment, as an alternative to current prescribed posttreatment procedures to further improve patient comfort and satisfaction.

**Acknowledgements** I would like to thank nurse Vanessa Sinden-Lafèche for conducting the patients' satisfaction survey, Dr. Sima Salahshor for her editorial contributions, and Allergan for the publication grant.

## Compliance with Ethical Standards

**Conflict of Interest** Dr. Alain Michon is a medical advisor and consultant with Allergan.

**Ethical Approval** Ethical approval was not sought for the present study because it was not required. This study was conducted following good clinical practice and regional laws and regulations and adhered to the Declaration of Helsinki principles.

**Informed Consent** Written informed consent was obtained for all subjects before combined cryolipolysis and shockwave therapy treatment, and a recorded verbal informed consent was obtained from all subjects before taking part in the survey study.

## References

1. Ugalmugale S, Swain R (2020) Body fat reduction market size by procedure (Surgical {Liposuction, Abdominoplasty}, Non-surgical {Cryolipolysis, Ultrasound, Laser Lipolysis}), By Gender (Female, Male), By Service Provider (Hospitals, Clinics, Medical Spas). Industry Analysis Report, Regional Outlook, Application Potential, Price Trends, Competitive Market Share & Forecast, 2020–2026. Global Market Insights, Report id: GMI3141
2. Rao RB, Ely SF, Hoffman RS (1999) Deaths related to liposuction. *N Engl J Med* 340:1471–1475
3. Ferraro GA, De Francesco F, Cataldo C et al (2012) Synergistic effects of cryolipolysis and shock waves for noninvasive body contouring. *Aesthet Plast Surg* 36:666–679
4. ASAPS (2018) Cosmetic (Aesthetic) Surgery National Data Bank, STATISTICS. Report by The American Society for Aesthetic Plastic Surgery
5. Jewell ML, Solish NJ, Desilets CS (2011) Noninvasive body sculpting technologies with an emphasis on high-intensity focused ultrasound. *Aesthet Plast Surg* 35:901–912
6. Klein KB, Zelickson B, Riopelle JG et al (2009) Non-invasive cryolipolysis for subcutaneous fat reduction does not affect serum lipid levels or liver function tests. *Lasers Surg Med* 41:785–790
7. Klein KB, Bachelor EP, Becker EV et al (2017) 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* 49:640–644
8. Stevens WG, Pietrzak LK, Spring MA (2013) Broad overview of a clinical and commercial experience with CoolSculpting. *Aesthet Surg J* 33:835–846
9. Manstein D, Laubach H, Watanabe K et al (2008) Selective cryolysis: a novel method of non-invasive fat removal. *Lasers Surg Med* 40:595–604
10. Thiam AR, Beller M (2017) The why, when and how of lipid droplet diversity. *J Cell Sci* 130:315–324



11. Boey GE, Wasilenchuk JL (2014) Enhanced clinical outcome with manual massage following cryolipolysis treatment: a 4-month study of safety and efficacy. *Lasers Surg Med* 46:20–26
12. Dierickx CC, Mazer JM, Sand M et al (2013) Safety, tolerance, and patient satisfaction with noninvasive cryolipolysis. *Dermatol Surg* 39:1209–1216
13. Krueger N, Mai SV, Luebberding S et al (2014) Cryolipolysis for noninvasive body contouring: clinical efficacy and patient satisfaction. *Clin Cosmet Investig Dermatol* 7:201–205
14. Antonic V, Mittermayr R, Schaden W et al (2011) Evidence supporting extracorporeal shock wave therapy for acute and chronic soft tissue wounds. *Wounds* 23:204–215
15. Carulli C, Tonelli F, Innocenti M et al (2016) Effectiveness of extracorporeal shockwave therapy in three major tendon diseases. *J Orthop Traumatol* 17:15–20
16. Kilmer SL, Burns AJ, Zelickson BD (2016) Safety and efficacy of cryolipolysis for non-invasive reduction of submental fat. *Lasers Surg Med* 48:3–13
17. US Food and Drug Administration (2014) 5 10(K) Summary of safety and effectiveness. FDA, [https://www.accessdata.fda.gov/cdrh\\_docs/pdf13/K133212.pdf](https://www.accessdata.fda.gov/cdrh_docs/pdf13/K133212.pdf)
18. ZELTIQ (2018) User Manual CoolSculpting System.
19. Zelickson B, Egbert BM, Preciado J et al (2009) Cryolipolysis for noninvasive fat cell destruction: initial results from a pig model. *Dermatol Surg* 35:1462–1470
20. Cohen PR (2017) Notalgia paresthetica: a novel approach to treatment with cryolipolysis. *Cureus* 9:e1719
21. Meyer PF, da Silva RM, Oliveira G et al (2016) Effects of cryolipolysis on abdominal adiposity. *Case Rep Dermatol Med* 2016:6052194
22. Nelson AA, Wasserman D, Avram MM (2009) Cryolipolysis for reduction of excess adipose tissue. *Semin Cutan Med Surg* 28:244–249
23. Vetrano M, d'Alessandro F, Torrisi MR et al (2011) Extracorporeal shock wave therapy promotes cell proliferation and collagen synthesis of primary cultured human tenocytes. *Knee Surg Sports Traumatol Arthrosc* 19:2159–2168
24. Kuo YR, Wang CT, Wang FS et al (2009) Extracorporeal shock-wave therapy enhanced wound healing via increasing topical blood perfusion and tissue regeneration in a rat model of STZ-induced diabetes. *Wound Repair Regen* 17:522–530
25. Zhang L, Fu XB, Chen S et al (2018) Efficacy and safety of extracorporeal shock wave therapy for acute and chronic soft tissue wounds: a systematic review and meta-analysis. *Int Wound J* 15:590–599
26. Greer N, Foman NA, MacDonald R et al (2013) Advanced wound care therapies for nonhealing diabetic, venous, and arterial ulcers: a systematic review. *Ann Intern Med* 159:532–542
27. Wang CJ, Kuo YR, Wu RW et al (2009) Extracorporeal shock-wave treatment for chronic diabetic foot ulcers. *J Surg Res* 152:96–103
28. Stojadinovic A, Elster EA, Anam K et al (2008) Angiogenic response to extracorporeal shock wave treatment in murine skin isografts. *Angiogenesis* 11:369–380
29. Knobloch K, Kraemer R (2015) Extracorporeal shock wave therapy (ESWT) for the treatment of cellulite: a current meta-analysis. *Int J Surg* 24:210–217

**Publisher's Note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.