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Capacitive-Resistive Monopolar Radiofrequency at 448 kHz as Coadjuvant Treatment in Plastic Surgery

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Abstract. Radiofrequency is widely used in the clinical practice thanks to the physiological effects of therapeutic heat on pain relief, reduction of inflammation and edema, and tissue regeneration. Capacitive-resistive monopolar radiofrequency (CRMRF) at 448 kHz has proven to have effects applied as diathermal and subthermal power. Work subthermally allows to focus on acute processes immediately after surgery, where hyperemia is contraindicated, and no other radiofrequency can be applied. The study focuses on the effect of applying 448 kHz as a coadjuvant treatment in plastic surgery, both before and after surgery, and the results have shown that, when applied before surgery, particularly in patients with risk factors, it prepares tissues by ensuring their oxygenation and accelerating recovery, reduces postoperative time, and obtains better results. When applied after surgery, it has the same effects aside from reducing tissue inflammation and hematomas and resolving fluid retention, which favors lymphatic drainage without pressotherapy. CRMRF applied as a coadjuvant treatment of plastic surgery is a safe, painless, and well-accepted treatment for patients, which reduces the time of surgery by 20%–30% in patients with fibrosis and the time of recovery by 40%–50%. It obtains better results, reduces costs, and patients can see the results of surgical treatments sooner.

Key words: capacitive-resistive monopolar radiofrequency, subthermia, edema, inflammation, hematoma, plastic surgery

Introduction

Radiofrequency (RF)-based electrophysical agents, including capacitive-resistive electric transfer (CRET) and capacitive-resistive monopolar RF (CRMRF)[1], consist of oscillating energy at specific frequencies, which generates therapeutic heat in body tissues, a technique known as diathermy[2]. RF is widely used in the clinical practice for its thermal effects, relieving pain and inflammation and improving tissue regeneration[3,4]. Until a few years ago, the most commonly used and researched RFs were short-wave therapies operating at 27.12 MHz[5].

Electrophysical agents employing much lower frequencies have recently emerged, such as CRMRF, which uses 448 kHz[6]. This particular wavelength has proven to have effects only on the affected area, both applied as a diathermal and subthermal power, i.e., without producing a significant increase in the temperature of the treated tissue[1]. In studies regarding the effects of subthermal 448-kHz CRMRF[1,7–13], we have observed a wide range of effects, including antiproliferative responses of human cancer cells[7], interference with the processes that control the synthesis and mobilization of fat at early adipogenic stages[8], fibroblast proliferation and the overexpression of biomarkers that are essential in skin regeneration[11], and stimulation of stem cell replication[1]. Since the effects of subthermia are frequency-dependent, the physiological effects of CRMRF indicate more substantial clinical benefits than other RFs[9].

Physiological Effects of 448-kHz Radiofrequency

According to studies on the stable frequency of 448 kHz, three different effects can be obtained based on the thermal increase generated (or the power ap-

plied) on the skin's surface. There are three operating ranges:

· **Hyperactivation:** When applied at a high power through hyperthermia (39 ºC–45 ºC), it activates lipolysis[14], drains toxins, increases cell metabolism[15], tissue detoxification and drainage, and promotes collagen production[16]. In the long term, it favors the restructuring of fat deposits and fibrosis, tissue tightening, and neocollagenesis (it acts on fibroblasts, activating the formation of collagen and elastin), which especially translates into an improvement in the quality of the skin[8,10,11]. This procedure is usually employed in more evolved processes.

· **Vascularization:** When applied at a medium power through thermia (36 ºC–38 ºC) to dilate blood vessels and increase blood flow, it causes tissue and cell oxygenation, increases vascularization and cell metabolism, and promotes drainage. In a subacute mode, it favors recovery and regeneration[17].

· **Biostimulation:** It is achieved using subthermia (32 ºC–35 ºC). At this level, the effect of a 448-kHz electric current has been described to promote stem cell proliferation[1]. It has an antiadipogenic action[8], among other properties of subthermia, allowing for there to be a focus on acute processes immediately after surgery, where hyperemia is contraindicated, and no other RF can be applied[18]. Subthermia is helpful for inflammation and edemas, lymphatic drainage, reabsorption of hematomas, scars, and pain relief[7,13,19]. It is essential to highlight that subthermal effects are frequency-dependent, so since these have not been described yet for other frequencies, they may differ from the effects of a 448-kHz current[9].

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Medical-Aesthetical Applications of Radiofrequency

Working with subthermia RF allows for the treatment of a wide range of conditions, such as pain, fibrosis, muscle weakness, localized and visceral fat, lipodystrophy, lipedema, pathological scarring, or the stimulation of blood circulation. In our clinical experience, CRMRF is applied as coadjuvant therapy in plastic surgery, is optimal for preparing patients that are still unsuitable to undergo surgery, and to favor the recovery of those that have been operated on. Its application helps to accelerate wound healing, allowing better results since the longer the procedure lasts, the higher the probability of undesired effects and comorbidities. Before surgery, three to five sessions are recommended to prepare the tissues and the metabolic and inflammatory responses, so the procedure is less aggressive and achieves better results. It can improve not only the skin appearance, but also its functionality and the patients' quality of life.

Its effects decrease the recovery time, allowing surgery results to be visible sooner and lowering the cost of treatment, and may help more patients to access these surgeries/treatments. It is estimated that, in patients with fibrosis, applying CRMRF before the treatment favors the release of fibrosis, reducing the time of surgery by 20%–30%. In addition, its application before and after the surgery decreases the recovery time by around 40%–50%. Furthermore, patients can see results faster, increasing their satisfaction level.

Due to all of the above, procedures in which applying CRMRF should be recommended are:

- **Body Contouring:** It helps to rebalance cells, increasing internal temperature, which activates cell metabolism and helps eliminate fat without damaging other cells. It can be combined with other techniques, such as liposuction or cryotherapy, to homogenize the surface of the treated area and favor skin tightening[8].
- **Cellulite Reduction:** It helps reduce cellulite (edematous, fibrotic, adipose, and mixed) and achieve smoother, firmer skin[20,21].
- **Skin Tightening and Hydration:** It increases blood flow and nutrient supply, hydrates the tissue and stimulates the production of collagen, which translates into healthier-looking skin[16].
- **Scar Treatment:** Hyperthermia successfully reduces keloids; thermia treats scars in the subacute phase, and subthermia acts on skin regeneration and scarring[22].
- **Facial and Body Rejuvenation:** It helps the body regenerate collagen and elastin fibers, thickening the skin and reducing wrinkles[16].
- **Breast Tissue:** Treatment with 448-kHz CRMRF is essential in breast procedures, not only for augmentation mammoplasty, but also for breast pexia or breast reduction surgery. It helps restructure the

tissue and balance fatty and breast tissues. A significant improvement in post-surgery hematoma resolution, acceleration of the wound healing process, and pain resolution has been observed. It is combined with a low intensity pulsed laser to decrease the risk of a possible capsular contracture. Microtextured implants are used to allow for less rotation and less risk of contractures[23].

- **Combined Treatments:** They can be used with other aesthetic treatments and technologies such as threads, fillings, and fractional CO2 lasers to reduce the recovery time or enhance effects[12].
- **Application Before and After Surgery:** Before treatment, it prepares the tissue to reduce the risk of complications during surgery, such as hematoma, edema, seroma, skin laxity, or scar-related, among others[24]. After surgery, it accelerates recovery and improves results[25].
- **Vaginal Rejuvenation:** It promotes the regeneration and fast and deep tightening of the tissues with visible results from the first session[26].
- **Capillary Treatments:** It restores capillary health, increasing blood flow and hair thickness and improving oxygen supply to the scalp and hair follicles[27].

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Contraindications and Precautions in the Radiofrequency Treatment

The use of 448-kHz CRMRF is contraindicated in pregnant women, carriers of pacemakers or other types of electronic implants, and patients with thrombophlebitis.

Possible Side Effects

After applying this treatment, patients are expected to perceive a thermal sensation in the treated area and may eventually report transient discomfort. The manifestation of erythema after the application is not uncommon, especially in treatments using thermia/hyperthermia and in those in which sensitive skin may suffer transient local irritation. Applying creams that help favor conductivity can rarely cause mild skin irritation.

Clinical Cases

CRMRF treatments of the cases presented below were performed using an INDIBA® Deep Care (INDIBA® S.A., Barcelona, Spain) device of continuous CRMRF operating at 448 kHz (from now on DC device). Treatment protocols applied in each case were those pre-established by the manufacturer. In treatments that required thermia/subthermia, the head or transducer used was the capacitive, which is recovered by a membrane that insulates the metallic electrode turning it into a capacitor, allowing the transmitted energy to increase the local temperature to the desired level, in this case, to be from 36ºC-38ºC (outer skin) and not exceeding 38ºC (*Figure 1-a*). In the case of treatments with hyperthermia, the transductor used was resistive with a metallic surface and without an insulating coating, which allows it to transmit the electric energy in a more direct way, to achieve higher temperatures up to 45º C (*Figure 1-b*). Due to its physical features, the energy provided by the capacitive electrode is mainly concentrated on the superficial part of the body, while the one provided by the resistive electrode reaches the deeper layers of the skin[6].

Participants used an 11-point subjective analog scale to self-report a thermal sensation from 0, no thermal sensation, to 10, worst possible thermal sensation[28,29]. It was expected to obtain high VAS scores during tightening treatments, whereas low VAS scores in acute processes, in which only subthermia can be used.

Prior to body surgeries such as liposculpture,

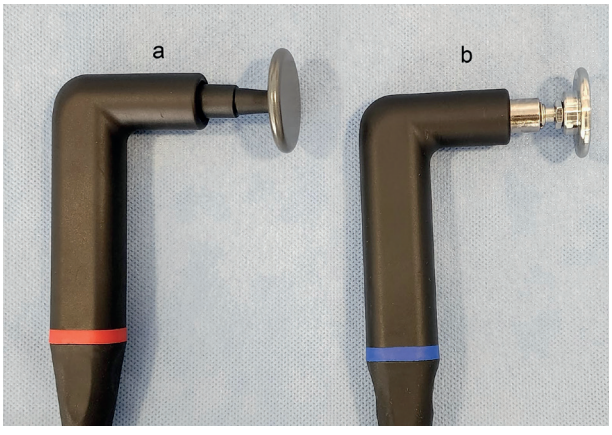

Figure 1 - Capacitive-resistive monopolar radiofrequency transductors: **a)** capacitive; **b)** resistive.

lipectomy, or reduction mammoplasty, patients were performed an impedancemetry with an InBody 230 (Biospace Co., Ltd, Seoul, Korea) scanner to quantify their parameters, including total body water, body fat mass, lean mass, fat-free mass, weight, skeletal muscle mass, body mass index, percentage of body fat, or segmental lean mass, among others. This data helped assess, based on each treatment, the suitability of the treatment and the number of sessions required.

A- Facial Treatment Protocol

Case 1

A 65-year-old man underwent a frontoplasty and rhytidectomy to manage the frontal region, upper eyelids, and fat lipojection in the chin and lower eyelids to improve his facial appearance. The surgery lasted 2.5 hours; a drain was placed in the retroauricular and retrocervical area, which was kept on for 24 hours.

CRMRF Treatment: The facial protocol was applied with the device in capacitive mode. The treatment combined five sessions before surgery and eight sessions after surgery. One day after surgery, the drain was removed, and the hematomas were resolved after two days. The patient showed facial paralysis of the lower part of the face due to liposculpture, which resolved after 15 days, a complication that usually, without CRMRF, requires three months (*Figure 2*).

Case 2

A 24-year-old woman attended the consultation with an injury to the right ciliary region due to an assault with a sharp, blunt object. Upon physical examination, she presented the inability to raise her eyebrow (due to the injury to the frontalis and corrugator muscles), loss of sensitivity of the entire affected hemiforehead, and alteration in the activation of the superciliary corrugator muscle. The patient underwent surgery to release the ophthalmic branch of the trigeminus and repair the muscle fibers and a combined skin flap before resectioning macerated or necrotic tissue (*Figure 3*).

Figure 2 - Facial treatment in men: **a** before surgery; **b** after surgery; **c** after 22 days.

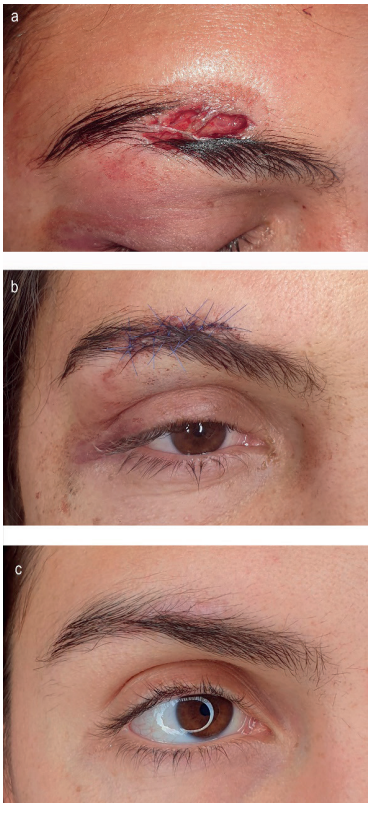

Figure 3 - Facial treatment in women: **a** before surgery; **b** immediately after surgery; **c** after three months.

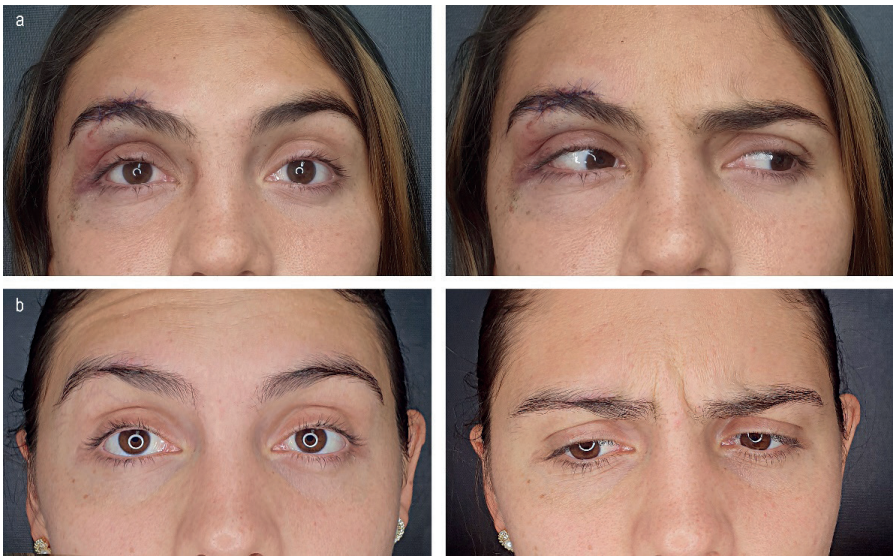

Figure 4 - Recovery of frontal mobility and activation of the corrugator muscles: **a** immediately after surgery; **b** after three months.

CRMRF Treatment: She was offered CRMRF treatment in the capacitive mode for tissue recovery, stimulation, and revascularization to prevent possible alopecia in the area after surgery and for the recovery of neural therapy. With the device set for the facial protocol in post-trauma mode, 15 sessions were applied (10 once per day and five every three days), and a capillary protocol to stimulate growth at that level. The patient's and operator's subjective thermal sensations were assessed. The patient recovered 100% of her frontal mobility and 93%–94% of the corrugator muscles activation in two months, which meant a regeneration and functional recovery of 95% (*Figure 4*).

There was follicle recovery in the operated area, a challenging accomplishment to be done only with surgery. After three months, the patient had recovered 100% of frontal mobility, 98% of the corrugator muscles activation, and 100% of sensitivity. That equates to a 97% full recovery (*Figure 3-c and Figure 4-b*).

B- Breast Tissue

Case 1

A 40-year-old woman was operated on for breast implants with microtextured prostheses.

CRMRF Treatment: It was applied through three sessions before surgery and five sessions after surgery in a mixed capacitive mode. Manipulation of the breast area is usually avoided after this type of surgery. However, we have observed that CRMRF therapy is painless, and excellent results regarding skin necrosis, fat necrosis, and scarring improvement can be obtained. The patient recovered after 8 days, when the usual recovery time would be around three weeks. A nodal activation was performed to improve lymphatic drainage (*Figure 5*).

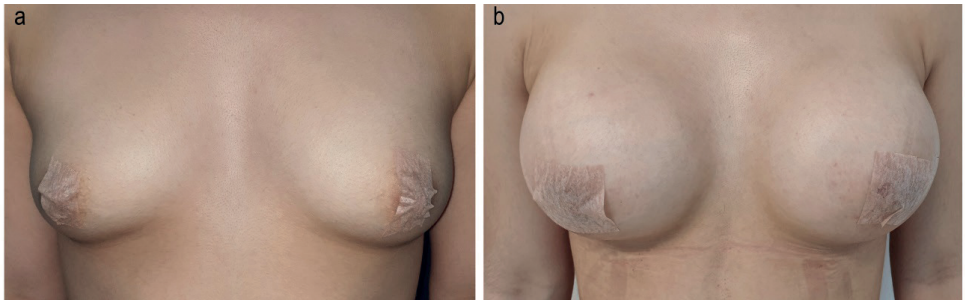

Figure 5 - Breast tissue: **a** before surgery; **b** after 21 days.

C- Body Management in Men

In men, the inflammatory process is usually more aggressive. In abdominal procedures, using 448-kHz CRMRF reduces the time required for marking or managing fibrosis, decreasing the risks of complications after surgery and associated costs.

Case 1

A 33-year-old man was treated solely with VASER (vibration amplification of sound energy at resonance) technology using a Vaser® 2 device (Solta Medical, Bothell, WA, USA).

***CRMRF Treatment*:** Before surgery, the body protocol was applied for men in mixed abdominal mode (visceral fat) in a resistive mode. After surgery, muscular stimulation was applied in the capacitive mode to define the abdomen further. After eight days, hematomas and fluid production resolved, and the drains were removed. At 15 days, there was a visible improvement in the definition of the lateral and middle lines, retraction at the level of the oblique muscles, and an improvement in the umbilical layout and the pectoral area (*Figure 6*).

D- Combining Technologies

Patients with multiple liposuctions usually present damaged skin, generalized fibrosis, lipodystrophy, fat accumulations, and cicatricial adhesions. Applying CRMRF in capacitive and resistive modes before and after surgery improves the skin's appearance and quality and improves cellulite and the distribution of stretch marks due to the stimulation generated by collagen production. It reduces the need for the surgeon's effort and surgery time if employed before surgery. This improvement was observed at ten days, when the usual time is between one and three months after surgery without the pre and postoperative CRMRF.

Case 1

A 26-year-old woman was proposed to undergo a lipectomy in another institution, but we discouraged

Figure 6 - Body management in men: **a** before surgery; **b** after seven months.

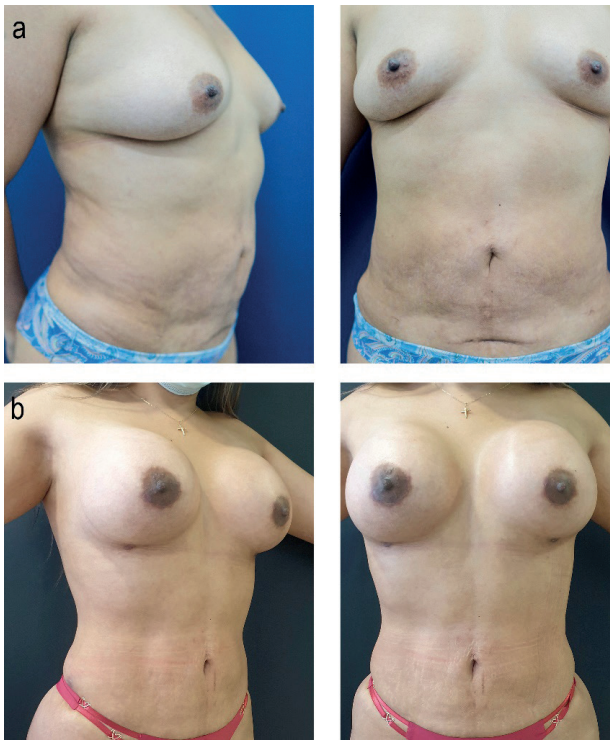

Figure 7 - Combining technologies: **a** before surgery; **b** after 40 days.

this procedure due to her age. She was offered therapy with CRMRF pre and postoperatively.

CRMRF Treatment: Before the surgery, five sessions were applied in liposuction mode, and tens of sessions in capacitive and resistive mode after the surgery. After ten days, her skin showed better retraction than if any other type of treatment had been applied (*Figure 7*).

Discussion

RF began to be used in medicine in 1920 and has been widely employed in almost all medical specialties[30]. The possibility of working subthermally, only using the electrical effect, makes it a highly versatile device for treating laxity, fibrosis, accumulations of fat, and tissue regeneration[1,8,10,11,17]. For this reason, the use of CRMRF in aesthetic surgery has increased in the last 15 years[31]. However, the use of CRMRF is considered in those patients that are candidates for surgery but do not want to undergo an excision procedure, patients who are not candidates but cannot obtain good results with other non-invasive techniques, or who have undergone prior surgeries and present recurring laxity. However, as our evidence clearly demonstrates, CRMRF can be applied as a coadjuvant treatment before and after plastic surgery. Its effects prepare tissues by ensuring oxygenation to accelerate recovery and reduce postoperative time—allowing for more surgical aggressiveness—and better results can be obtained, for example, with skin cuts or the amount of fat removed during a lipectomy or by defining tissues in high-definition liposculpture. Post-surgery 448-kHz CRMRF reduces tissue inflammation and hematomas and resolves fluid retention, favoring lymphatic drainage without pressotherapy, which requires a better management of drains[17]. This treatment is painless and well-accepted by patients, who can observe the results of surgical treatments sooner (*Figure 8*).

In a retrospective study of patients that underwent upper and lower blepharoplasty, external canthopexy, tumor removal, ptosis, and eyelid reconstruction, 83 patients were treated postoperatively with the DC device, and 16 patients were also treated with two sessions of the DC device before the surgery. On the seventh day after the intervention, 61.5% of the patients treated only with the DC device postoperatively did not show bruises, compared to 75% of the patients also treated before the surgery. In addition, patients in the group that applied CRMRF pre and post-surgery

Figure 8 - Fast recovery: **a** before surgery; **b** after ten days.

sessions showed faster recovery and subjectively perceived improved surgical comfort with less bleeding[32].

Using CRMRF to manage plastic surgery-related complications helps us resolve and prevent their evolution, shortening recovery times and favoring better results. For example, in Case 1 of facial surgery, in which the patient underwent a rhytidoplasty and, after surgery, presented with facial paralysis at the level of the depressor muscles of the oral commissure, the application of CRMRF accelerated the recovery. The paralysis was resolved in 15 days when the usual resolution would be around three months. In Case 2 of the facial surgery, after 30 days, the patient had 97% sensitivity and recovered mobility of the corrugator muscles, the inflammation decreased, and hair growth in the ciliary region was observed. In breast pexia, for example, which tends to produce hematomas that cause pain, applying CRMRF contributes to its prevention and a much faster resolution. In the case of lipectomies, it allows to be more aggressive during surgery since CRMRF favors angiogenesis and neovascularization of the tissue. In hypoperfusion areas, it optimizes new flows much faster, solving complications more easily. It is also crucial in treating foreign patients since the application of CRMRF shortens the time of postoperative stay, allowing them to return to their countries sooner and reducing the total cost of the procedure.

However, diet and or weight loss could influence the aesthetic results. This fact has not been considered because the cases presented had no diet or significant weight loss before the surgery.

In our application protocols of 448-kHz CRMRF, we distinguish between the following:

- **Patients with Risk Factors:** In this case, risk factors are related to patients who present degrees of advanced fibrosis and require prior management to minimize the risk of intestinal perforation due to a mechanical effect or patients who are going to undergo a skin cut and require improving the tissue irrigation on the face, breast, or abdomen. However, there are other risk factors associated with the patient, such as age, gender, body mass index, smoking, diabetes mellitus (type I and type II)[33], and nutritional deficiencies[34]; and risk factors associated with the procedure would be the surgery type and combined procedures[24]. Patients with any risk factors received three to five sessions before the surgery to prepare the tissues and prevent complications and several sessions after the surgery to favor recovery, resolve potential complications, and get better results.
- **Patients Without Risk Factors:** CRMRF sessions only after surgery. This working protocol has yielded a lower incidence of hematomas, fewer seromas, less pain, and fewer perfusion complications at the flap level in the distal part when performing lipectomies. Specifically, it allows for much faster recovery times.

Conclusions

Applying CRMRF at 448 kHz prior to aesthetic surgery allows tissue preparation and the metabolic and inflammatory responses to make it less aggressive during the procedure. An application post-surgery allows possible complications to resolve faster, reducing postoperative times and treatment costs and making it easier to achieve better results that can be observed sooner.

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