Chapter

Non-invasive Alternatives for Liposuction

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Abstract

Body dissatisfaction due to an increased amount of subcutaneous fat, muscle laxity and/or skin imperfection poses a great concern for today's society. Invasive surgical procedures intended for an immediate improvement of body contour such as liposuction were perceived as a means of restoring the optimum body shape. However, the invasive nature of liposuction plus a certain amount of discomfort and downtime leads to increasing popularity in the noninvasive esthetic procedures. This chapter aims to emphasize the use of latest noninvasive technologies as a viable alternative to the liposuction. Three patient cases with different levels of treatment outcomes were reviewed. Patients received treatments either with high-intensity focused electromagnetic field (HIFEM) procedure or a combination of HIFEM and synchronized radiofrequency (RF), optionally followed by the simultaneous therapy by targeted pressure energy (TPE) plus monopolar RF. HIFEM alone resolves muscle laxity, reduces the separation of abdominal muscles and reduces abdominal adipose tissue. When combined with synchronized RF, the effect on muscle and fat tissue is enhanced. Concomitant use of monopolar RF and TPE shows considerable improvements in skin quality, including diminished skin laxity or cellulite. The use of HIFEM, RF and TPE technologies can be a good noninvasive liposuction alternative.

Keywords: HIFEM, RF, TPE, laxity, toning, fat reduction

1. Introduction

Areas of exercise-resistant or diet-resistant fat, skin issues, and muscle concerns are many reasons the patients turn to cosmetic surgeries. Whether these concerns come from fatty areas at the abdomen, back, or thighs that would not budge, loose skin after dramatic weight loss, or pregnancy, many people try to find the best ways to eliminate these problems.

While skin excision is needed in some cases, liposuction is often the most preferred treatment for patients to contour or shape their bodies and eliminate the extra fat for different areas. Liposuction, also referred to as lipo, lipectomy, liposculpture suction, or lipoplasty, is a popular cosmetic surgery that breaks and sucks away the fat from the body. A cannula, a hollow instrument, is used to remove the fat during the procedure. The instrument is inserted into the skin, and a high-pressure, powerful vacuum is applied to the cannula to evacuate the fat. Due to its invasive nature, the whole procedure often requires anesthesia to combat patient discomfort associated with the insertion of a cannula. It is commonly used on the abdomen, flanks, upper back, neck, buttocks, thighs, and volar arms and calves.

The procedure is highly popular around the world and is one of the top-performing cosmetic procedures [1]. This treatment helps permanently remove the fat cells and enhance the shape of the body. Nevertheless, the remaining fat cells could grow bigger if the patient does not follow a healthy lifestyle after the surgery. Also, liposuction does not resolve skin irregularities as stretch marks, dimples, or cellulite. It does not affect muscle tissue by any means since it primarily focuses on enhancing or changing the body's adipose contour. Additionally, only a limited amount of fat can be eliminated, and there are certain risks and downtime associated with the treatment.

While most patients are happy with the outcome of their traditional body contouring procedures, a fair number of them are left with unresolved problems. Moreover, many are still reluctant to undergo surgery to reduce fat and prefer a procedure without any down time or scars. Fortunately, in recent years, numerous minimally invasive and non-invasive alternatives to liposuction have been introduced. These procedures for fat reduction and body contouring do not require any anesthesia or incision and have no downtime. The introduction of non-invasive treatments allows physicians to offer such patients with non-invasive fat reduction and body contouring treatments as an alternative to surgery-assisted liposuction (SAL).

While the numerous body-contouring treatments aim to target adipose tissue by utilizing light energy [2, 3], ultrasound [4, 5] or cold temperatures [6, 7], the new revolutionary non-invasive HIFEM technology [8–12] has brought attention to the underlying muscle tissue as well. In addition, the combination of High-intensity Focused Electromagnetic field (HIFEM) with synchronized [13] or externally applied radiofrequency (RF) and targeted pressure energy (TPE) [14] can provide a new solution for body contouring dilemmas, such as striae, skin contour irregularities, cellulite, residual subcutaneous fat, and diastasis recti without the need for any surgery.

This chapter aims to introduce non-invasive HIFEM, RF, and TPE technologies as a viable alternative to the conventional SAL procedure when used in a standalone regime or as a combination treatment. As always, patient selection and preferences are the key factors when prescribing the procedure that should fit his/her needs regarding the specific body area and imperfection that is going to be treated. Given the technological advancements in the non-invasive field of esthetics in recent years, we believe the technologies mentioned above may achieve competitive and perhaps advantageous results in some specific cases.

2. Technology and mechanism of action

Since patients who attend your practice are unique with varying goals and needs, it is essential to understand the importance of providing various solutions to help them accomplish their desired results. Over time, you might have encountered many patients who wanted to achieve a contoured body, tight muscles, and smooth skin appearance without the necessity of the invasive surgical procedure.

While this might have been impossible a decade ago, the non-invasive solution evolved greatly in the past few years. Today, with appropriate patient selection and treatment planning, it may offer an outstanding alternative to liposuction (see Section 3. Non-invasive technologies as an alternative to SAL). Not only these non-invasive solutions may provide an alternative to SAL, but they also have capabilities to enhance the results post-SAL. Physicians can combine these procedures to further enhance patient results post-liposuction based on the patient's expectations and goals. To understand the abovementioned procedures in detail, it is integral to learn about their mechanism of action (MOA).

A systematic electronic search by using the terms "HIFEM" and "targeted pressure energy (TPE)" was carried out to identify the relevant literature published since January 2018. Articles investigating the effect of the HIFEM procedure as a standalone tool or in combination with synchronized RF, and monopolar radiofrequency combined with TPE were further evaluated based on the Author's knowledge. In addition, the reference lists of analyzed articles were inspected to identify the additional valid source of information. Research that quantitatively documents changes in fat, muscle and skin tissue in response to the treatments was summarized with special attention given to histological studies, evidencing the induced changes at the molecular/tissue level. Besides, the outcomes, including but not limited to improvement of patient appearance, comfort, and satisfaction, have been reviewed as well.

2.1 HIFEM

The first-ever HIFEM based procedure was shown in 2018 when the Emsculpt device (BTL Industries Inc., Boston, MA) was introduced to the market and gained considerable popularity among patients and physicians. Emsculpt is FDA-approved for toning and strengthening the abdominal muscles, arms, calves and lifting and toning the buttocks. This technology treats muscle laxity in numerous parts of the body, including calves, thighs, biceps, triceps, abdominal areas, and buttocks. Its function is based on the law of electromagnetic induction. Hence it utilizes electromagnetic coil build-in the device's applicator, which generates a strong and varying magnetic field, penetrating the treated area and targeting neuromuscular tissue. Since medical usage did not require such an intensive magnetic field, broad spot size, and stimuli with a high repetition rate before introducing the Emsculpt device, HIFEM technology must be specifically engineered to meet the criteria necessary for esthetics.

Four treatment sessions are recommended to induce visible changes in the treated area. Nonetheless, some subjects may benefit from a few additional treatments to maximize their goals [10]. Each session typically lasts for around 30 minutes, including the pre-treatment preparations, and depending on the patient's availability. They can be scheduled 1–2 times a week. The device allows using two applicators simultaneously, enabling the concurrent application of HIFEM, especially over the buttocks, arms, calves, and abdomen in higher BMI subjects. It is necessary to take the subcutaneous fat thickness into account. Ideal candidates for HIFEM treatments are men and women with fat thickness up to 3 cm [15].

Overall, the treatment is safe without any side effects, and besides slight muscle soreness the day after the therapy due to the fatigue and muscle regeneration, it causes no discomfort. Emsculpt has shown considerable improvements in body image a few months following the final treatment [8–12, 16, 17], comparable to the progress one achieves after an intensive workout. Many patients claim that noticeable changes may be seen just after a few days of treatment.

2.1.1 Supramaximal contractions

HIFEM utilizes a rapidly changing magnetic field with intensities up to 1.8 T and penetration depth of roughly 7 cm, generated by the circular coil embedded in the device applicators. Based on the law of electromagnetic induction, this alternating field induces electrical currents in the targeted tissue. In general, the current passes across a nerve membrane into its axon. It results in depolarization, which is required to trigger the opening of voltage-gated sodium and potassium ion channels. Then, the action potential is initiated, and it is further propagated by the physiological mechanisms of nerve conduction, evoking a contraction of muscle fibers. The excitation is selective to muscle tissue due to the tailored parameters of the HIFEM field. The alpha motor neurons (a component of peripheral nerves) directly responsible for initiating muscle contractions are activated first [18, 19].

In normal conditions, the highest tension that can be physiologically held and developed is Maximal Voluntary Contraction (MVC), lasting for barely a second. The contractions with higher tension are referred to as supramaximal. The HIFEM technology can create supramaximal contractions and sustain them for multiple seconds to drastically enhance the physiologic stress required for muscles to adapt. On the contrary, in the voluntary means of muscle contractions, the muscles' fibers relax between every stimulus because of the inability of the central nervous system to signal the other impulse when it is still in action [18]. However, this non-invasive technology generates the impulses with such frequency that it offers no relaxation phase, thus generating the continuous contraction of high intensity. During one therapy, muscles are forced to contract several thousand times. When the muscle tissue is exposed to such overload, it adapts to these supramaximal contractions by remodeling its inner structure, leading to the growth of myofibrils (hypertrophy) and possibly generating new muscle fibers (hyperplasia) [20]. Consequently, this increase in muscle volume and density results in improved muscle definition and tone.

2.1.2 Breakdown of fat

Muscles require a sufficient amount of energy during any physical activity to generate contractions. This energy is primarily derived from Adenosine Triphosphate (ATP) and then from glycogen and creatine phosphate. However, if those compounds are insufficient, the body's catabolic processes occur through lipolysis, which refers to the breakdown of the lipid in glycerol and free fatty acids (FFA). FFA molecules are then utilized as the energy source required for body metabolism and muscle activity.

Supramaximal contractions demand a high amount of energy; thus, adipocytes – the basic unit of fat tissue – close to contracting muscles are depleted by lipolysis to compensate for the considerable increase in energy consumption. It has been evidenced that when FFA's are in a surplus, the fat cells get quickly overwhelmed and may enter apoptosis, otherwise known as a programmed adipocytes deletion, resulting in metabolically induced fat reduction [21].

2.1.3 Clinical evidence

So far, the abdominal and buttock body areas have received the greatest attention from researchers. Therefore, most clinical studies performed with HIFEM investigate the changes in fat and muscle tissue on the abdomen and buttocks. Although results may vary based on patient group and evaluation technique, the evidence is sufficient to extrapolate the expected results after the HIFEM procedure.

At first, various objective methods were used to assess changes in the treated abdominal tissues, including computed tomography (CT) [10], magnetic resonance (MRI) [8, 9], diagnostic ultrasound (USN) [11], and circumference measurements [17]. The results were consistent across the studies, with maximum improvement in fat and muscle observed 3 months after the last treatment. In the North American population sample, the average fat reduction was 18.9%, coinciding with a 15.6%

increase in muscle thickness, a 10.6% decrease in rectus abdominis separation, and a 4.1 cm decrease in waist circumference, on average. In specific patient samples, the results may have been offset even towards higher levels, as experienced in limited groups of post-partum subjects [8] or European patients [22]. Regarding the longevity of achieved results, Kinney and Kent [23], in their follow-up study, evidenced that results are maintained at 12 months post treatments in subjects who follow a healthy and active lifestyle. They also suggested an application of maintenance treatment after 1 year, which may be used as prevention against individual results decline. Also, the same authors recently unveil that HIFEM technology has a positive effect on visceral adipose tissue by using retrospective analysis of CT and MRI scans from the previous studies [24]. HIFEM was found to decrease visceral fat by 14.3% on average in reviewed patients, offering an interesting option to combat abdominal obesity non-invasively.

Correspondingly to the abdomen, reduction in fat and increase in muscle tissue was also observed when investigating HIFEM's effect on upper arms and calves. MRI examination revealed increment in cross-sectional area of musculus biceps brachii (+17.1%), triceps brachii (+10.2%), and gastrocnemius (+14.6%) while fat thickness on upper arms (−12.8%) and calves (−9.9%) was significantly reduced [16].

Finally, Busso, Denkova, and Jacob et al. have documented improvement of body image and lifting effect after HIFEM treatments on buttocks. In these questionnaire-based studies, the patients reported high satisfaction levels (up to 85%) and noticeable changes in buttock contour, visible on digital photographs. The buttock lifting effect was further explained by Palm's[12] MRI study, which found that a significant volumetric increase of gluteal muscles (+13.2% on average) occurs, while more prominent growth of musculus gluteus maximus, medius, and minimus was found in the upper buttock region. Interestingly, no significant changes in fat thickness were found, which was attributed to the different metabolic activity of adipose tissue on buttocks that shows considerably lower lipolytic rate [25].

2.2 HIFEM and synchronized radiofrequency

With an increasing demand for both fat reduction and muscle enhancement, with patients having to go for multiple procedures to target each, the further innovation of the HIFEM technology was inevitable. Since HIFEM is selective to muscle tissue only, there has been a strong focus on developing a novel technology simultaneously combining HIFEM's muscle conditioning with radiofrequency (RF) heating intended for fat elimination. Emsculpt Neo device (BTL Industries Inc., Boston, MA), introduced in late 2020, is the first device that combines RF and HIFEM in a single applicator. The combination of HIFEM+RF allows administering two distinct procedures in a single treatment. At the same time, the synergy of two proven technologies ensures a high level of efficacy even in subjects with considerable fat depots and fat thickness over 3 cm. The device has been FDA-cleared for non-invasive lipolysis, strengthening, toning, and firming. The treatment areas so far include the abdomen, buttocks, outer thighs, inner thighs, front & back thighs, calves, biceps, and triceps. Similar to its predecessor, four 30-minute sessions scheduled once a week is recommended. Combined treatments are safe and comfortable. The only documented side effects are skin redness that resolves within 30–60 minutes post-treatment without any further consequences and muscle soreness the day after the therapy due to the HIFEM component.

2.2.1 Radiofrequency component combined with HIFEM

RF is an electromagnetic wave in the frequency range of approximately 20 kHz to 300 GHz that can generate heat in the treated tissue by transforming its energy to the oscillation of molecules as propagating through. Utilizing specific frequencies of the RF spectrum allows for selective heating due to the difference in properties between the tissues in the targeted area. Most of the devices on the esthetic market utilize a solid metal electrode to emit RF energy. However, it would be impossible to simultaneously emit the HIFEM and RF alongside since there will be interference between them, resulting in the harmful overheating of the metallic electrode and increased risk of adverse events. Thus, the device employs a novel Synchrode RF electrode that eradicates this interference due to the unique interspaced design making it transparent to the propagating magnetic fields and allowing for synchronized emission of RF and HIFEM energy [13].

Fat tissue reduction is energy-dependent and may be achieved by reducing the lipids via lipolysis or permanently removing adipocytes. Therefore, the device's radiofrequency component (27.12 MHz) is designed to uniformly elevate the adipose tissue temperature to the levels of 42–45°C, inducing adipocytes deletion by the natural apoptotic pathways. Initially, the elevated temperature results in increased blood flow and acceleration of metabolic activity. In response, the lipids stored in fat cells are broken down into free fatty acids and glycerol. Also, the RF-induced fat loss is further enhanced during the intense localized muscle work provided by HIFEM, as described above. When the elevated temperature is sustained for a sufficient time period, the adipocytes exposed to temperatures up to 45°C lose viability. They are forced to enter the apoptotic process, i.e., natural and permanent cell deletion [26]. The apoptotic cells subsequently lose their membrane integrity and are ultimately digested by macrophages, responsible for clearing the degraded cells and the debris to maintain tissue homeostasis.

The combined use of HIFEM and RF not only enhances the effects on fat considerably but also introduces the synergy at the level of muscle tissue. It has been evidenced that controlled heating within safe limits for the muscle tissue (40–41°C) positively affects the muscle response during the workload. Additionally, muscle protein synthesis might be even more promoted when heat stress is combined with mechanical stress, as in the case of HIFEM application [27, 28]. The synergistic effect of simultaneous delivery of HIFEM and synchronized RF enhances muscle hypertrophy since it significantly increases the levels of myosatellite cells (muscle-derived stem cells), which activates the regeneration and strengthening of the existing muscle fibers through differentiation. Histology study in the animal model showed that the amount of activated satellite cells in muscle tissue after this dual-energy treatment is comparable with programs involving 12 to 16 weeks of intense exercise. Post-treatment, the increased number of large hypertrophic fibers and elevated levels of small-diameter muscle fibers were found, indicating that not only hypertrophy but muscle fiber hyperplasia may occur after the activation of satellite cells [29].

2.2.2 Clinical evidence

The synergistic effect of HIFEM+RF has already been studied and documented by several investigators [26, 30–32] by using proven diagnostic modalities such as MRI or USN. Like Emsculpt, device results improved with time and peaked at 3 months after the last treatment. However, the more profound effect on fat tissue due to the radiofrequency heating resulted in a bolstered average reduction of abdominal fat thickness by 29.6%, which showed to be highly consistent with a maximum reduction of 30.8% measured by MRI [31]. Muscle tissue benefited from elevated temperatures as well, since it reached an increase of 25.2% at 3 months on average. Most probably, due to the more developed musculature, abdominal muscle separation was reduced up to 19.8% when compared to the pre-treatment condition. At the same time, the considerable fat reduction inevitably contributed to circumference reduction exceeding 6 cm. Although the improvement in all aspects mentioned above was most recognizable at 3 months post-treatment, most subjects maintained the results up to 6 months with a slight but insignificant decline in some individual cases.

Since the technology is still relatively novel, it undergoes extensive research, which may possibly reveal the evidence for the superior efficacy of the RF + HIFEM procedure in other areas than the abdomen. Given the results from abdominal studies, it is strongly assumed that simultaneous application of RF and HIFEM will lead to more pronounced results in body parts previously treated by HIFEM alone. Also, combining two technologies of different modus operandi may allow efficient treatment of additional body areas, especially those with a high amount of subcutaneous fat overlying the muscle tissue. For instance, interim data gathered by Palm et al. showed promising results of RF + HIFEM treatment when applied on the lateral thigh, causing significant fat reduction [33]. Future studies should build upon the existing evidence and reveal all the possible use of RF + HIFEM technology, from which patients may benefit.

2.3 Radiofrequency and targeted pressure energy

Simultaneous use of targeted pressure energy (TPE) and RF for skin treatment was introduced in 2019 with the Emtone (BTL Industries Inc., Boston, MA) device, which is FDA-approved for reducing cellulite dimples appearance, and it is the first and only device that combines such technologies in a single applicator. The combination of monopolar RF with TPE allows physicians to treat major causes of loose skin and cellulite non-invasively and effectively. The synergistic emission of mechanical and thermal energy allows the procedure to focus on the root causes of the problem instead of focusing on merely treating the symptoms. The device treats major factors that cause cellulite, including loss of skin elasticity, loose connective tissue leading to dimpling and fat chambers protruding to the skin, metabolic waste accumulation, and lack of blood flow. RF and TPE treatment can be done in any part of the body affected by cellulite or skin laxity and has no downtime. Four treatments (often consisted of the bilateral application over both extremities) in a frequency of 1–2 sessions per week are recommended, while the duration of each treatment varies (10–25 minutes) depending on the area where it is administered. Application of monopolar RF + TPE is again safe and comfortable; harmless skin redness is visible up to 60 minutes after the therapy as a logical consequence of tissue heating.

The device uses monopolar RF (447 kHz) heating through a solid electrode that remains in direct contact with the patient's skin. The RF currents travel to the grounding pad, ensuring a safe flow of the energy through the treated area while controlling its delivery. TPE component consists of a tube with a floating projectile accelerated towards an applicator tip by the pneumatic system, transferring TPE energy of significant intensities (maximum of 4 bar) to the target tissue. A projectile is moved by the compressed air, hitting a transmitter that conveys energy from the impact to the patient's body. This process is repeated in quick succession (10 Hz). Both technologies are embedded in a single handpiece applicator, thus they are delivered simultaneously. During the therapy, the operator moves the applicator over the treated area to evenly distribute both energies. Handpiece also utilizes a build-in thermometer, providing immediate feedback to the physician regarding skin surface temperature, indicating whether the temperature stays in the expected range of 40–45°C, thus minimizing the risk of under/over-treatment [14].

2.3.1 RF and TPE for the reduction of cellulite and skin laxity

Collagen and elastin are primary elements of the connective tissue and an integral part of the structure of the papillary and reticular dermis and hypodermis. Skin laxity is manifested by the gradual degradation of dermal connective tissue. At the same time, cellulite is mainly characterized by the rigid structure of fibrotic collagen fibrils and the thickening of hypodermal connective septae. The simultaneous emission of TPE and RF activates the metalloproteinases (MMPs), responsible for degrading the protein structure of the collagen [34]. The mechanical stress leads to the fibrils dissociation that reduces the structural density and increases the conformational freedom while also decreasing the thermal stability of existing fibers.

Moreover, this phenomenon also reduces the temperature needed for collagen denaturation. The thermal stimulation interrupts the intramolecular hydrogen bonds and also partially shrinks the collagen triple helix [35]. Consequently, the neocollagenesis and remodeling of the collagen are initiated as a direct consequence to the treatment [36], since the fibroblasts' micro-inflammatory stimulation due to accumulation of heat leads to the proliferation process that significantly increases the procollagen mRNA production. Mechanical energy speeds up the fibroblasts' proliferative activity, creating an ideal environment for elastin and collagen synthesis by decreasing the tissue's oxidative stress [37]. In summary, the thermal and mechanical energy's simultaneous effect leads to a better organization and increased density of collagen and elastin fibers in the dermis and interlobular septa in the hypodermis. This leads to an increase in skin elasticity and thickening of the dermis. The skin thus becomes more tight and resistant to bulging caused by the underlying fat cells [36].

Also, due to the mechanical and heat stimulation exposure, there is a change in the cell membrane properties. The higher amount of cell membrane permeability enables the fluids to move throughout the membrane rapidly, and one can observe the increase in cell metabolism. Besides, both of the energies enhance the blood circulation and may contribute to the new blood vessels formation [36]. The accelerated cell metabolism and blood flow activate the enzymes that break down the fat stored in adipocytes underlying the skin. This leads to a significant reduction in the sizes of fat chambers protruded into the dermis and enhancement of the skin's visual appearance. TPE also positively affects lymph transport and waste removal, supposedly another key aspect associated with cellulite [38].

2.3.2 Clinical evidence

Recently, Fritz et al. utilized various means for cellulite and skin quality evaluation, providing ample evidence to demonstrate the clinical efficacy of RF + TPE simultaneous application. In their first study [39], significant changes at the level of adipose and dermal tissues were noticed. Ultrasound images and digital photographs showed diminished cellulite dimples and improved esthetic appearance of treated areas at 3 months post-treatment. Additionally, the enhancement of skin topography was also verified by the improved homogeneity of surface temperature. The high patient satisfaction correlates with objective results since cellulite was reduced in 93% of cases. The second study [40] was focused on improving abdominal skin laxity, showing promising results again. The elasticity measurement performed in this study showed considerable improvement in 90.9% of subjects.

In comparison, an even higher number of subjects (95%) responded to the treatment in terms of reduction in waist circumference. The primary outcome – reduction in skin laxity – was achieved in 86% of treated subjects derived from photography evaluation.

3. Non-invasive technologies as an alternative to SAL

The increased comfort level, lack of downtime, and low potential risks involved have made these non-invasive procedures popular among the patients and may provide a new solution for body contouring. With the capability of building, firming, and toning muscles without the need to go to the gym, the mixture of wellness and esthetic advantages offered through these technologies has attracted more patients who want to enhance their appearance and overall health. In addition, combining those treatments with RF and TPE technology for skin treatments in case of sagging or wrinkling may represent a complete esthetic solution that SAL alone cannot achieve.

We will be discussing the three specific case studies to highlight the clinical effects of these non-invasive alternatives for liposuction. Patients with different concerns who achieved significant improvements after combined therapies with HIFEM and/or RF with TPE are included. See a brief description of the cases below.

3.1 Straightforward case

Patient A presented with a localized region of abdominal fat and lax muscles. His chief concerns included muscle laxity and overall body contour. The patient underwent a set of HIFEM treatments. Two applicators were placed over the abdominal area with HIFEM intensity being gradually set to a maximum tolerable level, reaching 100% during his second session. The subject regularly goes to the gym for weight training 2–3 times a week and was looking for an improvement in muscle tone, strength, and laxity. His results are shown in **Figure 1**.

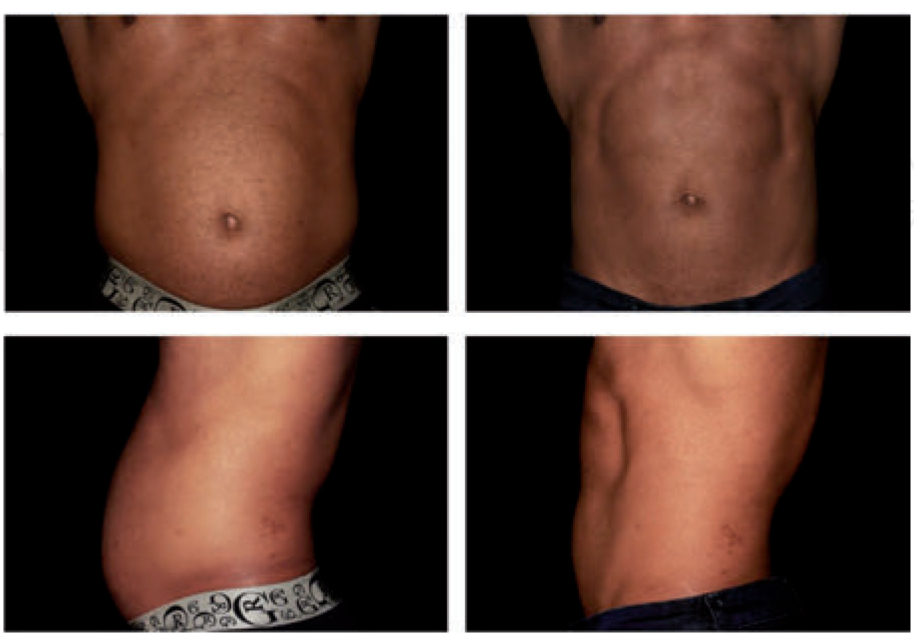

Figure 1.
Patient A - male 36 years old, BMI 26.6 kg/m^2, four treatments administered with HIFEM. 12 weeks after the last treatment (right), the subject showed significantly improved body contour and posture. The muscle laxity was resolved while the abdomen looks and feels tighter and stronger. The distribution of subcutaneous tissue changed considerably in response to the muscle enhancement.

3.2 Moderate case

Patient B presented with a protruding stomach due to excessive subcutaneous fat, visceral fat deposits, and loose muscles. The patient declined liposuction and abdominoplasty. He wanted to achieve both fat reduction and muscle strength. Therefore, he opted for HIFEM+RF procedure. Each treatment lasted for 30 minutes, starting with the HIFEM intensity set to 0%, increasing it to the maximum tolerable level. The RF intensity was set to 100% since the beginning of the procedure. Two applicators were used at the same time on the abdomen. Subject's results, captured in the digital photographs, are shown on the **Figure 2**. In addition,

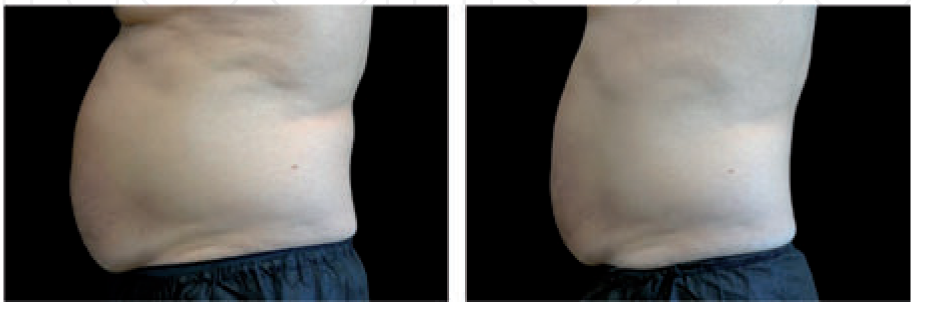

Figure 2.
Patient B - male 57 years old, BMI 32.8 kg/m^2, 3 treatments administered with HIFEM+RF, digital photographs captured at baseline (left) and 1-month (right) post-treatment. The subject reported none to mild discomfort during the procedure and maintained his diet and exercise regime post-treatments. At 3 months, the MRI showed a 30.3% increase in muscle thickness, 35.3% subcutaneous fat reduction, and 17.2% reduction in muscle separation. Due to these extensive changes, the body contour was improved greatly just after three HIFEM+RF treatments.

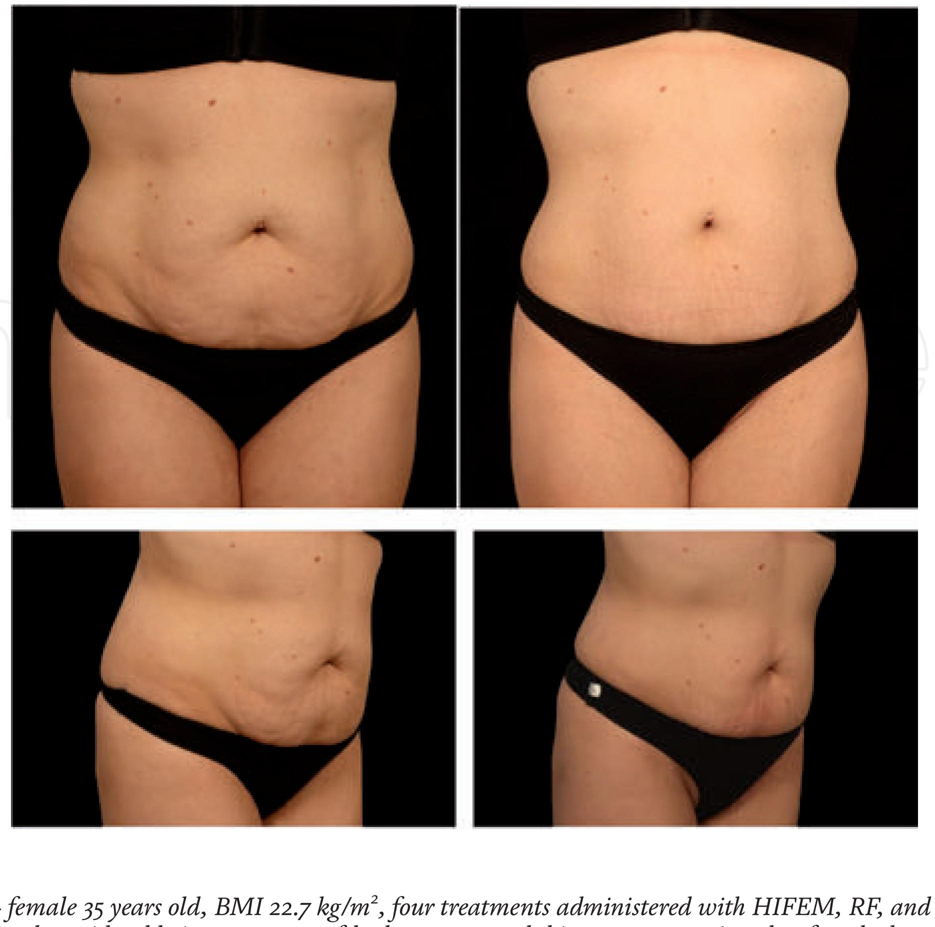

Figure 3.
Patient C - female 35 years old, BMI 22.7 kg/m^2, four treatments administered with HIFEM, RF, and TPE. The subject showed considerable improvement of body contour and skin appearance 6 weeks after the last treatment (right). The patient reported a noticeable muscle tightening effect on top of the improvement in skin laxity.

an MRI examination was performed to identify changes in the abdominal fat and muscle tissue.

3.3 Challenging case

Patient C presented with concerns regarding all three: Skin laxity, loose muscles, and localized fat. After multiple childbirths, the patient suffered from the separation of abdominal muscles (diastasis), excessive fat accumulation on the abdomen, and skin laxity (so-called jelly belly). She opted for the combination of HIFEM and RF + TPE treatments to target the skin, muscle, and partly fat tissues. Each HIFEM treatment lasted for 30 minutes, and intensity was gradually increased to maximum tolerable level within the range of 0–100%. RF + TPE combined therapies lasted 15 minutes and were administered immediately post each HIFEM procedure. The RF intensity was set to 65%, and the built-in thermometer monitored tissue temperature to be in the range of 40–45 degrees Celsius. TPE was set to 4 at the device's pressure scale. Both procedures were tolerated well. The achieved results are shown in **Figure 3**.

4. Discussion

Although the technologies mentioned above are new and still evolving, the clinical evidence combined with our personal experience highlights that using HIFEM, RF, and TPE may target multiple types of patients with skin, fat, or muscle concerns. It needs to be considered that every patient is different and has specific requirements based on the physical constitution and personal preferences when it comes to visual appearance and body contour. Liposuction has always been perceived as a problem-solving procedure regarding the improvement of esthetic appearance. However, due to its invasive nature and discomfort, which limits patient's post-treatment, many would prefer a more convenient way of achieving desirable improvement. The interest in non-invasive body contouring procedures is therefore on the rise in recent years.

Considering the patient comfort and safety, the non-invasive alternatives to SAL were searched intensively in the past. In 2009, Zelickson et al. [41] established a concept of controlled and selective destruction of fat cells by inducing temperatures in the subcutaneous fat layer close to or below the freezing point, termed cryolipolysis. Using the Yucatan pig animal model, they found the reduced thickness of the fat layer associated with local inflammatory response, inferring that such treatments in humans may lead to subsequent changes in body contour. The further studies conducted by several authors evidenced the proposed effectiveness for fat reduction in human subjects. It was found that, in general, cryolipolysis causes a 22% reduction of subcutaneous fat thickness when used on the abdomen or flanks, i.e., the most frequent body parts treated by traditional SAL [42–49]. However, although these body parts' efficacy is relatively high, cryolipolysis solely focuses on the reduction of fat tissue, limiting its application and versatility. Also, although the majority of animal or human studies found no significant risks associated with cryolipolysis, still it has been evidenced that on rare occasions, treated subjects may develop adverse reactions referred to as paradoxical adipose hyperplasia (PAH) [50, 51], leading to sudden fat bulging and need of corrective surgical treatment.

Similar to cryolipolysis, focused high-intensity ultrasound (HIFU) was also introduced in the past decade as a possible substitute for invasive procedures in body contouring. HIFU technology primarily relies on disruptive mechanical effects on adipocytes with minimal damage to neighboring structures such as vessels, nerves, and connective tissue [52, 53]. According to various sources [5, 53–56], the therapy may result in substantial contour improvement with fat reduction above 20% after multiple treatment sessions. Nonetheless, Shek et al. [52] concluded that HIFU treatments showed insignificant changes among the Southern Asians, suggesting design modifications for this particular group of patients.

Most recently, modalities such as HIFEM, RF, and TPE have emerged in esthetic practices. Due to its effectiveness, great safety profile, convenient use, and multifactorial treatment effect, it may pose a promising and complex alternative to SAL, with treatment outcomes not limited to fat reduction only. HIFEM is a patented technology and the first of its kind to be used in the esthetic field to enhance the overall appearance of individuals and, most importantly, target the muscle tissue, which has been neglected for a long time. Before this technology was introduced in 2018 with the launch of the Emsculpt device, intensive magnetic fields for esthetic treatments were barely understood. Since then, physicians are getting more and more familiar with the technology, discovering all its possible applications. Emsculpt pioneered the use of non-invasive body shaping through enhancing muscle strength. Nonetheless, the patient demand for outstanding results and the strong emphasis on reliable fat reduction are still pushing the technological progress forward. Therefore, the Emsculpt Neo device launched in 2020 took the concept of Emsculpt further by combining HIFEM with radiofrequency. Due to the simultaneous application and synergistic effect of both electromagnetic fields, physicians have now available the efficient tool to deliver two types of treatment in a single procedure. Recent clinical studies documented the more pronounced results stemming from the HIFEM+RF combination, showing the significant changes at the level of muscle and fat tissues (−30% in fat thickness, +25% in muscle thickness, and 19% reduction in abdominal separation). In response to the treatments, patients demonstrated measurable changes in body contour and muscle definition [26, 30, 31].

Certain concerns cannot be resolved with the customary liposuction as it only focuses on fat reduction. For instance, skin pendulosity and laxity cannot be addressed and even worsened after SAL, as the skin naturally contracts due to fat removal. While liposuction reduces the fat efficiently, in some cases, it leads to deformities accompanied by sagging skin. Fortunately, all of these concerns can be addressed non-invasively utilizing RF and TPE energy to ensure complete esthetic enhancement after the fat reduction. Emtone is one of the first and sole device that delivers both mechanical and thermal energy simultaneously, removing the major causes of loose skin and cellulite non-invasively and effectively. The combination of mechanical and thermal energy is designed to treat the major factors of cellulite and skin laxity on top of that. It may help eliminate any irregularities due to skin aging as well as correct visible sagging post liposuction treatments.

These innovative technologies are an excellent alternative to liposuction, or they can be used in some specific cases as a complementary solution to profound the results. They can help in strengthening muscles, improving core muscles, enhancing the overall esthetics of the patients by skin improvements in addition to fat reduction. HIFEM, RF, and TPE have proven effective in a standalone regime or when used as combination treatments. Particularly, the combination treatments usually show to be highly effective for many individuals. Generally, the pre-treatment assessment often determines that the cosmetic concerns are of multifactorial origin. Therefore, combining multiple modalities that targets multiple tissues or causes can provide the best possible results. While HIFEM alone focuses on the deep tissues, inducing predominantly changes in the muscles, monopolar RF and TPE focuses on improving the condition of superficial layers, including dermal microcirculation, improved quality, tone of the skin, and laxity reduction. This type of therapy is ideal for addressing the concerns of the patients regarding body contouring. When combined, it is recommended to use Emsculpt first to restore the musculature and body contour before using Emtone to address skin concerns. However, in cases where extensive fat tissue changes are required, the subjects may benefit more from simultaneous HIFEM+RF therapy, which eliminates excessive fat tissue alongside muscle toning.

There are definitely some specifics that come with non-invasive treatments. As mentioned above, physicians should carefully choose the most suitable procedure (for instance, see presented cases in Section 3). The subject's lifestyle may also help determine appropriate treatment and dosage since individuals with better-developed musculature and active lifestyles tend to achieve high HIFEM intensities sooner. Typically, the treatments are done over the course of two to four weeks in four sessions, requiring 30-minutes per application. In general, achieved results may vary from subject to subject. Nonetheless, the improvement should be best recognizable from 1 to 3 months after the last treatment, maintaining the enhancement level at a minimum for 6 to 12 months depending on the subject's dietary and sport habits [23]. Based on the reported results from multiple investigations, we recommend to follow-up your patients 12 to 24 months after their last treatment, and in case that any significant decline in results occurs, identify the cause and consider the importance of the maintenance procedures.

5. Conclusion

Even after countless squats, crunches, cardio, muscle training, or diets, many individuals remain unsatisfied with the core strength and body contour. There are certain areas that cannot be tackled even with a strict diet and exercise. Many opt for liposuction to resolve those issues, but some problems still may remain unresolved. Also, a certain number of individuals hesitate to go for surgeries and are looking for non-invasive ways to deal with their concerns. HIFEM, RF, and TPE can greatly enhance outcomes for body contour independently or following traditional liposuction. Fat reduction and muscle contouring, as well as skin smoothing and tightening, can be safely achieved by combining those technologies without the need for any anesthesia, surgery, and downtime. These treatments offer not only fast and comfortable therapy but also provide reliable results for patients who are not willing to undergo a surgical procedure or who still have concerns after liposuction, looking for a faster and easier remedy for their concerns.

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