

## Body Contouring

# High-Intensity Focused Electromagnetic Field With Synchronized Radiofrequency Achieves Superior Gluteal Muscle Contouring Than High-Intensity Focused Electromagnetic Field Procedure Alone

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## Abstract

**Background:** The high-intensity focused electromagnetic field (HIFEM) procedure is an effective method for noninvasive toning and shaping of buttocks.

**Objectives:** To investigate and compare the efficacy of simultaneous application of HIFEM procedure with radiofrequency (RF) heating vs HIFEM standalone procedure on the buttocks.

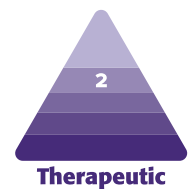
**Methods:** Sixty-seven subjects (21–67 years, BMI 16–34 kg/m<sup>2</sup>) were recruited and divided into two groups. Group A received simultaneous HIFEM + RF therapy, and group B received standalone HIFEM treatments. All participants underwent four 30-minute bilateral treatments on the buttocks. The MRI was used to evaluate the changes in muscle and fat thickness.

**Results:** Data of 32 subjects from group A and 31 subjects from group B were reviewed at 1-month follow-up. On average, subjects from group A showed a 31.3% higher increase in muscle thickness, as shown in the MRI evaluation. The gluteal muscle thickness continued to grow and peaked at a 3-month follow-up, wherein 27 patients were evaluated in each group ( $n = 54$ ). Group A showed on average +24.7% increase (gluteus maximus  $+8.5 \pm 1.9$  mm, medius  $+6.0 \pm 1.1$  mm, minimus  $+2.9 \pm 0.8$  mm), while group B exhibited only +15.9% increase in muscle thickness (gluteus maximus  $+5.2 \pm 1.1$  mm, medius  $+3.6 \pm 1.0$  mm, minimus  $+1.6 \pm 0.4$  mm). On average, group A showed a 35.6% higher growth in muscle thickness. Treatments were safe and comfortable with high satisfaction rates. No adverse event was reported throughout the study.

**Conclusions:** Our results suggest that simultaneous use of HIFEM + RF is safe and significantly more effective for gluteal contouring than the HIFEM procedure alone.

## Level of Evidence: 2

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Physical appearance is getting more important in everyday life and social media, where many focus on promoting the topics related to body image and active lifestyle, influencing the individuals who wish to reach for this new standard of beauty.<sup>1</sup> The hectic lifestyle of the modern age, lack of time for exercise, and one's desire for prompt results are all the reasons that drive the demand for effective aesthetic procedures.

Aesthetically pleasing buttocks are considered an essential attribute of beauty,<sup>2</sup> and according to 2021 statistics of the American Society for Aesthetic and Plastic Surgery, buttocks contouring was up 37% compared to the year 2020.<sup>3</sup> The buttocks contouring may be achieved by utilizing invasive means of sculpting through liposuction, as the most performed type of plastic surgery in the United States,<sup>3</sup> fat grafting, or implants. However, all of these procedures are associated with a risk of hematoma, seroma, infection, wound dehiscence, and even embolism.<sup>4</sup> Furthermore, implants or fat grafting are also accompanied by extended downtime and inconvenience because implants should be replaced every decade. Noninvasive (NIV) buttocks contouring includes exercising and 5 FDA-cleared technologies for body contouring: cryolipolysis, lasers, focused ultrasound, radiofrequency, and high-intensity focused electromagnetic field (HIFEM) treatments. Apart from the notable safety of NIV contouring, such technologies have proven to be effective as well, therefore gaining increased attention from patients in recent years.<sup>5</sup>

The most recent NIV technology introduced for body contouring relies on the concomitant HIFEM procedure with synchronized radiofrequency (RF). As evidenced in abdomen,<sup>6</sup> RF heating primarily targets the subcutaneous tissue causing apoptosis of the fat cells where the fat temperature is elevated and sustained in the range of 42 to 45°C<sup>7-9</sup> for most of the therapy time. The main principle of the HIFEM modality is based on alternating magnetic fields of high magnitude (1.8 Tesla units), which depolarizes neuromuscular tissue, thus inducing so-called supramaximal muscle contraction. This brain-independent type of contraction forces the muscle to adapt, activating muscle hypertrophy and hyperplasia, inducing myofibrils growth in size and numbers, respectively.<sup>10</sup> It has been researched that the effect on muscle tissue may be further promoted when heated with RF up to 40°C.<sup>11</sup> This increases the blood circulation within the targeted muscle tissue. The supramaximal muscle contractions create an increased need for energy.<sup>11</sup> The RF effect causes the increased blood flow in the tissue, thereby boosting oxygen and nutrient supply in the muscle, enhancing muscle tissue regenerative processes.<sup>12</sup> Synergetic application of HIFEM and RF leads to increased activation of satellite cells (SCs), which, upon activation, regenerate and strengthen the existing

muscle fibers through differentiation.<sup>13</sup> As the study by Halaas et al<sup>13</sup> concluded, the HIFEM + RF treatment course is comparable with the results of 12- to 16-week intense exercise programs, delivering the significant muscle enhancement applicable in body contouring.

The three gluteal muscles are the gluteus maximus, medius, and minimus.<sup>14</sup> These muscles have an anatomical function as abductors and adductors of the thigh, and aesthetic function, with the gluteus maximus as the largest muscle contributing to the shape and form of the buttocks the most. With age, the muscles lose their strength and volume, which leads to a less pleasing appearance of the buttocks and lower self-esteem.<sup>15,16</sup>

Thus, we hypothesize that the simultaneous use of HIFEM and RF technology on the buttocks may induce similar muscle activity patterns as seen on the abdomen, resulting in more pronounced muscle enhancement when compared to HIFEM only. Therefore, this study aims to investigate and compare the effect of HIFEM + RF treatment with a standalone HIFEM procedure on the buttocks.

## METHODS

This prospective, multi-center, open-label, two-arm study was approved by the IRB, registered at ClinicalTrials.gov (NCT04871503). The study was initiated in January 2020 and completed in January 2022. Procedures were done according to ethical principles stated in the Declaration of Helsinki. Patients eligible for the study were above the age of 21 years, below the BMI of 35 kg/m<sup>2</sup>, not pregnant, without any metal or electronic objects and implants, and not exhibiting any other condition that contradicts the use of HIFEM + RF fields. Subjects who did not meet the inclusion criteria were excluded. All patients who participated in this study signed written informed consent before enrolling.

Sixty-seven subjects (mean age 38.6 ± 11.6, 21-67 years and BMI 16.0-34.0 kg/m<sup>2</sup>) were recruited, divided into two groups, and treated by Emsculpt Neo device (BTL Industries Inc., Boston, MA), equipped with two applicators emitting HIFEM + RF fields. In group A, 34 patients with a mean age of 38.4 ± 10.3 years (21-57 years) and BMI 24.3 ± 4.2 kg/m<sup>2</sup> (16-34.0 kg/m<sup>2</sup>) received bilateral synergetic treatments over the buttocks with HIFEM and RF intensities set just below the patient's tolerance threshold. The gentle RF preset that maintains sub-apoptotic tissue temperature was used in all subjects from group A. Group B consisted of 33 patients aged on average 38.9 ± 13.3 years (23-67 years) with BMI 23.2 ± 5.5 kg/m<sup>2</sup> (17.4-31.7 kg/m<sup>2</sup>). Similar to group A, they received bilateral buttock treatments with energy settings modulated according to the patient feedback. However, only the HIFEM field was active during

**Table 1.** Treatment Results (Mean in mm  $\pm$  SD) and Difference (Increase in %)

Treatment groups		Gluteus maximus		Gluteus medius		Gluteus minimus	
		Group A	Group B	Group A	Group B	Group A	Group B
1-month follow-up data Group A: <i>n</i> = 32 Group B: <i>n</i> = 31	Baseline	34.9 $\pm$ 7.3	32.6 $\pm$ 6.0	24.7 $\pm$ 4.4	22.8 $\pm$ 6.1	12.2 $\pm$ 2.6	10.6 $\pm$ 2.3
	1 month	41.7 $\pm$ 8.6 (+19.4%)	37.0 $\pm$ 6.8 (+13.4%)	29.3 $\pm$ 5.0 (+18.6%)	25.8 $\pm$ 6.9 (+12.9%)	14.4 $\pm$ 3.1 (+18.3%)	11.9 $\pm$ 2.4 (+12.5%)
3-month follow-up data Group A: <i>n</i> = 27 Group B: <i>n</i> = 27	Baseline	33.8 $\pm$ 6.0	32.7 $\pm$ 6.0	24.9 $\pm$ 4.0	23.2 $\pm$ 6.1	11.8 $\pm$ 2.6	10.7 $\pm$ 2.3
	3 months	42.3 $\pm$ 7.3 (+25.2%)	37.9 $\pm$ 6.7 (+16.2%)	30.9 $\pm$ 4.5 (+24.46%)	26.8 $\pm$ 6.8 (+15.9%)	14.7 $\pm$ 3.3 (+24.4%)	12.3 $\pm$ 2.4 (+15.6%)

SD, standard deviation.

the treatments. The treatment protocol in both groups consisted of four 30-minute sessions administered in a prone position, spaced 5 to 10 days apart. The therapist checked for simultaneous contraction of gluteal muscles while ensuring the safe placement by avoiding the placement directly over the pelvic skeleton. There were two follow-up visits, 1 month, and 3 months posttreatment, to assess treatment outcomes.

The primary outcome was to assess changes in the gluteus musculus maximus, medius, and minimus thickness through MRI. Scans were performed and evaluated at baseline and both follow-up visits. Using a conventional 1.5 T MRI, fast axial spin-echo (T2 AX FSE) images, scans from the iliac crest to the upper third of the femur were acquired in digital imaging and communication format. Scanning protocol was set with regard to muscle tissue<sup>17-19</sup> as follows: repetition time (TR) 6040 ms, echo time (TE) 30 ms, a slice thickness 5 mm, spacing 6 mm, matrix size 512  $\times$  512, and field of view (FOV) sufficient to capture the whole scanned area. When acquiring the MRI, patients were positioned in the prone position, so the anterior superior iliac spine was parallel to the bed<sup>21</sup> to avoid compression of buttock contour. The gluteus medius and minimus measurements were taken at the level of the inferior point of the sacroiliac joint, and thickness of the gluteus maximus was measured at the level just above the femoral head.<sup>20</sup> At both measurement levels, the thickness of the adjacent fat layer was assessed as well. All measurements were performed on both glutes, averaged, and compared to baseline.

Patient data on weight, BMI, and digital photographs were taken at baseline, after the last treatment, and at the follow-up sessions. Subjects were instructed to maintain a regular diet and exercise routine to avoid possible bias due to the severe lifestyle changes, which was monitored via a Lifestyle questionnaire filled out at both follow-up visits. After each treatment, patients were asked to fill out a Therapy Comfort Questionnaire (TCQ) consisting of numerical evaluation of comfort (5-point Likert scale) and pain (10-point Visual Analog Scale; VAS) perception with the treatments. At the last treatment visit and both follow-

up visits, patients were also asked to fill in the Subject Satisfaction Questionnaire (SSQ) graded by a 5-point Likert scale, documenting the subject's satisfaction with the achieved results. Adverse events and side effects were monitored throughout the study.

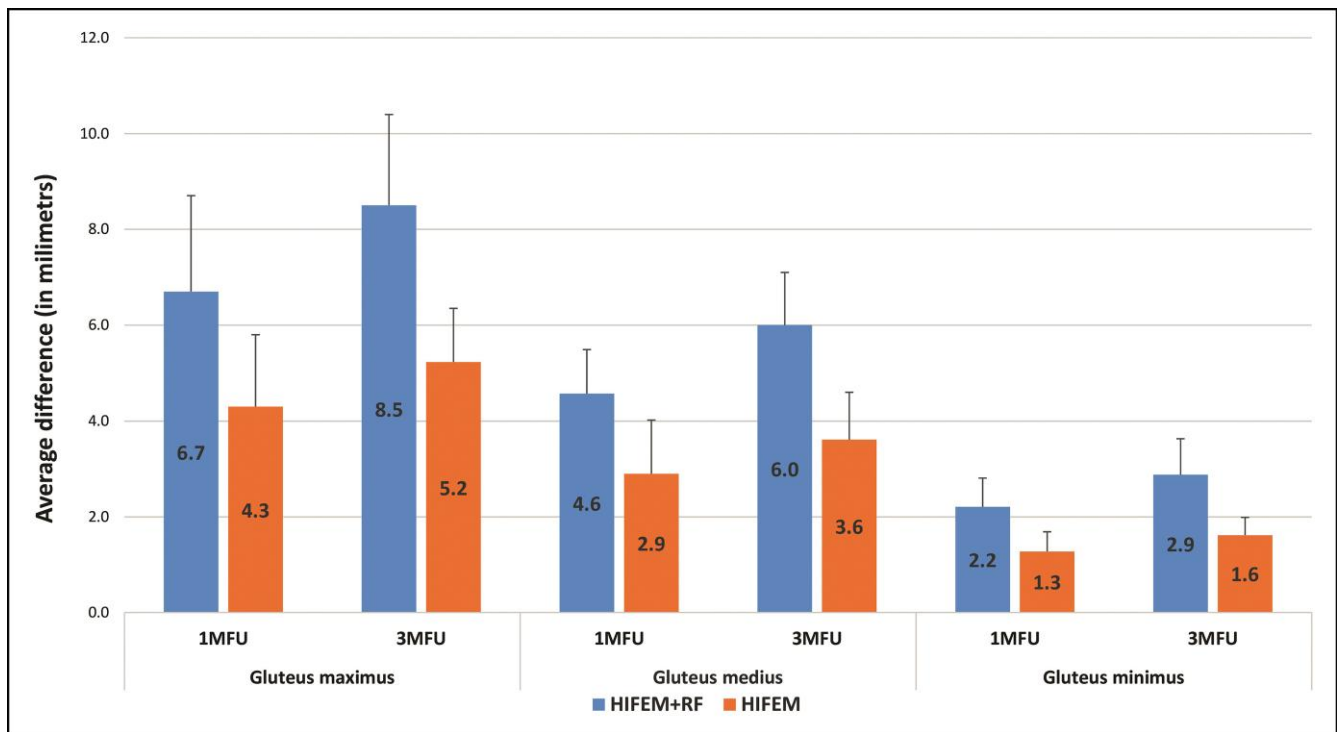
The statistical analysis was performed using the Real Statistics Resource Pack software for Microsoft Excel (Microsoft, Redmond, WA).<sup>21</sup> The paired differences between the values of individual subjects were tested by using 1 factor Analysis of variance (ANOVA) repeated measures followed by Tukey honestly significant difference (HSD) posthoc test. In addition, a two-tailed independent *t*-test was used to identify the significance between the group's results at particular visits. The significance level  $\alpha$  was set at 5% for all statistical tests.

## RESULTS

Sixty-seven patients were enrolled (64 females and 3 males), while 65 patients completed all treatments. At 1-month and 3-month follow-ups, the data of 63 and 54 patients were assessed, respectively. In both groups, the BMI (and weight) fluctuations turned out to be minor and insignificant throughout the study ( $P > .05$ ).

### Muscle Thickness Measurements

In group A ( $n = 32$ ), the overall muscle thickness significantly increased on average by 18.8% ( $P < .001$ ) at 1 month. The biggest change was observed in the gluteus maximus, where on average, this muscle increased in thickness by 19.42% ( $+6.7 \pm 2.0$  mm). In group B ( $n = 31$ ), the average increase was 12.9% at 1-month follow-up ( $P < .001$ ), again showing the highest absolute and relative increase in gluteus maximus (+13.4%;  $+4.3 \pm 1.5$  mm). At the 1-month follow-up, subjects from group A showed, on average, by 31.3% higher relative increase when compared to group B. The results in muscle thickness continued to grow at 3-month follow-up, when patients in group A ( $n = 27$ ) showed



**Figure 1.** Difference in gluteal muscles at 1-month follow-up and 3-month follow-up, with error bars representing the SD (in mm). Reproduced with permission from BTL Industries. HIFEM, high-intensity focused electromagnetic field; RF, radiofrequency.

on average 35.6% higher relative increase than in group B ( $n = 27$ ), with a significant difference in all gluteal muscles between the groups. In particular, the mean change in group A averaged at 24.7% ( $P < .001$ ), while group B reached an average improvement of 15.9% ( $P < .001$ ). As noted at 1 month, the gluteus maximus also showed the highest values at 3 months, followed by the gluteus medius and minimus. More detailed information can be found in Table 1 and Figure 1. There were no statistically significant differences between the groups at baseline ( $P > .05$ ), nonetheless as the study progressed, the differences became significant in all measured muscles, including gluteus maximus: ( $P = .02$  and  $P < .01$  at 1 and 3 months) gluteus medius and gluteus minimus as well ( $P < .01$  at both follow-ups). The evaluation of digital photographs showed the aesthetic improvement of buttocks in terms of lifting, shape, and firmness in both groups, with greater improvement in both shape and lifting effect in group A (Figures 2-4). The MRI evaluation supported the findings in digital photographs (Figures 5, 6).

### Fat Thickness Measurements

Subcutaneous fat layer values showed both clinically and statistically insignificant ( $P > .05$ ) changes at both follow-ups in each group. The average change of fat layer in group A was  $-0.2 \pm 1.4\%$  (range from  $-2.4$  mm to  $+0.7$  mm) at 1-month follow-up, while in group B the change was  $+0.2 \pm 1.5\%$  (from

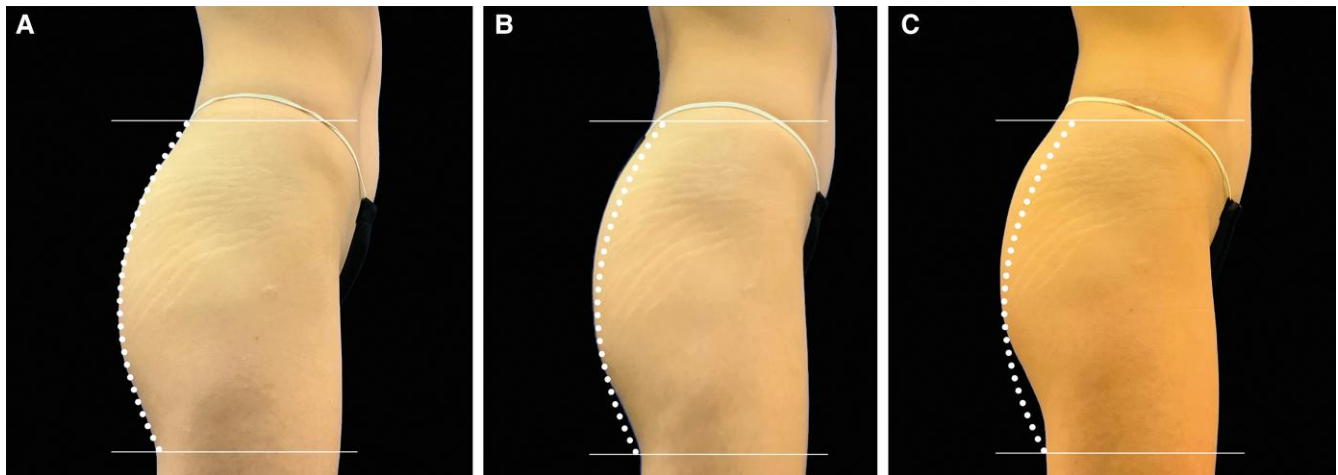
$-1.1$  mm to  $+1.4$  mm). At 3-month follow-up, the average change in group A was  $-0.1 \pm 1.4\%$  (from  $-1.7$  mm to  $+0.7$  mm), with  $-0.2 \pm 1.0\%$  (from  $-0.9$  mm to  $+0.4$  mm) in group B.

### Questionnaires

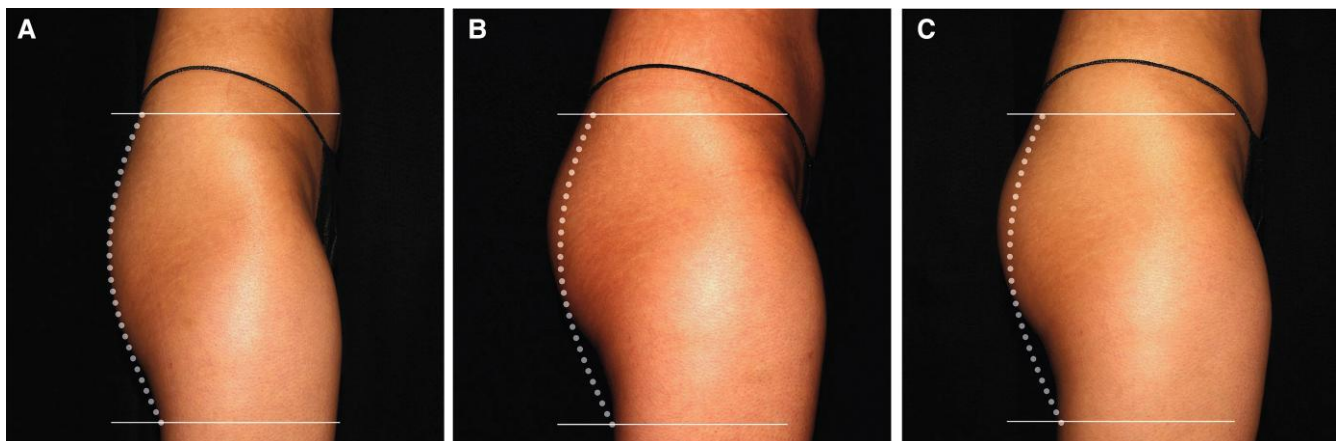
According to the TCQ and the SSQ, both groups found the therapy comfortable and painless, and patients were satisfied with the results. According to the TCQ, both groups agreed with the statement that the treatment was comfortable, and both groups found the treatment painless based on the VAS (group A:  $1.3 \pm 1.9$  points and group B:  $1.2 \pm 1.7$  points). The SSQ consisted of 3 questions, where the evaluation of the results showed that in both groups, more than 84% of the patients agreed that their appearance had improved, more than 93% of the patients noticed toning in the treated area, and more than 84% of patients were satisfied with the results. In addition, no adverse events, side effects, or complications were reported.

### DISCUSSION

Toning of the gluteal muscles has functional roles in preventing injury because of ankles' and spine overuse and in enhancing functional capacity during running and walking,<sup>22</sup> because muscle mass correlates with muscle



**Figure 2.** A 23-year-old female with a BMI of  $17.3 \text{ kg/m}^2$ , treated with high-intensity focused electromagnetic field (HIFEM) only, comparison of digital photos taken (A) at baseline, (B) after the fourth treatment, and (C) at 3-month follow-up (the average increment of muscle thickness by 14.6%). The dotted line represents the shape of the buttocks at baseline. Reproduced with permission from BTL Industries.



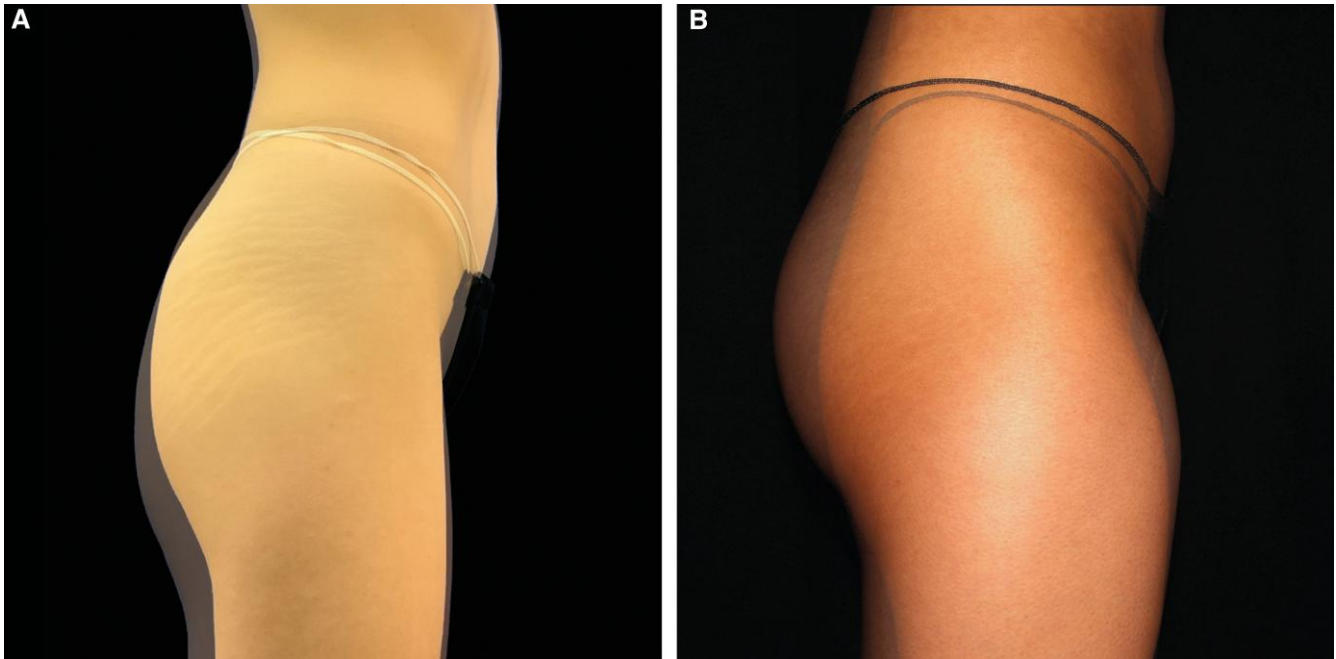
**Figure 3.** A 21-year-old female with a BMI of  $21.3 \text{ kg/m}^2$ , treated with combination RF + HIFEM, comparison of digital photos taken (A) at baseline, (B) after the fourth treatment, and (C) at 3-month follow-up (the average increment of muscle thickness by 22.8%). The dotted line represents the shape of the buttocks at baseline. Reproduced with permission from BTL Industries. HIFEM, high-intensity focused electromagnetic field; RF, radiofrequency.

strength.<sup>23</sup> On the other hand, it also influences the overall appearance of the buttocks and self-esteem of some individuals.

In this study, the treatments with a novel device, either combining HIFEM and synchronized RF or using stand-alone HIFEM treatments, resulted in significant gluteal muscle growth without reducing subcutaneous fat tissue. The observed outcomes in muscle thickness were gradually improving and peaked at a 3-month follow-up. Group A, treated with simultaneous use of HIFEM + RF, showed a greater improvement in muscle thickness at both follow-up visits (by 31.3% at 1 month and by 35.6% at 3 months) than group B, which was treated with HIFEM procedure only.

The benefits of the HIFEM treatment on buttocks were already described in preceding studies. Initially, the

researchers evaluated the concept of such treatment of buttocks, focusing on the assessment of digital photographs and subjective response.<sup>24-26</sup> Correspondingly, patients described the treatment as comfortable with high satisfaction levels in all questions. In the most recent MRI study by Palm,<sup>27</sup> 7 women underwent treatment using stand-alone HIFEM. By conducting a 3D analysis of gluteal muscles, she has found  $13.23\% \pm 0.91\%$  average volume enhancement of the gluteal muscles at a 3-month follow-up. Although a different methodology of assessing MRI scans was used when compared to this study, the relative increase found by Palm<sup>27</sup> is roughly comparable to the results mentioned above in our HIFEM only group, yet slightly lower (group B, +15.9% increase at 3 months). Given the



**Figure 4.** The overlap of baseline and 3-month follow-up digital photos from Figures 2 and 3. There is a visible improvement in both groups with a more pronounced shaping and lifting effect in group treated with the combination of HIFEM + RF (part B) than group treated with HIFEM only (part A). Reproduced with permission from BTL Industries.

results of group A (+24.7% on average at 3 months), one may suggest that the volumetric increase in gluteal muscle mass may be even higher when HIFEM and synchronized RF are used simultaneously.

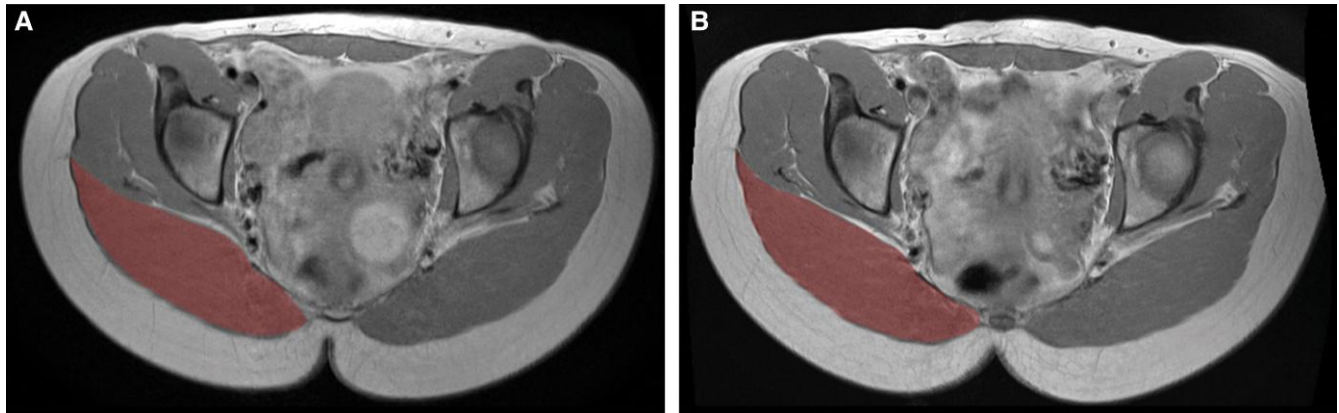
In our study, group A was treated with the combination of HIFEM + RF, where the RF component was set to gentle preset, ensuring that the adipose tissue in the treated area was not heated to apoptotic temperatures. The results show that fat tissue was not affected significantly, with negligible and comparable changes observed in both groups. Moreover, it has been shown that the buttock's fatty tissue has a different lipolytic activity because the fat cells in the gluteal area are more responsive to alpha 2-adrenergic agonists.<sup>28</sup> These neurotransmitters have an antilipolytic function and make the lipolytic processes in the buttock's fatty tissue significantly less active,<sup>29</sup> which may explain the mild changes in fat thickness seen in this study, regardless of the used modality.

This study's main strength is the MRI evaluation of changes in muscle thickness because the MRI provides spatial and detailed enough contrast resolution for the evaluation of individual muscles.<sup>30</sup> Further strengths include a large number of enrolled patients allocated into 2 groups that could be compared with each other. Although 13 patients did not attend their MRI appointment at 3 months (7 patients from group A, 6 patients from group B), the sample size was still large enough for the statistics to be conclusive. However, further studies are needed to fully understand the processes

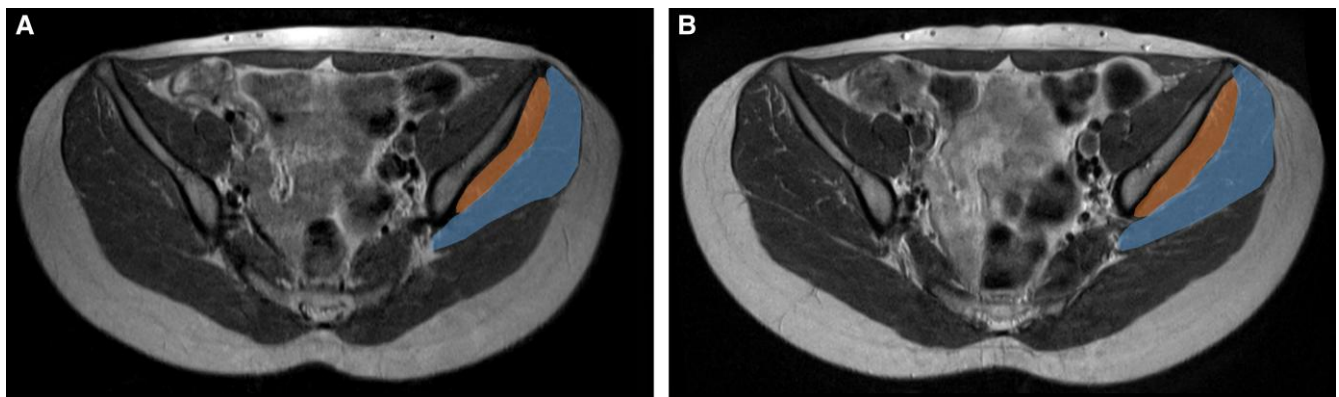
in gluteal fatty tissue while treated with HIFEM or HIFEM + RF. The limitations of the study include unequal gender representation, with only 3 treated males, use of a single measuring method being the linear muscle thickness measurements, and inexact replication of photographing conditions due to lighting levels and subject's posture, possibly affecting the readability of the resulting images. Future studies should focus on recruiting a greater number of male patients to verify and compare the effect on both sexes and conduct a more rigorous evaluation of muscle tissue, such as a change in volume. The subject photographs should be standardized and taken under uniform conditions at every visit, to enable proper visualization of the treated area. Moreover, it may be considered to extend the follow-up period to document the persistence and nature of achieved outcomes in the long-term with an emphasis on the particular needs of the subjects.

## CONCLUSIONS

The primary aim of this study was to compare a simultaneous application of the HIFEM + RF energy vs the standalone HIFEM procedure for its effectiveness, safety and overall effect on buttock contouring. The results revealed the greater efficiency of simultaneous application of HIFEM + RF in terms of superior increase in gluteal muscle thickness. Furthermore, high patient satisfaction and overall



**Figure 5.** The MRI scan of the 21-year-old female from Figure 3, MRI scans taken (A) at baseline and (B) at 3-month follow-up. The highlighted part represents the changes that occurred in gluteus maximus (red) during the study. Reproduced with permission from BTL Industries.



**Figure 6.** The MRI scan of the 21-year-old female from Figure 3, MRI scans taken (A) at baseline and (B) at 3-month follow-up. The highlighted part represents the changes that occurred in the gluteus medius (blue) and gluteus minimus (orange) during the study. Reproduced with permission from BTL Industries.

enhancement of buttock contour and appearance were documented. There were no significant changes in gluteal adipose tissue, and no adverse events occurred in both groups.

### Disclosures

Drs DiBernardo, Chilukuri, McCoy, Katz, and Goldberg are clinical investigators for BTL Industries, Inc. (Boston, MA).

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This multicenter study was sponsored by BTL Industries.

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