doi:10.36849/JDD.2020.4546
May 2020 Volume 19 • Issue 5

CASE REPORT
Journal of Drugs in Dermatology

MRI Assessment of Arm and Calf Muscle Toning With High-Intensity Focused Electromagnetic Technology: Case Study

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ABSTRACT

Arms and calves have long been a subject of interest in aesthetic medicine. Current surgical and non-invasive procedures focus on sagging skin and fat deposits without targeting the muscles. The aim of this study is to investigate the feasibility of high-intensity focused electromagnetic (HIFEM) technology for arm and calf toning through simultaneous fat reduction and muscle strengthening. In this case study, two subjects received four 20-minute HIFEM treatments of biceps, triceps, and calves, with the outcomes assessed by MRI. The analysis of MRI images showed an average increase in all three muscle groups, biceps muscle mass 17.1%, triceps muscle mass 10.2%, and gastrocnemius muscle mass increased by 14.6%. In addition, the arm fat thickness was decreased by 12.8% on average and the calf fat thickness decreased by 9.9%. The results suggest that HIFEM technology is a feasible modality for both arm and calf toning. However, it will be necessary to continue to validate this outcome in a larger sample size study.

J Drugs Dermatol. 2020;19(5): doi:10.36849/JDD.2020.4546

INTRODUCTION

In terms of our daily lives, arms and legs play an important functional role. Interestingly, they also play a significant role in our perception of beauty. Many surgeons and physicians have thus been looking for ways of correcting or altering the forms and volumes of calves and upper arms.[1–3]

In fact, the popularity of arm lifting (brachioplasty) has grown rapidly in previous years, with a 2017 top 5 ranking for the fastest growing surgical procedures with more than 18,000 performed procedures in a single year.[4] Similarly, for calves, the most popular procedure is surgery, specifically the insertion of calf implants or autologous tissue transfer.[5] Although the surgical procedure shows effective results, they are inextricably linked with downtime, pain, scarring, and risk of complications. Furthermore, the arm procedures only deal with sagging skin and excess fat, while neglecting the role of underlying muscles in the resulting overall appearance. Currently, there are only moderately effective non-invasive arm lifting alternatives such as cryolipolysis[6,7] or radiofrequency[8,9] devices, which focus on skin tightening and reducing arm fat while the muscles remain untouched. However, to maximize the treatment outcome and results it is necessary to take into account both muscle and fat. An innovative tool for this purpose appears to be a high-intensity focused electromagnetic (HIFEM) technology, which has already been successfully used for the simultaneous abdominal muscle strengthening and reduction of abdominal fat.[10,11] Applicability of such an effect on arms would bring new treatment possibilities for both physicians and patients. Due to its effect on muscle, HIFEM could also be beneficial for the treatment of calves through toning the calf muscle and increasing its volume.

The goal of this case study is to investigate the efficacy of HIFEM technology for toning of arms and calves as an alternative tool to the current surgical as well as noninvasive procedures.

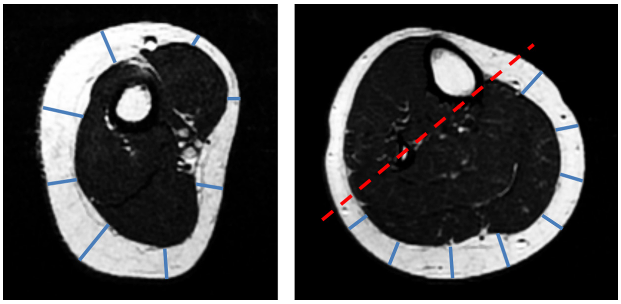
METHODS

One male (26 years) and one female (47 years) patients were recruited into the study. Both patients underwent the treatment of both calves and arms with a device utilizing HIFEM technology (EMSCULPT, BTL Industries Inc., Boston MA).

The treatment protocol consisted of 4 sessions scheduled twice a week for a two-week period. During each session, the patients received a 20-minute bilateral treatment for each muscle group, biceps/triceps, and calves. The calves and triceps treatments were administered in a prone position while the biceps treatment was applied in a supine position. The applicators were placed just under the treated muscle structure and the exact position was adjusted individually for the best muscle response. The applicators were always secured by a fixation belt.

To evaluate the treatment outcomes, the patients underwent MRI screening at baseline and 1 month after the last treatment. The scanned area for calves was defined by the knee and ankle and the scanned area for arms was defined by the shoulder and

FIGURE 1. Schematic illustration of measurement points used for the analysis of fat tissue (left – arm; right – calf).

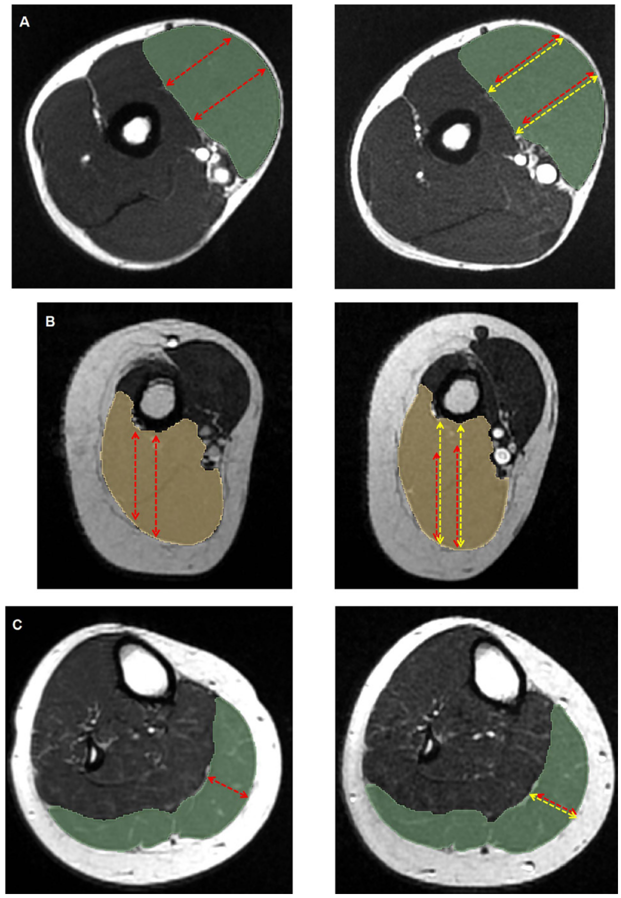


elbow joints. The MRI images for both treatment areas were acquired in the axial plane using the T1 fast spin-echo sequence with a slice thickness of 3 mm, matrix size 320x320, FOV 26, TR 200 ms. For each calf scan, the leg was bolstered under the ankle and the knee to avoid the suppression of the muscle. Similarly, for the arm scans, each arm was bolstered under the elbow.

To best analyze the changes in arm and calf muscle tissue, the biceps brachii m., triceps brachii m. and gastrocnemius m. were segmented in the MRI images. For each muscle, the slice with the largest cross-sectional area (CSA) was identified and was used for analysis along with two slices approximately 0.5 cm and 1 cm above and below this point (N=5 measurements). CSA for each of the slices and for each muscle was obtained and the average values were calculated. Segmented muscles can be seen in Figure 2.

To assess the changes in fat tissue, the fat thickness was measured in the same images which were used for muscle tissue analysis. For arms, the measurements were done at eight points equally sampled all around the arm circumference. For calves, the measurements were done only above the gastrocnemius m. at eight equally spaced points. Then, the average values were calculated. The points for fat measurements are displayed in Figure 1.

FIGURE 2. The B/A MRI images for biceps (A), triceps (B) and gastrocnemius (C).



RESULTS

A single male and a female subject were recruited for the study to examine the HIFEM effects on different body compositions. Interestingly, it should be noted that the male subject had more than three times the muscle mass in comparison to the female subject. Both patients showed an increase in all three examined muscles; biceps brachii m., triceps brachii m., gastrocnemius m.

TABLE 1.

The Average Muscle CSA for Each Subject and Muscle (mean ± standard deviation)

	Before (mm^2)	1M After (mm^2)	Diff. (mm^2)	Diff. (%)
Biceps_Male	1929.3 ± 37.2	2253.8 ± 5.0	324.4	16.8 %
Biceps_Female	589.4 ± 29.8	692.1 ± 4.7	102.7	17.4 %
Triceps_Male	3620.0 ± 98.7	4019.9 ± 76.8	399.9	11.1 %
Triceps_Female	1510.7 ± 37.6	1652.9 ± 22.2	142.3	9.4 %
Gastrocnemius_Male	3373.5 ± 79.4	3843.6 ± 85.1	470.1	13.9 %
Gastrocnemius_Female	2011.3 ± 67.4	2316.4 ± 85.2	305.1	15.2 %

FIGURE 3. Digital images of the female subject's biceps taken at baseline (left) and 1-month post-treatment (right). The red lines displayed at the baseline scans were duplicated into the 1-month scans to demonstrate the change.

Both subjects also showed a decrease in fat thickness, although the differences between the subjects were large.

The largest increase in the CSA was observed for the biceps brachii muscle as the average increase was 17.1%, while for triceps brachii it was 10.2%. The CSA of the gastrocnemius muscle was increased by 14.5% on average. Detailed results for each subject can be seen in Table 1. Examples of MRI images after the segmentation are shown in Figure 2.

The arm fat thickness for the male subject was decreased by 20.6% from 4.6 ± 2.3 mm to 3.7 ± 2.0 mm. The female subject lost 5.3% of her arm fat thickness as it decreased from 10.0 ± 3.8 mm to 9.5 ± 3.8 mm. The fat thickness on the calf was decreased by 11.9% for the male subject, from 4.6 ± 1.3 mm to 4.1 ± 1.2 mm. The female subject showed a reduction of 8.0%, from 12.3 ± 2.6 mm to 11.4 ± 2.5 mm.

Patients reported mild muscle fatigue after the treatments while no adverse events were reported. Digital photographs demonstrated aesthetic improvement in the treated area. The demonstration of the improvement in the biceps muscle observed for the female subject is shown in Figure 3.

CONCLUSIONS AND RECOMMENDATIONS

The MRI images showed an increase in muscle mass and a reduction in fat thickness after four HIFEM treatments, comparable with the results reported in previous studies.[10,11] Validation of observed results on a larger sample size is necessary.

The applicator placement appears to play a crucial role in the outcomes. It is interesting to note the anatomic individuality of each patient and the importance of proper applicator placement to achieve the largest muscle response, which differed subject to subject. Since HIFEM technology is based on stimulating motor neurons, the improper placement may not trigger contractions strong enough for the induction of a hypertrophic effect. It is thus important to pay special attention to the placement.

Based on the observed results, HIFEM technology appears to be feasible for arm and calf toning. Although it is necessary to collect data from a significantly larger sample size, the initial results provide a trace of what outcomes could be expected with a larger study population.

DISCLOSURES

The author has no conflict of interest to declare.

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