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Male Pectoralis Major Muscle Augmentation with Autologous Fat Transplantation Using VASER Lipoaspirate: Evaluation with MRI

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Background: The popularity of autologous fat grafts has increased for the reshaping, contouring, and augmentation of the male breast tissue. However, long-term maintenance of tissue viability and the ways for assessment serve as hot-spot topics in the field. This study was designed to evaluate the viability of fat grafts obtained by a vibration amplification of sound energy at resonance (VASER)-assisted lipoaspiration procedure using a magnetic resonance imaging–based approach.

Methods: This is a prospective examination of 20 male patients (40 breasts) who underwent VASER-assisted liposuction and fat grafting surgery, and long-term fat graft viability was evaluated by magnetic resonance imaging scans.

Results: Participants had an average age of 34.85 ± 7.37 years with a mean BMI of 26.73 ± 2.63 kg/m^2. The mean fat graft volume injected was 542.63 ± 144.78 mL on the right, and 548.95 ± 140.36 mL on the left side. On the magnetic resonance imaging follow-up, the mean intrapectoral adipose tissue thickness was 20.34 ± 6.31 mm on the right, and 18.94 ± 8.27 mm on the left sides and tissue viability was preserved in all cases. The mean follow-up duration was 22 ± 9.8 (range 14-44) months.

Conclusion: VASER-assisted lipoaspiration and autologous fat grafting of the major pectoralis muscle provide a satisfactory outcome and long-term maintenance of the grafted adipose tissue. *(Plast Reconstr Surg Glob Open 2023; 11:e4945; doi: 10.1097/GOX.0000000000004945; Published online 13 April 2023.)*

INTRODUCTION

Subcutaneous adipose tissue is a type of connective tissue, with a 90% predominance of fat cells, also called adipocytes. The plasticity of these cells provides various features, including serving as autografts, besides their roles in energy metabolism, endocrine and immune systems, and maintaining visceral tissues against external trauma injuries.[1]

Fat transplantation and autologous fat grafting has been a popular approach since the end of the 19th century for tissue reconstruction and contouring, treatment of postoperative and posttraumatic deformities, burns and scars, and congenital deformities, as well as their implementation in aesthetic rejuvenation procedures on the face, neck, and hands.[2,3] Adipose tissue is considered a favorable shaping material owing to its versatility, cost efficiency, biocompatibility, and obtainability for reconstructive and aesthetic interventions on various body regions, allowing the management of deformities and remodeling of the body architecture.[4]

Harvesting of the adipose tissue is a relatively uncomplicated method, yielding considerable amounts of readily available grafting material with immense efficiency and repeatability. On the other hand, the survival rate of autologous fat injected is between 10% and 80%, depending on various factors including sample processing, host defense, ischemia, and necrosis; thus, repetitive transplantation might be needed.[5,6]

Vibration amplification of sound energy at resonance (VASER) is an ultrasound-assisted technology, selectively targeting the adipocytes, and related to a lower incidence of postliposuction complications. With high selectivity and minimal invasiveness, damage to the surrounding tissues and adipose tissue was expected to be less, providing a more viable fat grafting process.[7]

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Magnetic resonance imaging (MRI) is an appropriate tool with a high soft-tissue resolution, allowing the evaluation of the live adipose tissue volume and structure of the autologous fat grafts without the use of ionizing radiation.[8]

There are limited data on the MRI evaluation of autologous fat grafts for major pectoral muscle augmentation in an attempt to achieve a better upper body structure in men; hence, the aim of this study is to investigate the VASER-assisted lipoaspiration and autologous fat graft preparation protocol used for the correction of irregularity and deformities, and long-term maintenance of post-surgical breast tissue correction, by utilizing an MRI-based approach, thereby assessing graft viability, integration, and distribution.

Takeaways

Question: What are the advantages of vibration amplification of sound energy at resonance (VASER)-assisted lipoaspiration for the augmentation of the major pectoralis muscle in terms of fat graft survival?

Findings: An MRI-based evaluation of the fat grafts obtained by a VASER-assisted lipoaspiration procedure revealed an efficient adipose tissue and fat graft survival.

Meaning: Our cases demonstrated that fat grafts obtained during VASER-assisted liposuction procedures provide a symmetrical and satisfactory intrapectoral adipose tissue thickness, and distance between pectoral muscle and thoracic wall, as a result of fat graft survival.

MATERIALS AND METHODS

Twenty healthy men undergoing high-definition VASER (Solta Medical; Hayward, Calif.)-assisted liposuction and liposculpture surgery and had an intraoperative autologous fat grafting of the major pectoralis muscle were evaluated using MRI scan in terms of fat viability, distribution, and stability.

The study was approved by the local ethics committee and conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants.

The procedures included VASER-assisted high-definition liposuction of the various combinations of breast, arms, shoulder, torso, abdomen, waist, and pubis. Adipose tissue transplantation was performed on the superior and inferior segments of the major pectoral muscle, and the upper arm and biceps muscle regions when requested by the patient.

Before the operation, anterior, posterior, and lateral photographs were taken, and the surgical regions were marked in an upright standing position using different colored markers for each anatomical section (Fig. 1).

Exclusion criteria were contraindication or reluctance of the patient for an MRI scan, obesity with a BMI of 30 kg per m^2 or more, autoimmune disease, chronic diseases including diabetes and hypertension, presence of a vascular or nonvascular condition that would affect graft viability, bleeding disorders, smoking, positivity for human immunodeficiency virus, lipoatrophy disorders, history of previous surgery on the regions of interest, and implementation of additional procedures during or following the surgery.

The radiological evaluation with an MRI scan of the fat grafts was done after the first year of the procedures in all patients, using a 1.5 T MRI scanner (Siemens Healthineers, Erlangen, Germany), and multiple T1-weighted sequences were obtained with an echo time of 4.76 milliseconds, repetition time of 280 milliseconds, and slice thickness of 4 mm. Volumetric analyses and fat viability evaluations were done by the same radiologist and plastic surgeon.

Liposuction Procedure

All patients received intravenous antibiotics before surgery and were operated on under general anesthesia.

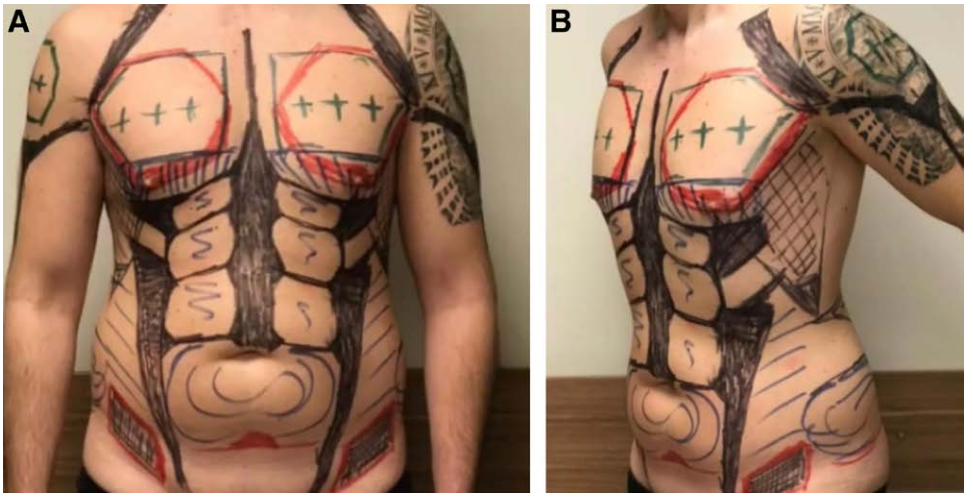

Fig. 1. Marking lines and borders of the operative zones before the surgery. A, Lateral view. B, Side view.

After surgical preparation with povidone-iodine solution, the patient was covered with a sterile drape in the prone position. A tumescent solution composed of 1000 mL of lactated Ringer's solution, including 1 mg adrenaline and 5 mL of 1% lidocaine was infiltrated in the areas of liposuction and fat harvesting.

VASER-assisted liposuction was performed by the conventional technique using 16-gauge multiple hole infiltration cannulas (1.2 mm of inner diameter) and 50 mL syringes on selected regions with a flow rate of 5.5 mL per second. All interventions were performed by the same surgeon (H.K.).

After adequate infiltration with expansion and tension under the skin in physical examination, the VASER mode was set to 100% C using a 3.7-mm five-groove probe, with a rate of 100 mL of infiltration per minute, allowing for the fat emulsification. The liposuction procedure was performed with 4-mm and 5-mm Mercedes tip three-port cannulas at 24–26 mm Hg of suction pressure.

Preparation of the Adipose Tissue Grafts

Adipose tissue for the fat transfers into the pectoral muscle was obtained from the abdominal lipoaspirates in all patients, and the average waiting time between the preparation and injection process ranged between 45 and 75 minutes. The lipoaspirates collected into an airproof system were transferred immediately to the preparation area and awaited the separation of fatty and fluid portions. Centrifugation procedure was performed only for lipoaspirates containing blood fragments in order to remove the cell debris, blood components, and supernatant with a rotor speed of 3000 rpm for 3 minutes. For prophylaxis, 125 mg per 1.5 mL Rifamycine SV was added per 1 L of the fat grafts, that transferred into 50 mL syringes, using a closed-circuit valve system. The syringes were placed on a tray in an upright position, and the fatty and liquid phases were separated with the gravity effect, in an attempt to obtain native fat cells.

Fat Grafting Procedure

After complete filtration and separation, the fat grafts in the 50-mL syringes were placed onto cold sterile ice packs frozen at −18°C, and applied in the supine position, through a 2–3 mm incision at the anterior axillary line. The reason for the choice of this region for surgical incision was due to safety reasons and in order to spare the anatomical structures around the muscle, and minimize the rick of pneumothorax. In addition, an ultrasound-guidance was not required during the muscle elevation and cannula penetration stages.

The adipose tissue transfers were made with the patient in a prone position, into the deltoid muscle through the posterior axillary line for the patients who underwent arm shaping and contouring. After the povidone-iodine sterilization of the incision area, the pectoralis muscle was elevated with one hand and reached under the muscle with a 26-cm 2.4-mm three-way curved Luer-lock cannula. A bolus injection of fat grafts was performed below and into the upper pole and medial portion of the pectoralis muscle. The amount of fat tissue to be injected was decided during the procedures, depending on the chest width and muscle size until reaching an optimum male chest sculpture, performed in several directions, and completed upon an efficient correction and sculpting. The volumes of lipoaspirates and filling fat tissue were recorded.

A total of four surgical drains were inserted as follows: two via the midline incision on the right and left sides, and two drains through the incisions on the pubic area. After the completion of the procedures, the entry sites were sutured with a 4/0 Vicryl Rapide (Ethicon Inc., Somerville, N.J.).

During postoperative recovery, a classical wound dressing was applied for 5–7 days, and the drains were removed after 24 hours. Compression garments and then a classical binder were worn for 2 weeks, each.

A fast recovery protocol was used by walking activities, starting on postoperative day 1. Heavy weight lifting and high-energy activities were prohibited for the first 2 months.

Statistical Analysis

Data were analyzed using the GraphPad Prism version 8.0.0 for Windows (GraphPad Software, San Diego, Calif.). The data were presented as mean ± SD (range).

RESULTS

The study group consisted of 20 male patients with an average age of 34.85 ± 7.37 years (range, 20–46 years). The mean BMI was 26.73 ± 2.63 kg/m^2 (range 19.9–30.1 kg/m^2), and the difference between post- and preoperative weight was −4.13 ± 2.72 kg (range -10 to 0 kg).

The mean tumescent solution volume given was 8049 ± 1688 mL (range, 4400–10150 mL; median 8310 mL), and the average volume of collected fat was 5266.75 ± 1556.82 mL (range, 2100–8450 mL; median 5205 mL) in the surgery. The samples obtained from three patients required further centrifugation.

The mean volume injected was 542.63 ± 144.78 mL (range, 180–800 mL; median 550 mL) for the right and 548.95 ± 140.36 (range, 260–790 mL; median 550 mL) for the left side (Table 1).

Two patients required an additional subcutaneous fat transfer of 50 mL per side. An additional autologous fat

Table 1. Patient Demographics (n = 20)

Characteristic	Mean ± SD	Range
Age (y)	34.85 ± 7.37	20–46
BMI (kg/m^2)	26.73 ± 2.63	19.88–29.18
Difference of weight before and after the procedure (kg)	−4.13 ± 2.72	−10 to 0
Tumescent solution volume (mL)	8049 ± 1688	4400–10,158
Lipoaspirate volume (mL)	5266.75 ± 1556.82	2100–8450
Injected fat graft volume—left (mL)	243.50 ± 66.45	113–395
Injected fat graft volume—right (mL)	239.20 ± 69.94	90–395
Follow-up duration (mo)	22 ± 9.8	14–44

Table 2. Intraoperative Variables of the Cases

Case(#)	Age(y)	BMI(kg/m²)	Tumescent Solution Volume (mL)	Lipoaspirate Volume(mL)	Fat Graft Volume—Right(mL)	Fat Graft Volume—Left(mL)	Duration of VASER(min)
1	36	27.7	10,100	6700	180	260	61
2	20	29	9800	8450	500	550	77
3	45	29.4	9940	6500	500	500	81
4	37	28	8500	5100	400	400	96
5	36	23.7	9700	7200	450	450	85
6	39	19.9	7200	5100	550	600	78
7	28	25.5	4800	4400	550	550	39
8	29	28	6400	4400	565	715	57
9	38	30.1	8050	6450	600	600	63
10	46	26.9	4100	2100	790	790	73
11	35	28.3	6400	5750	600	600	71
12	23	23.5	6800	4600	500	500	94
13	38	27.5	8900	5390	500	500	85
14	32	25.7	7500	3500	800	790	64
15	41	27.5	7750	6500	560	560	79
16	30	24.5	7350	3870	500	500	65
17	38	27.4	9250	4275	370	320	54
18	24	26.8	9480	6950	650	650	89
19	37	22.4	8000	3500	525	525	63
20	41	29.4	9200	2800	280	280	98

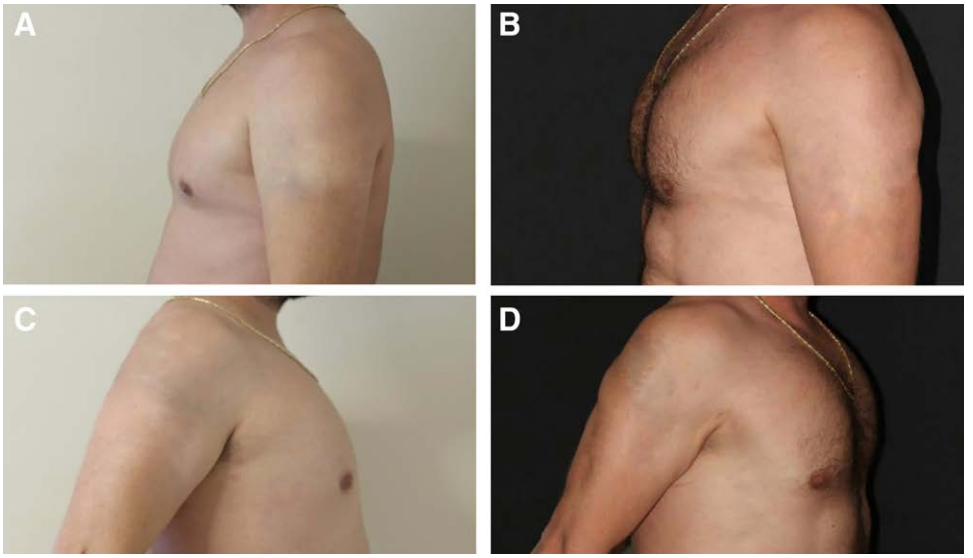

Fig. 2. Two-sided photographs of a patient who received autologous fat transfer to the breast, chest and upper arms. A, C, Preoperative lateral views. B, D, Postoperative lateral views.

tissue was transferred on the shoulders in 17, cheeks, chin line, and nasolabial folds in two patients, and buttocks in one patient.

The durations for VASER-assisted liposuction and case variables are shown in Table 2. On the follow-up visits, a visual evaluation revealed the maintenance of the surgical outcomes (Figs. 2 and 3).

On the MRI follow-up, the mean intrapectoral adipose tissue thickness was 20.34±6.31 mm (range, 10.10–30.20 mm) on the right, and 18.94±8.27 mm (range, 6.70–35.70 mm) on the left sides, whereas the distance between pectoral muscle and the thoracic wall was 37.20±11.92 mm (range, 18.30–59.40 mm) on the right and 32.91±13.04 mm (range, 12.50–57.20 mm) on the left side (Table 3; Fig. 4).

The mean follow-up duration was 22±9.8 (range 14–44) months.

We did not encounter postoperative complications, and none of the patients underwent additional grafting procedures before the follow-up MRI evaluations.

DISCUSSION

The definition of pectoral muscles is among the most-requested cosmetic surgery procedures in male patients. Amidst several approaches for the augmentation of

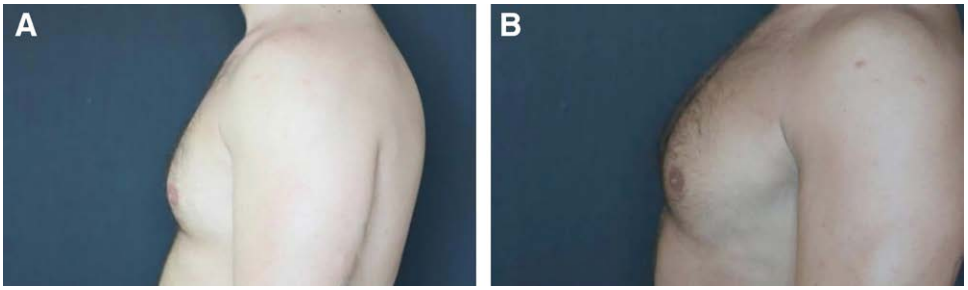

Fig. 3. Clinical outcome of a patient who underwent major pectoralis muscle augmentation and recontouring of the upper chest region with autologous fat grafts. A, Preoperative lateral view. B, Postoperative lateral view.

Table 3. Descriptive Analysis of the MRI Parameters per Region

Variables	Mean ± SD	Range
Intrapectoral adipose tissue thickness—right (mm)	20.34 ± 6.31	10.10–30.20
Intrapectoral adipose tissue thickness—left (mm)	18.94 ± 8.271	6.700–35.70
Distance between pectoral muscle and thoracic wall—right (mm)	37.20 ± 11.92	18.30–59.40
Distance between pectoral muscle and thoracic wall—left (mm)	32.91 ±13.04	12.50–57.20

major pectoral muscle for providing the desired upper body structure, fat grafting is the treatment of choice owing to its flexibility for the volume, location, and contouring of the fat grafts during the procedure, and success in obtaining individualized results with minimal scar tissue formation and fibrosis.[9] The proportions of the male torso are determined by environmental conditions, lifestyle, and dietary habits, as well as individual genetic factors, and its relatively higher involvement during the daily mobility, and weight-bearing activities of the individuals play a role in the survival and shape of the fat grafts.[10]

The implementation of live adipose tissue grafts was reported in various tissues for the treatment of disproportions as well as high-definition structuring of body regions, attempting to provide a more athletic and muscular sculpture.[11] In our study group, we reported a well-preserved breast volume and upper body structure in male patients who underwent a VASER-assisted liposuction and fat harvesting procedure, followed by autologous fat transplantation to the upper torso. A subsequent evaluation using an MRI-based approach on the follow-up visits revealed a symmetrical intrapectoral adipose tissue thickness, and distance between pectoral muscle and thoracic wall, corresponding to efficient adipose tissue and fat graft survival.

In their series of male patients with gynecomastia, Pilanci et al. performed a direct intrapectoral fat injection to the major pectoralis muscle, monitored the patients for up to 2 years, and reported highly satisfactory outcomes in the oral survey measures.[12] Compared with their injection volume range of 80–220 mL, the relatively higher injection volume in our group might be a consequence of the patient selection criteria. In their recent experimental study, comparing the survival trends of fat grafts obtained during traditional and VASER-assisted liposuction procedures, Hsiao et al reported an improved angiogenesis and fibrosis pattern in the VASER group in the histology specimens, despite a similar rate of adipose tissue survival.[13] An in vitro study assessing the viability of adipocytes following third-generation ultrasound-assisted liposuction revealed a higher osteogenic and adipogenic marker expression, suggesting that ultrasonic energy has no undesirable effect on the adipose tissue.[14] Furthermore, an enzymatic study demonstrated that postcollection procedures including washing and filtering reduce the metabolic activity of the adipocytes, with a rapid decline in the tissue viability.[15]

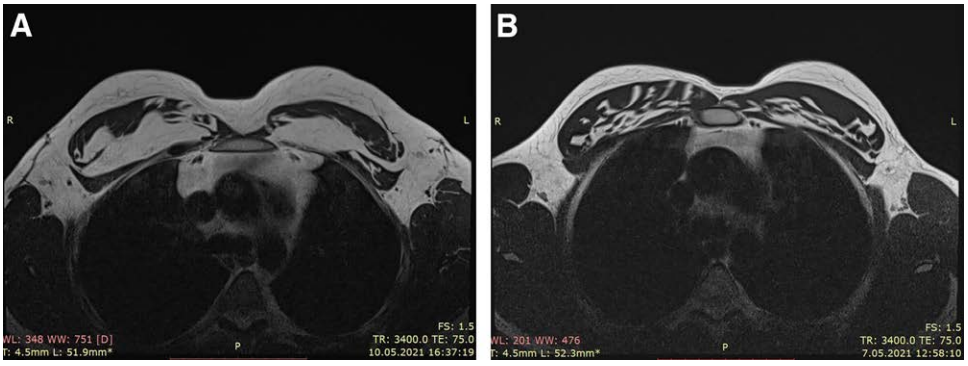

Fig. 4. Exemplar MRI slices of two patients. A, A 39-year-old man 24 months after the surgery. B, A 41-year-old patient on the third year follow-up visit.

Although cryopreservation of fat grafts is related to decreased graft viability and tissue disruption, in an experimental study, Svalgaard et al stored the aliquots of lipoaspirate at 4°C and reported that the viability of adipose tissue-derived stromal vascular fraction remained intact, whereas the vitality of the stromal vascular fraction decreased after 8 hours when stored at room temperature or 37°C, suggesting that the lipoaspirate should be stored in cool temperatures but not longer than 24 hours to maintain the optimal quality.[16] Another study of frozen-stored adipose tissue-derived stromal/stem cells for more than 10 years reported a viability rate of 78%–79% depending on the storage time. Also, they reported relatively intact immunophenotype characteristics proven with the flow cytometry evaluation.[17] Cell culture studies also concluded that the cryopreservation of lipoaspirates had a significant improvement on the apoptosis of adipose-derived stem cells apoptosis, however did not affect their necrosis, proliferation, or differentiation patterns.[18] However, Feng et al kept the lipoaspirates at −20°C without cryoprotectant for 1 month in their experimental setting, and the third-month evaluation of fat grafts yielded an almost 50% retention rate.[19] Depending on our experience on the subject, we preferred a −18°C storage on ice packs before lipofilling, particularly when the grafting would take longer than 30 minutes. However, the issue might still require further studies not only on the experimental but also patient-oriented basis.

To the best of our knowledge, the present study is among the limited number of studies, utilizing an MRI-based assessment method for the investigation of fat graft survival, since MRI is considered an efficient approach for the evaluation of fat tissue, allowing the quantification of its volume, and distribution, thereby determining body composition. Moreover, our study group is uniform and consisted of subjects who underwent a VASER-assisted liposuction procedure, in an attempt to provide a better fat graft survival.

On the other hand, based on its acoustic properties, the VASER-assisted fat harvesting procedure was doubted for its potential damage on the adipocytes, though, a series of well-designed in vitro studies demonstrated a smaller scale of cell lysis, tearing, and shearing during the lipoaspiration. In addition, providing smaller clusters of cells, with a limited effect on survival, VASER-assisted procedures might facilitate an independent adipocyte behavior, leading to an increased rate of angiogenesis and reduced transmission of tissue factors and cell signals between the neighboring cells.[14,20,21]

Our samples examined following the first year of the procedure exhibit a simultaneous augmentation and uniform size for both breasts and upper arm area, indicating an efficient fat graft survival, and the effectiveness of VASER assistance. The provided satisfactory results using a VASER-assisted technique might be a consequence of the optimal combination of the manual manipulation movements, cannula size used, a lower harvesting pressure at 24–26 mmHg, and a high ultrasound energy amplitude of 100% for all subjects. Although the theoretical assumption postulates a reduced survival rate for the adipocytes subjected to high amplitudes of ultrasound energy, homogenous harvesting of the fat tissue, avoiding unnecessary centrifugation and aggressive processing methodologies, combined with meticulous infiltration of the donor area would serve as the underlying factors of better adipose tissue survival.

Although there are a series of described complications after fat transplantation in muscles, ranging from cyst formation to fatal ones including necrotizing fasciitis and septic shock, in our series, we did not observe previously defined possible postoperative donor-site complications, such as dysaesthesia, paraesthesia, hematoma formation, and decreased sensitivity alongside the fat necrosis.[22,23] However, we performed an additional subcutaneous fat transfer of 50 mL per side in two patients; the remaining individuals did not require or request an additional augmentation procedure.

Although a study of a larger group of patients with a longer follow-up would yield different results, the occurrence of fat resorption at its highest rate between the third and ninth months of the procedure refers to the adaptability of the study outcomes to the prospective end results.

Despite the promising data presented, one of the major limitations of our study is the lack of a control group. Although we perform traditional lipoaspiration and fat grafting procedures in our clinic, MRI assessment was solely performed on the VASER-treated individuals. In addition, the MRI evaluation was solely based on the tissue thickness and distance, and a volume calculation study to estimate the resorption rate would yield more supporting evidence on the procedure. Furthermore, despite a relatively higher follow-up period, a radiological investigation with concomitant measures might yield more elaborated data. However, the procedure described herein was performed by an experienced plastic surgeon specialized in the use and preparation of fat grafts and high-definition body contouring procedures, and the measurements and fat viability evaluations were done by the same radiologist in order to avoid the interindividual comparison bias.

In conclusion, VASER-assisted lipoaspiration and autologous fat grafting of the major pectoralis muscle is an acceptable and favorable procedure, providing symmetrical and well-preserved surgical outcomes without using additional implants or grafts. Detailed experimental studies based on the effect of various modes of VASER ultrasound on cell survival, implementing the markers of the adipocyte survival, mediators of the inflammatory and angiogenic processes, and factors related to the matrix and the concomitant fractions are needed to contribute to obtaining ideal results for different patient groups.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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