

# Lipo Definition in Thighs: Volumizing and Defining the Vastus Muscles by Fat Transfer

Raúl Martín Manzaneda  
Cipriani, MD\*  
Gerardo A. Adrianzen, MD†  
Jaroslav Zulueta, MD‡  
Braulio Sarango, MD§

**Background:** Volumizing muscles in the thighs by fat grafting to complement body contouring surgeries has not been adequately investigated. Our objective was to describe a technique (VDVFAT) that defines and volumizes thigh muscles by lipo-transfer in the vastus medialis and vastus lateralis muscles.

**Methods:** VDVFAT was performed in 52 patients by the same surgeon at a private clinic in Lima, Peru, between 2018 and 2019. All patients were aged between 18 and 60 years, had no cutaneous flaccidity of the thighs, had a body mass index less than 28, and had Goldman surgical risk below Class II.

**Results:** A total of 45 women aged 19–41 years (mean: 29.2 years) and seven men aged 24–41 years (mean: 33 years) were included. A mean of 173.36 cm<sup>3</sup> of intramuscular fat was grafted to the vastus lateralis, resulting in increased muscle thickness of 21.09 mm, which is equivalent to 88.31% of the initial size of the muscle ( $P < 0.0001$ ). An intramuscular fat mass of 123.53 cm<sup>3</sup> was grafted into the vastus medialis, resulting in increased muscle thickness of 30 mm, which is equivalent to 87.02% of the initial size of the muscle ( $P < 0.0001$ ).

**Conclusions:** Volumizing and defining the vastus muscles by fat transfer is a safe and reproducible method for defining and volumizing muscles. However, further studies are necessary to determine the durability of fat grafts. (*Plast Reconstr Surg Glob Open* 2021;9:e3945; doi: 10.1097/GOX.0000000000003945; Published online 29 November 2021.)

## INTRODUCTION

Modern plastic surgery has been undergoing regular advancements in techniques for enhancing body contouring. This is evidenced by multiple studies on different techniques to achieve optimal results in sculpting and defining different muscle groups through liposuction of specific areas and lipografting of others, including the shoulders, pectoral muscles, abdomen, back, and more frequently, the gluteal muscles.<sup>1–3</sup> Currently, the surgical results expected in body-contouring surgery differ between men and women. However, similar athletic

results can be obtained in both, depending on the surgical technique used.<sup>2</sup>

Each patient's surgical goals and the harmony of the body's muscle groups must be considered to achieve better results when defining the thoracoabdominal muscles and the extremities via body-contouring procedures associated with volumization. Within this context, we found that many studies have focused on abdominal and thoracic procedures,<sup>2,4</sup> and little attention and consideration have given to procedures that define the muscles of the thighs.

Anger published a technique for thigh augmentation with acceptable results after using submuscular silicone implants to improve the inner face or aspect of the thighs.<sup>5</sup> Añorve-Borquez also presented a study about lipotransfer in the subcutaneous plane of the thighs to correct the inner face.<sup>6</sup> However, scientific evidence on intramuscular volumization of the thighs remains very limited.

Fat grafting has generally drawn considerable attention from plastic surgeons. Neuber proposed a fat grafting

From the \*Manzaneda Cipriani Clinic, Lima, Peru; †Cayetano Heredia University, Lima, Peru; ‡Plastic and Reconstructive Surgery, Archbishop Loayza National Hospital, Lima, Peru; and §Plastic and Reconstructive Surgery Department–Nataly Clinic, Loja, Ecuador.

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method in 1893.<sup>7</sup> Subsequently, Illouz et al further studied and developed the technique, which is now well known.<sup>8–10</sup> The muscle is a favorable choice for the reception and integration of fat grafts with a higher degree of survival; nevertheless, each muscle poses certain challenges specific to its characteristics, such as size, volume, and the presence of abnormal vessels that might interfere with fat injections.<sup>11</sup> Hoyos and Perez reported a case series of intramuscular volumization using autologous fat in the deltoid muscles, which yielded acceptable results.<sup>2</sup> Viaro et al published a similar study in which they infiltrated fat into the rectus abdominis using an ultrasound-assisted technique.<sup>1</sup>

Considering these previous studies, our study aimed to describe a modern technique used to define and volume the muscles of the thighs by lipotransfer to the vastus lateralis and vastus medialis, and by liposculpture of the different natural curves with controlled extraction of fat that provides dynamic enhancement of the different muscular structures of the thigh.

## MATERIALS AND METHODS

After receiving approval from our local committee and adhering to the principles outlined in the Declaration of Helsinki for the study, all patients were asked to sign an informed consent form before performing the VDFAT technique.

A prospective study was conducted among 52 patients (45 women, seven men) who underwent liposuction with thigh definition and volumization by intramuscular fat grafting in the vastus lateralis and vastus medialis (VDFAT).

All patients recruited in this study visited the plastic surgery practice, seeking evaluation for undergoing lipodefinition body-contouring surgery. Similarly, all patients shared a common desire for an athletic appearance of their legs. Furthermore, the participants included patients who, despite their strenuous workouts at the gym, could not achieve the expected results.

The procedure was performed by the same surgeon in a private clinic in Lima, Peru, between 2018 and 2019. All patients met the following criteria: aged between 18 and 60 years, no skin flaccidity of the thigh, body mass index of 28 or less, and Goldman surgical risk below Class II. All the information obtained from the patients before and after the surgeries was coded and recorded in a standardized database in Microsoft Excel 16.43 (Microsoft Corp, Redmond, Wash.) by the same record keeper.

For each patient, photographs and videos were taken at different angles with the patient being asked to perform different maneuvers to better emphasize and locate the vastus lateralis, vastus medialis, and the anterior edge of the iliotibial band. This allowed for creating a good preoperative design for all patients (See [Video 1 \[online\]](#), which displays maneuvers for presurgical design). Different colors were used to mark the areas targeted for definition and volumization (Figs. 1, 2).

A soft-tissue ultrasound specialist measured the thickness of the vastus lateralis and vastus medialis muscles before and after the surgical procedure (See [Video 2](#)

## Takeaways

**Question:** Does defining and volumizing the thighs improve body-contouring surgical results?

**Findings:** This prospective study included 52 patients who underwent surgery to define and volumize the muscles of the thighs with fatty tissues. Their muscle thickness before and after the surgery was measured. The vastus external muscle thickness was increased by 88.31%, whereas the vastus internal muscle was increased by 87.02% ( $P < 0.0001$ ).

**Meaning:** Defining and volumizing the thighs improves body-contouring surgical results.

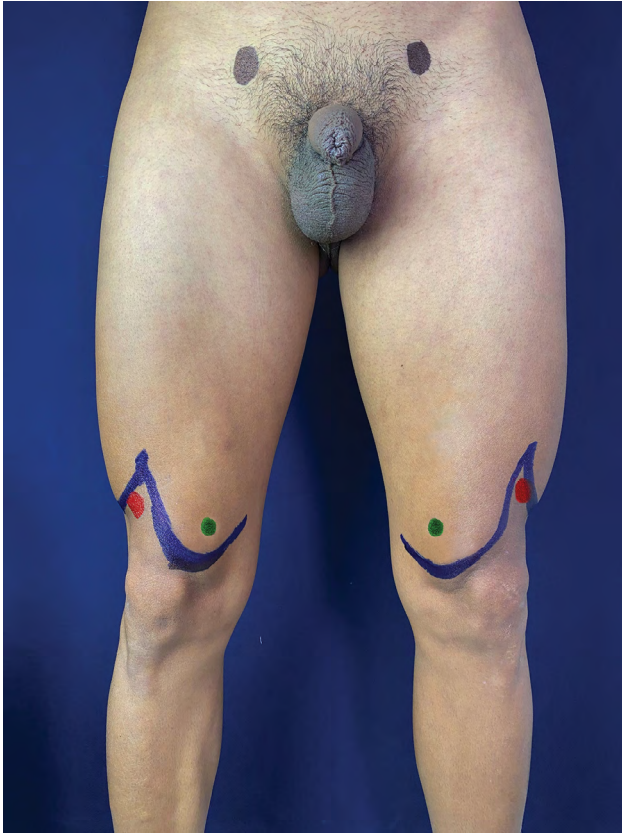
[online], which displays ultrasound measure). These measurements were recorded in a database. Statistical analysis was performed using SPSS version 25, and the data of ultrasound measurements before and after intramuscular fat grafting were analyzed using the Wilcoxon test.

Under general anesthesia, the patients underwent body-contouring liposuction surgery with the super-wet technique wherein normal saline and epinephrine with a 1:1,000,000 ratio were used. Subsequently, a period of 10 minutes was allowed before liposuction of the different areas for body contouring was performed with 4-mm and 5-mm Basket and Mercedes cannulas and a 160 mm Hg suction machine. The fat was collected in 2000 cm<sup>3</sup> sterile vials after a 20-min decantation time.

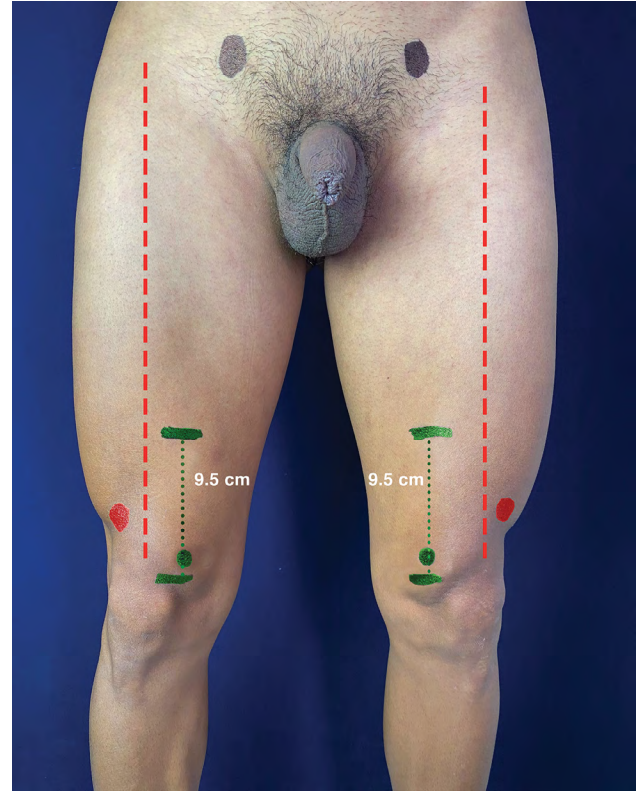
We used the suprapubic incisions that were previously made during the abdominal liposuction to infiltrate the targeted areas for treatment in the thighs with normal saline and epinephrine at a 1:1,000,000 ratio. A period of 20 min was allowed to lapse before proceeding with lipomarking of the medial edge of the vastus medialis and vastus lateralis, which forms an inverted V, and of the anterior edge of the iliotibial band, depending on each patient's unique preferences. Lipomarking of these anatomical areas was performed with superficial and deep liposuction using 4-mm and 5-mm angled and curved Basket and Mercedes cannulas that were 35–40 cm in length (Fig. 3).

A red line was drawn from the anterior superior iliac spine to the superolateral edge of the patella; the safe zone for fat injections in the vastus lateralis muscle are located in the lateral areas (Fig. 2). We used an 18-gauge needle for puncturing the skin, and used a 2-mm Coleman cannula to puncture the fascia and enter the intramuscular plane. This maneuver is performed by holding the vastus lateralis muscle in place using the nondominant hand and injecting the fatty tissue with 20 cm<sup>3</sup> syringes using the dominant hand in continuous and antero-retrograde movements (See [Video 3 \[online\]](#), which displays VDFAT procedure). This allows us to visually objectify the increase in the volume of the muscle being worked on (Fig. 4).

We determined the safe zone for the vastus medialis muscle by locating the superomedial edge of the patella. Further, the midline of the identified muscle was located with a green line (Fig. 2); so we could perform the same fat grafting technique used for the vastus lateralis in the



**Fig. 1.** Presurgical design. Black point: the site of insertion of the canulas for lipomarcation of the abdomen and lower limbs. Red point: the safe puncture site for external vastus muscle grafting. Green point: the safe puncture site for internal vastus muscle grafting.



**Fig. 2.** Safe areas of lipograft. Red lines: the safe zones for lipograft of the vastus external, which extends from the anterior superior iliac spine to the upper edge of the label. Green lines: the safe zones for internal vast lipograft comprising a length of 9.5 cm at the superomedial edge of the patella.

area lateral to this line. The vastus medialis was approximately less than 10 cm from this point (Fig. 4).

## RESULTS

We recruited 52 patients who underwent body-contouring surgery that included VDVFAT between 2018 and 2019. The patients included 45 women aged 19–41 years (mean: 29.2 years) and seven men aged 24–41 years (mean: 33 years) with a mean body mass index of 23.43. All patients experienced satisfactory recovery, and none developed postoperative complications (eg, infection, thromboembolism, bleeding requiring blood transfusion, death). The mean surgical duration for liposculpture with muscle definition, excluding the thighs, was 120 min, and the mean aggregate duration for muscular fat grafting and marking of the thighs was 20 min (Table 1).

For volumization, intramuscular fat was grafted in the right vastus lateralis using the VDVFAT technique with a mean of 168.50 cm<sup>3</sup> of infiltrated fat. This revealed a 21.65 mm increase in muscle thickness upon immediate postoperative ultrasound, which was equivalent to a 91.01% ( $P < 0.0001$ ) increase relative to the initial measurements. Intramuscular fat was grafted in the left vastus lateralis, using the VDVFAT technique, with a mean of 178.15 cm<sup>3</sup> of infiltrated fat. It revealed an increase of 20.54 mm in

muscle thickness upon immediate postoperative ultrasound, which was equivalent to an 85.60% ( $P < 0.0001$ ) increase relative to the initial measurements (Table 2). The mean volume of fat grafted into the vastus lateralis was 173.36 cm<sup>3</sup>, resulting in an increase of 21.09 mm in muscle thickness; this was equivalent to 88.31% ( $P < 0.0001$ ) of the initial muscle thickness (Table 2).

The same procedure was performed for the right vastus medialis. Intramuscular fat was grafted using the VDVFAT technique, resulting in a mean of 118.46 cm<sup>3</sup> of infiltrated fat. This revealed an increase of 29.38 mm in muscle thickness upon immediate postoperative ultrasound, which was equivalent to an 84.21% ( $P < 0.0001$ ) increase relative to the initial measurements. Similarly, a mean of 128.6 cm<sup>3</sup> of intramuscular fat was grafted into the left vastus medialis, revealing an increase of 30.63 mm in muscle thickness upon immediate postoperative ultrasound; this was equivalent to an 89.84% ( $P < 0.0001$ ) increase relative to the initial measurements (Table 3). The mean volume of fat grafted into the vastus medialis was 123.53 cm<sup>3</sup>, resulting in an increase of 30.00 mm in muscle thickness; this was equivalent to an 87.02% increase relative to the initial measurements (Table 3). The mean hemoglobin decrease 12 h after surgery was 2.13 mg per dl, which was equivalent to a decrease of 15.46% ( $P < 0.0001$ ) relative to the mean beginning hemoglobin (Table 1).

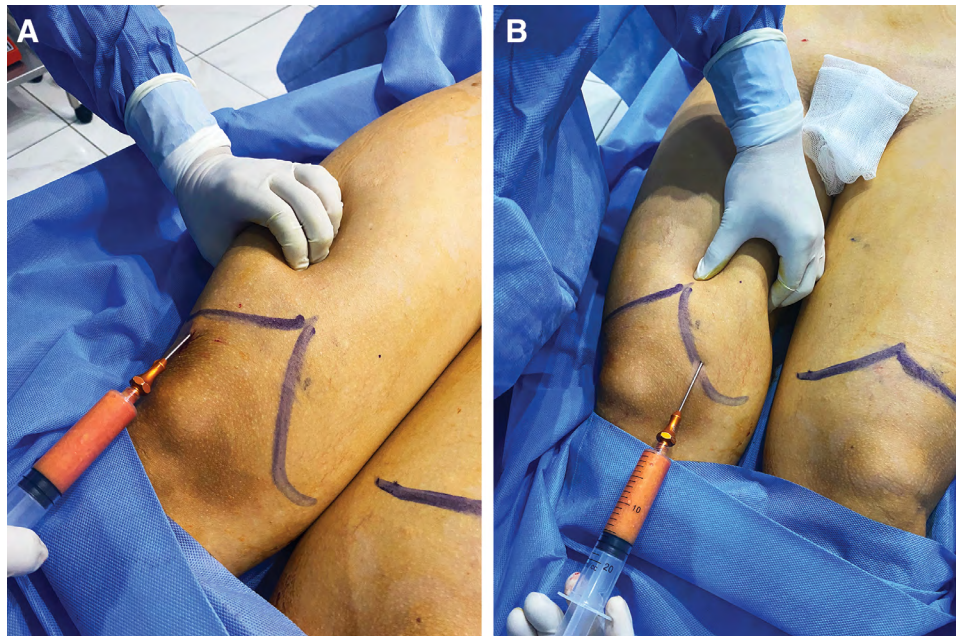


**Fig. 3.** The vastus muscle. Lipomarking of the vastus internal (A, B) and the vastus external muscle (C, D).

### DISCUSSION

When performing liposuction with muscle definition, it should be considered that this surgery aims to primarily achieve optimal results in terms of athletic anatomy; therefore, harmonization of the different muscle groups is important, including those comprising the upper limbs, back, abdomen, gluteal muscles, and lower limbs. However, all anatomical regions are not always considered, as liposuction is performed with muscle definition in the abdomen, thorax, and upper limbs with poor focus on their harmonization with the lower limbs. Providing adequate focus on the lower limbs is important, as its muscles

lead to a visual effect that complements the athletic figure sought by muscle defining techniques during the surgical procedure. Performing muscle definition is similar to performing muscular exercise routines that target specific areas such as the anterior or posterior thorax, upper limbs, rectus abdominis, and oblique abdominal muscles with no focus on the lower limbs. This leads to a morphological aberration that creates a visual impression of having a wide muscle volume in regions wherein more contouring was done while other areas wherein less contouring was done appear asymmetrical in terms of volume. This is also known as “chicken leg syndrome” in the field of bodybuilding.



**Fig. 4.** The vastus graft. A, External graft. B, Internal graft.

**Table 1. Demographic Data of the Patients**

Variable	Women	Men	Overall Mean
Number (52)	45	7	—
Age, y (range, mean)	19–41 (29.2)	24–41 (33)	29.71
BMI	19.47–28.91 (23.15)	21.63–27.28 (25.20)	23.43
Mean duration of surgery (min)	147.48	180	120
Mean duration for definition and volumization of thighs (min)	27.77	35	20
Mean before surgery Hb (mg/dl)	13.36	15.03	13.58
Mean after surgery Hb (mg/dl)	11.31	12.07	11.45
Absolute change in postoperative Hb (mg/dl)	2.01	2.96	2.13
Percentage change in postoperative Hb	14.88	19.17	15.46
Complications	0	0	0

**Table 2. Change in the Dimensions of Vastus Lateralis**

Variable	Women	Men	Overall Mean
Mean right vastus lateralis fat graft (cm <sup>3</sup> )	150–210* (168†)	142–210* (172.14†)	168.56
Mean change in the thickness of right vastus lateralis (mm)	21.89	20.10	21.65
% change in the thickness of right vastus lateralis	91.98	84.81	91.01
Mean left vastus lateralis fat graft (cm <sup>3</sup> )	143–210* (177.18†)	140–210* (184.43†)	178.15
Mean change in the thickness of left vastus lateralis (mm)	20.64	19.84	20.54
% change in the thickness of left vastus lateralis	85.58	85.74	85.60
Mean vastus lateralis fat graft (cm <sup>3</sup> )	173.36		
Mean change in the thickness of vastus lateralis (mm)	21.09	88.31%	

\*Range of grafted volume.

†Mean volumes.

Thigh definition surgery allows for the appropriate marking of muscle groups such as the vastus lateralis and vastus medialis. However, there might be patients who do not have adequate muscle size needed for the harmonious definition of the thighs. Muscle volume plays a fundamental role in this.

Different techniques are now used to volumize the thighs, which mainly include implanting silicone and grafting fat.<sup>5</sup> These techniques were mainly initiated to correct deformities or to act as a complement of

reconstructive surgeries for diseases such as poliomyelitis or injuries due to trauma.<sup>12</sup> However, they have been adapted over time to improve the results of cosmetic surgery of the lower limbs.<sup>13</sup>

In volumization by placement of silicone implants, two anatomical areas are used: (1) an anterointernal region in a natural concavity formed by the sartorius and adductor longus muscles and (2) an external region formed by the tensor of the fascia lata and sartorius.<sup>5</sup> The ease of placement depends largely on the expertise of the surgeon;

**Table 3. Change in the Dimensions of Vastus Medialis**

Variable	Women	Men	Overall Mean
Mean right vastus medialis fat graft (cm <sup>3</sup> )	100–160* (117.56†)	100–160* (124.29†)	118.46
Mean change in the thickness of right vastus medialis (mm)	29.44	28.93	29.38
% change in the thickness of right vastus medialis	83.51	88.69	84.21
Mean left vastus medialis fat graft (cm <sup>3</sup> )	100–159* (130.27†)	103–134* (117.86†)	128.6
Mean change in the thickness of left vastus medialis (mm)	30.73	30.00	30.63
% change in the thickness of left vastus medialis	88.92	95.75	89.84
Mean vastus medialis fat graft (cm <sup>3</sup> )	123.53		
Mean change in the thickness of vastus medialis (mm)	30.00	87.02%	

\*Range of grafted volume.

†Mean volume.

however, the major challenge with this technique is the risk of injuring vascular nerve structures located in the Hunter's canal, which is located deep in the anterointernal region where the implant is typically placed.<sup>14,15</sup>

Providing an athletic anatomical effect without the required muscle volume, the other technique for volumization uses subcutaneous fat grafting and presents good aesthetic results.<sup>6,9,12</sup> Intramuscular fat grafting can achieve a harmonious, athletic visual effect that allows the patient's grafted muscles to have an appearance of dynamic muscle development when they perform movements, which is already known in the case of the pectoral and deltoid muscles<sup>9</sup> (Fig. 5).

In our study, the surgical technique for fat tissue collection was performed by liposuction in a manner similar to that described by Coleman,<sup>10,16</sup> which is a precise, simple, easily reproducible,<sup>17</sup> and safe technique with few complications.<sup>18</sup> Based on our findings, we therefore propose an alternative technique of volumization for the thighs, which consists of intramuscular grafting in the vastus lateralis and vastus medialis to achieve volume according to the definition of our surgical plan and the anatomy of vascularization of the muscle groups to prevent adverse events such as muscle necrosis or fat embolisms.

In our bibliographic search, we could not find reports on surgical techniques for intramuscular grafting in the thighs, but those for other anatomical areas, especially the upper limbs, chest, and abdomen, were readily available.<sup>1,2,19</sup> Hence, we prepared a surgical plan based only on anatomical knowledge but still considered muscle vascularization and important structures related to the areas worked on to reduce the risks of grafting.

According to Mathes and Nahai's classification,<sup>20</sup> the vastus lateralis is a type 1 muscle with a single pedicle supplied by perforants of the descending branch of the lateral femoral circumflex artery, whose path usually runs through the intermuscular septum of the vastus lateralis and rectus femoris muscles. It is identified by drawing a straight line from the anterior superior iliac spine to the superolateral edge of the patella.<sup>21</sup> We recommend following this path and placing the intramuscular fat graft in an area lateral to this line and to the patella from bottom to top to prevent compromising its pedicle and potential complications (Fig. 2).

On the other hand, according to Mathes and Nahai,<sup>20</sup> the vastus medialis is a type 2 muscle supplied by perforants from the branches of the superficial femoral artery,

which runs through the Hunter's canal and goes deeper and posterior in the distal hiatus; this is approximately 9 and 9.5 cm from the base of the patella in men and women, respectively, which is at the medial edge of the vastus medialis.<sup>14,15</sup> Therefore, intramuscular fat grafting below this distance and near the midline of the muscle decreases the risk of fat embolism in the superficial femoral vessels (Fig. 2).

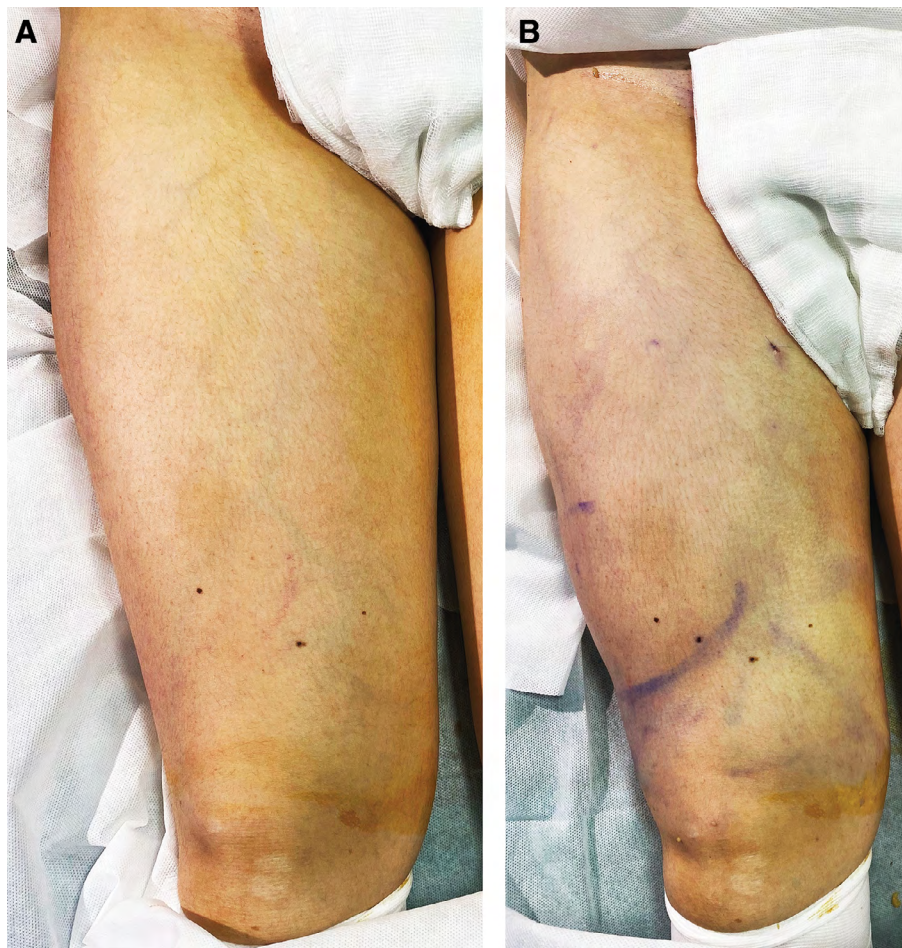
Considering these, we located specific and safe anatomical points to distally graft fatty tissue and achieve the visual effect of muscle volume (Fig. 2). In our procedures, we used blunt-tipped cannulas and preferred to apply fat grafts in the anteroposterior direction (Fig. 4).

One of the most concerning complications that can occur with intramuscular infiltration of fatty tissue is fat embolism. There are known cases of these events occurring when fatty tissue infiltrates the gluteus maximus muscle; however, vascular anatomy in the gluteal muscles is different compared with that of the other muscle groups; so intramuscular fat grafting can therefore be more safely performed.<sup>1,2</sup>

Fat embolism of the thigh is very rare compared with that of regions such as the gluteal area, where due to their large caliber, the lateral varicose veins associated with the piriformis muscle are more prone to injury due to the placement of fat into the deep muscular plane. Moreover, the negative pressure gradient in the injured gluteal vessels increases the risk of fat embolism.<sup>23,24</sup> This phenomenon is not usually observed in the thigh, where perforating vessels are smaller and large vessels are located lateral or medial to the lipografting point described in our technique.

The additional time required for bilateral muscle definition and volumization of both vastus muscles was approximately 20–30 minutes, which was similar to that required for volumization by subcutaneous fat grafting and less than the time required for silicone implants.<sup>2,5,6</sup>

None of the patients developed adverse events such as embolism, muscle or fat necrosis, surgical site infections, or bleeding. One of the limitations of our work is the lack of an adequate follow-up period to assess the durability of the grafted fat. However, it is well known that the durability of the fat grafted in the intramuscular plane is higher than that of the one grafted outside this plane. A longer follow-up of these patients is required to obtain further information on the durability of the graft. (See figure 1, Supplemental Digital Content 1,



**Fig. 5.** Before and after volumizing and defining the vastus muscles. A, The lower right limb before being identified and grafted into the operating room. B, The lower right muscle is immediately identified and measured postoperatively in the operating room.

which displays the patient before and 1 year after the procedure, wherein the female patient is seen in a standing position without muscle contraction. <http://links.lww.com/PRSGO/B840>.) (See figure 2, Supplemental Digital Content 2, which displays the patient before and 1 year after the procedure, wherein the male patient is seen in a standing position without muscle contraction. <http://links.lww.com/PRSGO/B841>.)

### CONCLUSIONS

The surgical technique for VDVFAT can be performed by intramuscular grafting as described in this article. It is a safe and reproducible procedure, which adequately complements the definition of muscle groups in terms of obtaining athletic and harmonious results. None of the patients in our study experienced adverse events, such as surgical site infections, thromboembolic disorders, fat embolism, and muscle necrosis. The increase in muscle volume quantified by ultrasound upon immediate postoperative period is evident; however, we need more information about the durability of fat grafts. Thus, more follow-up studies on patients who have undergone this technique are required to better understand their durability.

*Raúl Martín Manzaneda Cipriani, MD*  
Aurelio Miro Quesada 1048 San Isidro  
Lima, Peru  
E-mail: [rmanzanedacipriani@hotmail.com](mailto:rmanzanedacipriani@hotmail.com)

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