

# Adipose Tissue Transfer in Dynamic Definition Liposculpture Part III. The Arms: Biceps, Triceps, and Deltoid Muscles

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**Background:** Arm contouring usually represents a challenge for the surgeon due to zones with high risk of irregularities/asymmetries, the variable degree of skin laxity, and the differences between patient/gender preferences. In men, the bigger and muscular the arms the better, while women tend to prefer a slim and soft silhouette.

**Purpose:** Report our experience with intramuscular fat grafting of the arm, while also evaluating the safety of our technique by means of cadaveric dissections.

**Methods:** We performed arm cadaveric dissections and also searched our records for patients who underwent fat grafting of the arm in addition to HD2, from January 2016 to May 2022 at a single center in Bogotá, Colombia.

**Results:** Two hundred eighty-nine consecutive patients (275 males and 14 females) underwent high-definition lipoplasty/HD2 plus fat grafting of either the biceps m. (72 muscles), the triceps m. (46 muscles), the deltoids m. (426 muscles), or a combination of them. Mean age was 39 and 36 years for men and women, respectively. Range of the fat graft volume was 30–150 ml. No major complications were reported. Follow-up period ranged from 2 to 24 months. Most patients were satisfied with the results.

**Conclusions:** Men usually seek an overall well-toned and muscular extremity, while women tend to prefer a slim but also athletic contour. Such outcomes can be achieved through intramuscular fat grafting of the biceps, triceps, and deltoids. The proper recognition of the pedicles and a precise surgical technique will ensure both its safety and the reproducibility of the results. (*Plast Reconstr Surg Glob Open* 2022;10:e4651; doi: 10.1097/GOX.0000000000004651; Published online xxx xxx 2022.)

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Received for publication August 17, 2022; accepted September 16, 2022.

Presented at the 53rd Annual Baker Gordon Educational Symposium, February 7–9, 2019, Miami, Florida, and at the Aesthetics Meeting, ASAPS, April 20–24, 2022, San Diego, California.

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DOI: 10.1097/GOX.0000000000004651

## INTRODUCTION

Body contouring surgery has evolved abruptly in the recent years. There are huge differences between the standards of care we used in the past for traditional liposuction techniques and the ones we currently use for both dynamic and high-definition lipoplasty (HDL).<sup>1,2</sup> HDL involves an all or nothing premise in which all body segments must be intervened, and aesthetic concepts must follow the naturality of the results.<sup>3</sup>

Arms are of special aesthetic interest, since they guard the natural symmetry of the body and play an important

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**Disclosure:** Dr. Hoyos was an unpaid consultant and speaker for the product development team of Sound Surgical Technologies (SST) system and Cannulas (now: VASER 2018 Solta Medical—Bausch Health Companies Inc.) up to May 2013. He receives royalties for the liposuction kits named after him.

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role in sexual dimorphism. In men, the bigger and muscular the arms the more athletic and healthier the appearance, while for women, a bulky and sharply defined arm could be perceived as unpleasant; hence, they do prefer a slim and soft silhouette looking.<sup>4,5</sup> Liposuction, dermal flap resection (when severe skin laxity is present or in postbariatric patients), silicone implants, and fat grafting are among the most common techniques to contour the arms<sup>6,7</sup>; however, it usually represents a challenge for the surgeon to achieve optimal results due to some zones with high risk of irregularities, the variable degree of skin laxity, and the differences between patient/gender preferences. Dynamic definition liposculpture (HD2) has the overall goal of improving the aesthetic results while focusing on maximizing safety and minimizing complications.<sup>6,8</sup> Although there is a lot of evidence about arm liposuction, deltoids are, to our knowledge, the only muscles that have been studied and subject to autologous fat grafting. The aim of this article is to report our experience in a cohort of patients who underwent autologous intramuscular (IM) fat grafting of the biceps, the triceps, and the deltoid muscles, and support the safety of such technique by means of a cadaveric dissection that focuses on the neurovascular anatomy of the arm.

## ANATOMY

The superficial anatomy of the arm is determined by three main muscles: the deltoid, the triceps brachii, and the biceps brachii.

The *Deltoid* (named after the Greek letter delta) muscle has three segments: anterior, middle, and posterior.<sup>9</sup> Its main pedicle comes from the posterior circumflex humeral artery (Table 1; Fig. 1). The *Biceps brachii* has two muscular heads and represents the anterior bulk of the arm. It covers the coracobrachialis and the brachioradialis muscles at the top and the bottom, respectively (Fig. 2). The musculocutaneous nerve runs superficial to the brachioradialis m. and subcutaneous at the elbow.<sup>10</sup> The *Triceps brachii* consists of three heads: long, lateral, and medial. The long and lateral heads plus the deltoid give a prominent shape to the posterior arm, and the medial head (deep) contributes to the breadth of the arm (Fig. 3).<sup>10</sup> The proper identification of the pedicles, their direction, and distribution within the arm, are probably the most valuable information to acknowledge to perform a safe IM lipoinjection of the arm (Table 1).<sup>11-14</sup>

### Artistic Anatomy

Recently, we came up with a concept called feminizing facets for HD2, which refers to different artistic planes throughout body segments that interact with each other to shape a natural feminine silhouette. So, while the male's arm needs the enhancement of power muscles (biceps, triceps, and deltoids), the female one requires the interaction of a cylindrical shape, with smooth transitions between a deltoid plane and the lateral arm groove, as well as a smooth connection with a posterior plane (Figs. 4, 5).

## METHODS

We performed a cadaveric dissection of the upper limb in an attempt to support the safety and reliable approach of the IM fat grafting of its muscles. The biceps, the triceps, and the deltoid muscles were all dissected in a single specimen to locate the main pedicles, their distribution within the muscle, and the presence of risk/safe compartments as described in the gluteal region.<sup>15</sup> Scalpel with #15/#20 blades, tissue scissors, and tissue forceps were used to separate the anatomic layers, vascular retractors, and markers that were used to denote the main pedicles and vessels. First, we located the pedicle and then did a lipoinjection test following the usual blinded approach we use in HD2 methylene blue to identify its proper placement at the IM layer for the arm's muscles. (See Video 1 [online], which shows a cadaveric dissection of the biceps and the triceps muscles. Video includes the plain dissection of the pedicles from both muscles and a simulated IM lipoinjection as well; see Video 2 [online], which shows a cadaveric dissection the deltoid muscle. Video shows the plain dissection of the pedicles and a simulated fat grafting technique.)

We searched our medical records and looked for patients who underwent HDL/HD2 in addition to fat grafting of either the deltoid m., the biceps brachii m., or the triceps brachii m., alone or any combination of them, between January 2016 and May 2022, at a single surgical center (Dhara Clinic) in Bogotá, Colombia. Exclusion criteria were patients with severe skin laxity of the arms, postbariatric patients, those with body mass index greater than or equal to 30 kg/m<sup>2</sup>, patients with PMH of blood clotting disorders or any thrombotic event (ie, DVT and PE), and patients with American Society of Anesthesiologists risk classification greater than or equal to III. Cardiology assessment including EKG and chest X-Ray was required for patients above 40 years old. All patients were subject to protocols for safe large-volume liposuction including those for thromboembolic events' prevention, blood conservation, and hypothermia prevention.<sup>16</sup> IV medications used were: antibiotic prophylaxis with cefazolin (2-g IV, 60 minutes before incision) or clindamycin 600-mg IV (if allergic to beta-lactams), dexamethasone 8mg, metoclopramide 10mg, diclofenac 50mg, and ranitidine 50mg. Photographic records were taken before surgery and during follow-up appointments at 2 days and 1, 3, 6, and 12 months.

### Surgical Technique

#### Markings

They are all done at the standing position (Fig. 6):

- Adipose deposits: relaxed arm in adduction.
- Posterior sulcus of the deltoid #1: 90° arm abduction with 90° elbow flexion and neutral internal rotation of the shoulder.
- Anterior sulcus: shoulder at 90° external rotation.
- Posterior sulcus of the deltoid #2: a voluntary contraction of the triceps while on complete arm adduction creates a new groove at the posterior sulcus. The zone between #1 and #2 will be the "dynamic zone."

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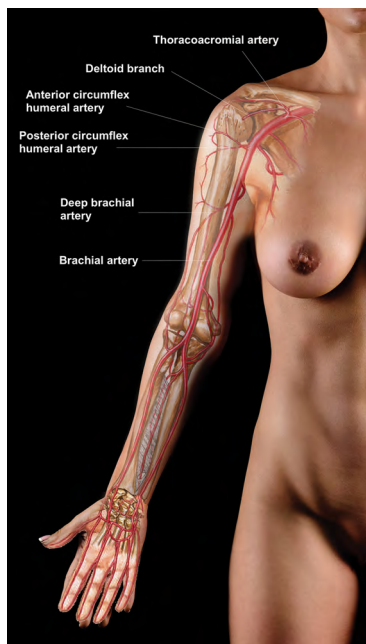
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**Table 1. Power Muscles of the Arm and Important Statements**

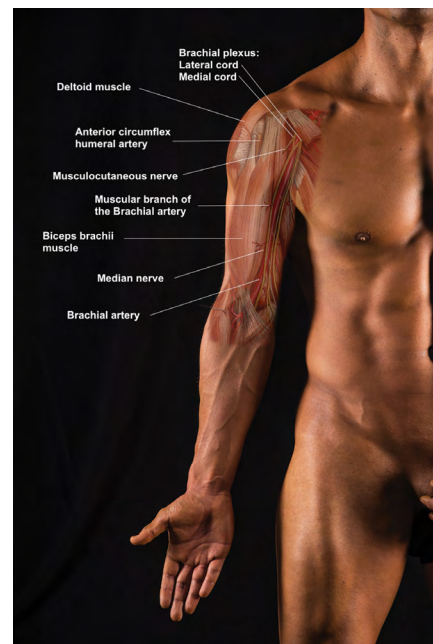
Muscle	Anatomy	Description
Biceps brachii m.	Origin	Long head: supraglenoid tubercle of scapula. Short head: coracoid process of scapula.
	Insertion	Radial tuberosity, fascia of forearm via bicipital aponeurosis.
	Main arterial pedicle	Muscular branches of brachial artery.
	Innervation	Musculocutaneous nerve.
Note	Brachial artery (continuation of the axillary artery) begins at the lower margin of the teres major muscle. Its diameter is 4.3–4.5 mm and has a relatively superficial and medial course.	
Triceps brachii m.	Origin	Long head: infraglenoid tubercle of scapula. Lateral head: upper half of posterior humerus. Medial head: distal 2/3 of medial and posterior humerus.
	Insertion	Posterior surface of olecranon process of ulna.
	Main arterial pedicle	Muscular branches of profunda brachii artery.
	Innervation	Radial nerve.
Note	Deep brachii artery runs posterior and then emerges through the humerus-triceps triangle, together with the radial nerve, which is located below the brachioradialis and biceps muscles. Its average diameter is 1.66–1.68 mm. It gives off an ascending deltoid branch, which aids to the blood supply of the deltoid muscle.	
Deltoid m.	Origin	Lateral third of clavicle (anterior fascicles), acromion (middle fascicles), and spine of scapula (posterior fascicles). Deltoid tuberosity of the humerus.
	Insertion	Posterior circumflex humeral artery (middle and posterior) and the deltoid branch of thoracoacromial artery (anterior).
	Main arterial pedicle	Axillary nerve
	Innervation	
Note	Thoracoacromial artery and its deltoid branch arise from the second part of the axillary artery immediately posterior to the pectoralis minor muscle, while the posterior circumflex humeral artery (the largest) enters the muscle posteriorly and deep by approximately 2–3 cm from the quadrangular space at the level of the humeral surgical neck.	

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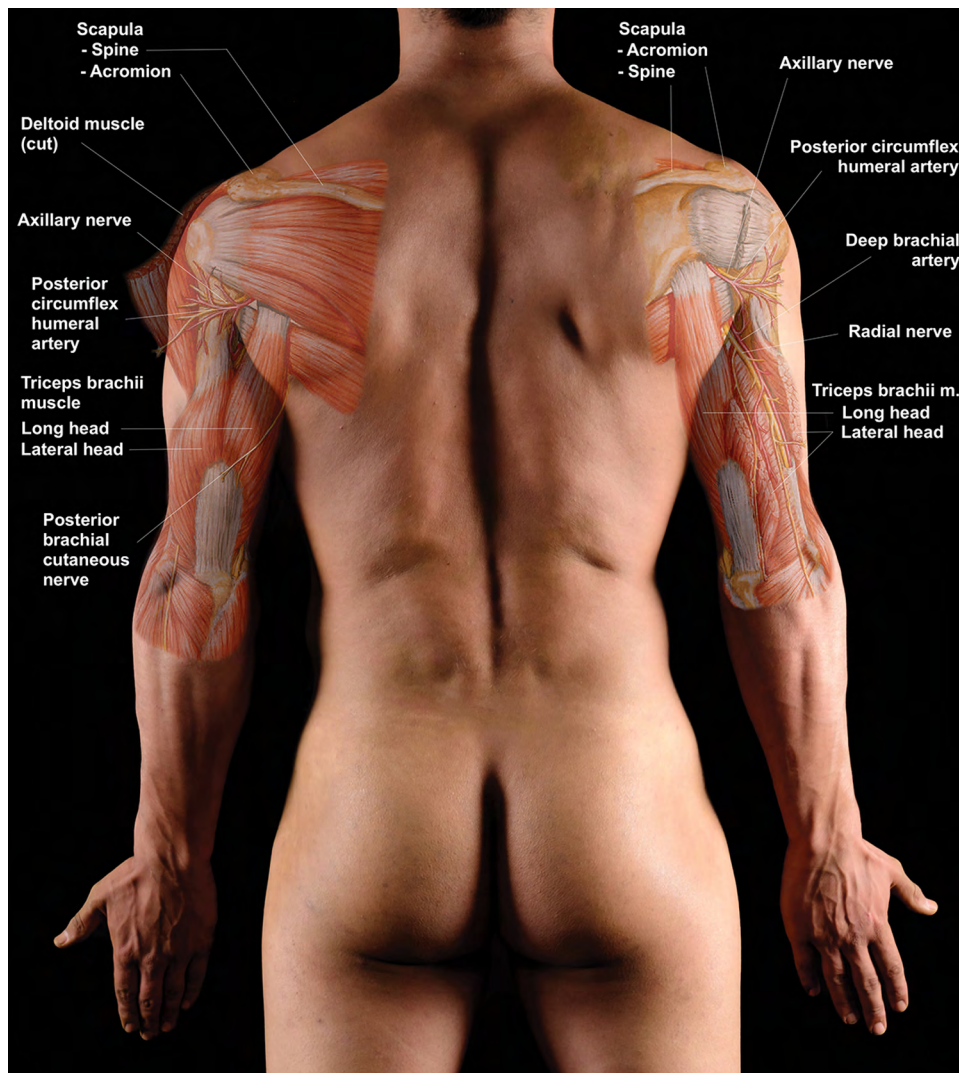
\*The cephalic and basilic veins (arm's main venous drainage) have a caliber of 4–6 and 6–8 mm, respectively. The latter runs along the medial edge of the arm, then perforates the brachial fascia in the middle third to go along with the brachial artery in a deep plane, while the former courses superficially in the arm along the lateral edge of the long head of the brachial biceps above the brachial fascia to reach the deltopectoral sulcus.

**Fig. 1.** Vascular anatomic map of the upper limb in a female patient.

- Outline the interfascicular limits of the triceps.
- Intermuscular creases between the biceps and triceps (negative spaces).<sup>6</sup>
- Any muscle requiring volume augmentation is marked with a crossed pattern, so as to recognize which one has to be grafted once at the operating table.

**Fig. 2.** Neurovascular structures related to the biceps brachii m. and their representation on the surface anatomy of the arm.

- For women, we usually mark the posterior sulcus and the facets of the arm in which the volume of the triceps will create a continuum with facets from the posterior torso.
- Optional: anatomic location of the pedicles and course.



**Fig. 3.** Neurovascular structures related to the triceps bacchii and their representation on the surface anatomy of the arm.

### Dynamic Definition Liposculpture

#### HD2 body contouring surgery is achieved by a 3-step process:

1. Infiltration: Tumescent solution (1000 ml of saline and 1 ml of 1:1000 epinephrine) + lidocaine (10 mg/kg), for both the lower limb and the arms liposuction, which will help to ameliorate the exquisite postoperative pain of the extremities.
2. Fat Emulsification: Third-generation ultrasound (US) (VASER system) in pulsed and continuous modes at 50%–60% power for the superficial and deep adipose layers, respectively. The clinical end point of fat emulsification is loss of tissue resistance.
3. Microaire-assisted Liposuction: We use 4.0- and 3.0-mm Mercedes cannulas for the male and female liposuction, respectively. We do deep debulking when necessary (most women), though we do superficial and intermediate layers' liposuction for detailed

muscular definition (based on the Basic, Moderate, Xtreme definition algorithm).<sup>8</sup>

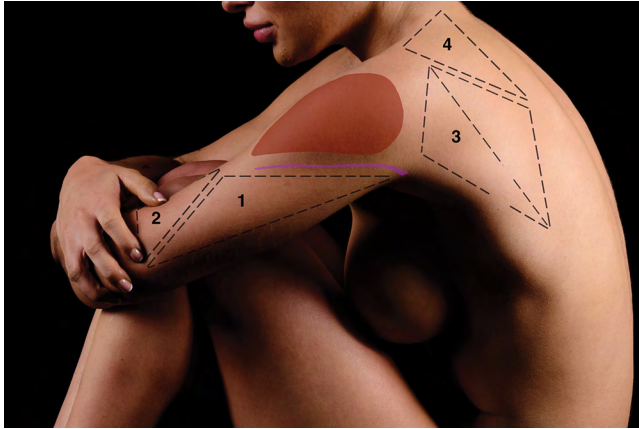
#### Fat Grafting

The adipose graft is harvested from the abdominal and inner thigh lipoaspirate. We add hypochlorous acid into the harvesting canister, which serves as both a bactericide and a cleansing solution. The Vibratory Tissue Separator (VTS Wells Johnson, Tucson, Ariz.) accelerates the process of decantation, then we transfer the supernatant to 60-ml syringes connected to a 30°-curved blunt tip cannula in preparation for lipoinjection. As a general rule: point the tip of the cannula upward at all times.

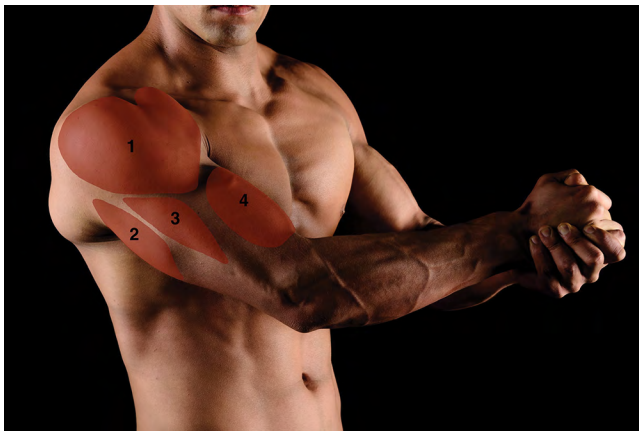
#### Biceps Brachialis

**Patient must be in supine position with 90° arm abduction and 90° elbow flexion.**

1. Access through the anterior axillary fold incision.



**Fig. 4.** Feminizing facets of the female arm and back: tricipital (1), bicipital (2), scapular facet (3), and superior trapezius (4). Other important reference is the posterior sulcus of the deltoid (purple), which is mainly a transition zone and should be marked sharply only for Xtreme definition cases. Although the deltoid is a definition muscle for the women (red), it works as a power muscle for the men.



**Fig. 5.** Power muscles of the male arm: deltoid (1), triceps brachii long (2) and lateral (3) heads, and the biceps brachii (4). All muscle limits must be sharply defined through Superficial liposuction.

2. The tip of the cannula must be perpendicular to and away from the pedicle: About 30°–45° away from the arm's horizontal axis.
3. Pinch the muscle with almost a complete hand grip.
4. Place the tip at the center of the muscle bulk and drive the cannula into it (by means of a gentle stab). One should feel a click or a decrease in resistance once inside.
5. Keep the tip stable and place the graft superficially through fanning and retrograde movements into both the long and short heads of the muscle. (See **Video 3 [online]**, which shows a 39-year-old man undergoing fat grafting of the biceps and HD2. The biceps were grafted with 80 ml of autologous adipose tissue. Then, a 42-year-old man undergoing fat grafting of the triceps + HD2. The lateral and long heads were grafted with 50 and 40 ml of autologous adipose tissue, respectively.)

### Triceps Brachialis

**Patient must be in prone position with 90° arm abduction and 90° elbow flexion.**

1. Access through the elbow and the posterior axillary fold incisions for the long head and the lateral head, respectively.
2. The tip of the cannula must be about 30°–45° away from the arm's horizontal axis.
3. Pinch the muscle.
4. Point the tip to the center of the muscle mass and stab it gently.
5. Place the graft into both the long and lateral heads of the muscle. (See **Video 3 [online]**, which shows a 39-year-old man undergoing fat grafting of the biceps and HD2. The biceps were grafted with 80 ml of autologous adipose tissue. Then, a 42-year-old man undergoing fat grafting of the triceps + HD2. The lateral and long heads were grafted with 50 and 40 ml of autologous adipose tissue, respectively.)

### Deltoids

1. Same position and same access as for the triceps muscle. Do not ever access through the anterior axillary fold as the risk of injury to the cephalic vein is high.
2. The tip of the cannula about 90° away from the arm's horizontal axis.
3. Pinch the muscle.
4. Rotate and point the tip to the center of the muscle mass once surpassed the posterior border of the deltoid, then stab the muscle gently.
5. Place the IM graft into the middle fascicles of the deltoid. (See **Video 4 [online]**, which shows a first patient who is a 35-year-old man undergoing fat grafting of the deltoids with 120 ml of autologous adipose tissue on bilaterally. Then, a 34-year-old woman undergoing fat grafting of the deltoids with 40 ml.)

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Perform intraoperative US imaging (if available) to ensure the proper IM placement of the graft. Both the posterior and anterior axillary fold incisions are sutured with 4-0 polypropylene.

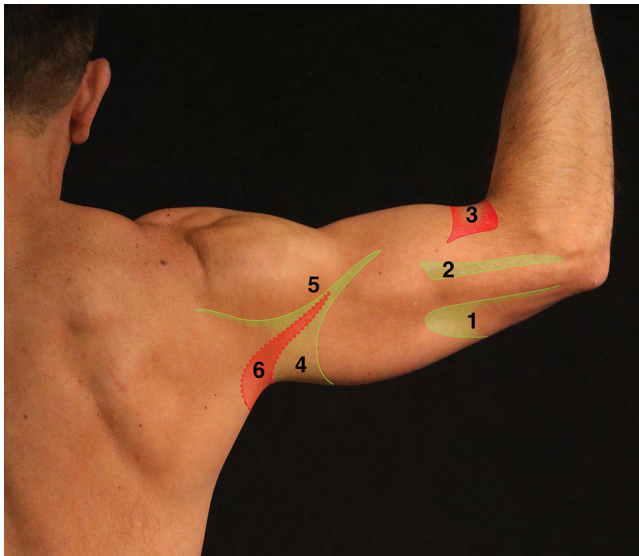
### Outcome's Evaluation

A nonstandardized survey aimed to evaluate the overall satisfaction with the procedure by asking the patient to rate their results in a scale from 1 to 5 (1 = poor results, 2 = below expectations, 3 = average results, 4 = good results, and 5 = above expectations) during the postoperative follow-up appointment.

### Ethical Considerations

Each patient was informed of the purpose, methods, sources of funding, any possible conflicts of interest, institutional affiliations of the authors, the anticipated benefits and potential risks of the study and the discomfort it may entail, poststudy provisions, and outcomes according to the Helsinki Declaration. They were also informed of the

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**Fig. 6.** Markings of a male patient undergoing arm dynamic definition lipoplasty (HD2) including the negative spaces and dynamic zones: tricipital groove (1), bicipital line (2), biceps adhesion zone (3), deltoid shadow (4), posterior deltoid sulcus (5), and dynamic zone (6). The latter is exposed after the triceps muscle active contraction.

right to refuse to participate in the study or to withdraw consent to participate at any time without reprisal. A freely given informed consent was signed for each patient participating in our report; hence, each patient had the autonomy to decide whether to undergo fat grafting of certain muscles or not. Patients were informed about the nature of the procedure, the experimental technique, the potential risks and benefits specific from fat grafting, and also dynamic definition liposculpture. Surgery was planned according to what the expectations of the patient were and the different degrees of muscular definition. Dissections were performed at a center for research and surgical training (Santé Université Paris Cité, Paris, France), which holds the ethical rights/standards and legal credentials to provide corpses for medical academic/private institutions for either training or research purposes.

## RESULTS

We found 289 consecutive patients (275 men and 14 women) who underwent HDL/HD2 plus fat grafting of either the biceps m. (72 muscles), the triceps m. (46 muscles), the deltoids m. (426 muscles), or a combination of them (Table 2). Mean age was 39 and 36 years for men

**Table 2. Patient Demographics**

n = 289	Male			Female		
	n = 275 (95%)	Average	Range	n = 14 (5%)	Average	Range
Age		39	25–65		36	28–51
Weight (kg)		69	62–97		58	49–71
Height (m)		170	160–194		158	152–180
Body mass index (kg/m <sup>2</sup> )		24.4	23.5–28.5		23.4	22.1–28.2
Smoking history (quit ≥2wk)	22 (8)			1 (7)		
Surgery		Volume (ml)			Volume (ml)	
HD2 + biceps FG	33 (12)	60	40–100	3 (21)	35	30–40
HD2 + triceps FG	23 (8)	70	50–120	0 (0)		
HD2 + deltoid FG	202 (74)	90	50–150	11 (79)	40	30–60
HD2 + 2 muscles	10 (4)			1 (7)		
HD2 + 3 muscles	21 (8)			0 (0)		
HD2 + Arm FG + other muscles	275 (100)			14 (100)		
Infiltration (ml)		6100	3800–10400		5400	3100–10200
Lipoaspirate (ml)		4400	3000–8600		4100	2400–8600
Complications						
Prolonged bruising	12 (4.4)			0 (0)		
Dysesthesia	4 (1.5)			0 (0)		
Infection	0 (0)			0 (0)		
Hematoma	0 (0)			0 (0)		
Necrosis	0 (0)			0 (0)		

FG, fat grafting; Hb, hemoglobin; HCT, hematocrit; HD<sup>2</sup>, dynamic definition liposculpture. In Table 1

**Table 3. Outcome's Evaluation through a Nonstandardized Survey**

Grading	Data, n = 253 (%)	Timing of the Survey			
		3 mo, n = 145 (57%)	6 mo, n = 74 (29%)	9 mo, n = 22 (9%)	12 mo, n = 12 (5%)
Poor results = 1	0 (0)	—	—	—	—
Below expectations = 2	0 (0)	—	—	—	—
Average results = 3	8 (3)	6 (2)	2 (1)	—	—
Good results* = 4	36 (14)	10 (4)	18 (7)	6 (2)	2 (1)
Above expectations* = 5	209 (83)	129 (51)	54 (21)	16 (7)	10 (4)

Patients were asked to rate their results from 1 to 5. Then, only results above average were considered optimal.

\*Two hundred forty-five out of 253 patients rated their results "good" and "above expectations," hence a satisfaction rate of 97%. There were no complaints or results below "average" score.

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and women, respectively. The deltoid was the most frequent muscle subject to fat grafting and also the one with the greatest volume injection (150 ml). In fact, all patients who underwent either biceps or triceps fat grafting underwent deltoid FG at the same time. Only four patients underwent selective FG of the lateral head of the triceps, while 23 did both heads. There were no major complications. Minor complications included 12 patients who complained of prolonged bruising at the lipoinjected areas, and they all solved entirely with physical means (massage and cold/warm dressings). Four patients did have temporary numbness sensation over the posterolateral forearm, which lasted for 1-2 weeks and solved entirely by its own. -Follow-up- period ranged from 2 to 24 months (average, 12 months). The -nonstandardized- survey showed that most patients (97%) were very satisfied with their postoperative results (Table 3).

### DISCUSSION

The evolution of arm contouring surgery has encouraged surgeons to seek new techniques and broaden our knowledge to provide optimal aesthetic results.<sup>17,18</sup> Certainly, different cultures and the new trends in social media have set new standards of beauty in which the arms have taken a very important place. For men, an overall well-toned and muscular extremity is compulsory while women tend to prefer a slim but also athletic contour. From the artistic point of view, these principles go together with the concepts of power muscles and feminizing facets, in which the bulky appearance and sharp limits of the biceps, triceps, and deltoids have to be different from the soft-transitioned planes of the arm for men and women, respectively.<sup>8</sup> Liposuction is often enough to achieve this purpose for both genders but specially for women (only 5% in our cohort); however, in some patients with underdeveloped muscles, contour defects, and/or mere individual request, we will require fat grafting to improve the arms' dimensions and as a result the interplay between its shadows and lights.

We are reporting our experience with IM fat grafting of over 540 muscles of the arm, in which deltoid muscle was the most prevalent, which raises the question whether the deltoid is the most difficult muscle to grow after hours of workouts or rather the one that actually represents the athleticism of the arm. In effect, our study showed that all patients who underwent either biceps or triceps fat grafting did it for the deltoid too (including women). By comparison, selective fat grafting of the lateral head of the triceps might contribute to the lateral volumetric perception of the arm, though men do prefer to have all muscles of the arm grafted at once. Fat grafting helped us to achieve a natural, anatomical, and athletic appearance of the arm in most cases (Figs. 7–9). Two hundred fifty-three (87%) out of the 289 patients answered the postoperative survey, which reported a satisfaction rate of 97% (Table 3). Most patients cherished the new strong appearance of the arm and its muscular definition. Both the cadaver-based study and the number of patients in our cohort helped us to understand why



**Fig. 7.** A 26-year-old man who underwent dynamic definition liposculpture in addition to fat grafting of the arms. 150, 60, and 100 ml were grafted into the deltoids, biceps, and triceps muscles, respectively. Note the new muscular and athletic appearance of the arm in the 10-month postoperative picture (B) compared with the preoperative one (A).

the IM autologous fat transfer has to follow some strict guidelines to be considered safe and reliable (Table 4). However, we encourage every surgeon to practice intraoperative US to ensure the graft location during lipoinjection, as it is nowadays considered the standard of care for gluteal lipoinjection after the 2018 practice advisory from the Multi-Society Task Force for Safety in Gluteal Fat Grafting which state: the use of US-guided documentation of cannula placement before and during fat injection, and the limitation of three BBL cases as a maximum amount of total operative cases per day.<sup>19</sup> Likewise, other authors such as Cancansao et al and Pazmiño et al have reported the advantages of US in the safety profile of aesthetic lipoinjection.<sup>15,20</sup>

Even though fat grafting is actually part of the HD2 technique itself, we described both procedures separately with the sole purpose to emphasize about the importance of a safety practice of IM fat grafting. In any case, the surgeon must be aware of any unexpected trauma to the arm that could result in acute compartment syndrome or in a worst case in fat embolism, both considered severe and devastating complications. To our knowledge, there has not been any fatality nor pulmonary fat embolism reported in the medical literature after IM fat grafting in a muscle other than the gluteus major,<sup>21–25</sup> neither any case report of acute compartment syndrome following aesthetic procedures of the arm.<sup>26–28</sup>

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**Fig. 8.** A 38-year-old man who underwent HD2 + fat grafting of the arms. Both the triceps and the deltoids were grafted with 100 and 120 ml of adipose tissue, respectively. Preoperative photograph (A) shows a good tone but rather cylindrical arm with no shadows. The 6-month postoperative picture (B) shows a completely different arm with sharp muscle contours and greater volume, which makes the patient look actually younger.



**Fig. 9.** A 34-year-old woman who underwent HD2 + fat grafting of the deltoids. Each one was grafted with 40 ml of adipose tissue. It is evident how the contour of the arm and the new deltoid volume helps the patient to look fitter and healthier in the postoperative picture (B) compared with the preoperative one (A).

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**Table 4. The “Fav Five”: Tips for a Safety Approach to IM Fat Grafting in Dynamic Definition Lipo**

1. Access should be as far from the pedicle as possible.
2. Direct the tip of the cannula in a perpendicular fashion in relation to the anatomical axis of the pedicle.
3. Place the graft at the most superficial plane within the muscle.
4. Perform fat grafting in a retrograde/fanning fashion.
5. Use 3–4-mm blunt tip curved cannulas for lipoinjection (bigger than the diameter of the pedicle).

If available, use real-time US imaging to make sure about the location of the graft just before the injection.

### Limitations

The lack of inferential statistics and the retrospective nature of the study decrease its power and also preclude a strong association between the procedure and the outcomes, though these were clinically evident. Prospective clinical trials and multicenter studies are required to further support our findings.

### CONCLUSIONS

Arm augmentation through IM fat grafting should be considered an alternative procedure to improve the athletic and natural appearance of the arm in both men and women. The proper recognition of the pedicles and a precise surgical technique will ensure both its safety and the reproducibility of the results.

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