Static Injection, Migration, and Equalization (SIME): A New Paradigm for Safe Ultrasound-Guided Brazilian Butt Lift: Safer, Faster, Better

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Abstract

Background: Although the Brazilian butt lift (BBL) is one of the most popular procedures in body contouring, it has been associated with the risk of pulmonary fat embolism when fat graft is injected into the gluteal muscles. The subcutaneous plane has been identified as a safe site for fat graft injection, but deaths from fat embolism continue to occur because there is no mechanism to confirm consistent subcutaneous placement.

Objectives: The aim of this paper was to determine if real-time intraoperative ultrasound could accurately identify the subcutaneous gluteal anatomic landmarks and permit a single surgeon to consistently target fat graft placement in the subcutaneous space.

Methods: In total, 4150 BBLs were performed with real-time intraoperative ultrasound being used to confirm the subcutaneous position of a static cannula during fat graft injection. Serial deposits of fat graft were performed in each buttock. Ultrasound confirmed that fat graft consistently remained above the deep gluteal fascia and migrated through the deep subcutaneous space. These fat graft deposits were then equalized with a moving cannula to correct any contour deformities. Operative times were recorded and compared with BBL performed by expansion vibration lipofilling without ultrasound.

Results: Real-time intraoperative ultrasound allowed for the visual confirmation of consistent subcutaneous fat graft deposition and the targeting of fat graft into specific gluteal subcutaneous compartments.

Conclusions: Real-time intraoperative ultrasound allows the surgeon to confirm a subcutaneous-only fat graft injection, target specific gluteal subcutaneous compartments, and take advantage of the unique architecture of the deep subcutaneous space to create gluteal projection and correct contour deformities.

Resumen

Antecedentes: Aunque el levantamiento de glúteos brasileño (BBL, Brazilian butt lift) es uno de los procedimientos más populares para el contorneado corporal, se ha asociado con el riesgo de embolia grasa pulmonar cuando el injerto de grasa es inyectado en los músculos glúteos. El plano subcutáneo ha sido identificado como un sitio seguro para la inyección de los injertos grasos, pero continúan ocurriendo muertes por embolia grasa porque no existe un mecanismo para confirmar la ubicación subcutánea de manera consistente.

Objetivos: El objetivo de este artículo fue determinar si la ecografía intraoperatoria en tiempo real podría identificar con precisión los puntos de referencia anatómicos subcutáneos del glúteo y permitir que un solo cirujano coloque consistentemente el injerto de grasa en el espacio subcutáneo.

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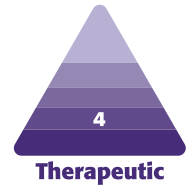
Métodos: En total, se realizaron 4150 BBL y se utilizó ecografía intraoperatoria en tiempo real para confirmar la posición subcutánea de una cánula estática durante la inyección del injerto de grasa. Se colocaron depósitos seriados de injerto graso en cada glúteo. La ecografía confirmó que el injerto de grasa permaneció consistentemente por encima de la fascia glútea profunda y migró a través del espacio subcutáneo profundo. A continuación, estos depósitos de injerto graso se nivelaron con una cánula móvil para corregir cualquier deformidad del contorno. Los tiempos operatorios se registraron y compararon con los del BBL realizado mediante lipotransferencia expansiva con vibración, pero sin ultrasonido.
Resultados: La ecografía intraoperatoria en tiempo real permitió la confirmación visual de la ubicación del injerto de grasa en el área subcutánea de manera consistente y la colocación del injerto de grasa en compartimentos subcutáneos del glúteo específicos.
Conclusiones: La ecografía intraoperatoria en tiempo real le permite al cirujano confirmar que una inyección de injerto graso se localiza solo subcutáneamente, abordar compartimentos subcutáneos del glúteo específicos y aprovechar la arquitectura única del espacio subcutáneo profundo para crear una proyección de los glúteos y corregir las deformidades del contorno.

Level of Evidence: 4



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Over the past 5 years, gluteal fat grafting, commonly referred to as a Brazilian butt lift (BBL), has been one of the most popular and controversial procedures in aesthetic surgery.[1,2] Although it can produce dramatic results, the consequences are sometimes fatal if not done correctly. Because of this, the BBL has been criticized, bashed, and banned by celebrity surgeons, the media, and plastic surgery organizations, respectively[3-5].

In October 2018, the British Association of Aesthetic Plastic Surgeons recommended that their members not perform BBLs because of the high reported mortality rate of this blind procedure.[6] Some insurers in the United Kingdom have withdrawn from underwriting BBLs in malpractice policies, and UK patients are now traveling to Turkey, Spain, and other countries for their BBL procedures. The British experience demonstrated that when trained plastic surgeons avoid this procedure, patients seek care from surgeons in other countries with less oversight.[7]

Multiple plastic surgery societies (including The Aesthetic Society) have published guidelines emphasizing that fat graft must only be injected above the muscle in the subcutaneous layer.[8] These guidelines have been adopted into law by some states, setting the precedent for legislative limitations being set on medical procedures.[9]

These guidelines and laws appropriately describe where the fat graft should be placed, but they do not show surgeons how to inject fat graft accurately and consistently in the subcutaneous space. This lack of total certainty as to the safe and correct placement of fat graft is the final obstacle in making the BBL safe, efficient, accurate, consistent, and teachable.

The purpose of this communication is threefold: (1) to review and examine BBL safety data and relevant publications to date; (2) to describe our experience with a new method of ultrasound-guided BBL with technical refinements that ensure safe, efficient, and accurate fat graft placement; and (3) to employ deductive reasoning to demonstrate why this injection technique is safe, justifying acceptance of the BBL as a safe, reproducible, and teachable procedure when performed with these methods.

METHODS

The authors performed 4150 BBLs by ultrasound-assisted gluteal fat grafting between May 2013 and September 2022. Each such BBL was performed by a single surgeon and this study reflects the experience of 2 surgeons. The general principles of the Declaration of Helsinki were followed and written patient consent was obtained from every patient. Patients ranged in age from 18 to 69 years with an average age of 34.2 years; their average BMI was 31.3 kg/m^2. The study included 119 male (assigned at birth) patients and 4031 female (assigned at birth) patients. Eight different ultrasound systems were used, including the CE Ultrasound (Beijing, China), Interson SeeMore (Pleasanton, CA), Philips Lumify L12-4 (Andover, MA), Butterfly iQ (Burlington, MA), PS-Imaging (Grand Rapids, MI), Clarius L7 and L15 (Vancouver, BC), and GE Vscan (Chicago, IL). During the fat injection phase of the procedure, operative times were recorded in a subset of 10 consecutive patients, to determine the length of time required to perform ultrasound-guided fat injection. In a second

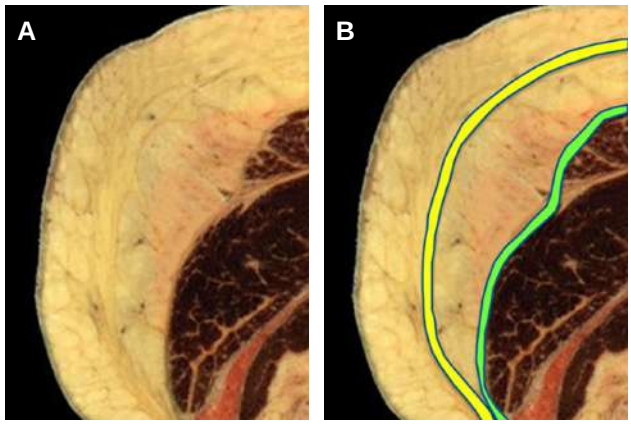


Figure 1. (A) Transverse cross section of female buttocks. (B) Transverse cross section of female buttocks with layers highlighted. The superficial gluteal fascia (yellow) is below the dermis and above the deep gluteal fascia and divides the subcutaneous region into 2 distinct spaces. The deep gluteal fascia (green) lies on the external surface of the gluteus maximus muscle. Reproduced with permission from Pazmiño 2020.[19]

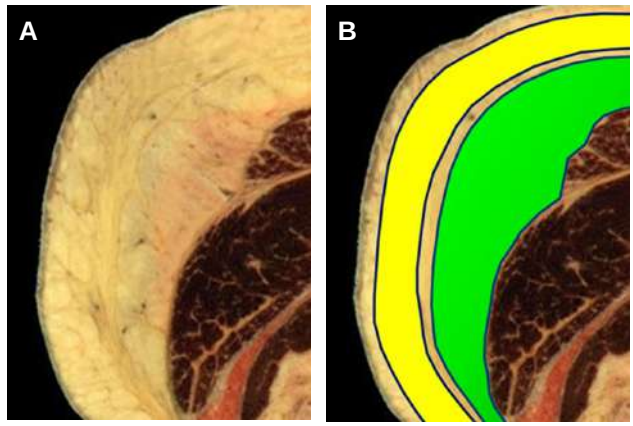


Figure 2. (A) Transverse cross section of female buttocks. (B) Transverse cross section of female buttocks with layers highlighted. The SGF divides the subcutaneous zone into 2 spaces. The superficial subcutaneous space (yellow) is below the dermis and above the SGF. The deep subcutaneous space (green) is below the SGF and above the DGF. Ultrasound allows the surgeon to accurately enter each space and manipulate it while always remaining above the DGF. Note the differences in connective tissue density and organization between the superficial subcutaneous space and the deep subcutaneous space. Clinically, the preferred fat grafting space is the deep subcutaneous space, due to its deeper position and its less dense fibroseptal network that permits the smooth subcutaneous migration of grafted fat. DGF, deep gluteal fascia; SGF, superficial gluteal fascia. Reproduced with permission from Pazmiño 2020.[19]

group of 10 consecutive patients, classic expansion vibration lipofilling (EVL) was performed without ultrasound guidance and fat injection times were recorded. Patients were followed from 6 months to 1 year with an average follow-up time of 8.8 months to measure adverse events and to assess aesthetic results.

Essential Gluteal Soft Tissue Anatomy—2 Fasciae and 2 Fat Layers

The pelvic bony framework, gluteal muscles, gluteal fat, and skin have been well described in the plastic surgery literature,[10-12] but less attention has been paid to the subcutaneous space.[13] Radiology and surgical anatomy literature have long described 2 distinct subcutaneous fasciae throughout the human body: a thinner, elastic, areolar fascia, called the superficial fascia (eg, Scarpa's fascia in the anterior abdomen) that divides the subcutaneous zone into 2 distinct spaces; and a thicker, inelastic fascia, called the deep fascia (eg, rectus fascia in the anterior abdomen) that invests the surface of the muscles. These 2 fasciae are morphologically, histologically, and functionally distinct[14-18].

Both of these subcutaneous fascial layers also exist throughout the gluteal region (Figure 1). The superficial gluteal fascia (SGF), which lies below the dermis and above the muscles, is part of the superficial fascial system and is analogous to Scarpa's fascia throughout the anterior abdomen. There is also a deep gluteal fascia (DGF), which is the muscular fascia that invests the external surface of the gluteus maximus muscle.[19]

The DGF is a single thick layer of fascia attached to the underlying gluteus maximus, whereas the SGF is impregnated with fat globules and has the appearance of bubble wrap on gross dissection. The SGF is clinically relevant because it divides the subcutaneous zone into 2 distinct subcutaneous spaces: the superficial subcutaneous space (between the dermis and the SGF); and the deep subcutaneous space (between the SGF and the DGF) (Figure 2).[16] The superficial subcutaneous space is more organized and demonstrates segmental palisades of dermofascial attachments, whereas fat in the deep subcutaneous space demonstrates a less dense fibroseptal network. This nuanced anatomic difference is critical and serves as the basis for our static injection, migration, and equalization (SIME) approach. Ultrasound allows the surgeon to visually appreciate these fascial layers and to accurately target these 2 distinct subcutaneous spaces in the operating room (Figure 3).

The DGF is clinically relevant because dynamic cadaver studies have demonstrated that if fat graft is injected above an intact DGF, or a DGF with small defects (defects <1 cm), the DGF acts like a "stout wall," preventing subcutaneous fat graft from migrating into or under the gluteus maximus muscle.[20] This cadaver study demonstrated that fat graft only migrated through the DGF when 1 cm or larger

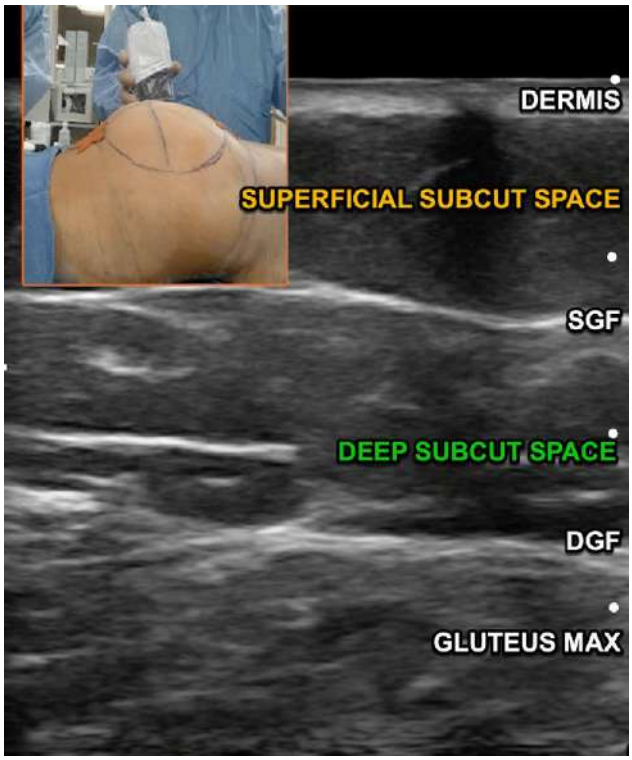


Figure 3. Ultrasound image of key gluteal anatomic landmarks. The dermis is seen at the top of the image abutting the surface of the ultrasound probe. The striated muscle of the gluteus maximus is at the bottom of the image. The DGF (white arrow) is the thick and uniform fascia layer overlying the gluteus maximus muscle. The SGF has the appearance of bubble wrap and is impregnated with fat globules. The SGF divides the subcutaneous zone into the superficial subcutaneous space and the deep subcutaneous space. DGF, deep gluteal fascia; SGF, superficial gluteal fascia.

sections were surgically excised from the DGF. Preventing fat graft from migrating into the gluteal muscles will also stop fat graft from reaching the gluteal veins, thus preventing a fatal pulmonary fat embolism (PFE). Surgeons should take comfort from these findings, because these indicate that small perforations in the DGF caused by inadvertent cannula placement are not large enough to allow subcutaneous fat graft to migrate into the gluteal muscles. Surgeons who can confirm subcutaneous fat graft placement can perform this procedure safely. All autopsies of BBL patients who perished from PFE have the common finding of fat graft within the gluteal muscles, emphasizing the importance of avoiding intramuscular fat graft placement.[21] These research and autopsy findings were the foundation of the 2018 Joint Society Task Force guidelines that recommended surgeons only inject fat graft subcutaneously, above the DGF.[8,22]

It is important to remember that the entire subcutaneous zone (from the dermis to the DGF) varies from patient to

Video 1. Watch now at http://academic.oup.com/asj/article-lookup/doi/10.1093/asj/sjad142

patient and can range in thickness from 1 cm at the lateral hip to 3 cm or greater at the gluteal dome.[23,24] Surgeons, therefore, must graft within a thin curved dome of varying thickness. The technical challenge of consistently remaining in this thin, irregular, variable space may account for the inadvertent deep intramuscular injections by well-intentioned surgeons performing fat grafting without ultrasound visualization.

The "Unmet Clinical Need" in BBL Safety

Over the past 5 years through dynamic cadaver studies and autopsy findings, we have collectively demonstrated that fat graft placed below the DGF is dangerous, whereas fat graft placed above the DGF is safe[20,22,25-27]. The "unmet clinical need" in consistent safe fat grafting is to provide the surgeon with a tool that would confirm accurate deployment of fat graft above the DGF at all times. Ultrasound-guided fat grafting addresses this "unmet clinical need."

Description of the SIME Technique

Previous descriptions of ultrasound-guided fat grafting note the need for 2 operators: one who performs the fat injection with a cannula in constant motion, and a second operator who tracks the moving injection cannula with an ultrasound probe.[28] The subtle nuance of a static approach to both the injecting cannula and the ultrasound probe was first conceived and described by one of the authors (P.P.) and is outlined below and demonstrated in an accompanying intraoperative video (Video 1, available online at www.aestheticsurgeryjournal.com). The ultrasound probe is

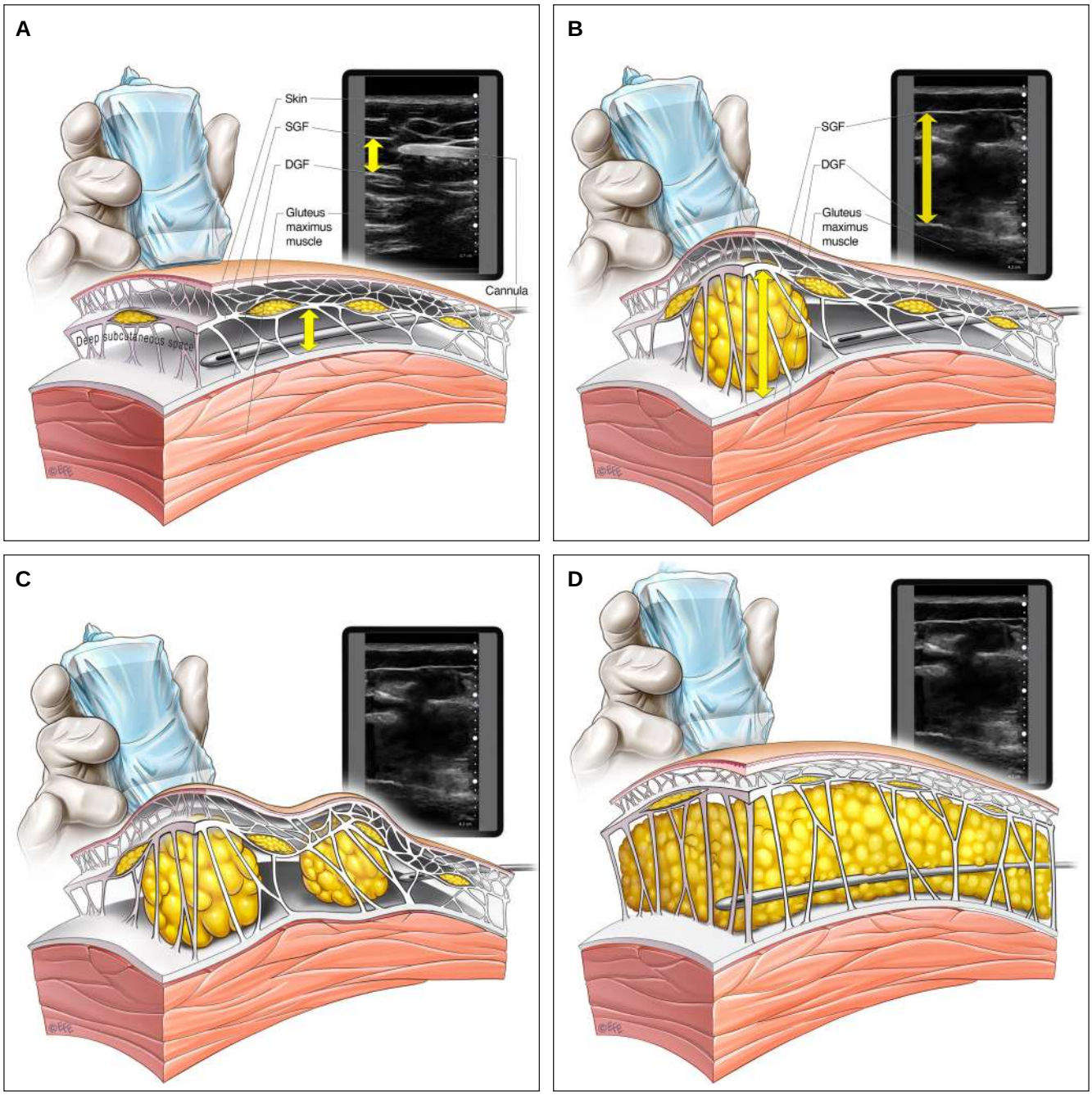


Figure 4. SIME technique: ultrasound probe and cannula position. (A) The ultrasound probe is placed on the skin over the first site of fat graft injection, typically at the center of the gluteal dome (Figure 5A). The injection cannula is inserted through the skin and advanced towards the ultrasound probe. The surgeon uses the ultrasound to visualize all subcutaneous structures and confirm the position of the cannula in the deep subcutaneous space, below the SGF and above the DGF. The height of the unexpanded deep subcutaneous space is noted (small yellow double-headed arrow). (B) Once the cannula position has been confirmed to be above the DGF, the cannula remains stationary and fat graft is injected (static injection). Fat graft migrates easily through the deep subcutaneous space (migration). During the injection, the surgeon assesses the external gluteal contour and stops the static injection when sufficient gluteal projection has been achieved. The ultrasound will confirm a doubling or tripling of the height of the deep subcutaneous space (large yellow double-headed arrow). (C) Once the desired projection and aesthetic endpoint of the first site has been achieved, the ultrasound probe is moved to the next injection site. The cannula is again advanced to the probe. Once the position of the cannula has been confirmed to be above the DGF, the cannula remains stationary and fat graft is injected at the second site (Figure 5B). (D) After all sites have been injected, the surgeon can use the cannula in a dynamic fashion to equalize the fat graft between the areas of injected fat to correct irregularities (equalization). Fat graft is only injected under ultrasound visualization and never when the cannula is in motion. DGF, deep gluteal fascia; SGF, superficial gluteal fascia; SIME, static injection, migration, and equalization.

Table 1. SIME vs EVL Times

	SIME				EVL							
Case	Time (min)		Volume (mL)		Rate (mL/min)		Time (min)		Volume (mL)		Rate (mL/min)	
	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
1	8.5	9	1200	1200	141	133	6.5	6.25	1100	1100	169	176
2	10.5	11	1300	1300	124	118	7	8	1350	1350	193	169
3	8.75	10	1000	1000	114	100	7.75	8.5	1300	1300	168	153
4	11	11.75	1250	1250	114	106	5.75	6.75	1000	1000	174	148
5	10	10.75	1100	1100	110	102	6.75	7	1200	1200	178	171
6	8.75	8.25	1200	1200	137	145	8	7.5	1000	1000	125	133
7	11.5	11	1800	1800	157	164	7.5	7	1050	1050	140	150
8	9.5	12	1400	1400	147	117	7.75	7.25	1200	1200	155	166
9	8.25	7.75	1200	1200	145	155	6.75	7.25	1000	1000	148	138
10	10.5	10	1600	1600	152	160	7	6.5	1300	1300	186	200
Average	9.73	10.15	1305	1305	134	130	7.08	7.2	1150	1150	164	160
SD	1.08	1.36	226.33	226.33	16.43	23.32	0.65	0.64	130.38	130.38	20.16	18.92
P-value	.0003	2E–04	.1143	.1143	.019	.015						

EVL, expansion vibration lipofilling; SD, standard deviation; SIME, static injection, migration, and equalization technique.

placed on the skin over the first site that will receive fat graft. The injection cannula is inserted through a skin incision and advanced to the first injection site just underneath the ultrasound probe and remains stationary. Ultrasound confirms the cannula's position above the DGF and below the SGF within the deep subcutaneous space (Figure 4A). The cannula remains stationary and fat graft is injected (ie, static injection). By confirming that the fat graft is only injected in the deep subcutaneous space we can exploit the principle of subcutaneous migration and visualize the fat graft filling this contained space until an aesthetic endpoint is achieved (ie, migration) (Figure 4B).[22] The ultrasound probe is then placed on the skin over the next injection site. The cannula is then advanced under the ultrasound probe, remaining in the deep subcutaneous space. Once the ultrasound confirms the new cannula position above the DGF, fat graft is then injected into this second site (Figure 4C). The technique is repeated along multiple points around the gluteal dome until aesthetic lipofilling has been achieved. After all the desired fat graft volume has been placed in the deep subcutaneous space, and with no further fat injection, the surgeon can move the cannula in a dynamic fashion as necessary to distribute the fat graft and smooth irregularities (Figure 4D), employing the equalization concept (ie, equalization) first described by Wall and Lee in their classic SAFE lipo communication.[29]

It is the unique and privileged anatomy of the deep subcutaneous space—with a relative paucity of connective tissue—that allows for the migration of fat by static injection, without the creation of a bolus deposition. In the SIME surgical plan, fat is first inserted under the central dome, then to multiple sites laterally until the "C point" described by Mendieta is reached,[10,11] and ultimately at the lower outer quadrant of the gluteal region, inferolateral to the infragluteal crease. After all fat graft has been injected, the surgeon can use a moving cannula to disperse fat graft and smooth any contour irregularities (ie, equalization) (Figure 5). It is important to note that fat graft is only injected under ultrasound visualization and never when the cannula is in motion.

RESULTS

Graft injection times were measured while performing SIME. The injection time data for 10 consecutive SIME cases (D.D.V.) were compared with injection times for standard EVL on 10 consecutive BBL procedures (D.D.V.) and are depicted in Table 1. The SIME and EVL groups were comparable in patient sex, age, BMI, and amount of fat extracted and grafted.

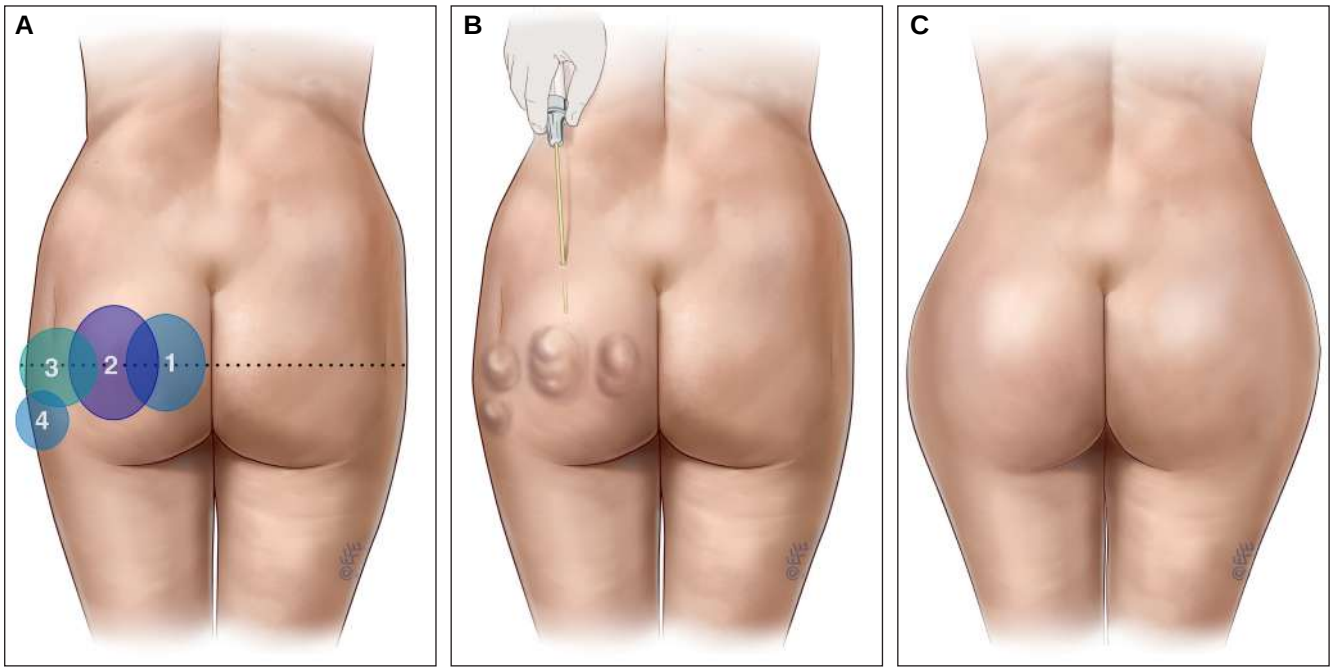


Figure 5. SIME technique: injection strategy. (A) Sites for fat graft injection are determined preoperatively to achieve gluteal dome projection and lateral hip fullness. Fat graft is first placed with a static cannula under ultrasound visualization in the deep subcutaneous space in the central dome compartment (areas 1 and 2). The cannula is then moved to a new position laterally along the transverse line from the midportion of the natal cleft to the desired point of maximum projection at the lateral hip. Fat graft is injected at these sites with a static cannula under ultrasound visualization (area 3). Fat graft can be injected in the inferolateral hip as needed (area 4). Ultrasound is used to confirm that a static cannula is above the DGF during all stationary fat grafting (static injection). Fat graft migrates smoothly through the deep subcutaneous space (migration). (B) After all sites have been injected, it is common for the external surface to appear bumpy or irregular. (C) A moving cannula can be used to distribute injected fat graft between these sites and create a smooth final contour (equalization). DGF, deep gluteal fascia; SGF, superficial gluteal fascia; SIME, static injection, migration, and equalization.

Complications included 5 infections (0.12%), 180 seromas (4.3%), 30 unfavorable (hypertrophic) scars (0.7%), 18 fat necrosis cases (0.4%), 27 lipid cysts (0.7%), 25 cases of excess fat absorption (0.6%), 72 cases of asymmetry (1.7%), and 90 contour irregularities (2.2%). In total, 81 patients (1.95%) required revision surgery to correct irregularities from asymmetric fat absorption and 675 patients (16.3%) elected to receive a secondary BBL to further augment gluteal volume and projection. There were no instances of burns or skin changes from the ultrasound probe, no deep venous thrombi, no thromboembolic pulmonary emboli, no fat pulmonary emboli, and no critical care admissions, or deaths.

On occasion, both surgeons noted that after the initial insertion of the cannula, the ultrasound probe revealed that the cannula tip was under the DGF and within the muscle body of the gluteus maximus. In these instances, the ultrasound alerted the surgeon to recognize this incorrect cannula position, withdraw the cannula, and place it correctly above the DGF before any fat graft was deployed. This is a critical safety feature of using real-time intraoperative ultrasound for gluteal fat grafting.

DISCUSSION

Over the last 10 years, our understanding of the principles of gluteal fat grafting and our surgical techniques have dramatically evolved. In 2015, Cárdenas-Camarena et al collected the experience of plastic surgeons in Mexico and Colombia over the past 10 and 15 years, respectively, and identified 13 PFE deaths in Mexico and 9 PFE deaths in Colombia after gluteal fat grafting. They reviewed the autopsy findings and found that the deaths were associated with intramuscular fat grafting and recommended surgeons avoid fat graft injections into the deep muscle planes.[30] Mofid et al performed an online surgeon survey and raised the alarm that PFE deaths were happening in the United States as well, with a seemingly high number coming from Florida.[31] The state of Florida represents 6.5% of the US population,[32] but represents over 28% of US deaths from BBL. The mortality rate in Florida is 4.3 times what would be expected on a pro rata population basis.

Two dynamic cadaver studies on deep intramuscular migration and subcutaneous migration, referred to as the "DIM SUM" papers, have demonstrated that fat graft

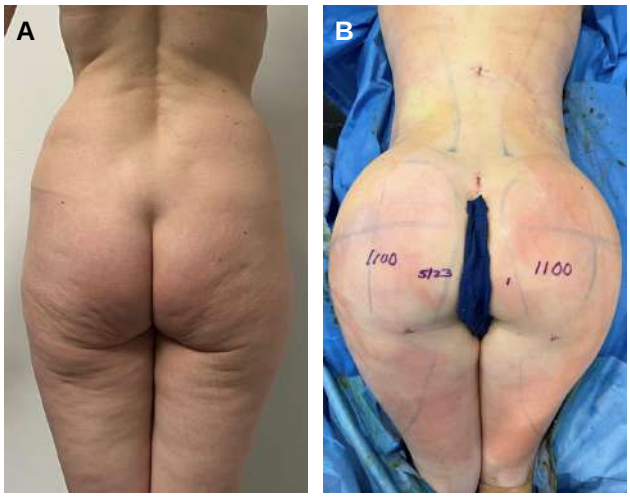


Figure 6. (A) Preoperative view of a 36-year-old female patient interested in gluteal augmentation and contouring. (B) Postoperative "on table" view: Brazilian butt lift by the static injection, migration, and equalization technique (D.D.V.). Note the relatively low volumes required to achieve satisfactory posterolateral projection and smoothness of contours.

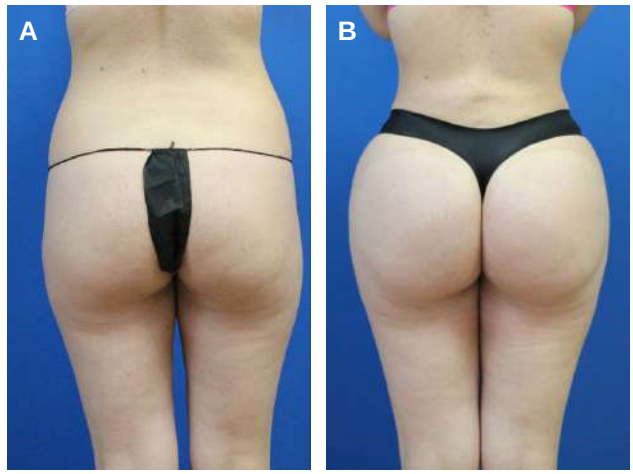


Figure 7. (A) Preoperative view of a 28-year-old female patient interested in gluteal augmentation and contouring. (B) Postoperative 12-month view: Brazilian butt lift by the static injection, migration, and equalization technique after 900 mL of fat injected per buttock (P.P.). Note the dramatic change in the hip to waist ratio and the relatively low volumes required to achieve satisfactory posterolateral projection and smoothness of contours.

injected under the DGF readily migrated throughout and under the gluteus maximus muscle.[20,22] It was also noted that so long as any defects in the DGF were small (<1 cm), it could act as a "stout wall" to prevent subcutaneous fat graft from extending into the gluteus maximus muscle.[22] These studies highlighted that subcutaneous gluteal fat grafting could be performed safely, as small openings in the DGF caused by a passing cannula were not large enough to allow fat migration below the DGF. These cadaver studies and supporting autopsy findings were the basis of recommending a "subcutaneous-only" BBL technique[25-27].

All of these studies emphasize limiting fat graft to the subcutaneous space; however, the missing link remains: how does a surgeon ensure that they are subcutaneous and above the DGF at all times? Real-time intraoperative ultrasound provides this "missing link" by allowing every surgeon to confirm their subcutaneous fat graft placement in every case.

Previous descriptions of ultrasound-guided fat grafting recommended a 2-operator approach to visualize continuous cannula movement during fat graft injection.[28] Cannula motion made continuous ultrasound tracking time-consuming and difficult. Having 2 different brains trying to work in tandem, one with a cannula and the other with an ultrasound probe, is extremely difficult. As a single errant pass of the cannula under the DGF could incite a pulmonary fat embolism, failure to visualize a moving cannula even for a single stroke could leave uncertainty that all of the fat graft had been placed in the correct space.

With the SIME technique, once the correct subcutaneous position of the cannula tip above the DGF has been confirmed, fat graft is injected in a static manner. The SGF and DGF remain intact and create a compartment that allows for the dynamic migration of fat through the deep subcutaneous space. Ultrasound allows the surgeon to witness the doubling or tripling in height of this deep subcutaneous space as it fills with fat graft (Figures 6-8).

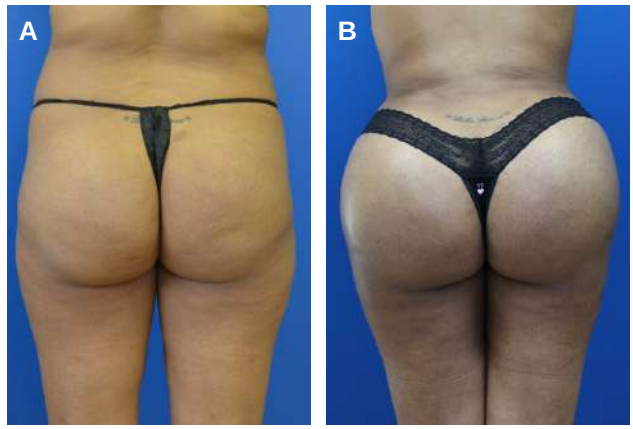
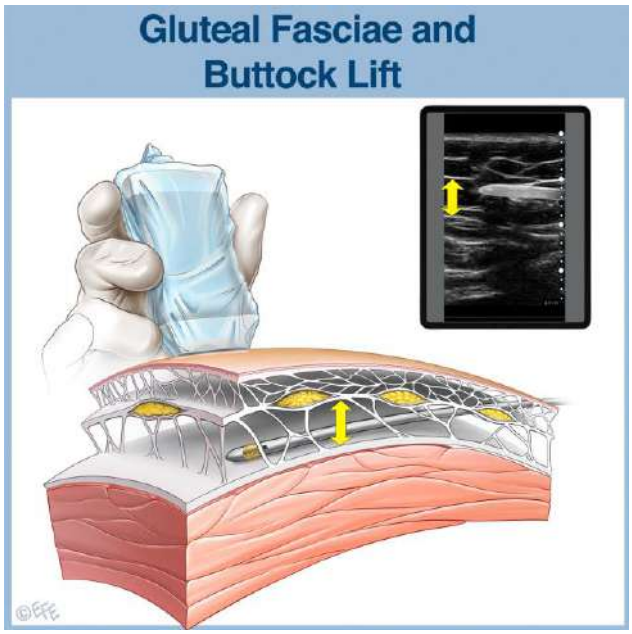


Figure 8. (A) Preoperative view of a 31-year-old female patient interested in gluteal augmentation and contouring. (B) Postoperative 12-month view: Brazilian butt lift by the static injection, migration, and equalization technique after 1100 mL of fat was injected per buttock (P.P.). Note the firmness and fullness of the buttocks when fat is placed as deep as possible in the deep subcutaneous space. Reproduced with permission from Pazmiño 2020.[19]



Video 2. Watch now at http://academic.oup.com/asj/article-lookup/doi/10.1093/asj/sjad142

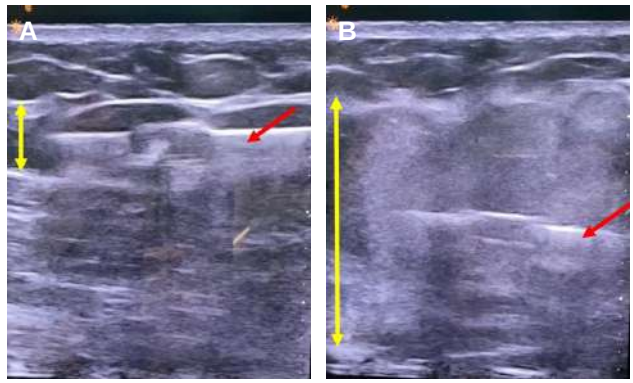


Figure 9. Static injection, migration, and equalization: Case 1. (A) Intraoperative real-time gluteal ultrasound is used to confirm the position of the cannula tip (red arrow) above the DGF and below the SGF. (B) The cannula (red arrow) is held stationary and fat is injected. The injected fat will result in a 3- to 4-fold increase the height (yellow double-headed arrows) of the deep subcutaneous space (between the SGF and the DGF) and a pressure-related migration of fat without the need to move the cannula to distribute the fat. The gluteus maximus muscle and the DGF are pushed down by this injection of fat. DGF, deep gluteal fascia; SGF, superficial gluteal fascia

After the deep subcutaneous space has been adequately filled at the first injection site, the surgeon places the ultrasound probe over the next injection site. The surgeon advances the cannula under the ultrasound probe and once the correct position of the cannula above the DGF is confirmed, fat graft is statically injected at the second site. To be clear, there is no cannula motion during fat injection. After the fat graft has been deposited within the deep subcutaneous space at all desired locations, the surgeon can move the cannula to distribute or equalize the fat graft to address any irregularities between the recipient sites, as needed.

When performing fat grafting with EVL and a peristaltic pump with a flow rate of 300 mL/minute without ultrasound, the average time for fat was 20 minutes for both buttocks compared with about 14 minutes with SIME for both buttocks, as delineated in Table 1. However, the average volume of fat inserted per buttock was approximately 150 mL lower with SIME, which could partially explain the shorter insertion times.

To exclude the variable of lower insertion volumes affecting insertion speed with SIME, a derivative "insertion rate" in mL per minute was calculated by dividing the volume of fat grafted per buttock by the time taken to insert it. Although the volumes with SIME were lower on average than the volumes of classic non–ultrasound-guided fat grafting, the volume difference was not statistically significant, as recorded in Table 1.

However, when comparing the insertion rates with SIME vs classic non–ultrasonic fat grafting, the volume-adjusted insertion rates with SIME were higher and were statistically significant, suggesting SIME is not only a safer technique but is also more time-efficient. Shorter insertion times may stem from the fact that static insertion does not require the operator to move the cannula throughout the recipient site as much, as targeted grafting may be occurring in what may be discrete gluteal fat compartments. Further studies using dynamic cadaver models have been completed and delineate the nature, size, and location of these apparent deep subcutaneous compartments.[33] Guidelines recently released emphasize the role of surgeon awareness of the subcutaneous space and the use of ultrasound to confirm proper cannula tip location and placement of fat graft in all BBL cases.[27]

Targeted Compartmental Grafting and "Fascia Preservation"

Safe and effective fat transplantation requires accurate placement of the cannula and grafted fat in the deep subcutaneous space, keeping the DGF and the SGF intact. Such precise placement is only possible with ultrasound visualization. Targeting the deep subcutaneous space and employing "fascia preservation" allows the surgeon to take advantage of the dynamic migration characteristics of this unique space and allows for greater projection with lower overall volumes than had previously been accomplished when fat was not preferentially solely in the deep subcutaneous layer. By avoiding fat placement in the superficial

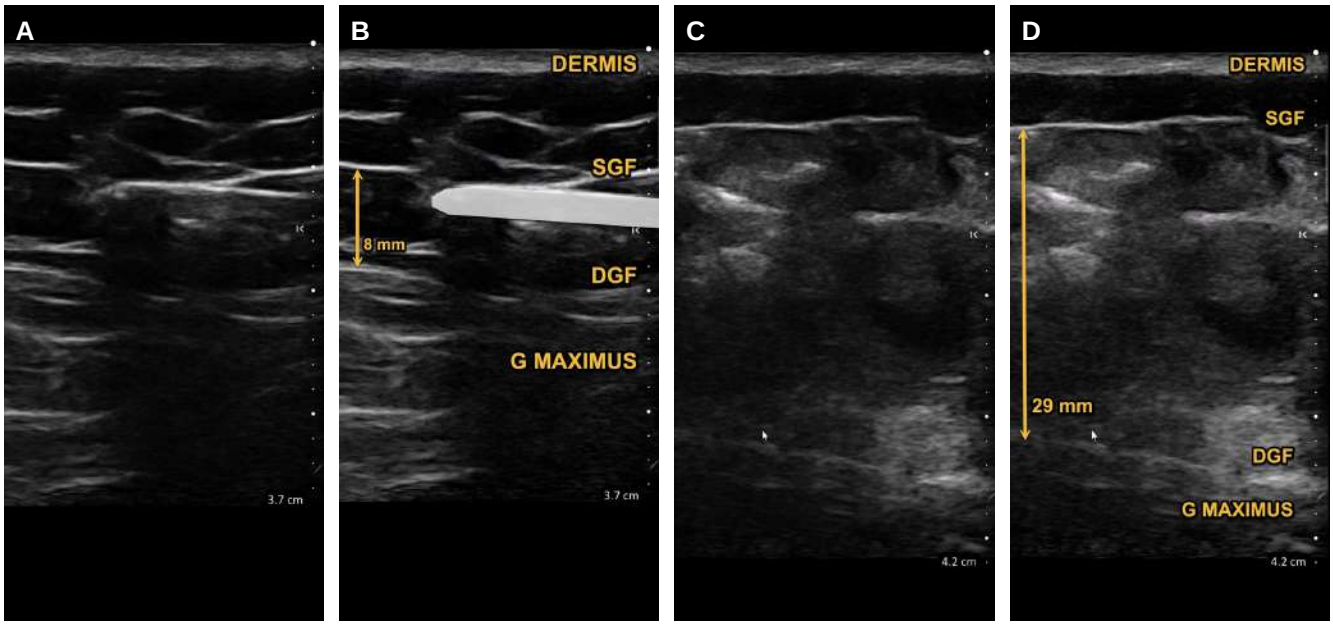


Figure 10. Static injection, migration, and equalization: Case 2. (A) Preinjection original sonogram: the cannula is noted within the deep subcutaneous space directly beneath the SGF. The deep subcutaneous space has a preinjection height of 8 mm. Note the sonographic shadow artifact obscuring the view of the deeper structures beneath the cannula. (B) Preinjection annotated sonogram. (C) Postinjection original sonogram: injected fat graft has now filled the deep subcutaneous space and displaced the DGF downward and the SGF upwards. Both fasciae remain intact, and the height of the deep subcutaneous space has now increased by a factor of 3.6. (D) Postinjection annotated sonogram. DGF, deep gluteal fascia; SGF, superficial gluteal fascia

	Syringe- Based	EVL - (No Ultrasound)	SIME
Safety	√ Hand/Arm Operator Fatigue Leads to Reduced Proprioception, Inadvertant Sub-Fascial Insertion of Fat	√√ Less Fatigue due to Mechanical Roller Pump, But not 100% Certain of Cannula Position	√√√ Less Operator Fatigue Due to Roller Pump, AND 100% Certain of Cannula Position at ALL times During Insertion
Aesthetics	√ Less Ability to Disperse Graft Due to Manual Motion, Lack of Mechanical Vibration, and Thenar-Induced Fat Flow	√√ Better EVL Dispersion, But Inadvertant Insertion into Superficial Subcutaneous layer causes Flattening and/or "Blowouts"	√√√ Better EVL Dispersion, and 100% Certainty in the Deep SC layer Creates Better Projection and Less "Blowout" Risk
Efficency	√ Syringe Loading and Injecting is Time-Consuming	√√ EVL More Efficient, But Axial Movement of Cannula During Insertion Requires More Time	√√√ EVL More Efficient, and Stationary Insertion of Fat in the Deep SC Layer Exploits Fat Migration and Requires LESS time

Figure 11. Static injection, migration, and equalization technique vs expansion vibration lipofilling attributes.

subcutaneous fat layer, one also avoids a flattened "discoid" appearance of the dome and a peau d'orange effect on the skin. Such aesthetic disharmonies are a manifestation of fat being above the SGF in superficial subcutaneous space with its dense fibroseptal network that results in sluggish and irregular horizontal migration of fat.

This nuanced EVL derivative, SIME, can only be performed under ultrasound guidance. Ultrasound not only allows for the confirmation of safe subcutaneous fat graft placement, but also allows the surgeon to maintain the integrity of both gluteal fasciae so that these structures can guide the subcutaneous migration of the fat graft. Without ultrasound, fat graft could be inadvertently placed under the DGF and into the muscle, exposing the patient to the risk of PFE.[21,34] Without ultrasound, the SGF could be disrupted. If the SGF remains intact, it can retain the fat graft that is specifically injected below it, like the casing of a sausage. Fat graft injected into this deep subcutaneous space can act like a subfascial implant, creating excellent volumetric augmentation and central dome projection. Fat graft injected into the superficial subcutaneous space (below the dermis and above the SGF) in the central gluteus can flatten the gluteal dome and can also potentially lead to "blow-out" fat fractures, skin changes, and surface irregularities. Ultrasound guidance can allow the surgeon to selectively target the superficial space to correct minor superficial contour deformities and depressions, but superficial subcutaneous space grafting is not relied upon for large volume or large contour changes, per se.

Benefits of the SIME technique include accurate fat graft placement, more efficient grafting with shorter injection

times, smaller volumes of fat required to achieve an overall aesthetic result, and 100% certainty that the fat graft has only been placed in the subcutaneous space and above the DGF. Video documentation of the procedure and of the operating surgeon with a self-facing camera also serves to record the procedure's safe execution and provides visual identification of the operating surgeon (Video 2, available online at www.aestheticsurgeryjournal.com). Intraoperative ultrasound images and video can be recorded and may also be saved as part of the patient's medical record.

Limitations of SIME and ultrasound-guided fat grafting include the one-time purchase of the ultrasound equipment (<$4000) and the learning curve of 3 to 5 cases as surgeons familiarize themselves with the new equipment and practice the coordination of the ultrasound probe and the fat grafting cannula.

The SIME technique represents a further evolution of Wall and Lee's SAFE lipo principles[29] and is a fusion of 3 body contouring benchmarks: SAFE lipo, EVL, and ultrasound-guided BBL. The SIME technique of ultrasound-guided BBL ensures the safe placement of fat graft above the muscle, allows for more efficient fat grafting with less cannula motion, and better control in gluteal shaping. In short, it is "safer, faster, and better" as outlined in Figures 9-11.

Deductive Reasoning—How SIME Improves BBL Safety

All cases of PFE deaths after a BBL revealed fat under the DGF and within the gluteus maximus muscle.[21] Dynamic cadaver studies show fat graft injected under the DGF can migrate through the gluteus muscle, but fat graft placed over an intact DGF cannot migrate through the DGF or into the muscle.[20,22,25] The risk of PFE from fat grafting is minimized if fat graft has only been placed in the subcutaneous space above an intact DGF.[21] Ultrasound imaging can precisely identify a cannula tip's location in the deep subcutaneous space, directly over the DGF.[28] If a cannula tip is confirmed by ultrasound to be in the deep subcutaneous space directly over the DGF and it is not moved, it remains in the deep subcutaneous space and cannot be below the DGF. If fat is grafted in the gluteal region with a cannula, identified by ultrasound to be above the DGF, and the cannula remains stationary during fat injection, this eliminates/minimizes the risk of PFE.

CONCLUSIONS

Static injection, migration and equalization, or SIME, represents the missing link in performing safe subcutaneous buttock augmentation. Training in real-time intraoperative ultrasound is recommended for residents and practicing surgeons who perform gluteal fat grafting.[27] Through a better understanding of the pathophysiology of PFE, a better appreciation of the migrational properties of grafted fat, identifying safe and unsafe recipient sites, targeting distinct compartments in the deep subcutaneous space, and through technical refinements in ultrasound-guided fat transplantation, surgeons now have the necessary tools to perform gluteal fat grafting in a safe, efficient and accurate manner. This will lead to a decreased overall mortality rate for this procedure, approaching that of liposuction, and will allow surgeons to offer a safer procedure for their patients.

Supplemental Material

This article contains supplemental material located online at www.aestheticsurgeryjournal.com.

Disclosures

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