A Clinically Relevant Model for Hands-on Training in Ultrasound-Guided Gluteal Fat Grafting: The Miami Butt Model

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Abstract

Background: Many board-certified plastic surgeons believe that accessibility of hands-on training in ultrasound-guided gluteal fat grafting (US-GGFG) is insufficient. Cadaver models utilized to practice ultrasound-guided fat grafting have proven to be expensive and difficult to procure.

Objectives: The authors present a novel, clinically relevant buttock model, and compare this model with the costs and logistics of the cadaver model with the aim of providing affordable hands-on training for US-GGFG.

Methods: A clinically relevant buttock model, the Miami butt model (MBM) was created by attaching a hemiabdominoplasty specimen to a portion of pork belly with its skin attached.

The costs and logistics related to 2 separate ultrasound-guided Brazilian butt lift (BBL) workshops, 1 with cadaver specimens and the other with the MBM, were compared.

Results: The specimen costs for a workshop with 20 participants (10 stations with 1 cadaver specimen for 2 participants) were $4580 per station. After adding the cost of delivery and disposal for the cadaver specimens ($7770), the total price for a 10-cadaver-specimen workshop amounted to $53,570. The MBM was found to be anatomically relevant and provided a close facsimile of US-GGFG experience in humans, at a cost of $47 per specimen. The MBM cost of specimens for a 20-participant workshop totaled $940, compared to a cadaver-based workshop with specimen costs of $53,570.

Conclusions: Compared to the cadaver model, the MBM is significantly less expensive and allows the participant to perform US-GGFG on a close facsimile of human gluteal anatomy, improving the accessibility of US-GGFG training.

From 2010 to 2020, the Brazilian butt lift (BBL) had an unparalleled growth in popularity, becoming the fastest growing aesthetic surgical procedure.[1] Unfortunately, this surge in BBL procedure popularity was accompanied by an unprecedented rise in procedure mortality. The past 3 years have seen a decline in the number of BBL surgeries performed by board-certified plastic surgeons, and The Aesthetic Society reported a 20% decrease in the number of procedures performed over the past year.[2,3]

As fat transfer volumes increased to a level that would overwhelm the subcutaneous recipient site, surgeons began grafting deeper into the well-vascularized gluteal musculature. This approach, known as "intramuscular grafting," was thought to enhance survival for large volumes of grafted fat by grafting into a well-perfused recipient site. This led to surgeons with expertise in gluteal contouring surgery developing specific techniques for intramuscular grafting, delineating what were thought to be "safe areas" for fat grafting within the gluteal musculature.[4-7] Nonetheless, subsequent MRI venography studies of the gluteal venous system have reported that there is no "safe zone" for fat grafting in the intramuscular or submuscular plane.[8]

In 2015, Cárdenas-Camarena et al conducted a review of BBL mortality in Mexico and Colombia spanning 10 and 15 years, respectively. This review identified 22 fatalities from pulmonary fat emboli (PFE); 13 in Mexico and 9 in Colombia, following gluteal fat grafting

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procedures.[9] The autopsies confirmed that all deaths were associated with intramuscular fat grafting. In July 2016, The Aesthetic Surgery Education and Research Foundation (ASERF, now known as The Aesthetic Foundation), conducted an on-line survey distributed to all active members of The Aesthetic Society and The International Society for Aesthetic Plastic Surgery (4843 total members) to estimate BBL mortality. This survey received 692 surgeon responses that collectively reported 198,857 BBL procedures. Results of this survey estimated the mortality rate after BBL to be between 1 in 2351 to 1 in 6241 cases, earning it the title of the deadliest elective aesthetic surgical procedure.[10]

By this time, it had become increasingly apparent that BBL patients were dying from a cause rarely seen in other plastic procedures, a pulmonary fat embolus. Surgeons who studied BBL mortality described the physiologic and clinical distinctions between macroscopic fat emboli (MAFE), and microscopic fat emboli (MIFE).[11,12] For a pulmonary macroscopic fat embolus to occur during a BBL procedure, there are 2 essential events that must take place; the fat graft must be injected intramuscularly and there must be an injury to the gluteal vasculature that creates a route of entry for the fat graft into the venous system. Out of concern for the high mortality highlighted by the 2016 ASERF survey results and the discovery of this "2-hit hypothesis," the Intersociety Gluteal Fat Grafting Task Force was created to study the surgical techniques and anatomical factors that contribute to the unacceptably high BBL mortality rate.

Under the guidance of Dr Peter Rubin, the task force convened in Miami in 2017 with the aim of developing an appropriate anatomical model to recreate various BBL techniques. Both OG and PP served as consultants to the task force.

The task force hypothesized that "safe approaches for gluteal fat grafting could be delineated by modeling the operation in cadavers." Unfortunately, merely a "fresh" cadaver specimen did not allow for a clinically relevant BBL operation to be performed. Through a model validation process, it was determined that the ideal cadaver specimen for ultrasound-assisted BBL training purposes should be ultra-fresh, female gender, with a high BMI (greater or equal to 28 kg/m^2), never stored supine, and without any previous pelvic surgery (including postmortem harvests). This cadaver model was verified by the Intersociety Gluteal Fat Grafting Task Force to be clinically relevant and able to simulate BBL fat injection under ultrasound guidance.

The task force held 2 separate sessions with invited surgeons who performed their typical BBL technique under video fluoroscopy monitoring with dyed fat to document fat graft dispersion. Buttocks were then anatomically dissected, and the dyed fat dispersion documented with high-resolution photography. These cadaver sessions were the foundation for the ASERF recommendations that emphasized that gluteal fat grafting should only be performed above the deep gluteal fascia in the subcutaneous space and that surgeons should employ techniques to avoid inadvertent insertion of the grafting cannula into the gluteal musculature.[13]

In 2019, another gluteal fat grafting survey was conducted to evaluate recent BBL mortality after the ASERF safety recommendations were released. This survey invited 5048 surgeons, with 572 plastic surgeons responding and commenting on 29,843 BBL cases. The reported mortality rate from this survey was 1 in 14,921 cases, which if accurate, would surpass the 1 in 13,193 mortality rate of abdominoplasty procedures.[14] In August 2019, the Florida Board of Medicine (FL BOM) was alarmed when in a single session they reviewed 3 recent BBL deaths in Miami alone. Both OG and PP testified on behalf of the Florida Society of Plastic Surgeons (FSPS), sharing recommendations from the task force and the results of the latest gluteal fat grafting survey. The FL BOM then introduced the Florida BBL Surgery Rule that mandated that surgeons could only inject fat graft in the subcutaneous space and that intramuscular or submuscular fat graft injection would now be prohibited.

Unfortunately, rather than observing a decrease in mortality, the plastic surgery community witnessed a paradoxical increase in BBL-associated PFE. The state of Florida, with the strictest BBL surgery regulations in the country, was now responsible for the highest BBL-associated mortality in the world. South Florida alone reported 15 cases of fatal PFE in the 3-year period that followed the subcutaneous injection ruling. The year 2021 was the worst on record, with 6 fatal and 2 nonfatal instances of PFE.[15] The FL BOM highlighted this alarming finding in early 2022 and declared that BBL mortality was a public health emergency in Florida. An emergency rule was passed, limiting surgeons to 3 BBL procedures in 1 day and mandating ultrasound guidance during fat graft injection. Once the emergency rule expired, the safety recommendations including the insistence on ultrasound guidance were passed into law by the Florida legislature in 2023.[16]

The anatomy of the gluteal region is relatively straightforward and easy to learn for a board-certified plastic surgeon. However, expertise in gluteal fat grafting under ultrasound guidance is best learned through hands-on training. In our experience, a board-certified plastic surgeon can effectively learn the technique in a single demonstration session. Surgeons expressed their desire for in-person training in a survey distributed by The Aesthetic Surgery Education and Research Foundation (ASERF)/The Aesthetic Foundation in March 2023, which found that more than half of aesthetic plastic surgeon respondents believed that availability of training in ultrasound-guided gluteal fat grafting was currently insufficient.[17]

Ultrasound-guided gluteal fat grafting workshops at national plastic surgery meetings have been able to accommodate a few participants. One limiting factor is the absence of an anatomically relevant, cost-effective, and readily available clinical model.

The authors have recently developed and tested a novel, clinically relevant model for technical training in ultrasound-guided BBL surgery. This report will compare the Miami butt model to established cadaver specimens to confirm its clinical relevance with the hope that this model can increase the accessibility of ultrasound-guided BBL training.

METHODS

The Miami butt model (MBM) consisted of a hemiabdominoplasty specimen that was bonded with Gorilla Glue (Gorilla Glue Company, Cincinnati, OH) or rubber cement (Elmer's, Westerville, OH) to a portion of pork belly with skin attached (the surface area of the pork belly was approximately that of an 8-1/2″ × 11″ sheet of paper) (Figure 1A, B). The hemiabdominoplasty specimen skin was then sutured to the pork belly skin in a circumferential fashion, completing the construction of the MBM (Figure 2). The abdominoplasty specimen portion provided the intact full-thickness skin and subcutaneous tissue for the model. The superficial subcutaneous space was analogous to the superficial gluteal fat compartment, Scarpa's fascia was analogous to the superficial gluteal fascia and the sub-Scarpa's fat was analogous to the deep gluteal fat compartment. The pork belly skin represented the deep gluteal fascia, and the pork belly muscle corresponded to the underlying gluteus maximus muscle. Under ultrasound visualization the Miami butt model was indistinguishable from the human buttock (Figure 3A-C). The model was originally created in December 2021 and was recently clinically validated during

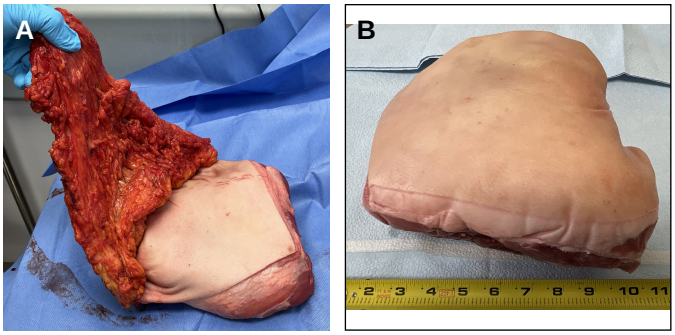

Figure 1. (A) Abdominoplasty specimen bonded to a portion of pork belly with skin. (B) Closure with a peripheral suture.

the Annual Plastic Surgery Forum of the Florida Society of Plastic Surgeons, in December 2024.

The Miami Butt Model Workshop

Workshops that employed the Miami butt model had separate workstations with the following equipment: a disposable #15 scalpel, a portable handheld ultrasound device, a peristaltic infiltration pump with the appropriate tubing, and fat injection cannulas. Previously harvested liposuction fat aspirate could also be collected, along with abdominoplasty specimens. However, for ease of use, the authors strongly recommended substitution of human fat aspirate with a surrogate such as applesauce or instant grits. OG prefers grits, because they closely resemble the flow and dispersion characteristics of human fat aspirate. Instant grits are inexpensive, easy to prepare in a microwave, the viscosity can be adjusted by adding water, and they readily absorb standard food coloring. This allowed injection of a dyed fat surrogate that would not stain surrounding tissues. The grits were dyed with green and purple food coloring to identify grafting into the deep and superficial subcutaneous spaces (Figure 4).

The workshop began with a brief didactic session reviewing gluteal anatomy and a demonstration on how to utilize the ultrasound to identify the analogous anatomic landmarks on the MBM. Participants then practiced their hand-to-probe coordination by inserting the injection cannula into the specific subcutaneous spaces with ultrasound guidance. They then practiced injecting the dyed fat surrogate into the desired subcutaneous space. Participants confirmed that the tip of their injection cannula was always above the analogous deep gluteal fascia before injecting the surrogate fat graft. First, the green dyed fat surrogate was injected into the deep subcutaneous space and then the purple fat surrogate into the superficial subcutaneous space (Figure 5). After all surrogate fat graft injections had been completed, the Miami butt model was dissected into sections (bread loaf incisions) to confirm that the green and purple dyed fat surrogate was placed into the correct subcutaneous spaces (Figure 6). Upon completion of the workshop, the MBM specimens were disposed of as medical waste.

RESULTS

The costs and logistics of a workshop employing the Miami butt model were compared to a similar workshop with the validated cadaver model. The comparisons focused only on the costs related to the specimens. The costs of renting a facility, tables, staff, ultrasound equipment, instrumentation, and disposables were not reviewed because they would be equivalent between the 2 workshops.

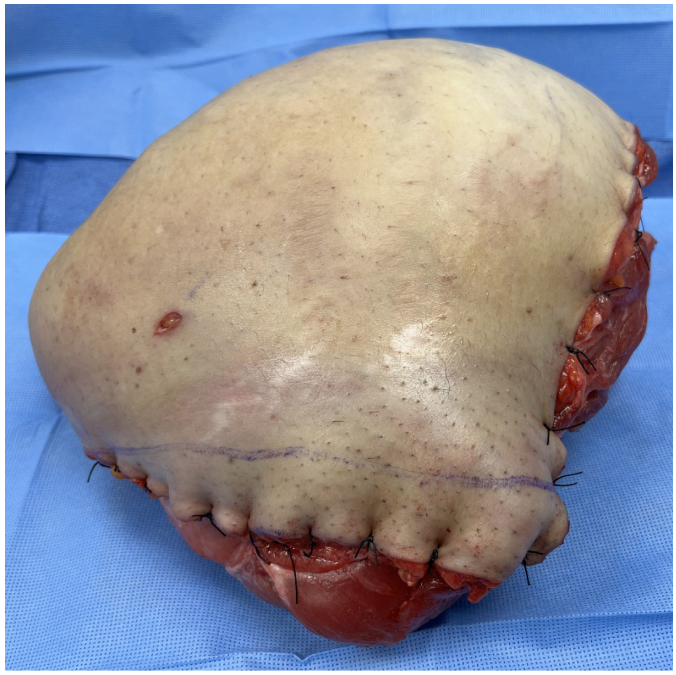

Figure 2. Completed Miami butt model hemibuttock specimen.

Established Cadaver Model

The cadaver model had been previously validated by the Intersociety Gluteal Fat Grafting Task Force as clinically relevant for simulation of BBL fat injection with ultrasound guidance. A 20-participant workshop had 10 cadaver stations with 2 participants per station. The ideal cadaver specimens for gluteal fat grafting training were ultra-fresh, female gender, high BMI (greater or equal to 28 kg/m2), never stored supine, and had no previous pelvic surgery (including postmortem harvest). These cadaver specimens were priced at $4580 per specimen. The cost for 10 cadavers ($45,800) plus the cost of delivery and disposal ($7,770) brought the total cost of specimens for a 20-participant workshop to $53,570 (Table 1).

Miami Butt Model (MBM)

Local plastic surgeons could donate abdominoplasty specimens after obtaining proper releases in the days preceding the workshop. Each abdominoplasty specimen was halved and employed to create 2 Miami butt models. Pork belly cuts with skin could be purchased from most local food markets at an average cost of $18 per specimen. Bonding and suturing of the abdominoplasty specimen to the pork belly was a relatively simple task and could be completed within a few minutes at a cost of $29 per specimen. The total cost of the completed model was $47. The MBM could be stored in a standard refrigerator for several days. Following the end of the workshop, the models were disposed of as medical waste. An ultrasound-guided BBL workshop for 20 participants, each with their own MBM, cost $940. If the models were shared by 2 participants per station, the total cost for a 20-participant, 10-station workshop was $470.

DISCUSSION

The South Florida experience with BBL mortality, in which surgeons employed a variety of injection equipment, techniques, positions, and depths without visually confirming the precise position of the

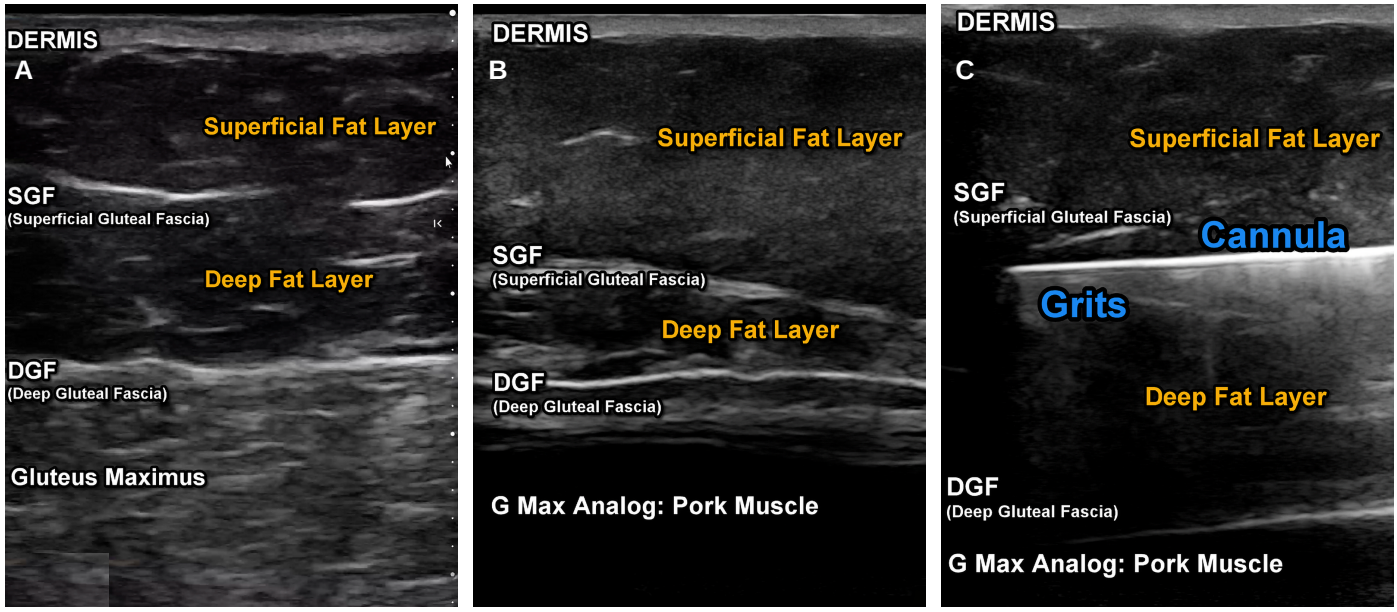

Figure 3. Under ultrasound imaging, the Miami butt model is a close facsimile of the human gluteus. (A) Miami butt model. (B) Human buttock. (C) Ultrasound-guided injection of fat surrogate (grits).

Figure 4. Instant grits is a good fat aspirate surrogate because viscosity can be controlled by adding water, and it has the flow and dispersion characteristics of human fat aspirate. Grits are readily dyed with standard food coloring, which is well absorbed. The dye will not bleed into the tissues.

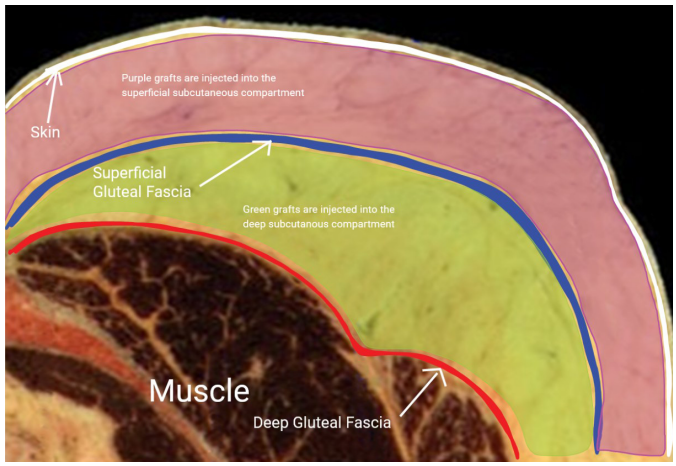

Figure 5. Green fat aspirate surrogate is injected into the more compliant, deep gluteal subcutaneous space under ultrasound guidance. The purple fat aspirate surrogate is injected in smaller volumes into the tighter, and less compliant, superficial gluteal subcutaneous space.

tip of the cannula, have proven that a "blind" injection technique cannot consistently avoid intramuscular injection during a Brazilian butt lift.[18] The subcutaneous space is a thin, arcing dome of tissue that typically ranges in thickness from 1 cm laterally to 4 cm at the center of the buttock.[19,20] The gluteal subcutaneous space is further subdivided into the deep gluteal compartments described by Frojo et al.[21] These subcutaneous spaces are even more shallow in the male buttock, which increases the potential for inadvertent intramuscular injection during male BBL surgery.[22] Compounding this difficulty, fat graft should be preferentially injected into the less dense, deep subcutaneous space to enhance vertical height and minimize superficial complications. The challenge gluteal surgeons face is that they must consistently inject into the deeper section of the subcutaneous zone. If their cannula is placed too deep and they inject into the muscle, they risk a fatal pulmonary fat embolus. If they overcorrect and inject too superficially, they face a higher risk of fat necrosis, lipid cysts, and surface irregularities. Confirming the position of the cannula tip before injection allows the gluteal surgeon to thread this delicate needle. Ultrasound-guided, gluteal fat grafting provides real-time, precise information on cannula tip position and confirmation that fat will be injected subcutaneously, enhancing patient safety.[23] Ultrasound-guided fat graft injection can be readily taught to gluteal surgeons, and now it can be taught affordably as well. The handheld ultrasound probe is relatively inexpensive and has multiple applications in the clinic beyond gluteal procedures.

A 2023 ASERF survey revealed that, nationwide, over half of board-certified plastic surgeons performing Brazilian butt lift surgery continue to do so without ultrasound guidance. The survey also noted that 62% of surgeons felt that availability and accessibility of ultrasound-guided BBL training was not sufficient. Some respondents were concerned that by holding the ultrasound probe with their nondominant hand they would lose the tactile feel that they were accustomed to. There is significant evidence based on the mortality associated with BBL surgery that blind fat injections guided only by tactile feel do not protect patients from pulmonary fat emboli complications.[24,25]

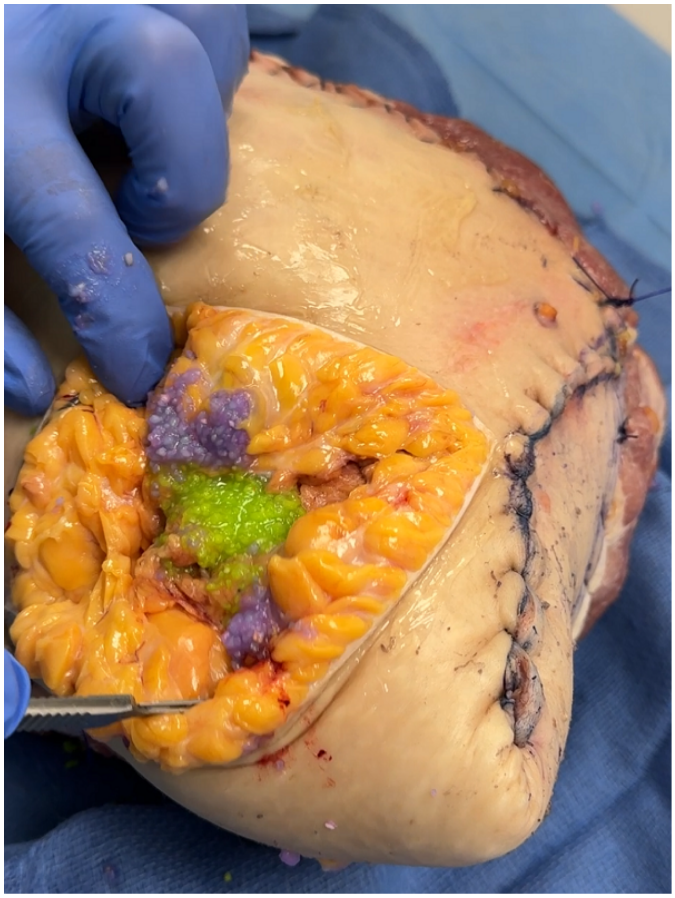

Figure 6. After completion of the ultrasound-guided injections, the Miami butt model is dissected to assess the placement of the dyed fat aspirate surrogate within the appropriate tissue planes.

Table 1. Cost Estimates for Hosting a 20-Participant Ultrasound-Guided Brazilian Butt Lift Workshop in South Florida

	Service	Total (10 cadavers)	Per cadaver
Cadavers	Specimens (10)	45,800	4580
	Delivery	4270	427
	Disposal	3500	350
	Total	53,570	5357
	Service	**Total (20 cadavers)**	**Per Model**
MBM	Models (20)	940	47

MBM, Miami butt model.

Attempting to follow a moving injection cannula by ultrasound can be challenging and imprecise, because even a small portion of fat graft injected into the gluteal muscle can lead to a catastrophic complication and death. The static injection technique (SIME) described by Pazmiño et al is a safe, extremely accurate, and highly efficient injection technique that removes cannula malposition from the equation by only injecting fat graft when the cannula tip is confirmed to be above the deep gluteal fascia and not moving the cannula during the injection.[26] With this technique, the injector can observe and document with ultrasound video the precise placement of fat graft into the appropriate subcutaneous spaces (Figure 7). Availability of

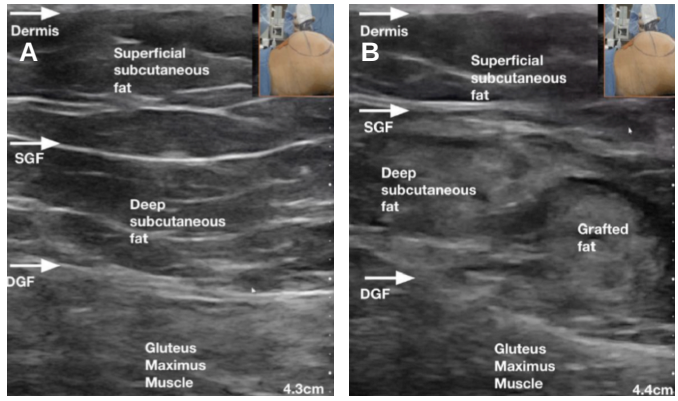

Figure 7. (A) Ultrasound of gluteal area. (B) Ultrasound-guided, static, fat injection (SIME) techniques allow the injector to visualize in real time the precise placement of the grafts into the appropriate subcutaneous spaces.

Table 2. Recommended Core Competencies for Ultrasound-Guided Gluteal Fat Grafting

Core competencies
1. Knowledge of optimal ultrasound settings.
2. Ability to create a video recording of ultrasound-guided gluteal fat grafting.
3. Identification of key anatomical landmarks and ability to measure the subcutaneous spaces of the gluteal anatomy.
4. Ability to identify the injection cannula in all spaces under ultrasound guidance.
5. Differentiate between a subcutaneous and an intramuscular cannula position.
6. Demonstrate consistent subcutaneous cannula position during injection.
7. Reposition from an intramuscular cannula position to a safe subcutaneous position before injection.
8. Distinguish the different gluteal subcutaneous spaces under ultrasound.
9. Inject into a targeted subcutaneous space under ultrasound.

training workshops has been constrained by the cost and accessibility of appropriate cadaver models for simulating gluteal anatomy. However, mastering techniques in ultrasound-guided fat grafting requires hands-on training. The American Society of Plastic Surgeons (ASPS) hosted one of the first ultrasound-guided BBL workshops at their 2022 annual meeting in Boston, MA. The participants were given a list of 8 core competencies in ultrasound-guided, gluteal fat grafting that they should acquire by the end of the session (Table 2). Two of the authors, O.G. and P.P., participated as faculty for this workshop, which utilized a cut of raw beef as the clinical model to illustrate fat injection under ultrasound guidance. Participant feedback at the end of the course commented on the lack of clinical relevance of this model, stating that it poorly resembled the cannula impedance and necessary anatomical layers that would be encountered during a real BBL procedure. The Miami butt model was developed to address these limitations, offering a cost-effective and easily reproducible option for workshops and self-assessment sessions. Since then, the MBM has been clinically validated at the ultrasound course presented during the 2023 Aesthetic Society Annual Meeting in Miami Beach, FL, and most recently during the ultrasound

Table 3. Ideal Cadaver Specimen for Ultrasound-Guided BBL Training

Ideal specimen characteristics
Ultra-fresh
Female gender
High BMI (>28 kg/m2)
Never stored supine
No previous pelvic surgery (including postmortem)

BBL, Brazilian butt lift; BMI, body mass index.

workshop at the annual forum of the Florida Society of Plastic Surgeons, Palm Beach, FL, in December 2024. Over 30 board-certified plastic surgeons participated in this hands-on workshop. The MBM allowed appropriate assessment of the recommended core competencies in ultrasound-guided gluteal fat grafting.

The instructional video that accompanies this manuscript describes in detail the construction of the model and its use, so that individual surgeons can easily create their own models. The Miami butt model is also suitable for practicing the static fat injection (SIME) technique.

Early attempts at fat injection with cadaver specimens revealed that simply utilizing "fresh" cadaver specimens did not accurately reproduce the expected anatomy encountered in live BBL surgery, because the subcutaneous layers gradually become compressed and thinner over time. Supine storage and previous pelvic manipulation of the specimens further contributed to distorted gluteal anatomy. It soon became evident that specific criteria must be met for cadaver specimens to be clinically relevant for ultrasound teaching purposes (Table 3).

Procuring ultra-fresh cadaver specimens has proven to be a challenging and time-consuming task. There may be uncertainty regarding the availability of appropriate cadaver specimens at the time of the workshop. Moreover, conducting a cadaver-based workshop is dependent on facilities that allow human specimens and finding vendors willing to deliver and dispose of the specimens. Arguably the most significant hurdle in utilizing cadaver specimens is their high cost. The cost of a 20-participant workshop with the appropriate cadaver specimens would exceed $53,000. The MBM addresses these obstacles. This novel model closely emulates the anatomical layers and structures of the human buttock, allowing the workshop participants to experience cannula impedance equivalent to that encountered in a live patient. These models can readily be assembled. Their greatest advantage is their significantly lower cost of approximately $47 per model. The ease of planning, assembly, and affordability allow this model to be easily implemented at plastic surgery meetings, thereby increasing the availability of ultrasound-guided fat grafting training.

A limitation of this study is the cost calculation, which only considered the price of a workshop hosted in South Florida for 20 participants. The total cost differences between models may vary somewhat according to the geographic location of the workshop, the number of participants, and the supplier of the specimens (in the case of cadaver models); however, we do not expect this to substantially decrease the significant difference in price between the Miami butt model and the cadaver specimen. Furthermore, expenses related to the hosting facility, refrigerated storage, equipment, instruments, disposables, and the staff required for setup and cleanup were not included in the total cost estimates. The logistics associated with a validated cadaver workshop are also significantly more complex than for one employing the MBM. For example, at the recent Florida Plastic Surgery Forum, the venue allowed the MBM for a hands-on workshop but would not allow cadaver specimens to be transported onto the property. Also, recently a cadaver workshop scheduled at the 2025 Aesthetic MEET in Austin, TX, had to be canceled when a state law prohibited the transport of cadaver specimens to the venue. We feel that the addition of the construction and use of the MBM to the plastic surgery literature will contribute to an increase in accessibility of training for ultrasound-guided fat grafting for plastic surgeons.

CONCLUSIONS

The Miami butt model consists of a hemiabdominoplasty specimen bonded to a cut of pork belly with skin, creating an anatomical facsimile of the human gluteal region. Ultrasound examination of this model confirms that it is analogous to the gluteal anatomy found in cadaver specimens or live patients. Injection cannula impedance within the MBM is similar to that encountered during a BBL procedure on a live patient. The model allows for participants to have hands-on training and meet all the suggested core competencies for ultrasound-guided gluteal fat grafting. In comparison to the ultra-fresh cadaver specimen, this model is analogous, easily assembled, and cost effective for ultrasound-guided training courses and for individual self-assessment practice sessions. The MBM can be utilized by training programs and regional and national plastic surgery societies to host workshops, thereby increasing the accessibility and availability of ultrasound-guided fat grafting training for surgeons performing BBL procedures.

Disclosures

Dr Finkelstein has no disclosures. Dr Pazmiño is a director of The Aesthetic Foundation (ASERF), a consultant for The Aesthetic Society's Gluteal Fat Grafting Task Force, and a clinical editor for *Aesthetic Surgery Journal*. Dr Garcia is currently the president of The Aesthetic Foundation (ASERF), and a consultant for The Aesthetic Society's Gluteal Fat Grafting Task Force, Mentor (Irvine, CA), Solta Medical (Bothell, WA), MTF Biologics (Edison, NJ), and BD (Franklin Lakes, NJ). Dr Garcia also receives royalties from Springer Publishing Company (New York, NY).

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