Clinical Implications of Gluteal Fat Graft Migration: A Dynamic Anatomical Study

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e PATIENT SAFETY

Background: The intraoperative mortality and overall complication rate for gluteal augmentation with fat transplantation is unacceptably high. The current controversy among experts regarding safety is whether fat should be placed within the gluteus muscle or limited to only the subcutaneous space. The purpose of the present study was to test the hypothesis that under certain pressures, fat injected within the gluteal muscle can actually migrate out of the muscle and into a deeper plane containing critical neurovascular structures, by means of the process of deep intramuscular migration.

Methods: A total of eight human cadaver dissections were performed. Four hemibuttocks were selected for intramuscular fat injection. The patterns of subfascial fat migration were evaluated in three of these hemibuttocks by direct visual inspection and in one hemibuttock by endoscopic evaluation. Four other hemibuttocks were selected for subcutaneous or suprafascial fat injection.

Results: Proxy fat was found to migrate through the muscle and into the deep submuscular space with each intramuscular injection. With subcutaneous injection, no proxy fat was found during dissection in the intramuscular septae or submuscular space.

Conclusions: The intramuscular insertion of fat, which up to this point has been considered reasonable to perform in the superficial muscle and even recommended in the literature, is now deemed to be an inexact and risky surgical technique. This technique, because of the migratory nature of injected fat, should be avoided from further use in fat transplantation to the gluteal region. (*Plast. Reconstr. Surg.* 142: 1180, 2018.)

Despite having the highest annual growth rate of any cosmetic surgical procedure, the intraoperative mortality rate for gluteal augmentation with fat transplantation (i.e., "Brazilian butt lift") is unacceptably high.[1–7] A recent survey performed by the American Society for Aesthetic Plastic Surgery estimates the intraoperative death rate from this operation to be approximately one in 2351.[1] In addition to these fatal complications, serious nonfatal complications, namely microfat embolism and sciatic nerve injury, are also surprisingly high.[8,9] The root cause of these complications focuses on the depth of fat insertion.[1,4–6] The current controversy among experts is whether fat should be placed within the gluteus muscle or whether fat should be limited to the subcutaneous space only, which lies superficial to the muscle fascia.[7,10–31]

Surgeons who have experienced complications of sciatic nerve injury in their own patients as a result

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Received for publication February 13, 2018; accepted July 11, 2018.

DOI: 10.1097/PRS.0000000000005020

Disclosure: *Dr. Rohrich receives instrument royalties from Eriem Surgical, Inc., and book royalties from Thieme Medical Publishing. He is a clinical and research expert for Allergan, Inc., and MTF Biologics, and the owner of Medical Seminars of Texas, LLC. No funding was received for this article. Dr. Del Vecchio is a founder of Surgistem Technologies, LLC, a device company involved in fat transplantation, receives royalties from Microaire, and is a founding member of Peninsula Partners, LLC, a consulting firm in the plastic surgery sector. The remaining authors have no financial interest to declare in relation to the content of this article.*

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of gluteal fat transfer insist that fat was injected only within the muscle and not below it.[8] Similarly, surgeons who have experienced patient death from pulmonary fat embolism insist that their gluteal fat injections remained only in the subcutaneous tissue and superficial muscle. Nevertheless, such devastating complications continue to be seen with the Brazilian lift, with a reported rate of 1.7 percent for sciatic nerve injuries alone.[4] The fact that these morbidities and mortalities continue to be reported at unacceptably high rates despite seemingly superficial fat injections suggests that another mechanism of injury other than direct cannula hits of major gluteal vessels and nerves may be playing a role.

In this study, we introduce the phenomenon of deep intramuscular migration, wherein large volumes of fat injected into the gluteus muscle have the potential to migrate along the path of least resistance within the muscle and, ultimately, even out of the muscle in the setting of exceedingly high pressures. This process describes subjacent fat migration to danger zones deep to the gluteal muscle leading to potential pressure-induced injuries of the sciatic nerve or traction-induced tears of major venous structures in the region. This in turn may explain conditions of sciatic nerve impairment and pulmonary fat embolism after the Brazilian lift procedure despite surgeon insistence that injection was performed in a more superficial plane.

The purpose of this study was to test the hypothesis that under certain pressures, fat injected in the gluteal muscle can actually migrate out of the muscle into a deeper plane containing critical neurovascular structures, by means of the process of deep intramuscular migration.

MATERIALS AND METHODS

A total of eight dissections were performed in four fresh human cadavers obtained with permission from the Willed Body Program at the University of Texas Southwestern Medical Center. The cadavers were selected randomly to be in one of three groups. Four hemibuttocks were selected for intramuscular fat injection. The patterns of subfascial fat migration were evaluated in three of these hemibuttocks by direct visual inspection and in one hemibuttock by endoscopic evaluation. Four other hemibuttocks were selected for subcutaneous or suprafascial fat injection.

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Intramuscular Fat Injection

Direct Inspection of Subfascial Fat Migration

On three hemibuttocks, the posterior superior iliac crest, the sacral hiatus, and the greater trochanter were palpated. Drawing the letter A from the structures, the approximate location of the

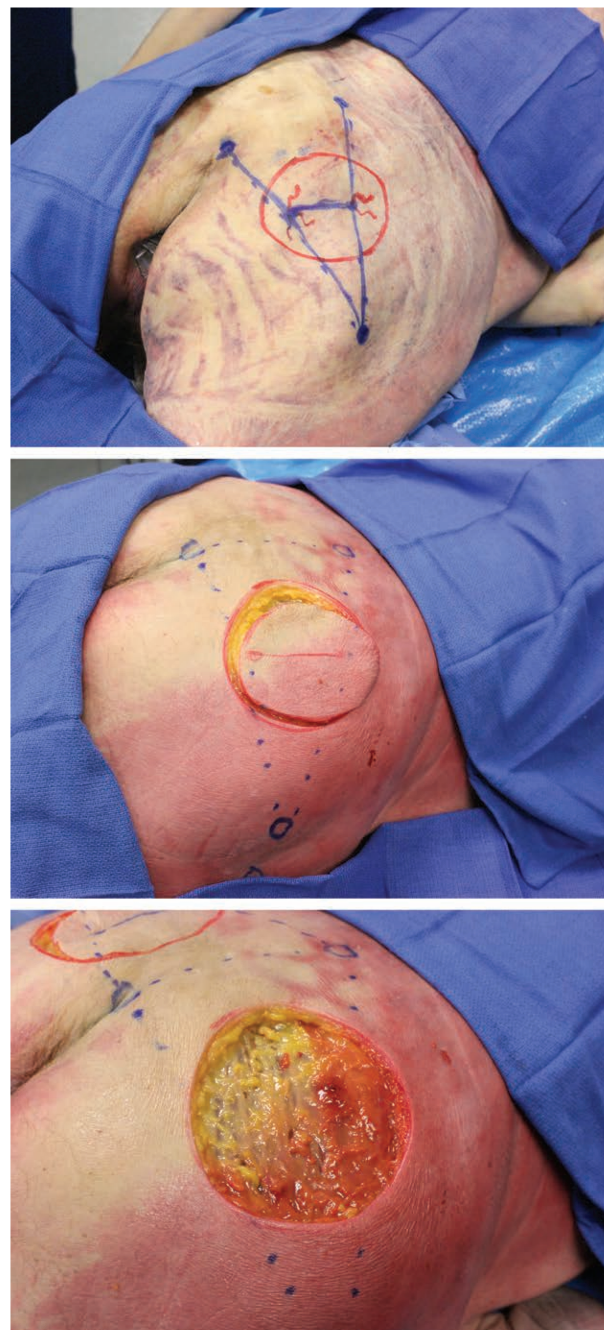

Fig. 1. (*Above*) Landmarks, (*center*) dissection zone, and (*below*) posterior gluteus fascia.

superior gluteal and inferior gluteal vascular leashes were marked (Fig. 1, *above*). A 10-cm-diameter circle encompassing these vascular structures was then marked on the skin (Fig. 1, *center*). Dissection of the skin and subcutaneous tissue was performed, revealing the superficial gluteal fascia (Fig. 1, *below*).

Using a 4-mm Luer-lock multihole injection cannula (Lipo, Farmingdale, N.Y.), applesauce (Motts, Inc., a division of Dr. Pepper Snapple, Plano, Texas) was stained using blue food coloring as a proxy for transplanted fat. This "proxy fat" was injected into the superficial intramuscular space of the gluteus maximus muscle using 60-ml syringes. Care was taken to avoid cannula passage deeper than 2 cm, keeping the cannula tip visibly in the superficial muscle throughout the course of the injection. With each progressive 60-cc syringe injection, intramuscular recipient-site pressures were measured using a Stryker compartment pressure monitor (Stryker, Inc., Kalamazoo, Mich.).

The gluteus muscle was then reflected laterally off of its sacral origin to expose the subjacent musculature and venous plexus of the superior gluteal and inferior gluteal vascular systems, and to inspect for the location of fat migration. The deep surface of the gluteus muscle was examined for the presence of demonstrable fascia.

Endoscopic Inspection of Intramuscular Fat Migration

A 3-cm horizontal incision was made in the upper outer quadrant on one hemibuttock. Using digital dissection, the most cephalad portion of the gluteus medius was encountered. More distally, the cephalad border of the gluteus maximus was identified and the submuscular space was navigated using a 10-mm 0-degree endoscope (Karl Storz, Charlton, Mass.). An endoscopic breast system including a fiberoptic camera and an endoscopic breast retractor was used to expose the superior gluteal and inferior gluteal vascular bundles. The proxy fat was again injected into the superficial intramuscular space of the gluteus maximus muscle using 60-ml syringes. Direct real-time inspection of the submuscular space was monitored for the appearance of migrated proxy fat.

Subcutaneous Fat Injection

Direct Inspection of Subcutaneous (Suprafascial) Fat Migration

On four hemibuttocks, a 10-cm-diameter circle in the same location as shown in Figure 1, *above* was drawn. Using a percutaneous needlestick, the same 4-mm Luer-lock multihole injection cannula used previously was placed beneath the skin, and proxy fat loaded into 60-ml syringes was injected into a subcutaneous space, directly between the estimated location markings of the superior and inferior gluteal vessels, and superficial to the gluteus maximus muscle fascia. With each progressive injection of 60-cc increments, intramuscular recipient-site pressures were measured using a Stryker compartment pressure monitor (Fig. 2, *above*) and the location of the cutaneous contour change was recorded as the distance from the visible "migration front" to the injection epicenter (Fig. 2, *below*). At the completion of the subcutaneous injection, gross inspection of subcutaneous fat migration was performed by dissecting the subcutaneous layer from the superficial gluteal fascia. Finally, the gluteus maximus muscle was reflected laterally from its sacral origin to inspect for the presence of fat migration within the gluteus maximus muscle or into the deep submuscular space in proximity to the superior and inferior gluteal vascular systems.

Anatomical Dissection

Using a traditional "pages of a book" dissection, skin and subcutaneous tissue of one hemibuttock was reflected inferiorly, followed by gluteus maximus muscle, exposing the submuscular areolar space, the gluteal vessels, the sciatic nerve, and the sciatic notch. (**See Video, Supplemental Digital Content 1**, which demonstrates anatomical dissection. The detailed anatomy deep to the gluteus maximus muscle is shown. There is a robust posterior fascia overlying the gluteus maximus muscle but there is no clinically apparent anterior fascia. The location of the gluteal vessels is highlighted in this dissection, available in the "Related Videos" section of the full-text article on PRSJournal.com or, for Ovid users, available at ***http://links.lww.com/PRS/D46***.)

RESULTS

Direct Inspection of Subfascial Fat Migration

Subfascial insertion of proxy fat volumes ranged from 540 ml to 720 cc. With each 60 ml of proxy fat inserted, visual expansion of the buttock volume was observed. As larger volumes were inserted, expansion of buttock projection was observed from the perisacral area all the way to the greater trochanter, consistent with the shape of the gluteus maximus muscle (Fig. 3). With each progressive 60 ml of proxy fat inserted, intramuscular compartment pressures increased progressively, as shown in Table 1. Of note, during one of the injections, there was a sudden drop in

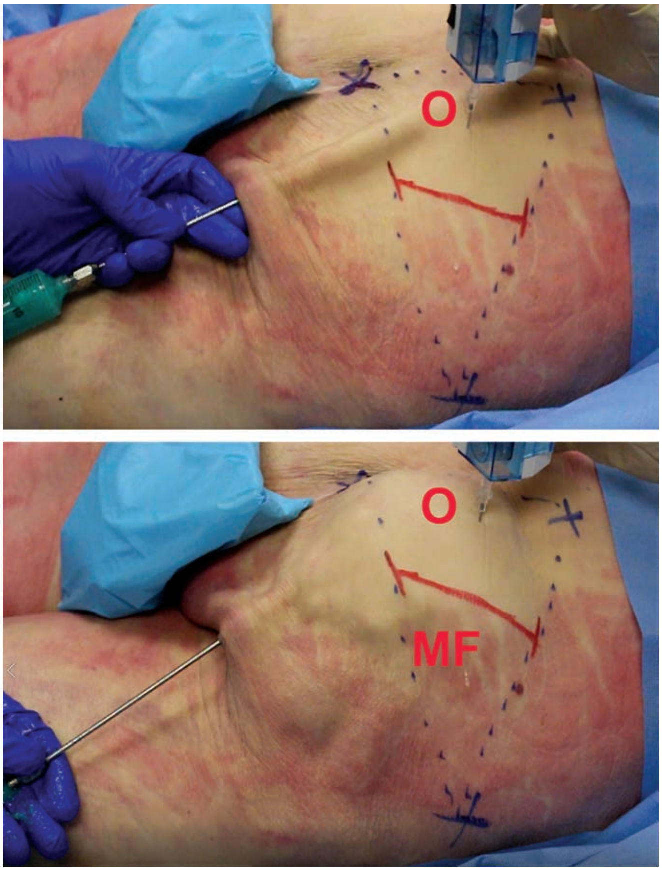

Fig. 2. (*Above*) Initiation of subcutaneous injection. *O* represents the epicenter of proxy fat insertion. (*Below*) After 500 cc of proxy fat, a contour change representing the maximum migration front (*MF*) is identified and its distance from the epicenter *O* is measured.

Video 1. Supplemental Digital Content 1 demonstrates anatomical dissection. The detailed anatomy deep to the gluteus maximus muscle is shown. There is a robust posterior fascia overlying the gluteus maximus muscle but there is no clinically apparent anterior fascia. The location of the gluteal vessels is highlighted in this dissection, available in the "Related Videos" section of the full-text article on PRSJournal.com or, for Ovid users, available at ***http://links.lww.com/PRS/D46***.

Fig. 3. Proxy fat placed in the central portion of the gluteus muscle (*green arrow*) results in submuscular proxy fat emanating near the origin of the gluteus maximus muscle.

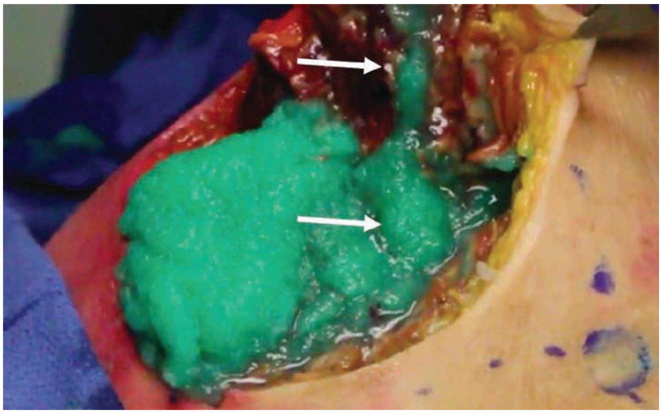

Fig. 4. Deep intramuscular migration. Proxy fat (*upper arrow*) escaping between muscle fibers of the gluteus maximus muscle to enter the deep muscular space in the area of the superior gluteal vessels (*lower arrow*).

injection resistance followed by a decrease in pressure. On further volume injection, the pressure began to rise once more.

Table 1. Subfascial Migration*

Volume Injected (cc)	Pressure (mmHg)
60	48
120	55
180	55
240	65
300	70
360	79
420	87
480	92
540	95
600	117
660	121
720	128
780	112

*Changes in intramuscular pressure with increasing injection volume.

When the gluteus maximus muscle was released from its sacral origin, a large rush of proxy fat was noted to emanate from the submuscular space, in an area far medial and deep to the original cannula insertion (Fig. 4). [**See Video, Supplemental Digital Content 2**, which demonstrates the migration of intramuscular fat in gluteal augmentation. The landmarks to identify the location of the gluteal vessels are first shown. Underneath the subcutaneous layer, the posterior fascia over the gluteus maximus muscle is observed. Applesauce (pseudofat) is injected into the superficial fascia of the gluteus maximus muscle. The pressure within the submuscular space increased with each injection. The pseudofat migrated underneath the muscle and spread throughout the submuscular space. Because of the lack of anterior fascia on the gluteus maximus muscle, the pseudofat migrated deep to the muscle and surrounded the gluteal

Video 2. Supplemental Digital Content 2 demonstrates the migration of intramuscular fat in gluteal augmentation. The landmarks to identify the location of the gluteal vessels are first shown. Underneath the subcutaneous layer, the posterior fascia over the gluteus maximus muscle is observed. Applesauce (pseudofat) is injected into the superficial fascia of the gluteus maximus muscle. The pressure within the submuscular space increased with each injection. The pseudofat migrated underneath the muscle and spread throughout the submuscular space. Because of the lack of anterior fascia on the gluteus maximus muscle, the pseudofat migrated deep to the muscle and surrounded the gluteal vessels, available in the "Related Videos" section of the full-text article on PRSJournal.com or, for Ovid users, available at ***http://links.lww.com/PRS/D47***.

vessels, available in the "Related Videos" section of the full-text article on PRSJournal.com or, for Ovid users, available at ***http://links.lww.com/PRS/D47***.] When the gluteus maximus muscle was reflected laterally to expose the gluteal vessels, proxy fat was noted to occupy the space beneath the gluteus maximus muscle, tracking all the way to the greater trochanteric insertion. In addition, fat was noted to occupy intermuscular septal spaces within the muscle itself (Fig. 5). Finally, during inspection of the undersurface of all gluteus maximus muscles in the study, there was no evidence of a deep fascial layer on the undersurface of the gluteus maximus muscle (Fig. 6).

Endoscopic Inspection of Intramuscular Fat Migration

During endoscopic inspection of the undersurface of the gluteus muscle, it was possible to safely enter the deep submuscular space by means of a cephalad approach and to identify the superior and inferior gluteal vessels that closely coincided with the topographic cutaneous landmarks (Fig. 7). During simultaneous endoscopic inspection and real-time intramuscular injection of proxy fat, fat was noted to well up in the submuscular space, consistent with an intramuscular septal "blowout" and subsequent entrance of proxy fat into the submuscular space (Fig. 8). (**See Video, Supplemental Digital Content 3**, which demonstrates the migration of intramuscular fat in gluteal augmentation. After injection of pseudofat into the superficial fascia of the gluteus maximus muscle, we show that the pseudofat migrates deep and is deposited within the submuscular space. The pseudofat enters deep to the muscle through multiple areas within the muscle. Using an endoscope, we demonstrate that these injections of pseudofat into the superficial fascia of the muscle migrated into the space deep the muscle. The posterior fascia of the gluteus maximus muscle acts as a backstop and prevents migration of pseudofat into the subcutaneous space, available in the "Related Videos" section of the full-text article on PRSJournal.com or, for Ovid users, available at ***http://links.lww.com/PRS/D50***.)

Direct Inspection of Subcutaneous (Suprafascial) Fat Migration

During subcutaneous insertion of 500 to 1500 cc of proxy fat in 60-cc increments, intramuscular

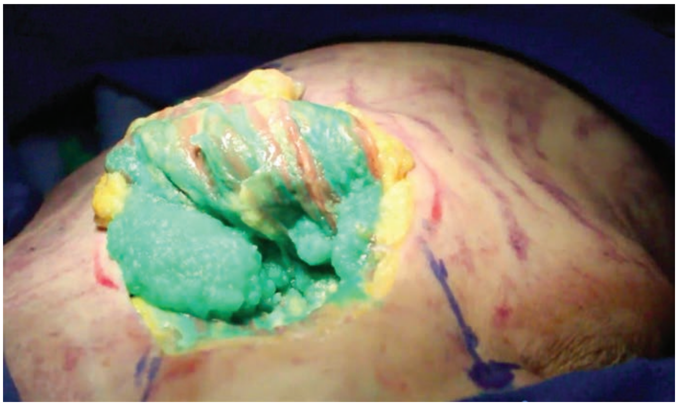

Fig. 5. Intramuscular fat migration. Fat was noted to occupy intermuscular septal spaces within the muscle itself.

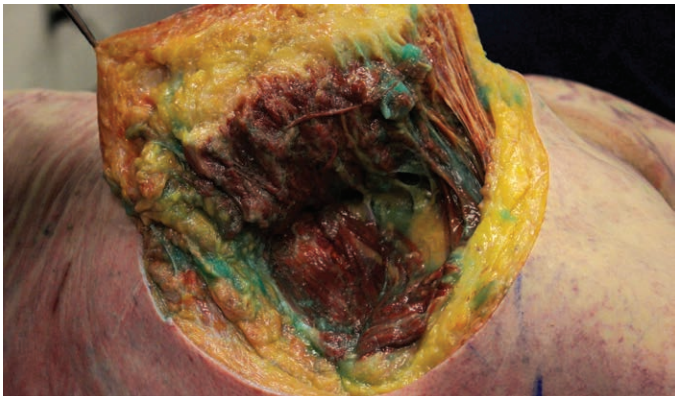

Fig. 6. Lack of anterior gluteal fascia. Note that on the deep or anatomically "anterior" side of the gluteus maximus muscle there is no fascial layer.

compartment pressures did not change (remained at 0). As the volume of proxy fat increased in the subcutaneous space, topographic contour change, as represented by a visible migration front, increased in dimension and subcutaneous pressures increased to as high as 55 mmHg. Postinjection dissection of the subcutaneous space revealed proxy fat, which freely traversed throughout the subcutaneous tissue. Neither the gluteus maximus intramuscular septa nor the deep submuscular space subjacent to the gluteus maximus muscle revealed any evidence of disruption or the presence of proxy fat (Fig. 9).

DISCUSSION

Intramuscular fat grafting in the gluteal region has been a mainstay of Brazilian lift surgery for the past decade or more.[12–16,19,21–34] This is because of the theoretically increased volume capacity of the intramuscular space compared with the subcutaneous space. Without active disruption of recipient-site connective tissue, internal expansion of the subcutaneous space is impossible, as is the case when using traditional syringe-based injection techniques that simply "wedge" fat in as microdroplets.[35] Thus, the intramuscular space has been traditionally favored as a recipient site for gluteal fat transfer. However, since the inception of expansion vibration lipofilling, which creates intraoperative expansion of the subcutaneous space by means of mechanical disruption with internal caged reciprocating cannulas, there has been less reliance on the intramuscular space as the only recipient site capable of accepting relatively large fat volumes.[36] Expansion vibration lipofilling can potentially increase the capacity of the subcutaneous recipient site and allow for effective gluteal lipofilling without the need to resort to the muscle.[37]

There has been much discussion about the safety of intramuscular fat grafting to the gluteal region, many with the stipulation that surgeons

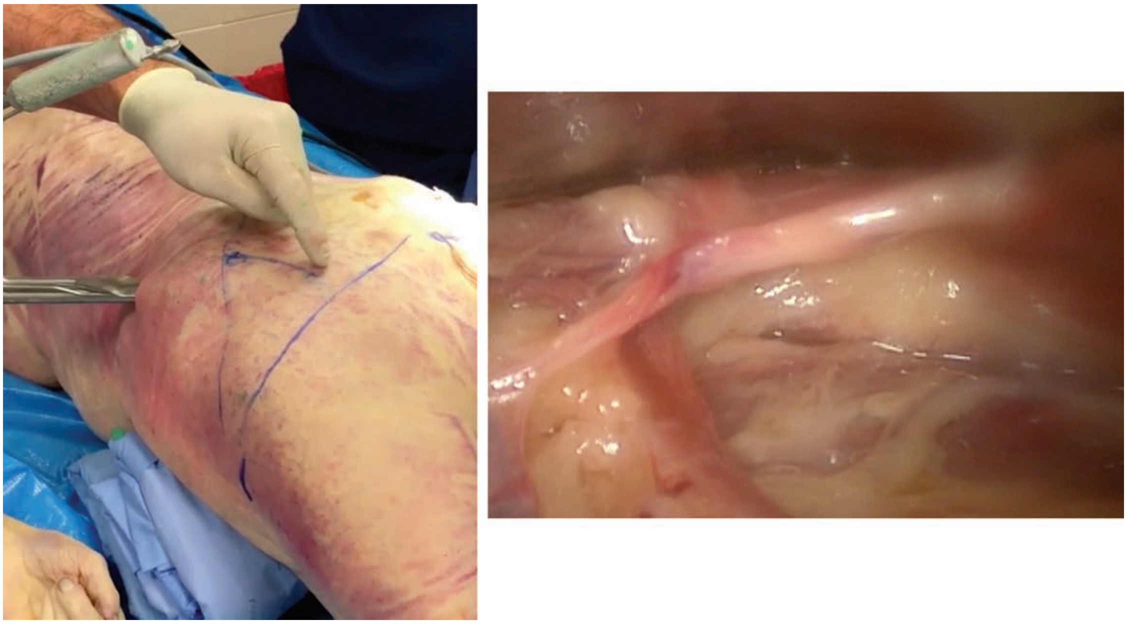

Fig. 7. Accuracy of cutaneous markings and navigation of the submuscular space. (*Left*) The submuscular plane can be entered from above (this is the left hemibuttock). The inferior gluteal vascular leash is visible in the loose areolar submuscular plane, and its location coincides with the topographic markings. (*Right*) Endoscopic real-time inspection of fat migration. Endoscopic view of the undersurface of the gluteus maximus muscle before subfascial fat injection. Note the absence of fascia.

follow "safety zones" or stay in the "superficial muscle."[3] Although the anatomical basis of the "safety triangle" theoretically makes sense, there is insufficient clinical evidence to prove that it is failsafe in human patients. The opinion that intramuscular fat transplantation is "safe" rests on an important assumption—that fat placed in the intramuscular space remains in the intramuscular space. The findings of the present study suggest that fat grafted within the muscle can migrate through the deep side of the gluteus muscle into the underlying submuscular space, implying that there is no zone within the gluteus maximus muscle that can be considered safe.

Whether one inserts fat in the deep or superficial muscle, given enough volume, it will not remain in the muscle and will spill deep to the submuscular space. There have been reports of the direction of cannula insertion as connoting some element of safety.[10,38] Insertion from the inferior gluteal crease incision (from below) has been suggested to be more dangerous than injecting from a natal cleft approach (from above, medial). This has been traditionally explained by a "direct hit" paradigm, namely that angulating the cannula in certain directions poses increased risk for penetrating the submuscular space and hitting a deep vein coming from below. The deep intramuscular migration theory provides an alternative explanation, whereby injecting from the natal cleft directs the cannula parallel to the muscle fibers, depositing fat along longitudinally separated fibers without disrupting the muscle. By keeping the muscle and connective tissues grossly intact, the grafted fat is more likely to remain within the muscle. In contrast, injection from below results in a cannula course perpendicular to muscle fibers. By disrupting the muscle fibers and septa, the cannula creates a perpendicular passage through the muscle fibers through which fat can more easily track down to the submuscular space, along the path of least resistance (Fig. 10).

The absence of deep fascia on the gluteus muscle has not been described previously. Other large truncal muscles, including the latissimus dorsi and the pectoralis major muscle, exhibit similar anatomy, with a superficial subcutaneous-facing fascial component that is dense and a deep component that is nonexistent. Similar to the gluteus muscle, fat injected into the pectoralis muscle can also be presumed to migrate posteriorly into the subpectoral space given the lack of deep fascia to serve as a barricade. Yet unlike gluteal fat injections, fat grafting to the pectoralis muscle has not been associated with pulmonary fat embolism.[39] The likely reason for this is twofold. First, the maximum fat volumes injected into the pectoralis muscle are on the order of 100 to

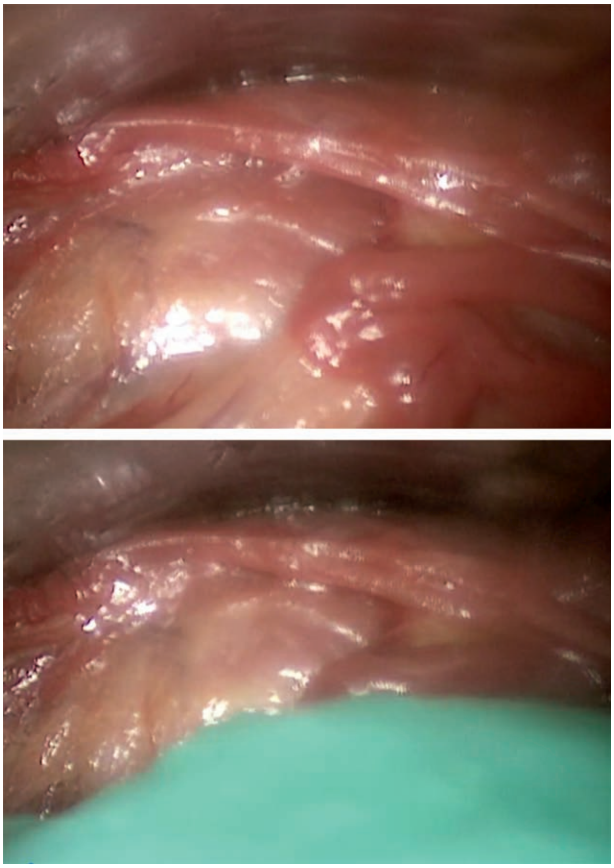

Fig. 8. Endoscopic anterior septal blowout. After 180 cc of fat, proxy fat is noted to burst through muscle fibers and well up in the subcutaneous space.

150 cc, much less than volumes reported in gluteal fat injections. Without high volumes creating a high-pressure effect, fat is less likely to egress. Second, unlike the deep gluteal region, the subpectoral space is devoid of significant large and fragile veins that carry with them the potential for devastating embolisms.

Because of the lack of deep fascia lining the undersurface of the gluteus muscle, sufficient volumes of fat placed in the muscle can migrate freely out of the muscle from its deep surface into the submuscular plane, along the path of least resistance. The superficial surface of the gluteus muscle, in contrast, is lined with a dense superficial fascia that acts as a "backstop" to prohibit intramuscular fat from egressing out of the muscle in the opposite direction, into the superficial subcutaneous space. Indeed, in the current study, there was no egress through the superficial fascia even with recipient-site pressures exceeding 100 mmHg. As such, the fascial anatomy of the gluteus muscle creates the basis for the deep intramuscular migration phenomenon, wherein high volumes of fat preferentially migrate deep to the muscle because of the lack of deep fascial structures acting as a barricade.

The migration of fat parallel to or longitudinally between muscle fibers appears to occur both proximally and distally along the gluteal muscle to some extent. However, there is higher resistance in this direction because the fibers must separate longitudinally for fat deposition. This leaves only the deep egress as the path of least resistance. In this scenario, fat dissects between, or perpendicular to, muscle fibers, spreading only a small distance in the anterior direction before egressing into the lower pressure submuscular space. The fat exits the deep surface of the muscle in the area between the gluteal vessels and is deposited in the deep intermuscular space near the sciatic notch. Fat entering the notch causing a wedge can potentially lead to sciatic nerve entrapment with subsequent transient or permanent nerve injury.

The Venous Traction Theory

A mechanism of venous trauma, without direct cannula contact injury to the vein, can be postulated to occur as a result of acute venous traction. This may occur when a volume of grafted fat collecting in the submuscular space causes posterior projection of the muscle (Fig. 11, *left*). As the muscle expands posteriorly, it puts traction stretch on the fixed venous plexus, potentially causing failure, or venous tear, setting up a pressure gradient for siphoning of fat into the venous system and pulmonary fat embolism (Fig. 11, *right*).

Vascular surgical studies on the tensile strength of veins suggest that as low as a 7 percent increase in axial length by traction on a filled vein can lead to failure of the conduit.[40] Assuming the average length of a superior gluteal vein is 2.5 cm, a submuscular fat collection secondary to deep intramuscular migration causing venous traction of (0.07 × 25 mm) less than 2 mm could potentially lead to avulsion of the superior gluteal vein.[41] As such, deep intramuscular migration–induced traction injury poses another potential mode of venous injury aside from the obvious direct cannula trauma.

The superficial gluteal fascia, not the muscle, acts as the lynchpin in this polemic. If the fascia acts as a superficial backstop to force fat deeper during intramuscular injection, pressure generated during the intramuscular injection can create the danger. If, in contrast, the superficial gluteal fascia acts as an equally powerful deep backstop during "subcutaneous only Brazilian butt lift" (i.e., SAFEBBL), it serves as an effective barricade to

Video 3. Supplemental Digital Content 3 demonstrates the migration of intramuscular fat in gluteal augmentation. After injection of pseudofat into the superficial fascia of the gluteus maximus muscle, we show that the pseudofat migrates deep and is deposited within the submuscular space. The pseudofat enters deep to the muscle through multiple areas within the muscle. Using an endoscope, we demonstrate that these injections of pseudofat into the superficial fascia of the muscle migrated into the space deep the muscle. The posterior fascia of the gluteus maximus muscle acts as a backstop and prevents migration of pseudofat into the subcutaneous space, available in the "Related Videos" section of the full-text article on PRSJournal.com or, for Ovid users, available at ***http://links.lww.com/PRS/D50***.

prevent subcutaneously placed fat from entering the muscle. In this scenario, pressure generated from the subcutaneous injection can be used to help guide the dispersion of fat within this space, a concept analogous to "lipotumescence."[42,43] Said differently, "if pressure beneath the fascia is your enemy, pressure above the fascia is your friend."

Some reading this may be wary of the concept of creating intentionally high pressures in the subcutaneous space in gluteal lipoaugmentation.

Fig. 9. Inspection of subcutaneous migration. Fat injected into the subcutaneous (suprafascial) space generated high subcutaneous pressures and migration through the subcutaneous tissue (*red arrow*), whereas the submuscular space pressures remained 0 and were devoid of proxy fat (*green arrow*). In this setting, the posterior gluteal fascia acted as a protective "backstop."

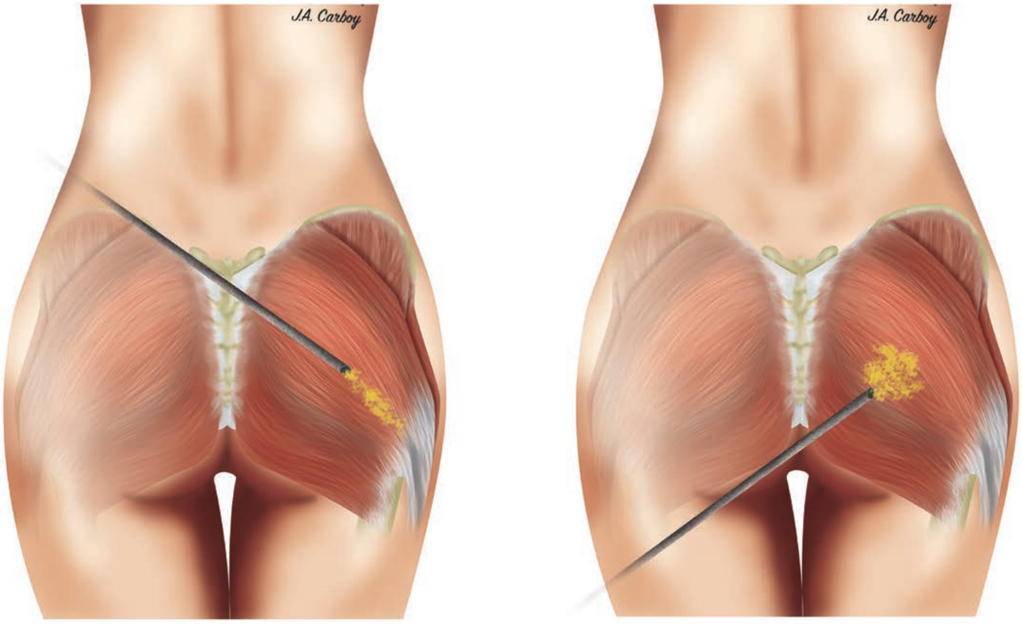

Fig. 10. (*Left*) Injection from above leads to cannula disruption and graft placement parallel to muscle fibers. (*Right*) Injection from below causes cannula disruption and graft placement perpendicular to muscle fibers. Deep intramuscular migration may occur more readily when grafting perpendicular to muscle fibers.

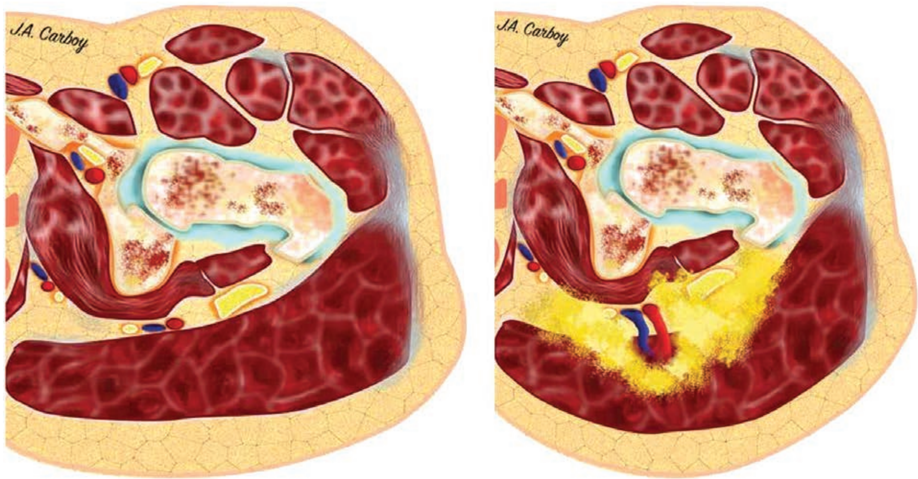

Fig. 11. Venous traction theory of pulmonary fat embolism. (*Left*) Fat from deep intramuscular migration collecting in the submuscular space separates the gluteus muscle, projecting it posteriorly. (*Right*) At some stretch length, a vein fails and ruptures, allowing a pressure gradient and siphoning of fat into the venous circulation.

However, with postgraft relaxation of connective tissue, water absorption, and internal recipient-site expansion provided by expansion vibration lipofilling, such high pressures created by lipotumescence are transient after the completion of postgraft shaping, recipient-site equalization, and "fat shifting."[44,45] It must be noted, however, that if the superficial gluteal fascia is violated, the subcutaneous fat can take a path through the fascial defect into the muscle. With sufficiently high volumes and pressure, fat may migrate even deeper into the submuscular space.

In the Aesthetic Surgery Education and Research Foundation survey, many surgeons reporting pulmonary fat embolism mortality insisted they were in the subcutaneous plane. As a response, the authors of the survey stated that "it is also possible that subcutaneous injections may track between a muscle plane or along a vascular pedicle deep and into an area of large veins or a venous plexus."[1] We saw no evidence of this in the present study. In fact, the anatomical findings derived from this cadaver study speak directly against the validity of this statement. Although we applaud the Aesthetic Surgery Education and Research Foundation survey finding that the mortality rate associated with the Brazilian lift is unacceptably high (prompting this research), to our knowledge, there has never been a case of fatal pulmonary fat embolism where, at autopsy, fat was confined only to the subcutaneous or suprafascial plane. Furthermore, although the numbers are too low for statistical significance, there have been no cases of pulmonary fat embolism reported when subcutaneous only Brazilian lift has been performed. The Aesthetic Surgery Education and Research Foundation statement that subcutaneous fat insertion can lead to pulmonary fat embolism is not substantiated by the scientific data of this anatomical study.

CONCLUSIONS

Although a great deal of attention has focused on the gluteus maximus muscle in fat grafting safety, it appears the superficial gluteal fascia is the key anatomical structure, forcing intramuscular fat deep, and keeping subcutaneous fat superficial, over a wide range of interstitial tissue pressures. Because of the migratory ability of fat within the gluteus muscle during fat transplantation, deep intramuscular migration is a phenomenon that may occur when fat is inserted in any part of the gluteus maximus muscle. The intramuscular insertion of fat, which up to this point has been considered reasonable to perform in the superficial muscle and even recommended in many articles and textbooks on the subject, is now deemed to be an inexact and potentially dangerous technique. This strategy, because of its migratory uncertainty, should be discontinued in fat transplantation to the gluteal region.

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ACKNOWLEDGMENTS

The authors thank the Dr. Rod Rohrich Research Fund from the University of Texas Southwestern Department of Plastic Surgery, Garret Adams of Stryker for the compartment pressure monitor, Jourdan Carboy for illustrations, and the Willed Body Program of the University of Texas Southwestern.

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