Aesth. Plast. Surg. 30:460–468, 2006
DOI: 10.1007/s00266-005-0202-1

Aesthetic Plastic Surgery

Original Articles

Magnetic Resonance Imaging Assessment of Gluteal Fat Grafts

Germán A. Wolf I., M.D.,[1] Sabrina Gallego G., M.D.,[1] Alfredo S. Patrón G., M.D.,[1] Federico Ramírez Z., M.D.,[1] Jorge A. Delgado de B., M.D.,[2] Alberto Echeverri A., M.D.,[3] and Mónica M. García G., M.D.[4]

[1]Division of Plastic Surgery, School of Medicine, Universidad de Antioquia, Cll 64 Cr 51 D. Hospital Universitario San Vicente de Paul, Medellín, Colombia
[2]Instituto de Alta Tecnología Médica de Antioquia, Cra 50 # 63–95, Medellín, Colombia
[3]Clínica Las Américas, Diag 75B # 2ª–80, Medellín, Colombia
[4]Private Practice, Cll 33 # 42B–06 Cons. 1220, Medellín, Colombia

Abstract

Backgrounds: One goal of lipoplasty is to create a round and projected buttock contour. Despite multiple papers evaluating lipoinjection, controversies still remain.

Methods: This report describes a series of patients who underwent liposuction, gluteal lipoinjection, and evaluation with magnetic resonance imaging (MRI). From January 2003 to January 2004, the patients scheduled for contour surgery by the investigators were evaluated using MRI, photographic records, and gluteal circumference measurement 1 week before surgery, then 2 weeks and 3 months after the procedure. A statistical analysis was performed for 10 patients who received, on the average, a 350-ml injection of fat obtained during liposuction.

Results: Gluteus muscle volume increased, reaching a higher level 2 weeks after the injection than the level 3 months afterward ($p < 0.001$). The gluteal circumference, modified 2 weeks after surgery by about 1 to 3 cm, came back to previous values 3 months after the procedure ($p < 0.05$), a phenomena interpreted as reabsorption and resolution of the postoperative edema. There is no correlation between the gluteus muscle volume obtained by MRI and the gluteal circumference ($p > 0.05$).

Conclusions: The findings led to the conclusion that enhancement of the gluteal contour after fat injection results from survival of the injected tissue 3 months after the surgery, which was objectively evaluated by MRI as having a calculated reabsorption rate of 24% to 36%.

Key words: Fat graft—Fat reabsorption—Gluteal contour—Lipoinjection—Magnetic resonance imaging

Presented at the XXX Congress of the Sociedad Colombiana de Cirugía Plástica, SCCP and the IV Bolivarian Regional Meeting of the Federación Iberolatinoamericana de Cirugía Plástica, FILACP, Cartagena, Colombia 27, 31 March 2005

Correspondence to Sabrina Gallego G., M.D. Division of Plastic Surgery, School of Medicine, Universidad de Antioquia, Cll 64 Cr 51 D. Hospital Universitario San Vicente de Paul, Medellín, Colombia; *email:* sgallegog@epm.net.co; sabrina1236@hotmail.com

Autologous fat grafting , introduced by Neuber in 1893 for the correction of soft tissue deformities, still is a widely used procedure for reconstructive and aesthetic purposes [11,16,25]. The development of liposuction by Illouz in 1977 [11,23] allowed plastic surgeons to improve body contours with minimal scars and provided the best way to obtain considerable amounts of fat grafts to accomplish this goal [19]. Fat obtained by lipoaspiration then was available to fill depressions and improve the gluteal shape [13,35,37]. Since the work of Guerrerosantos [16] in 1996 standardized a technique to prolong viability of injected fat in the buttock region, gluteal augmentation by fat grafting has become an increasingly common practice in many centers around the world [20,43].

Several clinical studies have reported successful results from buttock augmentation by autologous fat grafts. These results, based mainly on clinical measurements, photographic records, and patient satisfaction, lack objective parameters of fat integration to the recipient site [1,8–10,12,14,24,41].

However, the behavior of fat grafts remains a controversial issue in plastic surgery. In experimental studies, the reabsorption rate varies between 30% and

Fig. 1. Measurement of the gluteal circumference: (1) pubic tubercle, (2) maximal buttock projection point.

100% depending on multiple factors including the model, fat processing, aspiration technique, body location, and site of injection [2,4,7,18,22,29,31–33,38,40,45]. Magnetic resonance imaging (MRI) has the ability to distinguish all the components of soft tissue in the gluteal region (fat and muscle) [21,26,28,34]. It can be used as a suitable imaging technique to document fat graft integration and volumetric variations produced in the buttocks after fat injections [30].

This study was designed to determine, on the basis of a standardized surgical technique and MRI measurements, the behavior of fat grafts in the gluteal region during the early and medium postoperative period in terms of the graft's reabsorption volume and correlation with clinical observation [42].

Methods

This study aimed to demonstrate the permanence of fat grafts using MRI, to calculate the rate of reabsorption of the injected volume, and to correlate the results with the clinical measurements during the early and medium postoperative periods.

Patients

Between January of 2003 and January 2004, 21 consecutive patients (20 women and 1 man) requesting body contour improvement were included in the study. All procedures included liposuction of the abdominal, trocanteric, and dorsal regions as well as gluteal contouring by autologous fat grafts. Abdominoplasty was used for six patients as a complementary procedure. The fat grafts were monitored by MRI in 10 patients and by gluteal circumference in all 21 patients. The criteria for exclusion from the study specified reluctance of patients to participate in the study, contraindications for MRI (e.g., pregnancy, pacemaker, metallic valvular prosthesis) [34], postoperative complications (infection, hematoma, or sebaceous cysts) [37], and incomplete follow-up imaging. For 11 of the studied patients, MRI was not performed for various reasons. Three of the patients did not accept the evaluation. Two patients did not submit to postoperative controls, and it was not possible for six patients to receive the scans due to maintenance of the resonator from late December 2003 to late January 2004.

Clinical Assessment

Each patient was evaluated preoperatively by clinical observation, standardized photographic records, and measurement of gluteal circumference (perimeter taken at the superior border of symphysis pubis and the maximal buttock projection point used as references). The same evaluation was repeated 2 weeks and 3 months after surgery. Informed consent was obtained from all patients before their inclusion in the study (Fig. 1).

MRI Evaluation

Ten patients underwent magnetic resonance imaging (MRI) of the gluteal region 1 week before surgery, then 2 weeks and 3 months after surgery. A 1.5-Tesla resonator was used for measurements. Data were obtained with a T1 volumetric short T1 inversion recovery (STIR) sequence and axial cuts (fat suppression) from the umbilicus to the minor trochanter. Altogether, 90 to 100 cuts were obtained in the T1 sequence with a 3-mm interval, and 45 cuts were obtained in the STIR sequence with a 0.6-mm interval. The volume for each pair of right and left gluteus muscles was calculated and analyzed separately because of interside preoperative gluteal volume variability. For standardization of the slides, the limits of the volumetric measure were defined as the iliac crest at the level of the sacroiliac articulation, the posterior gluteus musculature at the level of the major trochanter, and the level of the ischium inferiorly.

Special care was taken to follow these limits for all the patients. The subcutaneous tissue and the osseous structures were excluded using resonator volumetric software. The data were recorded and analyzed by the same radiologist, which made the measurement more standardized (Fig. 2).

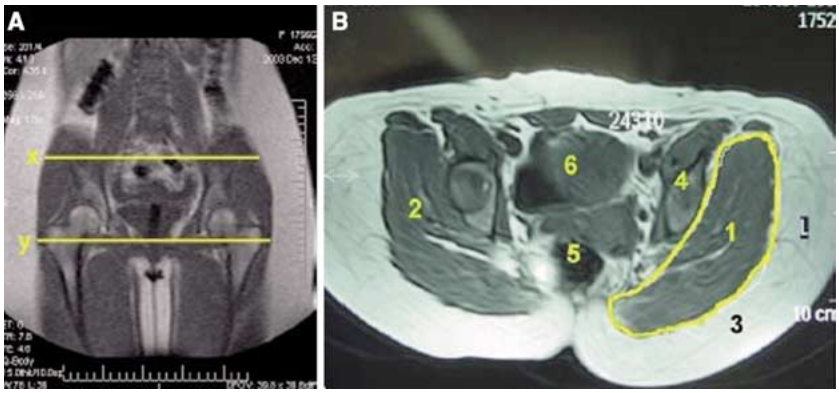

Fig. 2. Standardized measurement of the gluteus muscle tissue by magnetic resonance imaging. (**A**) Coronal view showing the superior (x) and inferior (y) limits. (**B**) Measurement in an axial cut: (1) left gluteus muscle, (2) right gluteus muscle, (3) subcutaneous tissue, (4) major trochanter, (5) sigmoid colon, (6) bladder.

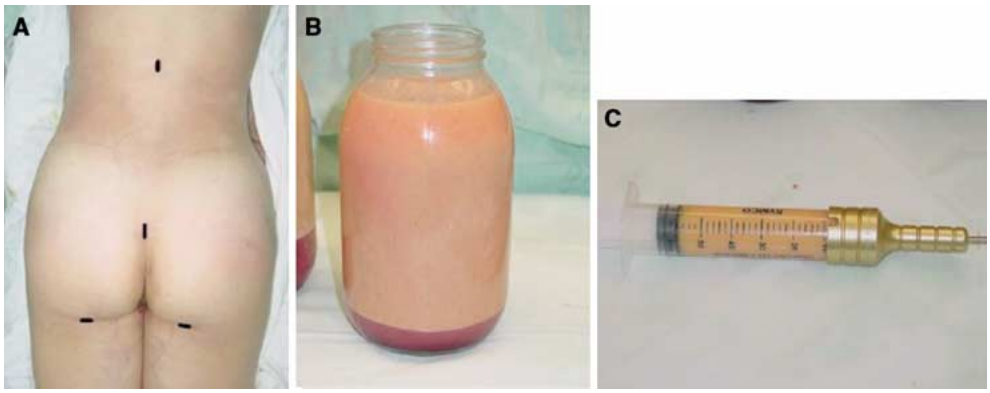

Fig. 3. Surgical technique. (**a**) Incisions. (**b**) Fat tissue after suction during the decantation process. (**c**) Fat graft prepared for injection.

Surgical Technique

Under general anesthesia and after surgical preparation with povidone/iodine soap, the patient was placed in the prone position. Next, 0.5-cm surgical incisions were made in the intergluteal crease, inferior gluteal crease, and midline of the thoracolumbar region. Liposuction was performed by the conventional tumescent technique using 3- and 4-mm blunt cannulas [13,37].

The tissue for injection was put in a sterile container. After 20 min of decantation, the superficial layer was taken with a 60-ml syringe, then injected in the gluteal muscle mass, creating thin tunnels for fat grafts 4 mm × 10 cm in size with a blunt cannula in a fanlike distribution through the intergluteal incision.

For the required patients, grafts in the subcutaneous tissue were performed according to the same pattern. Manual molding of the buttock was performed after injection to achieve finally a more rounded contour. The patient then was held in the supine position while the complementary anterior liposuction or additional procedures were performed.

Prophylactic IV first-generation cephalosporins were used 1 h before the incisions in all the patients. Compression garments with 20 mmHg of differential pressure were routinely used for 6 weeks after surgery, and the patients were instructed to avoid weightbearing by the buttocks for 3 weeks (Fig. 3) [32].

Statistical Analysis

Data were analyzed using the Statistica 6.0 software (Statsoft, Inc., Tulsa, OK, USA), with application of the Pillai–Bartlet test, the Newman–Keuls test, and the Spearman coefficient [44].

Results

During the study period, we operated on 21 patients (20 women and 1 man) with an average age of 29.3 ± 5.4 years (range, 21–42 years). The clinical data for all the patients were recorded during the studied intervals, and MRI measurements were recorded for 10 patients separately during all the studied periods. The volume of each gluteus muscle (right and left) was calculated separately. The mean volume injected was 350 ml (range, 300–400 ml) per side. The results are shown in Table 1.

The average volume of the right gluteus muscle was 669.2 ± 72.5 ml (range, 550.1–743.9 ml) in the preoperative period, 787.65 ± 126.8 ml (range, 586.6–990 ml) at week 2, and 759.7 ± 116.5 ml (range, 574.2–938 ml) at month 3. The average volume of the left gluteus muscle was 705.4 ± 95.6 ml (range, 539.7–881.4 ml) during the preoperative period, 806 ± 95.5 ml (range, 610–931.4 ml) at week 2, and 770.7 ± 93.3 ml (range, 591.2–897.5 ml) at

Table 1. Volume of gluteus muscle tissue in cubic centimeters

Case	Preop vol (right)	Preop vol (left)	2-week vol (right)	2-week vol (left)	3-month vol (right)	3-month vol (left)
1	685.4	731.2	785	776.5	756.9	771.4
2	550.1	539.7	586.6	699.1	574.2	639.5
3	639.6	728.9	780.9	850.1	755.1	810.9
4	743.9	744.3	899.6	859.4	858.7	831.2
5	730	881.4	990	931.4	938	897.7
6	742.4	822	851.2	872.3	840.3	830
7	675.1	698.4	740.5	758.8	710	728.3
8	554.1	542.7	591.6	610	578.2	591.2
9	643.5	703.6	785.3	840.8	761.9	804.6
10	728.1	731.6	865.7	861.3	824.4	802.3

Preop, preoperative; vol, volume

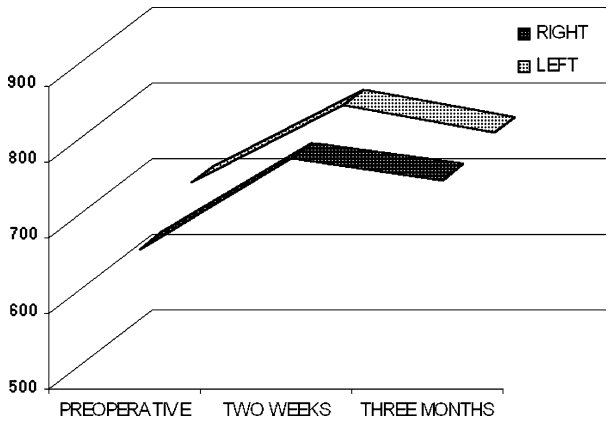

Fig. 4. Comparison of gluteus muscle volumes before surgery, then 2 weeks and 3 months afterward.

month 3. The average volume of all the studied gluteus muscles was 687.3 ± 84.7 ml (range, 539.7–881.4 ml) in the preoperative period, 796.8 ± 109.7 ml (range, 586.6–990 ml) at week 2, and 765.2 ± 102.9 ml (range, 574.2–938 ml) at month 3.

The volumes of the gluteus muscles during the three periods were analyzed. The multivariate analysis showed similar behavior in terms of volume variation between the left and right sides ($p = 0.1$, Pillai–Barlet test). When the measurements of the volumes for each gluteus muscle were compared, a difference was found between the preoperative and week 2 data, between the preoperative and the month 3 data, and between the week 2 and month 3 data. All these differences were statistically significant ($p < 0.001$, Newman–Keuls test) (Fig. 4). The gluteal circumferences during the three studied periods were, respectively, 94.7 ± 5.3 cm (range, 85–105 cm), 97.9 ± 5.3 cm (range, 86–107 cm), and 95.5 cm ± 5.7 (range, 85–106 cm). Table 2.

The statistical analysis showed a significant difference between the preoperative and week 2 perimeter measurements as well as a significant difference between the postoperative week 2 and month 3 measurements ($p < 0.05$). No correlation could be found between data obtained on the volumetric measurement and gluteal circumference ($p > 0.05$, Newman–Keuls test) (Fig. 5).

Table 2. Gluteal circumference in centimeters

Case	Preop circumference	2-week circumference	3-month circumference
1	97	100	98
2	89	91	89
3	98	102	99
4	92	96	93
5	95	98	96
6	101	101	101
7	95	99	96
8	88	89	88
9	100	103	102
10	93	99	95
11	100	104	102
12	91	94	91
13	100	102	100
14	98	101	100
15	93	96	94
16	86	88	86
17	99	103	100
18	85	86	85
19	92	93	92
20	105	107	106
21	88	89	88

Preop, preoperative

The reabsorption rate was calculated using the volumetric measurements of fat remaining in each gluteus muscle 2 weeks and 3 months after surgery. This rate was estimated as 24% to 36% (average, 28%) at month 3.

Discussion

A principal goal of plastic surgeons has been to create a round and projected buttock contour. There are multiple choices, each one with its disadvantages such

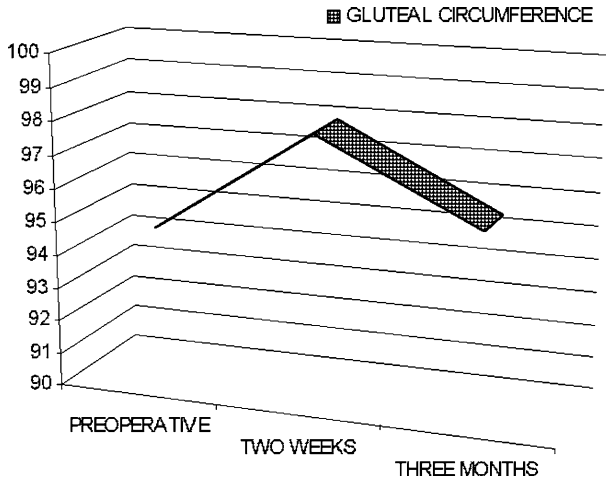

Fig. 5. Comparison of gluteal circumferences before surgery, then 2 weeks and 3 months afterward.

as visible scars from cutaneous excision, high cost, and the need for a prosthesis implant [3,6,13,15,16,27,35,36]. The lack of buttock definition is a frequent issue for Latin women because of altered fat distribution in this region, with a periphery excess and a void in the superior area. It is a cultural beauty pattern to have a slim waist with prominent buttocks, making buttock contour enhancement a frequent consultation issue [6] (Figs. 6–8).

The introduction of liposuction has allowed surgeons to redistribute body fat tissue and obtain autologous material for implantation. Experimental studies discuss the permanence of the injected tissue as a percentage, which directly reflects the amount of reabsorbed fat [17,18,33,39,45]; However there is no objective quantitative assessment of this event in the gluteal region in human models. A paper by Murillo shows by MRI (a qualitative measurement) the presence of fat tissue within the gluteus muscle after long-term lipoinjection [30]. Brandenburg et al. [5] and Hörl et al. [21], using MRI, evaluated survival of the grafted fat tissue after its injection in the vocal cords and face, respectively. Hörl found that approximately 95% of total reabsorption occurs during the first 3 postoperative months.

No studies have investigated the volume of gluteus muscle in the general population. The knowledge of this volume would provide physicians with a standardized parameter for objective assessment of gluteal augmentation with fat tissue injection. The current study determined the right and left gluteus muscle volumes by MRI and found a slight difference between them in all patients. This difference had no clinical or statistical significance.

When the results of the gluteus muscle volumes during the three studied periods were compared, we found that the injected fat tissue significantly augmented the total volume of the gluteus muscle toward postoperative week 2 and month 3. The achieved augmentation was a maximum of 2 weeks after surgery, as compared with the volume at month 3, which can be explained by reabsorption of injected tissue. This phenomena increases during the first 3 postoperative months, reaching a 49% loss of tissue injected, as Hörl et al. [21] showed in their study. We found a fat reabsorption rate of 24% to 36% at 3 months after surgery. In our opinion, the better graft take can be attributed to the major concentration of vessels in muscle, as compared with subcutaneous tissue (the site of facial injection) [16,18] (Fig. 9).

In most studies that evaluate lipoinjection used to enhance the aspect of any body area, pre- and postoperative photographs and records of patient satisfaction are used as parameters for documenting results [1,3,6,8–10,12–15,24,27,35,36,41]. Guerrero-santos [16] showed a gluteal circumference increase of

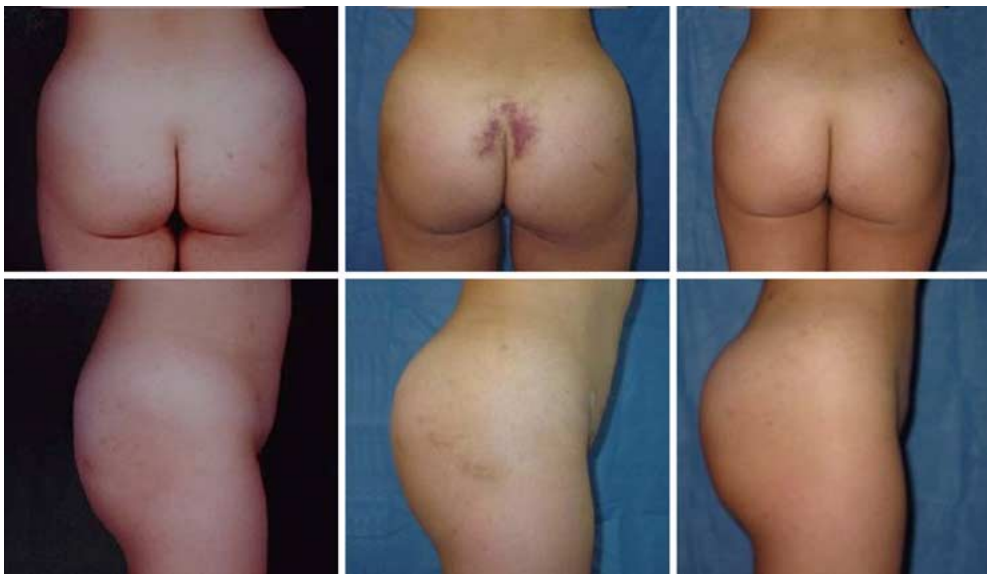

Fig. 6. Case 5. *Below left:* lateral preoperative view. *Below center:* lateral view 2 weeks after surgery. *Below right:* lateral view 3 months after surgery. *Above left:* posterior preoperative view. *Above center:* posterior view 2 weeks after surgery. *Above right:* posterior view 3 months after surgery.

Fig. 7. Case 9. *Above left:* lateral preoperative view. *Above center:* lateral view 2 weeks after surgery. *Above right:* lateral view 3 months after surgery. *Below left:* posterior preoperative view. *Below center:* posterior view 2 weeks after surgery. *Below right:* posterior view 3 months after surgery.

Fig. 8. Case 21. *Below left:* lateral preoperative view. *Below center:* lateral view 2 weeks after surgery. *Below right:* lateral view 3 months after surgery. *Above left:* posterior preoperative view. *Above center:* posterior view 2 weeks after surgery. *Above right:* posterior view 3 months after surgery.

up to 4 cm in patients who underwent posterior liposuction followed by injection of 200 ml into each buttock. In the current series, we measured the gluteal circumference in all the patients, but could find no statistically meaningful difference between measurements before surgery and 3 months afterward. Comparing the previous evaluation with that performed 2 weeks after the injection, we found that at 2 weeks, the circumference was greater, which can be explained, in part, by the inflammatory process that fades progressively with time [37]. On the other hand, concurrent liposuction of the lower abdominal zone and adjacent areas as well as gluteal lipoinjection create just a slight modification in the circumference measurement, although we can see an important clinical improvement of the gluteal contour (Fig. 10).

No correlation was found between the gluteal volumes obtained with the MRI and the measurement of gluteal circumference. The gluteus muscle volume represents an estimate of grafted tissue, and the circumference is a measurement influenced by other factors such as inflammation, fat reabsorption, and liposuction of the adjacent zone (trochanteric area, thighs, lower abdomen, back, and flanks).

Conclusion

The findings show that the improvement of body contour after gluteal lipoinjection results from survival of fat tissue injected 3 months after the procedure. The results confirm that MRI is a suitable

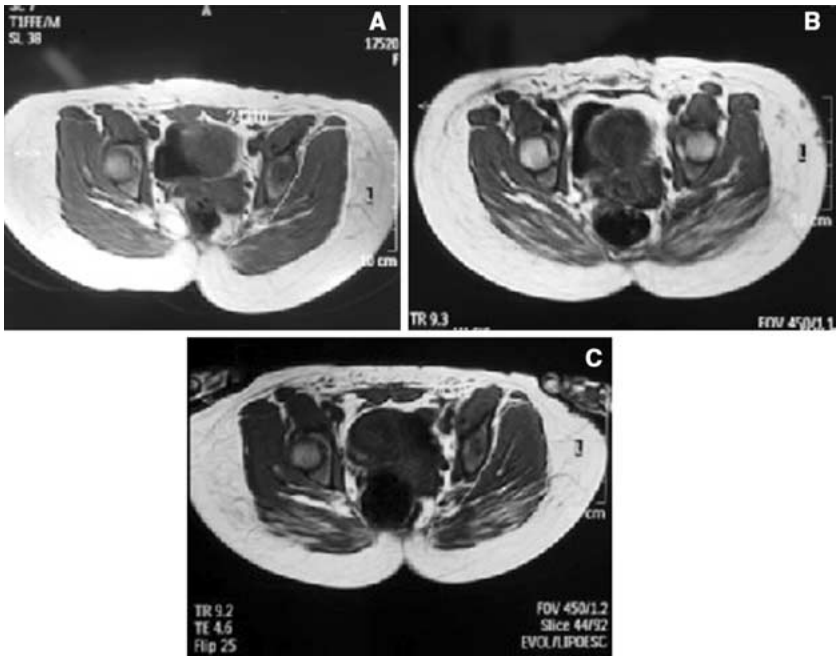

Fig. 9. Case 3. Magnetic resonance imaging, axial views. (**A**) Preoperative. (**B**) At 2 weeks after surgery. (**c**) At 3 months after surgery. Hyperintense tunnel-like areas within the topography of the gluteus muscle can be seen in the postoperative scans.

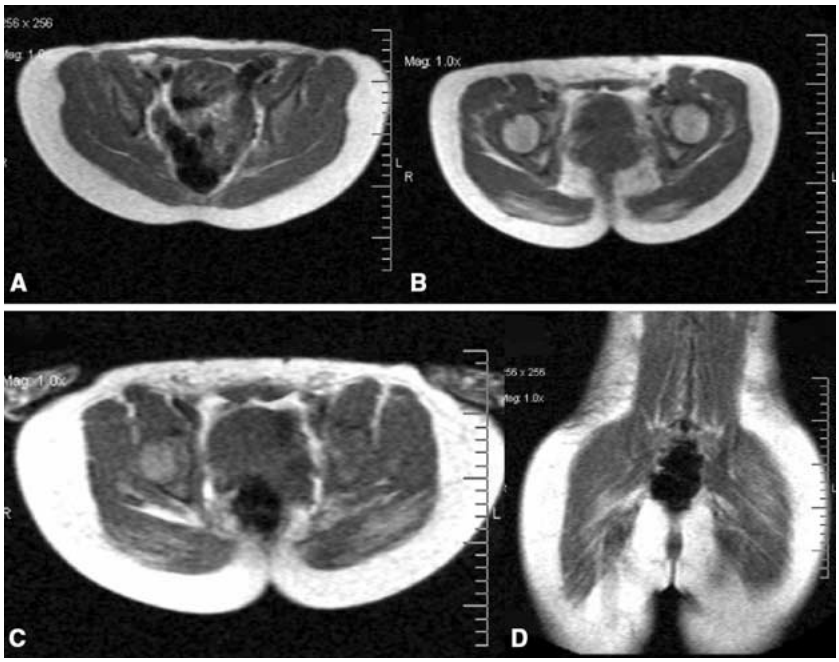

Fig. 10. Case 5. Magnetic resonance imaging. (**A**) Preoperative. (**B**) At 2 weeks after surgery. (**C**) At 3 months after surgery. (**D**) Coronal view 3 months after surgery. Hyperintense tunnel-like areas within the topography of the gluteus muscle can be seen in the postoperative scans.

imaging technique for documenting fat graft integration and volumetric variations produced in the buttocks after fat injection. The average tissue loss because of reabsorption after lipoinjection in the buttock varies between 24% and 36%. This report can serve as a reference for future investigations in the field of body contour. We recognize the need for long-term evaluation and the lack of later information in this report, but the current study was designed to evaluate the medium postoperative period making rational use of the available resources.

Acknowledgments. This study was supported by the Corporación de Cirugía Plástica de Antioquia, CORCIRUPLAST and the Instituto de Alta Tecnología Médica de Antioquia, IATM, Medellín, Colombia.

References

1. Apostolos D, Mandrekas, et. al.: Cyst formation after fat injection. *Plast Reconst Surg* **102**:1708–1709, 1998
2. Ayhan M, Senen D, Adanah G: Use of beta-blockers for increasing survival of free fat grafts. *Aesth Plast Surg* **25:**338–342, 2001
3. Billings E, May J: Historical review and present status of free fat graft autotransplantation in plastic and reconstructive surgery. *Plast Reconstr Surg* **83:**368–381, 1989
4. Boschert M, Beckert B: Analysis of lipocyte viability after liposuction. *Plast Reconstr Surg* **109:**761–765, 2002
5. Brandenburg JH, Unger JM, Koschkee D: Vocal cord injection with autogenous fat: A long-term magnetic resonance imaging evaluation. *Laryngoscope* **106** (2 Pt 1)**:**174–180, 1996
6. Cardenas-Camarena L, Lacouture AM, Tobar-Losada A: Combined gluteoplasty: Liposuction and lipoinjection. *Plast Reconstr Surg* **104:**1524–1533, 1999
7. Carpaneda. Study of aspirated adipose tissue. *Aesth Plast Surg* **20:**399–402, 1996
8. Carson M, Lewis M: The current status of autologous fat grafting. *Aesth Plast Surg* **17:**109–112, 1993
9. Chajchir A: Fat injection: Long-term follow-up. *Aesth Plast Surg* **20:**291–296, 1996
10. Chajchir A, Benzaquen I: Fat-grafting injection for soft-tissue augmentation. *Plast Reconstr Surg* **84:**921–934, 1989
11. De Benito J, Fernandez I, Nanda V: Treatment of depressed scars with a dissecting cannula and an autologous fat graft. *Aesth Plast Surg* **23:**367–370, 1999
12. Dominik L, Feinendegen M, Ralph W, et al.: Autologous fat injection for soft tissue augmentation in the face: A safe procedure? *Aesth Plast Surg* **22:**163–167, 1998
13. Gasparotti M, Carson M, Toledo L: *Superficial liposculpture: Manual of technique* Springer-Verlag, New York, p 134, 1993
14. Gatti JE: Permanent lip augmentation with serial fat grafting. *Ann Plast Surg* **42:**376–378, 1999
15. Grazer F, Grazer J, Sorensen C: Suction-assisted lipectomy. In: Achauer BM, Eriksson E, Guyuron B, et al. *Plastic surgery: Indications, operations, and outcomes*. 1st ed. Mosby: St Louis, MO, pp 2859–2887, 2000
16. Guerrerosantos J: Autologous fat grafting for body countouring. *Clin Plast Surg* **23:**619–631, 1996
17. Guerrerosantos J: Long-term outcome of autologous fat transplantation in aesthetic facial recontouring: Sixteen years of experience with 1,936 cases. *Clin Plast Surg* **27:**515–543, 2000
18. Guerrerosantos J: Long-term survival of free fat grafts in muscle: An experimental study in rats. *Aesth Plast Surg* **20:**403–408, 1996
19. Guerrerosantos J: Simultaneous rhytidoplasty and lipoinjection: A comprehensive aesthetic surgical strategy. *Plast Reconst Surg* **102:**191–199, 1998
20. Har-Shai Y, Lindenbaum ES, Gamliel-Lazarovich A, Beach D, Hirchouitz B: An integrated approach for increasing the survival of autologous fat grafts in the treatment of contour defects. *Plast Recontr Surg* **104:**945–954, 1999
21. Hörl H, Feller A, Biemer E: Technique for liposuction fat reimplantation and long-term volume evaluation by magnetic resonance imaging. *Ann Plast Surg* **26:**248–258, 1991
22. Huss F, Kratz G: Adipose tissue processed for lipoinjection shows increase cellular suvival in vitro when tissue engineering principles are applied. *Scand J Plast Reconstr Surg Hand Surg* **36:**166–171, 2002
23. Illouz Y: Study of subcutaneous fat. *Aesth Plast Surg* **14:**165–177, 1990
24. Illouz YG: Present results of fat injection. *Aesth Plast Surg* **12:**175–181, 1988
25. Illouz Y-G: History and current concepts of lipoplasty. *Clin Plast Surg* **23:**721–830, 1996
26. Johnson D, Cormack G, Abrahams P: Computed tomographic observations on subcutaneous fat: Implications for liposuction. *Plast Reconstr Surg* **97:**387–396, 1996
27. Lewis CM: Correction of deep gluteal depression by autologous fat grafting. *Aesth Plast Surg* **16:**247–250, 1992
28. Liang M, Narayanan K, Davis P: Evaluation of facial fat distribution using magnetic resonance imaging. *Aesth Plast Surg* **15:**313–319, 1991
29. Moscona R, Shoshani O, Lichtig H: Viability of adipose tissue injected and treated by different methods: An experimental study in the rat. *Ann Plast Surg* **33:**500–506, 1994
30. Murillo WL: Buttock augmentation: Case studies of fat injection monitored by magnetic resonance imaging. *Plast Reconst Surg* **114:**1606–1614, 2004
31. Nichimura T, Hashimoto H: Microvascular angiogenesis and apoptosis in the survaval of free fat grafts. *Laryngoscope* **110:**1333–1338, 2000
32. Novaes F, Dos Reis N, Baroudi R: Counting method of live fat cells used in lipoinjection procedures. *Aesth Plast Surg* **22:**12–15, 1998
33. Novaes F, Reis N, Baroundi R: Counting method of live fat cells used in lipoinjection procedures. *Aesth Plast Surg* **22:**12–15, 1998
34. Pedrosa C: *Diagnóstico por imagen*. Vol. I. 2nd ed. Mc Graw-Hill Interamericana: Madrid: 944 pages, 1998
35. Pereira LH, Radwanski HN: Fat grafting of the buttocks and lower limbs. *Aesth Plast Surg* **20:**409–416, 1996
36. Perén P, Gómez J, Guerrerosantos J: Gluteus augmentation with fat grafting. *Aesth Plast Surg* **24:**412–417, 2000
37. Pitman GH: Liposuction and Body contouring. In: Aston S, Beasley R, Thorne Ch, "*Grabb's* and *Smith's Plastic surgery*", 4th ed. Lippicon-Raven, Philadelphia, PA: pp 669–691, 1997
38. Rieck B, Schlaak S: Measurement in vivo of the survival rate in autologous adipocyte transplantation. *Plast Reconstr Surg* **111:**2315–2323, 2003
39. Saccogna PW, Werning JW, Setrakian S, Strauss M: Lipoinjection in the paralyzed feline vocal fold: Study of graft survival. *Otolaryngol Head Neck Surg* **117:**465–470, 1997
40. Shoshani O, Shupak A, Ullmann Y: The effect of hyperbaric oxygenation on the viability of human fat injected into nude mice. *Plast Reconstr Surg* **106:**1390–1396, 2000
41. Stampos M, Xepoulias P: Fat transplantation for soft tissue augmentation in the lower limbs. *Aesth Plast Surg* **25:**256–261, 2001

42. Thomas E, Saeed N, Hajnal J: Magnetic resonance imaging of total body fat. *J Appl Physiol* **85:** 1778–1785, 1998
43. Toledo LS: Syringe liposculpture: A two year experience. *Aesth Plast Surg* **15:**321–326, 1991
44. Trapp RG, Dawson-Saunders B: *Bioestadística médica*. 1st ed. Manual Moderno: Mexico, DF: 403 pages, 1997
45. Viterbo F, Marqués M, Valente M: Fat-tissue injection versus graft: Experimental study in rabbits. *Ann Plast Surg* **33:**184–192, 1994