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Clinical Evaluation of 310 Abdominoplasties and Measurement of Scar Level

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Background: Most published studies on abdominoplasty focus on methods to reduce the risk of seromas. These methods include limited dissection (lipoabdominoplasty), quilting sutures, and preservation of the Scarpa fascia. Quantitative evaluation of the aesthetic result has been lacking.

Methods: A retrospective study was undertaken of all patients undergoing abdominoplasty in the author's practice from 2016 to 2022. A full abdominoplasty was performed, usually with liposuction (87%). All patients were treated under total intravenous anesthesia without paralysis or prone positioning. A single closed suction drain was removed 3 or 4 days after surgery. All procedures were performed as outpatients. Ultrasound surveillance was used to detect any deep venous thromboses. No patient received chemoprophylaxis. The operating table was flexed, often to 90°. Deep fascial anchoring sutures were used to attach the Scarpa fascia of the flap to the deep muscle fascia. Measurements of the scar level were made at intervals after surgery up to 1 year.

Results: Three hundred ten patients were evaluated, including 300 women. The mean follow-up time was 1 year. The overall complication rate, which included minor scar deformities, was 35.8%. Five deep venous thromboses were detected. There were no hematomas. Fifteen patients (4.8%) developed seromas that were successfully treated by aspiration. The mean vertical scar level 1 month after surgery was 9.9 cm (range, 6.1–12.9 cm). There was no significant change in scar level at subsequent follow-up times up to 1 year. By comparison, the scar level in published studies ranged from 8.6 to 14.1 cm.

Discussion: Avoidance of electrodissection reduces tissue trauma that causes seromas. Flexed patient positioning during surgery and deep fascial anchoring sutures are effective in keeping the scar low. By avoiding chemoprophylaxis, hematomas can be avoided. Limiting the dissection (lipoabdominoplasty), preserving the Scarpa fascia, and adding quilting (progressive tension) sutures are unnecessary.

Conclusions: Total intravenous anesthesia offers important safety advantages. Avoiding electrodissection is effective in keeping seroma rates at a tolerable level (5%), and the scar low and more easily concealed. Alternative methods present disadvantages that may contribute to a suboptimal aesthetic result and require additional operating time.

Key Words: abdominoplasty, anchoring sutures, chemoprophylaxis, deep venous thrombosis, flexed positioning, hematoma, lipoabdominoplasty, quilting sutures, progressive tension sutures, scar level, Scarpa fascia, seroma, total intravenous anesthesia

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Most recent publications on abdominoplasty focus on reducing the risk of complications, particularly seromas.[1–55] Outcome surveys have been published, documenting a high level of patient satisfaction and improved quality of life after traditional abdominoplasty,[56–62] especially when combined with liposuction.[58,59] However, few studies assess aesthetic outcomes using measurements.

A panniculectomy is undertaken to remove a large pannus to improve function, including mobility and hygiene.[46] An abdominoplasty is primarily an aesthetic procedure, undertaken to improve the appearance of the abdomen.[46,50] Excess skin and fat are removed, and the muscle wall is usually tightened to improve the abdominal contour, while minimizing visible scarring and leaving a natural-appearing umbilicus.[27,31,55] Although historically abdominoplasty patients have been hospitalized for 1 to 4 days,[35] this procedure is frequently performed today on outpatients.[25]

The main drawback of abdominoplasty is the scar, which typically runs from hip to hip. Many women considering this procedure are concerned about the appearance of such a long scar. Studies have shown that if the scar is located inferiorly, within the panty line, scar dissatisfaction is low (4.3%).[59] Flexed positioning in surgery and deep fascial anchoring sutures assist in keeping the scar low and avoiding upward scar migration.[25]

Numerous methods have focused on ways to reduce the incidence of seromas. Lipoabdominoplasty (ie, a limited abdominoplasty "tunnel" dissection with liposuction) has received a great deal of attention in the literature since its first publication 20 years ago.[2] Scarpa fascia preservation is advocated by several authors.[10,23,33,34,44,47–49,54] Many surgeons have adopted quilting (or progression tension) sutures.[1,6,7,12,22,36,37,39,52,53,55] A largely overlooked alternative approach is to avoid electrodissection and reduce the potential for an inflammatory exudate to collect and create a seroma.[25]

This study was undertaken to evaluate the clinical outcome of a full abdominoplasty, in combination with liposuction and other procedures, including the seroma rate. In addition, the vertical level of the abdominoplasty scar was evaluated. The scar level was compared with measurements on published photographs from studies using other methods.

PATIENTS AND METHODS

Patients

A retrospective study was undertaken among consecutive abdominoplasty patients who underwent surgery between January 2016 and November 2022. Before initiation of the study, a waiver was obtained from the Advarra Institutional Review Board, accredited by the Association for the Accreditation of Human Research Protection Programs. Clinical data were tabulated for all patients. The inclusion rate was 100%; no patients were excluded from the study. Patients underwent preoperative ultrasound examinations of the abdomen to identify any possible fascial defects or hernias, along with ultrasonic assessment of the deep veins of the lower extremities.[63]

Abdominoplasty was recommended for treatment of abdominal skin redundancy and musculofascial laxity, usually in combination with liposuction of the abdomen and flanks and other body areas. Patients treated with simultaneous lower body lifts (ie, abdominoplasty plus outer/thigh buttock lifts)[64] were included.

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Surgery

All procedures were performed by the author at the Surgery Center of Leawood, a state-licensed ambulatory surgery center. All patients were discharged the same day. Preoperative marking was performed with the patient in a standing position wearing photo panties (see video, Supplemental Digital Content 1, http://links.lww.com/SAP/A822, which demonstrates preoperative marking). The lower incision marking was made as a gentle concave line, coursing below any existing abdominal scar. The lower incision was marked so that the scar would fall within the panty line. Some patients brought their bikini bottoms to assist in marking.

Patients underwent a standing preparation using chlorhexidine. Total intravenous anesthesia was administered, with a laryngeal mask airway. No muscle relaxants or anesthetic gas were used. Patients breathed spontaneously during surgery. Sequential compression devices were routinely applied until July 2016, when they were discontinued. All patients underwent ultrasound surveillance for deep venous thromboses with Doppler ultrasound scans before surgery, the day after surgery (or in some cases the same day after surgery), and approximately 1 week after surgery.[63] Chemoprophylaxis was not prescribed. If done simultaneously, breast surgery was performed first to optimize sterility for breast implant placement.

Patients were first positioned supine on the operating table. The abdomen was infused with up to 1 L of normal saline containing 0.025% bupivacaine and 1:500,000 epinephrine. Liposuction of the epigastrium, and often the pubic area and inner thighs, was performed first, followed by the abdominoplasty (see video, Supplemental Digital Content 2, http://links.lww.com/SAP/A823, which demonstrates the abdominoplasty and rectus diastasis repair).

A concave incision was made within the bikini line, with elevation of the flap to the level of the costal margins, maintaining lateral blood supply to the flap. No attempt was made to limit the dissection to a tunnel or preserve medial row perforators. Rectus muscle plication was performed using 2 layers of monofilament polypropylene sutures (0 Prolene; Ethicon, Somerville, NJ). The operating table was flexed up to 90° to facilitate wound closure (Fig. 1). The wound was closed in 3 layers using absorbable braided polyglactin sutures (2-0 Vicryl) to anchor the Scarpa fascia of the upper abdominal flap to the lower Scarpa fascia, with an additional bite of the deep rectus muscle fascia centrally to anchor the flap, reduce skin tension, and prevent upward scar migration (Fig. 2). Deep dermis approximation was accomplished with interrupted 3-0 Vicryl sutures, followed by an intradermal 4-0 Monocryl suture. A single closed suction drain, exiting the right side of the abdominoplasty incision (not a separate incision), was inserted.

After the abdominoplasty, in patients undergoing simultaneous liposuction, the patient was turned from side to side on the operating table. Patients were never positioned prone. Other body areas (flanks, outer thighs, arms, axillae, knees) were infused in a superwet fashion using 0.05% lidocaine and 1:500,000 epinephrine and then treated with liposuction in the same sequence. In patients undergoing simultaneous buttock fat injection, the fat was injected after completion of liposuction, turning the patient from side to side and injecting from a lateral approach into the subcutaneous plane. Facial procedures were done after body contouring.

Postoperative Care

In men, the garment was simply a Velcro binder. In women, who often underwent liposuction of the thighs, an above-knee or below-knee girdle was applied. Patients were seen in office the day after surgery. The dressing was removed. Doppler ultrasound examination of the lower extremities was performed (see video, Supplemental Digital Content 3, http://links.lww.com/SAP/A824, which demonstrates a patient seen in follow-up 24 hours after surgery). The drain was removed at the next appointment 3 or 4 days after surgery.

Measurements

Measurements were performed on photographs of women who were seen in follow-up at least 1 month after surgery. Male patients were not evaluated with measurements simply because this measurement is not possible in men. All photographs were taken in the same room, with identical lighting, blue background, photo panties, 60-mm lens, camera (Nikon Digital; Nikon, Tokyo, Japan), and distance from the camera to the patient (Figures 3 and 4). The same patient position was used, with the hands held above the head. A ruler was included in 1 of the photographs for the purpose of calibration. The images were later matched for size and orientation using the Canfield 7.4.1 Mirror imaging software (Canfield Scientific, Fairfield, NJ). Measurements were made from the lowest point of the (covered) perineum to the midline level of the abdominoplasty scar. To gauge the desired bikini level, photographs of 10 supermodels wearing bikinis were also evaluated, googling "bikini supermodels," and using a 32-cm hip width for calibration.

To compare the scar level among different methods, the same measurement method was applied to published photographs, using a 34-cm hip width for calibration.[66] When more than 1 set of photographs was available, the first set of published photographs was selected.

Statistical Analysis

A repeated-measures analysis of variance was computed among measurements at 3 time points: 1, 3, and 6 months. The analysis was rerun for a smaller subsample using 4 time points: 1, 3, and 6 months and 1 year. Results of pairwise comparisons with Bonferroni adjustment are reported. Only patients with data at all 3, or 4, time points were included. A χ^2 test was used to compare categorical variables. $P < 0.05$ was considered significant.

RESULTS

Patient data are reported in Table 1. There were 300 women and 10 men. The mean follow-up time was 12 months (range, 1 day to 6 years). Follow-up times refer to the time between the surgery and the most recent office visit. In some cases, out-of-town patients were not seen in follow-up in the office, accounting for follow-up times of as little as 1 day. These patients were followed up with telephone calls and emails. Electronic communications were not counted in the follow-up times.

The mean liposuction aspirate volume was 1169 mL (range, 50–3950 mL). The mean abdominoplasty flap weight was 1404 g (range, 54–5443 g). The mean operating time was 3 hours 20 minutes, including other procedures performed simultaneously. Only 11 patients underwent an abdominoplasty without any other procedure (mean operating time, 88 minutes). Most patients (87%) had liposuction (Table 2). Many patients had simultaneous cosmetic breast (45%) or facial (22%) procedures. Twenty-five patients (8%) underwent an abdominoplasty as part of a near-circumferential lower body lift.[64] Simultaneous buttock fat injection was frequently performed (37%) (see videos, Supplemental Digital Content 4, http://links.lww.com/SAP/A825, which demonstrates the outer thigh lift and buttock fat injection, and Supplemental Digital Content 5, http://links.lww.com/SAP/A826, the full-length video showing preoperative marking, lower body lift, and 24-hour follow-up, appointment). Accurate superficial placement of fat was confirmed in a previous study using intraoperative ultrasound.[67]

Complications

The overall complication rate was 35.8% (Table 3). Five deep venous thromboses were detected by ultrasound in the office, one on the day after surgery and the others between 6 and 10 days after surgery. Three of these complications were reported previously in a series of 1000 ultrasound scans[63]; 1 was reported in a later case report[68]; and 1 occurred subsequently. Four thromboses involved the calf veins without

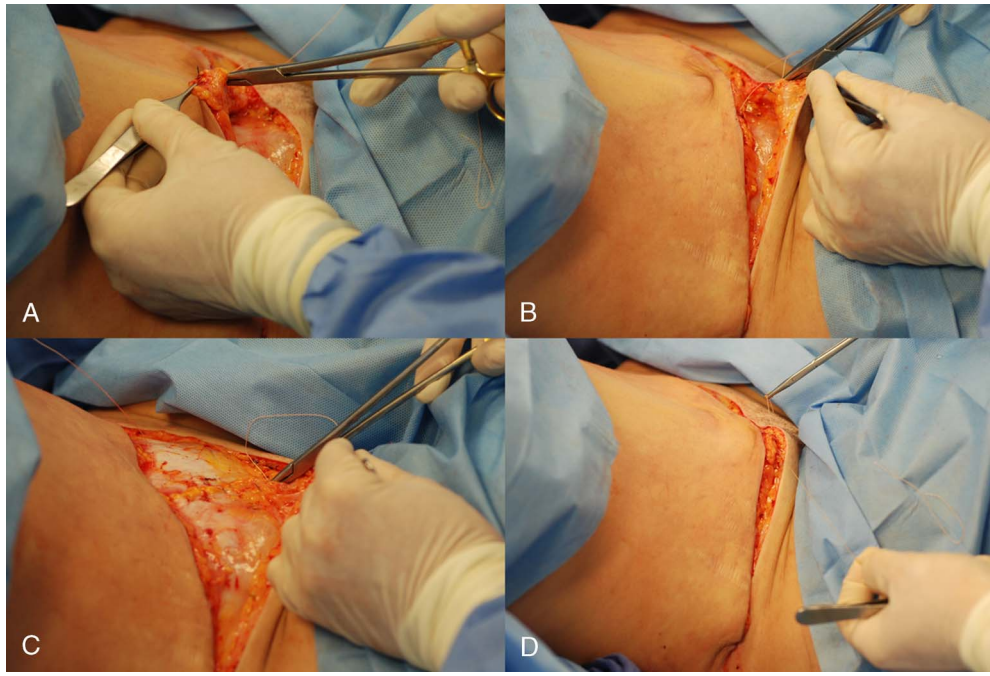

FIGURE 1. Intraoperative photographs of a 34-year-old woman undergoing abdominoplasty. A, The operating table is flexed 80°. B, A 2-0 Vicryl (Ethicon, Bridgewater, NJ) suture is anchored to the deep fascia. C, The suture is passed through the Scarpa fascia of the abdominal flap. D, The deep fascial suture provides secure fixation and limits skin tension. Reprinted from Swanson.[25]

proximal propagation. Two patients were asymptomatic and had no asymmetrical leg swelling. One patient simply had a sore ankle. One patient experienced a small pulmonary embolism 2 days after detection of an asymptomatic deep venous thrombosis (without leg swelling) and initiation of anticoagulation in the form of rivaroxaban 15 mg by mouth twice a day.[68] All 5 patients were followed up with regular ultrasound

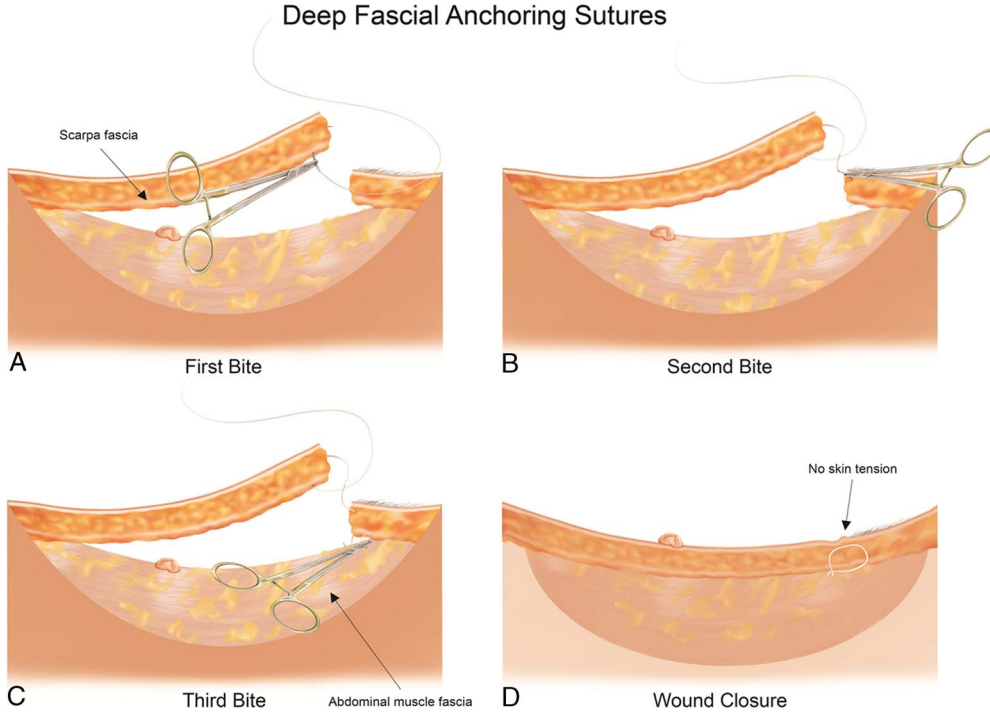

FIGURE 2. A, A 2-0 Vicryl suture is used to provide deep fascial anchoring, starting with an inverted bite of the Scarpa fascia on the margin of the abdominoplasty flap, followed by (B) a second bite in the corresponding Scarpa fascia of the pubic resection margin. C, A third bite of the abdominal muscle fascia secures the flap to a dense connective tissue (D), alleviating skin tension and preventing upward skin and scar migration. Reprinted from Swanson.[65]

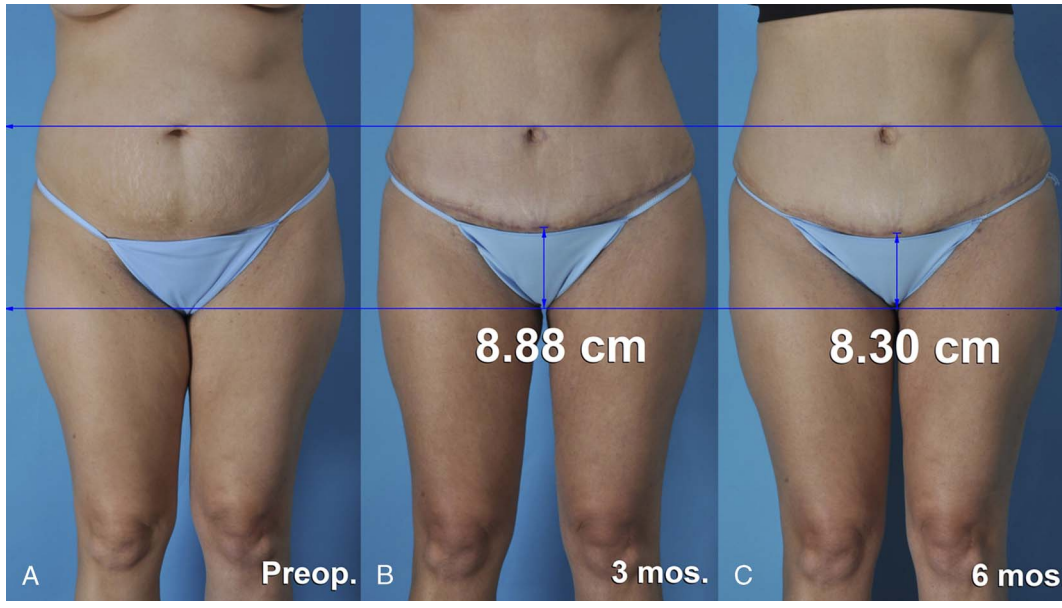

FIGURE 3. This 35-year-old woman underwent an abdominoplasty and liposuction of the abdomen, flanks, inner and outer thighs, knees, arms, and axillae. The resection weight was 1330 g, and the liposuction aspirate volume was 2400 mL. A–C, She is shown before, 3 months, and 6 months after surgery. The scar level is 0.6 cm lower at the 6-month visit.

scans and made a full recovery with complete resolution of their deep venous thromboses and no sequelae. There were no deaths. None of the patients developed a hematoma. Fifteen patients (4.8%) developed seromas requiring aspiration. Sixty-two patients (20.0%) underwent scar revisions, removal of a palpable suture, or repair of a persistent umbilical hernia.

Among the 15 patients who underwent needle aspirations of a seroma in the office, the mean number of aspirations was 3.5 (range, 1–7). The first aspiration took place, on average, 11.6 days after surgery (range, 8–15 days); the last aspiration averaged 21 days after surgery (range, 8–38 days). The mean aspirate volume was 112 mL (range, 5–700 mL).

Measurements

One hundred ninety-seven women (65.7%) were available for photographs 3 months after surgery. Fewer women were photographed at 1 and 6 months (41.0% and 29.0%, respectively). The mean height of the abdominoplasty scar 1 month after surgery was 9.90 cm (range, 6.14–12.92 cm). The mean scar levels at 3 and 6 months were 9.70 and

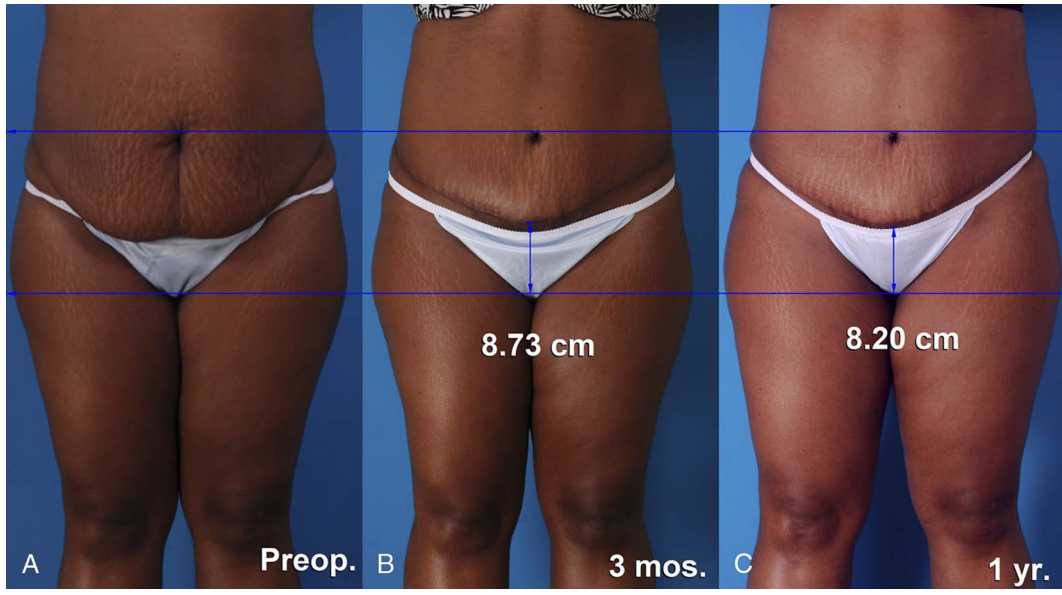

FIGURE 4. This 40-year-old woman underwent an abdominoplasty and liposuction of the abdomen, flanks, arms, and axillae. The resection weight was 1814 g, and the liposuction aspirate volume was 650 mL. A–C, She is shown before, 3 months, and 1 year after surgery. The scar level is unchanged.

TABLE 1. Patient Data for 310 Consecutive Abdominoplasty Patients

Parameter	Value (%)
Age, y	
Mean	42.4
Range	21–69
Follow-up time, mo	
Mean	12.0
Range	0.3–71.1
Sex	
Female	300 (96.7)
Male	10 (3.3)
Smoking status	
Nonsmoker	275 (88.7)
Smoker	35 (11.3)
Previous abdominoplasty	
No	307 (99.0)
Yes	3 (1.0)
Preoperative BMI, kg/m^2	
Mean	28.1
Range	18.5–41.1
Lipoaspirate volume, mL	
Mean	1169
Range	50–3950
Flap weight, g	
Mean	1404
Range	54–5443
Operating time,* min	
Mean	202
Range	75–412

*Total operating time, including other simultaneous surgery.
BMI, body mass index.

TABLE 2. Simultaneous Procedures for 310 Consecutive Abdominoplasties

Procedure	n (%)
Facial procedures	
Any	68 (22)
Fat injection	30
Submental lipectomy	19
Facelift	4
Breast surgery	
Any	140 (45)
Breast augmentation	28
Mastopexies	8
Augmentation/mastopexies*	77
Breast reduction	5
Body surgery	
Any	283 (91)
Liposuction	
Any area	270 (87)
Abdomen	261
Flanks	227
Thighs	144
Axillae	122
Arms	108
Knees	78
Calves	5
Buttock fat injection	114 (37)
Outer thigh and buttock lift	25
Inner thigh lift	24
Brachioplasties	20

*Includes breast reduction (>300 g per breast) plus implants.

9.79 cm, respectively. Among a smaller number of patients with values available at 1 year (14.3%), the mean scar level was 9.92 cm. Two subsets of patients underwent analyses of variance (Figs. 5 and 6). The first comparison was among women with measurements available at 1, 3, and 6 months (n = 65). The second comparison was a subset of this one, evaluating women who also returned at 1 year, so that 4 time points were available (n = 26). There was no significant difference in scar level at the various postoperative times. Among supermodels, the bikini typically covered less than 10 cm of the pubic height (mean, 7.5 cm; range, 6.0–9.2 cm) (Fig. 7).

Many publications did not include photographs that allowed measurement of the scar level, because photographs either were missing,[4–7,9,12,14,17,20,21,23,29–32,34,35,37–39,41,42,44–47,52–59] were overcropped,[8,10,16,18,51,61] did not show the scar,[50] or were slightly out of focus.[43] Photographs in additional articles by the same authors were not measured.[1,2,11,13] In 15 publications, suitable photographs were available (Table 4).[3,15,19,22,24–28,33,36,40,48,49,60] The scar level ranged from 8.6 to 14.1 cm.

DISCUSSION

A recent study by Saldanha et al[48] concluded that, in the opinion of the senior author, the aesthetic result from lipoabdominoplasty is superior to the result from the traditional technique. However, no measurement data or survey responses were offered to support this opinion. Unlike breast surgery, which has been subjected to measurements for decades (the most basic measurement being the suprasternal notch-nipple distance), abdominoplasties have largely escaped quantitative evaluation

TABLE 3. Complications in 310 Abdominoplasty Patients

	No. (%)
Complications*	
No	199 (64.2)
Yes	111 (35.8)
Local	
Scar deformity	53 (17.1)
Delayed wound healing	21 (6.8)
Seroma	15 (4.8)
Cellulitis/infection	15 (4.8)
Palpable suture	6 (1.9)
Wound dehiscence	4 (1.3)
Persistent umbilical hernia	1 (0.3)
Scrotal edema	1 (0.3)
Radial neuropraxia	1 (0.3)
Systemic	
Deep venous thrombosis	5 (1.6)
Pulmonary embolism	1 (0.3)

*Eight patients had 2 complications, and 2 patients had 3 complications.

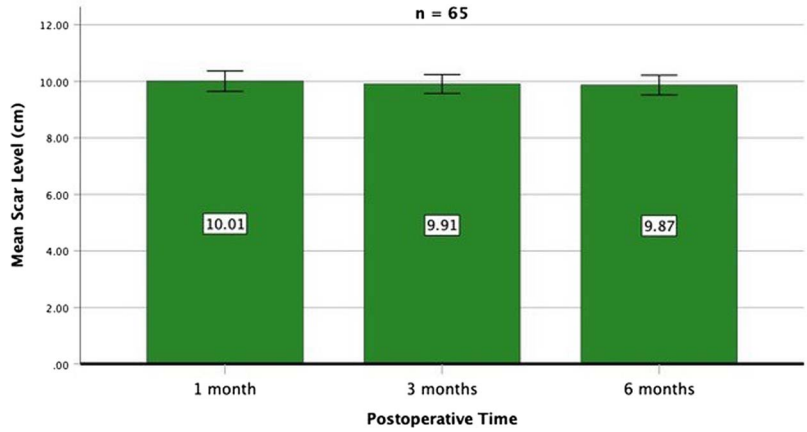

FIGURE 5. The vertical level of the abdominoplasty scar at the midline is compared at 3 time intervals after surgery, 1, 3, and 6 months, among the 65 female abdominoplasty patients who had photographs available at all 3 times.

of the aesthetic result. At present, there is no information regarding postoperative scar level and any possible change in the scar level over time. This study was undertaken to fill this deficiency in our knowledge base and to gather clinical data, particularly complications, and compare these data with other methods.

Advantages of this study design include a reasonably large patient population (n = 310), a 100% inclusion rate, and a quantitative measurement of a key aesthetic consideration—scar placement. The same surgeon performed all cases, minimizing confounding variables. By comparison, another series of an almost identical size (n = 306) featured cases performed by 23 different surgeons.[46] An outcome study using the same technique has been published previously, providing patient-reported outcome data.[59] This method has also been subjected to laser fluorescence imaging to evaluate perfusion of the abdominal skin.[30]

Abdominoplasty Scar Level

An abdominoplasty scar that is higher than the panty level is a cosmetic concern for women who may not be able to wear a bikini because the scar is exposed (Figs. 8–10), or they are forced to wear bikinis that cover half or more of the lower abdomen (Fig. 9). Upward tension on the perineum can displace pubic hair onto the lower abdomen (Fig. 9). This is especially of concern in modern culture, which puts a premium on a toned and exposed abdomen. Ironically, the lipoabdominoplasty method, which can leave a high scar (Fig. 8), has been popularized in Brazil,[11,48] a country that is not known for modest bikinis (Fig. 7).

Plastic surgeons typically perform marking to ensure that the skin take-out between the incision that courses just above the umbilicus and the lower incision is not too wide. Otherwise, there will be excessive skin tension on the closure. It may not be possible to remove the opening made for the umbilicus, so that a midline vertical scar is needed.[19,41] However, a vertical midline scar compromises the aesthetics of the lower abdomen (Fig. 11).[51] Ideally, no vertical scar should be present on the abdomen.[65] When the scar is located within the panty line, patient satisfaction is very high.[59] Patients tolerate a long scar, provided it is concealed.

It is generally acknowledged that the umbilical orientation should be neutral or slightly downward.[41,65] An umbilicus that opens upward appears unnatural and can create a hygiene issue. Methods that incorporate a limited dissection, Scarpa fascia preservation, or quilting sutures often leave the umbilical opening well above its original location (Figs. 8–10).

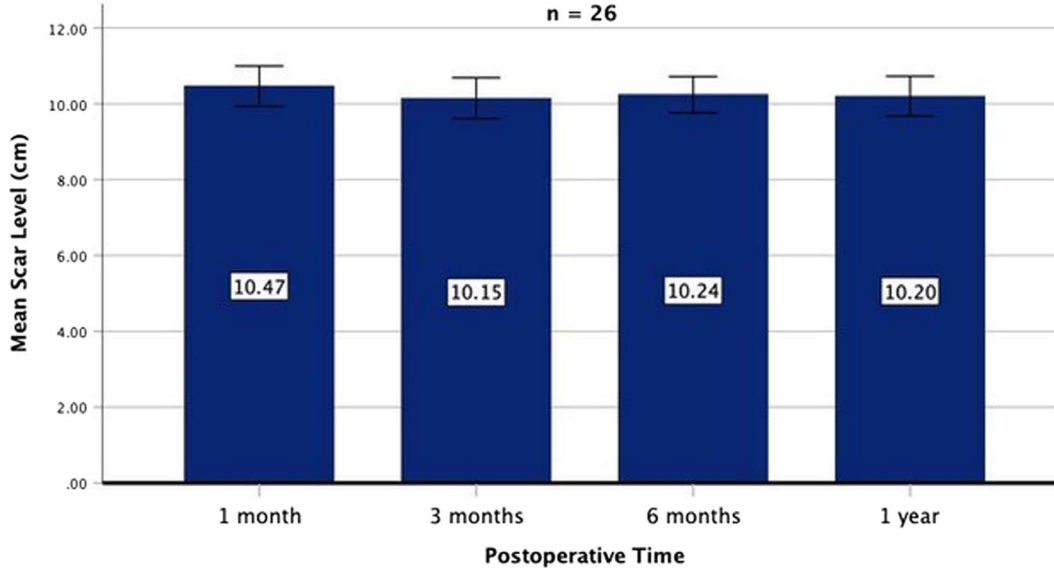

FIGURE 6. The vertical level of the abdominoplasty scar at the midline is compared at 4 time intervals after surgery, 1, 3, and 6 months and 1 year, among a subset of 26 women who had photographs available at all 4 times.

FIGURE 7. Bikini level in a Brazilian supermodel. A hip width of 32 cm is used for calibration.

To consistently locate the scar within the panty line, the author uses a combination of flexed intraoperative patient positioning and deep fascial anchoring sutures (Figs. 1 and 2).[25] The incision is always made inferior to any existing scar on the lower abdomen, such as an old cesarean section scar. A midline vertical incision is always avoided. The degree of intraoperative hip flexion is often 90° (Fig. 1). This degree of table flexion is created by tilting the operating table to raise the lower extremities 45° and raising the back the same amount. Quilting sutures would be difficult or impossible to perform with a patient in a jackknife position.[65] This issue is not as important in patients with a large apron of redundant abdominal tissue. Maximum intraoperative table flexion and anchoring sutures are essential in lean patients with minimal to

TABLE 4. Scar Level After Abdominoplasty in 15 Published Studies

Authors	Year of Publication	Figure	Age, y	Technique	Postoperative Time, mo	Scar Level,* cm
Cárdenas Restrepo and García Gutiérrez[3]	2004	4	36	Abdominoplasty, trunk liposuction	16	10.93
Trussler et al[15]	2010	5	N.A.	Abdominoplasty, flank liposuction	24	11.85
Weiler et al[19]	2010	3	36	Lipoabdominoplasty	6	11.70
Pollock and Pollock[22]	2012	7	35	Abdominoplasty, hip liposuction, progressive tension sutures	3	14.09
Neaman et al[24]	2013	1	48	Full abdominoplasty, flank liposuction	11	12.91
Swanson[25]	2013	4	29	Abdominoplasty, liposuction, anchoring sutures	60	9.69
Villegas[26]	2014	2	30	TULUA	17	8.63
Matarasso et al[27]	2014	12	35	Abdominoplasty, liposuction of back rolls	N.A.	12.21
Di Martino et al[28]	2015	8	N.A.	Standard abdominoplasty, no liposuction	1	8.89
Costa-Ferreira et al[33]	2016	13	43	Full abdominoplasty, flank liposuction, Scarpa fascia preservation	24	11.04
Isaac et al[36]	2017	11	52	Drainless abdominoplasty, barbed progressive tension sutures	6	9.87
Hoyos et al[40]	2018	8	38	High-definition lipoabdominoplasty	12	8.81
Papadopulos et al[60]	2019	3	N.A.	Abdominoplasty	6	12.12
Saldanha et al[48]	2020	10	36	Lipoabdominoplasty, Scarpa fascia preservation	6	10.25
Torres-Silva et al[49]	2021	8	30	Full abdominoplasty, Scarpa fascia preservation, flank liposuction	35	10.88

*A 34-cm hip width was used for calibration.

TULUA, transverse plicature, no undermining, unrestricted liposuction, neoumbilicoplasty, abdominoplasty.

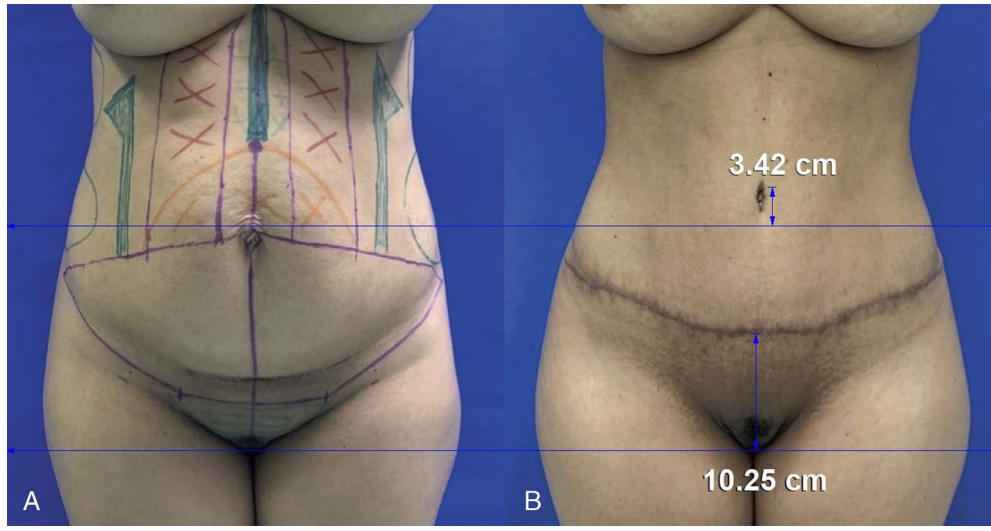

FIGURE 8. A and B, This 36-year-old woman underwent a lipoabdominoplasty with Scarpa fascia preservation. She is shown before and 6 months after surgery. The photographs have been matched for size and orientation using the Canfield 7.4.1 Mirror imaging software. A 34-cm hip width was used for calibration. The scar level is 10.25 cm. The umbilicus has moved superiorly. Adapted from Saldanha et al.[48]

moderate skin redundancy, a high-riding umbilicus, or secondary abdominoplasties. The deep fascial anchoring sutures are used to apply tension to the Scarpa fascia layer, "anchoring" it to the deep muscle fascia (aponeurosis) of the rectus abdominis (Figs. 1 and 2). Skin tension is avoided, optimizing scar quality and avoiding traction pulling the hair-bearing pubic skin up onto the abdomen.

Although up to 3 weeks may be needed for a woman to resume a fully erect posture after maximum hip flexion during surgery,[59] patients readily accept this temporary inconvenience as a worthwhile trade for a low scar and elimination of any need for a vertical scar. Measurement data show that these intraoperative measures are successful in locating the scar within the panty line (Figs. 3–6). Measurements up to 1 year after surgery show no tendency for the scar to migrate superiorly (Fig. 6).

In the lipoabdominoplasty technique,[11] the Scarpa fascia is preserved on the lower abdominal wall. Wound closure is achieved by suturing a superficial fascial layer together. An aesthetic concern is

FIGURE 9. A and B, This 30-year-old woman underwent a full abdominoplasty with Scarpa fascia preservation and flank liposuction. She is shown before and 35 months after surgery. She also had a thigh lift 15 months after her abdominoplasty. The photographs have been matched for size and orientation. The scar level is 10.88 cm. The pubic skin and hair have been pulled up onto the lower abdomen. The umbilicus has moved superiorly. Her tan line shows that the scar is concealed, but the bikini covers more than half of the abdomen below the umbilicus. Adapted from Torres-Silva et al.[49]

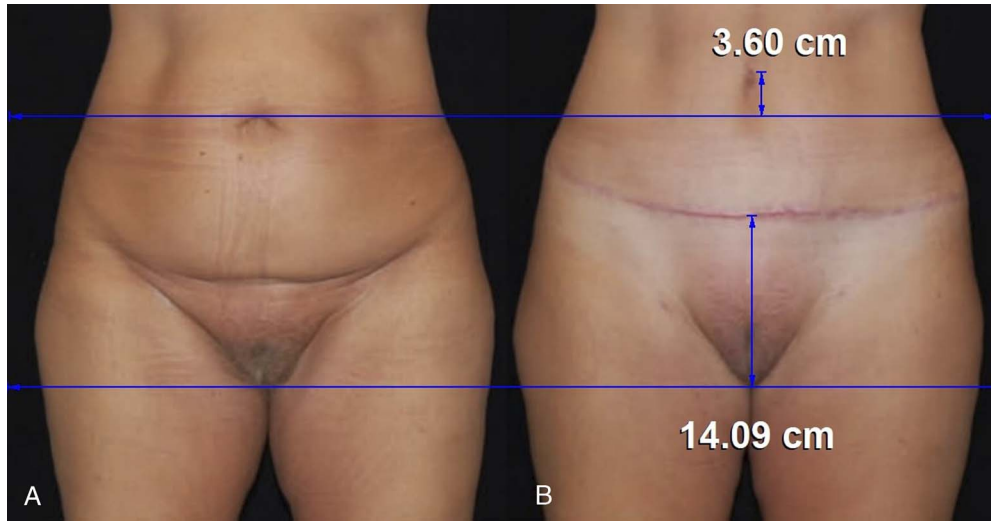

FIGURE 10. A and B, This 35-year-old woman underwent an abdominoplasty, hip liposuction, and progressive tension sutures. She is shown before and 3 months after surgery. The photographs have been matched for size and orientation. The scar level is 14.09 cm. The umbilicus has moved superiorly. Adapted from Pollock and Pollock.[22]

the additional volume that is left on the abdominal wall and more limited mobility of the abdominal flap (Fig. 12). The lipoabdominoplasty procedure does not include deep fascial anchoring sutures.[11] Additional skin is resected, done during closing. However, this maneuver does not seem to be effective in lowering the scar (Fig. 8).

Simultaneous liposuction of the abdomen is commonly performed. Recent studies recommend "high-definition liposuction" of the abdominal flap to enhance the underlying muscle anatomy.[40,48,50] It has not been shown that a simulation of rectus muscle definition can be created in the abdominal flap by liposuction: any attempt to do so is likely to jeopardize the skin blood supply and cause flap morbidity. Horizontal lines are not attempted.[48] Hoyos et al[40] report a high rate of secondary procedures after high-definition lipoabdominoplasty; 50% of patients require a delayed neoumbilicoplasty. Ramirez et al[50] express concern that overtreatment may masculinize the abdomen in women. Saldanha et al[48] caution against "stigmatized results that pretend to simulate muscular hypertrophy."

Venous Thromboembolism Prevention

Some surgeons intentionally limit the degree of operating table flexion during surgery.[58] It is believed by some investigators that table flexion may cause undue compression on the large veins of the lower extremities, possibly causing venous stasis and increasing the risk of deep venous thrombosis.[69,70] Some authors advise caution in repairing the rectus fascia for the same reason.[69,70] Huang et al[71] reported a temporary increase in intra-abdominal pressure after rectus abdominis plication. However, the pressure returned almost back to the preoperative pressure the next day. All pressures were <20 mm Hg, considered clinically unimportant.[71] There was no significant difference comparing pressures between abdominoplasty patients and a control group of breast reduction patients at any time before, during, or after surgery. A recent case-control analysis reported no greater risk of venous thromboembolism in patients who underwent diastasis repair.[72] A temporary increase in intra-abdominal pressure is probably not clinically relevant in healthy adults.[73] However, caution is needed in patients with a compromised respiratory status from smoking or chronic obstructive pulmonary disease[73] or obesity. Anesthesia (discussed below) is an important consideration for these patients.

The author has been using Doppler ultrasound in all patients since 2013,[74] including the 310 abdominoplasty patients in this study. Only 1 patient developed a deep venous thrombosis diagnosed on a scan the day after surgery.[63] This patient was found to have May-Thurner syndrome, a congenital compression of the left common iliac vein from the right common iliac artery. Clinical and ultrasound evidence supports both rectus abdominis plication and flexed intraoperative positioning as safe in abdominoplasty patients.[63] This is a fortunate finding because both maneuvers are helpful in optimizing the surgical outcome, by reducing abdominal protuberance and lowering the scar. Compression garments have also been implicated in venous thromboembolism risk.[69,70] Ultrasound evaluations show that the use of a compression garment, which was worn postoperatively by all patients, is also safe.[63]

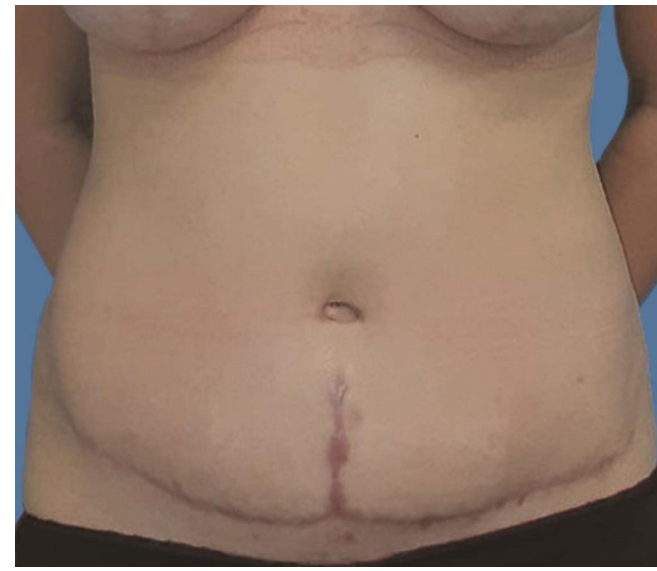

FIGURE 11. This 35-year-old woman underwent an abdominoplasty with diastasis repair and a laparoscopic umbilical hernia repair. The authors found it necessary to include a vertical scar to achieve wound closure. Adapted from Person et al.[51]

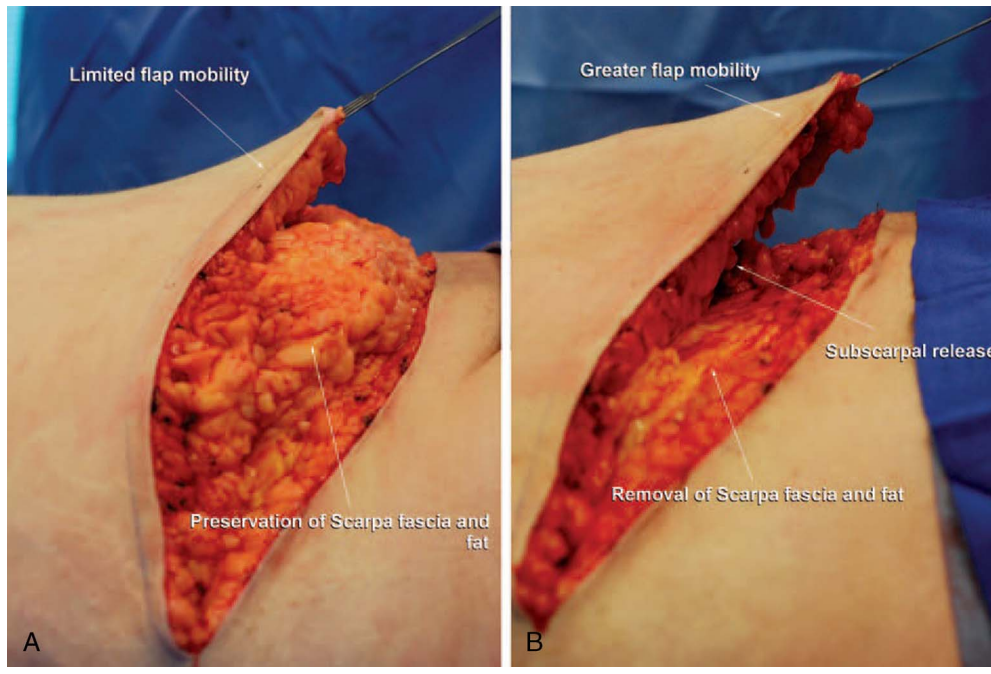

FIGURE 12. A and B, Lateral intraoperative photographs compare the limited and full dissections in the same patient. The retained Scarpa fascia and fat leave bulk on the abdominal wall, compromising the degree of flattening of the lower abdomen and creating a longer distance for the upper abdominal flap to travel. After conversion to a full dissection, the abdominal wall is flat, and the flap has greater mobility. Reprinted from Swanson.[30]

Although many factors have been implicated in venous thromboembolism risk, such as age, abdominoplasty, combined procedures, and operating time, a rigorous study of 1000 consecutive cosmetic surgery outpatients who were all screened for deep venous thromboses using ultrasound found that only age persisted as an independent risk factor on logistic regression.[63] Sequential compression devices did not reduce risk.[63] A separate level 1 randomized study revealed no fibrinolytic benefit.[75] Accordingly, the author has abandoned the use of sequential compression devices.

To minimize blood loss, the author uses 1:500,000 epinephrine concentrations in infusion solutions (<4 L) and limits liposuction aspirate volumes (<4 L). Blood loss from abdominoplasty is reduced by thorough infusion of wetting solution before the dissection.[76] The operating room temperature is kept warm (ie, 75°F). Warmed fluids and blankets and a Bair Hugger (Arizant, Inc, Eden Prairie, MN) are also used to avoid hypothermia. Age is obviously not a modifiable risk factor. The most important consideration in reducing the risk of venous thromboembolism is avoiding muscle paralysis in surgery and preserving the calf muscle pump.[77]

Performing concomitant cosmetic procedures is commonly done by plastic surgeons.[25,29,56] However, surgeons need to be knowledgeable of expected blood loss for these procedural combinations.[76] Plastic surgeons need to be both proficient and efficient in performing the procedures individually before offering them in combination.

Anesthesia and Patient Positioning

An important advantage in using total intravenous anesthesia without paralysis is spontaneous breathing. The patient is not on a ventilator. The rectus diastasis may be repaired while the patient is breathing spontaneously, with no muscle paralysis. Any change in respirations can alert the operator that the repair might be too tight.[78] Using a laryngeal mask airway, the anesthetist is able to gauge anesthetic administration by peripheral stimulation rather than tolerance of an endotracheal tube. Spontaneous breathing makes the respiratory rate available so that intraoperative anesthesia (propofol) and opioid (fentanyl) administration can be titrated closely. Both pain and respiratory rate are clinical signs that are unavailable if general endotracheal anesthesia is used. Avoiding mechanical ventilation has other safety advantages, including avoidance of respiratory alkalosis from overventilation and secondary hypokalemia.[76] The fewer physiological alterations during surgery, the better.

Patients are never positioned prone, which is the least desirable position for patient breathing and airway access, in addition to the extra time commitment for patient repositioning and the inevitable break in sterility. Some anesthesia providers may need to be introduced to the merits of total intravenous anesthesia; many will be favorably inclined if they no longer need to ventilate patients in a prone position.

Adequate regional anesthesia is essential. Administration of (nonliposomal) bupivacaine in a wetting solution allows the anesthetic to permeate tissues planes easily, including the rectus sheath, making subfascial injections unnecessary.[78] Bupivacaine's greater affinity for fat is an important advantage over lidocaine, in terms of both efficacy and safety (ie, more in the tissues, less in the blood). Plastic surgeons are often concerned about toxicity. This is not a problem when bupivacaine is infused in dilute form in adipose tissue. Bupivacaine is not even detected in the plasma until 4 hours after its infusion. Its plasma level rises slowly over 20 hours, never approaching toxic levels, and then gradually drops.[76]

Bupivacaine released gradually from its fat cell reservoir may act as a "physiological pain pump."[78] Adipocytes serve a natural slow-release lipid chambers, making expensive ($300 vs $6 for a 50-mL bottle of 0.5% bupivacaine) synthetic capsules (Exparel; Pacira Pharmaceuticals, Parsippany, NJ) unnecessary. Tissue perfusion of the anesthetic delivered in 1 L of infusion solution is much superior. By blocking the pain peripherally, less medication is needed centrally, which can only benefit the patient and reduce time in the recovery room, on average, to 51 minutes.[76] A reliable field anesthetic makes

time-consuming regional nerve blocks (eg, transversus abdominis plane blocks) unnecessary.[78]

Seromas

When plastic surgeons discuss seroma rates, they typically mean seromas that require treatment. The average seroma rate reported in the literature is approximately 10%.[38,45,55] An ultrasound study detected at least 20 mL of fluid in 38% of abdominoplasty patients 11 days after surgery.[28] Most clinical studies on abdominoplasty have focused on seroma prevention. The word "seroma" frequently appears in the title.[5,7,8,17,18,20,21,28,32,35,37–39,52] Remarkably, the 3 major changes in surgical method in the last 2 decades—quilting sutures, Scarpa fascia preservation, and a limited dissection lipoabdominoplasty—are all directed toward reducing the risk of this single complication and account for almost all publications on abdominoplasty.[1–55] Such a heavy emphasis on a self-limited event, to the exclusion of other more important considerations (eg, anesthetic considerations, improved safety, analysis of the aesthetic result), seems disproportionate. In the author's experience, seromas are typically managed in the office with aspirations (Fig. 13) and resolve, without any lasting effect.[25] The 4.8% seroma rate in this study is almost identical to the 5.4% seroma rate in a previous study of patients treated between 2002 and 2006.[25] This rate is sufficiently low to represent a minor nuisance. No patient required a return to the operating room for its treatment. This rate compares favorably with other series using alternative methods (range, 3.5%–32%).[65]

A major focus has been on the elimination of drains.[13,14,29,36,37] The author uses a single suction drain, which is removed 3 or 4 days after surgery regardless of drainage volume. In some cases, when there has been very little bleeding at surgery and minimal fluid accumulation in the suction bulb, the drain is removed earlier. The drain is well-tolerated by patients. The rationale for its use is to minimize the need for needle aspirations in the office. Forgoing a drain is a reasonable option; the minimal nuisance of a drain is traded for the increased likelihood of office seroma aspirations. It is not a weighty decision. Fibrin sealant has not been found to be effective in reducing seroma risk.[38]

Quilting Sutures

Quilting sutures, also called progressive tension sutures, are frequently recommended to reduce the seroma risk.[1,7,8,13,22,36–39,53,55] The sutures are used to reduce the dead space and movement of the flap on the aponeurotic layer.[53] As might be expected from the name, quilting sutures can produce dimpling.[37] Some plastic surgeons believe the evidence for their efficacy is irrefutable.[53,55,79]

FIGURE 13. This 36-year-old woman underwent an abdominoplasty and liposuction of the lower body, arms, and axillae. Fifteen days after surgery, a seroma was aspirated from the upper abdomen after confirmation using ultrasound. A volume of 20 mL was obtained. She did not require any other aspirations.

This method adds approximately 30 minutes to the operating time.[7,37,53] One study reported an extra time commitment of 50 minutes.[8] Martins et al[53] use 28 to 30 nonabsorbable 2-0 nylon sutures; Nahas et al[7] use 30 to 40 sutures. Patients are hospitalized for 24 hours.[7,53] A Penrose drain is left in place for 24 to 48 hours.[7,53] These sutures may be palpable because of their large caliber and stiffness. The seroma risk is not eliminated.[53] Seroma rates of 2.9% to 9.5% are reported.[7,53] One meta-analysis reported a 5.8% seroma risk among patients treated with quilting sutures,[38] similar to the rate found in this study (4.8%), using scalpel dissection and no quilting sutures. A recent survey showed that most (58%) respondents use quilting sutures, most commonly between 10 and 20 sutures, and 74% of respondents combine them with drains.[55]

Quilting sutures may be technically difficult to perform if the patient is maximally flexed during surgery. Any cosmetic benefit is questionable. Care must be taken not to ligate the lateral femoral cutaneous nerve with a quilting suture.[22] Techniques that use quilting sutures may produce high levels of the scar and superior malposition of the umbilicus (Fig. 10).

Scarpa Fascia Preservation

Preservation of the Scarpa fascia is also a major focus of publications on the topic of abdominoplasty. Like quilting sutures, advocates often consider the evidence for its efficacy undeniable.[80]

Leaving a thin layer of areolar tissue on the abdominal wall is a traditional method used by most plastic surgeons[81]; it is not the same as Scarpa fascia preservation, which typically leaves a thick layer of tissue (depending on patient weight) on the abdominal wall that includes the Scarpa fascia and subscarpal fat (Fig. 12).[25,30] Meta-analyses supporting this method[35,38] include a level 1 randomized study by Costa-Ferreira et al.[23] Ordinarily one might consider the findings of such a high-level study almost irrefutable. However, a confounder undermined the authors' conclusion.[82] In the group treated with Scarpa fascia preservation, an avulsion technique was used.[23] Flap elevation in the control group was performed using electrodissection. The authors recognize the additional thermal injury associated with Bovie electrodissection and have changed the energy setting from a cutting mode to coagulation mode in subsequent studies.[44,49]

In a 2020 study by the same senior author comparing 2 versus 3 closed-suction drains, the authors treated 9 seromas among 73 patients (12.3%).[44] This seroma rate was much higher than their earlier reported rate of 2.5%.[23] The authors are reassured by the fact that these seromas did not impact the final result. Nevertheless, this subsequent experience weakens the case for Scarpa fascia preservation as a means to avoid seromas. The authors' most recent publication reported a seroma rate of 4.0%.[49] The authors no longer use the avulsion technique, in favor of electrodissection instead, because this avulsion tends to disrupt the Scarpa fascia.[49] One patient required readmission for excision of a pseudobursa secondary to a seroma. Notably, the authors used 2 suction drains, which were removed when the drain output per day was ≤30 mL,[49] typically 3 days after surgery. The mean hospital stay was 3 days (range, 1–10 days). The authors believe that their Bovie dissection preserving the Scarpa fascia represents a major improvement over classic abdominoplasty and that the evidence is robust, and there is no reason to consider avoiding electrodissection.[49]

The hypothetical basis for Scarpa fascia preservation is that a dissection plane superficial to the Scarpa fascia preserves vascular and lymphatic structures.[38] Anatomic studies have examined this possibility. Friedman et al[83] found that most lymphatic vessels are located superficially; only 9.4% of the lymphatic vessels were contained within the Scarpa fascia. Tourani et al,[84] in a cadaveric study, concluded that

Scarpa fascia preservation would not preserve the lower abdominal lymphatic collectors.

There is a downside to Scarpa fascia preservation. By leaving this fatty layer intact, the abdominal flap must be draped over a bulge, limiting its mobility and making it more difficult to achieve a low flap repair (Fig. 12).[30] Proponents of Scarpa fascia preservation suggest that this layer is not very thick,[49] which may be true in a thin patient. However, this is not the case in a patient who is overweight. Patients with body mass indices greater than 25 kg/m^2 represent a large number of patients who present for abdominoplasty, including this study (mean body mass index, 28.1 kg/m^2). Saldanha et al[11] describe open liposuction to reduce the bulk created by the preserved tissue layer.

The quality of the wound closure may be compromised. Costa-Ferreira et al[23] reported a trend toward more wound healing problems among patients treated with Scarpa fascia preservation. Indeed, a suboptimal scar is apparent in a photograph depicting this method (Fig. 9). Even if there was a benefit in preserving the Scarpa fascia and reducing the risk of a temporary fluid collection that can be easily managed in the office, that advantage must be weighed against a long-term aesthetic compromise.[65]

Lipoabdominoplasty

Saldanha et al[48] believe lipoabdominoplasty has replaced traditional abdominoplasty (with liposuction) as the gold standard. Saldanha et al[11] reported a seroma rate of 60% before adopting a limited dissection and Scarpa fascia preservation. Subsequently, their seroma rate dropped to less than 1%. The authors believe that improved vascularity is responsible for the improvement. However, this theory is not supported by perfusion studies.[30,85] A reduced seroma rate may be related to less electrodissection and therefore less tissue injury, rather than preservation of perforators and the Scarpa fascia.[30,86]

Laser perfusion studies suggest that, contrary to first principles, a lipoabdominoplasty does not significantly improve perfusion of the abdominal flap.[30,85] This finding is consistent with the angiosome concept; anastomotic connections allow an adjacent vascular zone to provide sufficient blood supply to ensure flap survival.[87] One vascular area can take over the perfusion of another adjacent vascular territory. Likely, the reduced seroma rate is a consequence of a more limited dissection using the Bovie, which causes an internal burn and increases the risk of a fluid extravasation leading to a seroma.[65] The author does not use electrodissection, preferring scalpel dissection instead. This approach is associated with a tolerable (5%) seroma rate.[25] The seromas that do occur are managed easily in the office with needle aspirations guided by ultrasound.[67]

Meta-analyses

Published meta-analyses have reported a reduction of seroma risk for lipoabdominoplasty over traditional abdominoplasty,[42] quilting sutures,[35,37,38] and Scarpa fascia preservation.[34,35,38] Systematic reviews are limited by heterogeneity of the data and inconsistent definitions of complications.[42,45] Publication bias is a factor.[42,45] A recent meta-analysis concluded that there is no significant advantage in the use of either progressive tension sutures, drains, or preservation of subscarpal fat in abdominoplasty patients.[45] Scalpel dissection of the abdominal flap is associated with a lower risk of seromas than electrodissection.[54]

Avoiding Electrodissection

An overlooked method to reduce seroma risk is to avoid the cause.[88,89] In their comparison of 327 patients treated with scalpel dissection versus 320 patients treated with electrodissection, Rousseau et al[90] reported significantly more seromas after electrodissection. Similarly, Valença-Filipe et al[91] reported no seromas in 39 scalpel dissections versus 15 seromas in 80 abdominoplasty patients (18.8%) treated with electrodissection. Both studies documented a significant reduction in drain output and time to drain removal after scalpel dissection. The metadata yield a significant ($P < 0.01$) seroma risk reduction using scalpel dissection.[65]

Seroma fluid resembles an inflammatory exudate,[92] as opposed to a transudate from lymphatic obstruction. Total protein, lactate dehydrogenase, cholesterol levels, and neutrophil percentage are higher in seromas than in lymphatic fluid.[93]

Electrodissection was introduced decades ago to reduce bleeding, before wetting solutions containing epinephrine were introduced. Dissecting with electrical current has become commonplace in operating rooms. Operating personnel have become accustomed to the smell of smoke. Of course, this smoke represents hydrocarbons from burnt tissues, signaling tissue injury. Perhaps surgeons would be more concerned if there were visible signs of the tissue injury that is occurring at a cellular level.[65]

Hematomas

The absence of hematomas in this series merits comment. Reported rates range from 0% to 9.3%.[29] Today, many plastic surgeons prescribe chemoprophylaxis after abdominoplasty. Hemorrhage is the most common adverse reaction associated with enoxaparin.[94] Dini et al[95] were forced to end a level 1 study because they were finding so many hematomas in abdominoplasty patients who received rivaroxaban. Dutot et al[96] reported 64 hematomas among 1128 abdominoplasty patients (5.7%) who received postoperative enoxaparin. A recent study concluded that chemoprophylaxis does not increase bleeding among abdominoplasty patients.[97] However, the study omitted the publications by Dini et al[95] and Dutot et al.[96] Inclusion of either study would have produced a highly significantly ($P = 0.01$ and $P < 0.00001$, respectively) increased risk for patients receiving perioperative anticoagulation.[98]

Other Complications

As recognized by the authors of a recent meta-analysis,[45] a problem in comparing complication rates is in how a complication is defined. Complication rates between 4% and 80% have been reported.[45] If such minor complications as scar thickening or small dog ears at the end of abdominoplasty incisions are included in the complication rate, this rate can exceed 45%.[25,60,61] Revision rates between 25% and 43% have been reported.[4,9,56] The author has a low threshold for revising minor scar deformities of the umbilicus or small, sometimes tiny, persistent dog ears, often bringing it to the patient's attention. Revisions are typically done in the office under local anesthesia at no charge.

In comparing complication rates with an earlier clinical study,[25] 2 changes are apparent—a decrease in infections (10.8% to 4.8%) and surgical revisions (32.3% to 20.0%). Both of these differences are significant ($P < 0.05$). The reduction in scar revisions may simply be explained by greater operator experience. The difference in infection rate may be related to a change in operative sequence. In the earlier study, all body liposuction was done before the abdominoplasty. Before the second study was undertaken, this sequence was changed. Liposuction of the abdomen (and inner thighs when they are treated) is performed followed immediately by the abdominoplasty while the patient remains in the supine position. The abdomen is closed before the patient is turned from side to side to perform liposuction on the remaining areas. The rationale is that the level of sterility is improved. It is difficult to maintain strict sterility once the patient's position is changed and the extremities are treated with liposuction. Fortunately, the infection risk with liposuction alone remains extremely low, with no cases of infection in a previous study that included 384 liposuction-only patents.[25]

CONCLUSIONS

The vertical level of the abdominoplasty scar is a key concern for women. Methods to keep the scar low include a traditional abdominoplasty

approach with intraoperative hip flexion and deep fascial anchoring sutures. The lipoabdominoplasty technique often results in a higher scar, which is less acceptable to women.

There is no advantage in a tunnel dissection (lipoabdominoplasty), preserving the Scarpa fascia, or in using quilting sutures compared with a full abdominal dissection, with liposuction, and avoidance of electrodissection. These alternative methods have disadvantages that may contribute to a suboptimal aesthetic result and additional operating time without a compensatory benefit in safety. The cause of seromas—tissue trauma by electrocautery—is unaddressed. Reducing tissue trauma makes seromas an infrequent (5%) and easily managed minor issue.

Considerations that merit greater consideration by plastic surgeons include total intravenous anesthesia, avoidance of paralysis, adequate regional anesthesia, no prone positioning, and avoidance of routine anticoagulation that is likely to increase the risk of hematomas without effectively reducing the risk of venous thromboembolism.[63,65,98]

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