Continuing Medical Education Article

Post-Bariatric Body Contouring

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Abstract

Background: The "epidemic" of obesity has recently been accompanied by a new "epidemic" of massive weight loss. The demand for post-bariatric contouring is rising and, as such, it is extremely important for plastic surgeons to be well versed in the treatment of these patients. Unfortunately, the problem is not solely surgical.

Objectives: The aim of this article is to understand the nutritional and psychological complications that can occur in patients following massive weight loss, to understand the anatomic deformities in massive weight loss as a means to correct those deformities surgically, and to understand the complications from post-bariatric contouring procedures in an effort to avoid them.

Methods: This article discusses the nutritional and psychological considerations in the massive weight loss patient, anatomical considerations in this patient group, and the surgical techniques designed to address these anatomic concerns. Important pertinent studies are reviewed and discussed.

Results: Anatomical changes are encountered in each region of the body: there are surgical options available to correct them, although potential complications are associated with these surgical procedures. These surgical options are reviewed as well as the risk and benefits associated with them.

Conclusions: There are many problems that need to be addressed in the massive weight loss patient prior to embarking on surgical treatment. Additionally, surgery on massive weight loss patients has unique considerations that distinguish these operations from those performed on the non-bariatric population.

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LEARNING OBJECTIVES

The reader is presumed to have a basic understanding of bariatric and body contouring procedures. After reading this article, the reader should be able to:

(1) Review the nutritional and psychological derangements that can occur in patients following massive weight loss.
(2) Discuss the anatomic deformities in massive weight loss as a means to correct those deformities surgically.
(3) Recite the complications from post-bariatric contouring procedures in an effort to avoid them.

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With the rising rate of obesity in the country, bariatric procedures have become increasingly popular. In a study of data from the National Health Interview Survey between 2004-2011, the overall prevalence of obesity among US workers was 26.2%.[1] In addition, as more surgeons are offering minimally-invasive operations, patients are increasingly likely to request consultations for bariatric surgery. In fact, bariatric surgery is estimated to account for the second most common abdominal procedure performed in the United States.[2]

As obesity is associated with many comorbidities, including diabetes, hypertension, hyperlipidemia, obstructive sleep apnea, and cardiovascular disease, severe obesity can reduce life expectancy by 5-20 years.[3] Bariatric surgery has been found to be effective not only at improving weight loss, but also at improving these comorbidities. The criteria for bariatric intervention are either a BMI > 40 kg/m^2, or a BMI > 35 kg/m^2 in the presence of severe comorbidities.[3]

Bariatric procedures can be classified as restrictive, malabsorptive, or both. In a restrictive procedure, the anatomy is altered to restrict the amount of food that a patient can consume, thereby limiting the intake. A malabsorptive procedure, on the other hand, bypasses a section of small intestine, which limits the amount of food that the intestinal tract can absorb. The most commonly performed laparoscopic bariatric operations are the adjustable gastric band, Roux-en-Y gastric bypass (RYGB), and sleeve gastrectomy. Of these, the gastric band and sleeve gastrectomy are restrictive, whereas the RYGB has elements of both restriction and malabsorption.

In the gastric band procedure, an inflatable silicone band is placed just below the gastroesophageal junction. When this is inflated, the cardia is compressed, causing an earlier sense of satiety and limiting intake. Although the sleeve gastrectomy is also classified as a restrictive procedure, it differs from the banding procedure because 60-80% of the stomach along the greater curvature is removed, leaving the "sleeve"-shaped remnant.

The RYGB is performed by first creating a 20-30 mL gastric pouch that is anastomosed directly to the jejunum: this is the Roux limb. The duodenal limb, which is no longer in continuity, is re-anastomosed to the Roux limb between 75-150 cm. Bypassing the distal stomach, duodenum, and a portion of the proximal jejunum comprises the malabsorptive element of the procedure; the longer the Roux limb, the greater the degree of malabsorption. The smaller gastric pouch comprises the restrictive element of the RYGB. Following RYGB, patients generally lose between 60-70% of their excess weight over several months. Patients with gastric bands lose about 50% of their excess weight, but at a slower rate which may take a year or longer. Certainly, compliance with diet and exercise have a large part to do with achieving weight loss; it is well-known that dense, sugary high-calorie liquids such as milkshakes can bypass the gastric band, defeating its purpose.

All three of these procedures are commonly performed today. In a recent prospective study spanning from 2004 to 2013, Kruger et al[4] found that the RYGB is still the most common procedure performed, while the number of laparoscopic adjustable gastric bands is decreasing and the number of sleeve gastrectomies is increasing. This trend does not seem to be limited to the United States, as Lazzatti's group[5] in France also found a constant decrease in adjustable gastric bands placed and a steady increase in RYGBs and sleeve gastrectomies.

After any bariatric procedure, patients tend to find significant improvement in their comorbidities. One of the most impressive examples is in the case of type 2 diabetes, where up to 75-85% of patients may experience complete resolution, although greater improvement has been found after RYGB compared to the gastric band. Hyperlipidemia has been found to improve in more than 70% of patients, hypertension improves in almost 80% and resolves in about 60%, and obstructive sleep apnea resolves in more than 80% of patients. After five years, the risk of cardiovascular disease has been shown to decrease by 72% as well.[3]

Following bariatric surgery and subsequent massive weight loss, patients are often candidates for post-bariatric contouring procedures. However, in a recent study performed by Reiffel et al,[6] only 11.6% of post-bariatric patients opted for body contouring afterwards. Although the most common reason cited was expense, many patients stated that they were not counseled by their bariatric surgeons about post-bariatric contouring. However, 40% also reported that they would have opted for contouring procedures if they had received more counseling or information about the subject. However, in the past few years, more information has become readily available to patients via mass media such as the Internet, so bariatric procedures have shown a trend toward even greater popularity.[7]

DIAGNOSIS AND EVALUATION

The post-bariatric patient typically presents with both functional and cosmetic complaints. Functional complaints should be carefully noted in the patient's record. These include skin rashes and breakdown in the abdominal or thigh folds, history of skin infections requiring topical and/or oral antibiotics or antifungals, difficulties maintaining hygiene, and difficulty ambulating due to the heft of the abdominal pannus. Cosmetic complaints vary by body region. They all are similar in that they are the result of skin ptosis.

Patients require comprehensive medical evaluation prior to body contouring surgery. As discussed in a later section of this article, these patients present with unique nutritional deficiencies that may affect wound healing and recovery. In addition, a history of cardiac disease, lung disease (including asthma), deep venous thrombosis,

clotting abnormalities, and reactions to anesthesia may be present and require further investigation prior to considering surgery. A history of smoking can have a deleterious effect on healing. We require a minimum of 3 months of abstinence from smoking prior to surgery. Weight loss after surgery should be complete before considering body contouring. In our practice, we delay surgery until the patient's weight has been stable within 10 lbs for at least 6 months and for at least 1 year from the time of the bariatric surgery.

Evaluation of the deformities presenting after weight should be done in a systematic fashion. Many different systems for classifying such deformities have been described, including the Pittsburgh classification. The Pittsburgh Rating Scale was devised as a way of classifying and treating different contour deformities across the different body regions.[8]

Skin excess, location of adipose deposits, and musculofascial laxity in each area should be evaluated. The specific deformities that need to be addressed are discussed by body area later in this article. Location of scars is important, as the scars may compromise skin flap circulation. In this patient population, vertical scars from open gastric bypass as well as Kocher scars are commonly encountered. In patients who have undergone gastric band surgery, attention needs to be paid to the location of the port. Ports located very medially may interfere with abdominal wall plication.

NUTRITIONAL CONSIDERATIONS IN THE POST-BARIATRIC PATIENT

Nutritional Changes Following Massive Weight Loss

The patient who has undergone bariatric surgery has unique nutritional needs that are different than those of other patients. Many of these problems are due to changes that occur with obesity and unhealthy dietary habits, which can lead to protein, mineral, and vitamin deficiencies. In addition, by altering the anatomy and physiology of the gastrointestinal tract, bariatric surgery can decrease the patient's ability to absorb nutrients and electrolytes.[9-11]

After undergoing a RYGB procedure, patients are commonly deficient in iron, folic acid, and vitamin B_{12},[12] as well as vitamin A, zinc, and selenium.[13] Severe protein deficiencies have been identified in post-bariatric patients,[14] although Blume et al[15] recently followed patients for 3 years after their RYGBs and found no significant differences between their pre-operative and postoperative albumin levels.

Iron, Folate, and Vitamin B_{12} Deficiencies, and Anemia

Iron deficiency, one of the most common nutritional deficits in the post-bariatric patient, appears to be multifactorial. Not only does bariatric surgery affect absorption, the operation also seems to trigger an aversion to red meat in patients,[16] contributing to inadequate iron intake. Obinwanne et al[17] found that as many as 53.9% of women may have iron deficiency after weight loss, which can only partially be accounted for by menstruation and abnormal uterine bleeding. In 1998, Brolin et al[18] studied 348 patients who had undergone a RYGB procedure, and found that 47% had iron deficiency, 37% had vitamin B_{12} deficiency, 35% had folate deficiency, and 54% were anemic. Similar to Obinwanne and colleagues's results, 51% of Brolin's group's female patients were iron-deficient compared to 22% of their male patients.

Although patients with iron, B_{12}, or folate deficiencies are often treated with multivitamins, Brolin et al[18] reported that iron supplementation corrected only 43% of the iron deficiencies. Oral vitamin B_{12} corrected 81% of B_{12} deficiencies. Folate deficiencies were nearly all corrected with multivitamin supplementation. Recent recommendations by Vargas-Ruiz et al[19] indicate that "vitamin supplementation is not sufficient to prevent iron and vitamin B_{12} deficiencies in most patients." Because the RYGB procedure bypasses the portions of the gastrointestinal tract that facilitate the binding of vitamin B_{12} to intrinsic factor, which is essential to vitamin B_{12} absorption, B_{12} deficiency can be readily explained. Folate deficiency is slightly less common, as the non-bypassed portions of the small intestine have the ability to absorb folate. However, its absorption is impaired by the decrease of hydrochloric acid secretion due to the small gastric pouch created during the procedure.

Apart from these anatomic explanations, patients who ignore their strict nutrition instructions are more likely to develop deficiencies and anemia. As Brolin et al[18] also identified in their study, iron deficiency anemia caused symptoms of fatigue more often than did deficiencies of vitamin B_{12} and folate. Their conclusion, therefore, was that vitamin B_{12} and folate deficiencies were not as clinically important as anemia stemming from iron deficiency.

Because iron deficiency is so common following surgery, bariatric patients should have a full hematologic workup prior to undergoing surgery. They require lifelong surveillance of their iron, B_{12}, and folate levels. This recommendation was also given by Marinella,[20] who reinforced the important message that anemias in the post-bariatric patient should be properly explored and promptly analyzed when discovered.

Protein Deficiency

Protein deficiency is not always present following Roux-en-Y gastric bypass. However, since protein intake is necessary for essential amino acids and to prevent the patient's muscles from being broken down as an energy source, protein malnutrition can lead to devastating effects. Faintuch et al's[14]

retrospective study of 236 patients found that only 11 developed severe malnutrition. However, of these 11, six were hospitalized and two died.

Because of changes in taste preferences as well as food intolerance following surgery, it is initially difficult for patients to increase their protein intake postoperatively. Moize et al[21] reported that over the course of 1 year, patients were able to consume 55% of their daily protein intake goal at 3 months, 61% at 6 months, and 73% at 1 year. Current guidelines recommend at least 60-120 grams of protein intake daily or 1.0-1.5 g of protein/kg to prevent loss of lean muscle mass.[22,23]

Thiamine Deficiency, Beriberi, and Wernicke Encephalopathy

Thiamine (vitamin B_1) is a cofactor in the metabolism of carbohydrates and branched-chain amino acids. It is not well stored in any particular organ, so patients require a constant intake of the vitamin.[24] Thiamine deficiency can present with a range of symptoms: a patient with subclinical thiamine deficiency may be irritable and fatigued, a patient with wet beriberi may develop congestive heart failure and edema, and a patient with dry beriberi may develop peripheral neuropathy in the distal extremities.[25] The most severe manifestation of thiamine deficiency presents as Wernicke encephalopathy, in which a patient will present with nystagmus, ophthalmoplegia, and gait ataxia. Because the process of glucose oxidation is thiamine-intensive, administering dextrose intravenously may strip undiagnosed thiamine-deficient patients of their last thiamine reserves, thereby triggering Wernicke encephalopathy.[26]

Calcium Deficiency, Vitamin D Deficiency, and Postoperative Development of Metabolic Bone Disease

Calcium and vitamin D levels are affected by the anatomical changes of gastric bypass as well, since the duodenum, jejunum, and ileum are bypassed with the operation. As a result, patients with insufficient dietary calcium intake are at increased risk for developing osteomalacia or osteoporosis. In 2005, De Prisco and Levine[27] studied four post-bariatric female patients who had undergone their procedures 9 to 12 years earlier, and found that all four of them had either osteopenia or osteoporosis, in addition to hypocalcemia, secondary hyperparathyroidism, and increased serum alkaline phosphatase. Interestingly, all four patients presented with fatigue, myalgias, and arthralgias for years before they were properly diagnosed. Fortunately, many investigators have found that the combination of postoperative surveillance with appropriate supplementation is effective at preventing bone disease following gastric bypass.[28,29] Although Newbury et al[30] focused more on the biliopancreatic diversion procedure in their study from 2003, they reinforced the conclusion that post-bariatric patients will invariably require routine lifelong calcium and vitamin D supplementation. This recommendation is unquestionably applicable to the Roux-en-Y gastric bypass as well.

Because bariatric operations create a state of dietary fat malabsorption, it is logical that fat-soluble vitamin levels would be also affected. This was shown by Slater et al[31] in 2004, who studied 170 patients who had undergone bileopancreatic diversion. Out of these, 69% had vitamin A deficiency, 68% had vitamin K deficiency, and 63% had vitamin D deficiency. As deficiency can easily lead to secondary hyperparathyroidism, this can further contribute to increased bone resorption. Therefore, these vitamin levels should be routinely checked postoperatively and appropriately supplemented.

Miscellaneous Fat-Soluble Vitamin Deficiencies: Vitamins A, E and K

As mentioned earlier, Slater et al[31] reported that 68% of 170 patients were found to have vitamin K deficiency following biliopancreatic diversion procedures. However, its deficiency was not associated with increased bleeding and difficulty clotting, as would normally be expected. In the same study, Slater also found that vitamin E levels tended to remain normal for 1 year postoperatively, and sometimes for up to 4 years after surgery.[31]

In contrast, vitamin A deficiency is not only common following restrictive and bypass procedures, but can be clinically significant as well. Clements et al[32] found that 11% of their patients developed vitamin A deficiency following RYGB. Eckert et al[33] also reported that 11% of their patients developed vitamin A deficiency. More importantly, of the patients with identified vitamin A deficiency, 86% haddecreased visual acuity and xerosis, 71% had worsened night vision, and 57% had eye pain. Despite these findings, the American Society for Metabolic and Bariatric Surgery does not recommend routine vitamin A supplementation in addition to the vitamin A normally found in multivitamins.[34] Even with multivitamin and additional retinol acetate supplementation, vitamin A deficiency can persist.[35] However, vitamin A levels should still be monitored postoperatively. In an asymptomatic patient where a deficiency is identified, the American Society for Metabolic and Bariatric Surgery (ASMBS) guidelines recommend oral supplementation with 10,000-25,000 IU daily until the levels improve. Patients with deficiency and corneal changes should receive 50,000-100,000 IU intramuscularly daily for three days, followed by 50,000 IU intramuscularly daily for two weeks.[36]

Summary

Nutrition is clearly of paramount importance in the post-bariatric patient. Routine levels should be checked, and

any deficiencies should be corrected. Patients should keep a log of their dietary habits, paying strict attention to their protein intake, and should be encouraged to get as close to their daily goal as they can tolerate The authors typically test for specific deficiencies in accordance with the ASMBS guidelines, including electrolytes, B1, B6, B12, folate, iron, zinc, albumin, prealbumin, and vitamins A, D, E, and K. In addition, routine supplementation with a daily multivitamin that contains vitamin A, zinc, and copper is recommended, as well as additional supplementation with 1000 mcg of vitamin B_{12}, 1700-2000 mg of calcium, and 1000-2000 IU vitamin D. Elective surgery on a malnourished patient should clearly be deferred until all deficiencies have been appropriately corrected.

PSYCHIATRIC CONSIDERATIONS

Many studies have linked psychopathology to bariatric surgery candidates. In 2012, Mitchell et al[37] studied 199 patients who were being considered for bariatric surgery, and found that as many as 68.6% of their patients had been diagnosed with an Axis I psychiatric disorder during their lifetimes. 33.7% had an active disorder at the time of evaluation, with the most common class of medication used among all the patients being antidepressants (40.8%).

This is especially pertinent to the plastic surgeon because of the association between obesity, personality, mood disorders, and body image dissatisfaction, as well as full-blown body dysmorphic disorder. This can be partially explained by the overlap between overeating and mental disorders of addiction and dependence. The multifactorial etiology of morbid obesity includes a wide range of biopsychosocial factors, from genetics, to brain chemistry, to family pressures, to self-image.[38] Studies indicate that there is a positive correlation between body mass index and body image dissatisfaction, which in turn is associated with increased depressive symptoms and decreased self-esteem.[39] Sarwer and Fabricatore's[40] work in this field also identifies the possibility of psychosocial distress due to stigmas, discriminatory treatment, and biases against more severely obese patients. Recognizing that patients often have concomitant psychiatric disorders, the National Institutes of Health recommends pre-operative selection and counseling for all bariatric candidates. An ideal program includes counseling in dietary regiments, exercise, and behavior modification, as well as psychological support.[41] Patients should also continue to follow up postoperatively to monitor appropriate treatment, whether it is psychopharmacologic management or psychotherapy. In addition, as Adams et al[42] reported, post-bariatric patients have been shown to be 1.58 times more likely to commit suicide than matched patients who did not undergo surgery. Therefore, any patients with depression, comorbid alcohol use, or other warning signs should be referred for immediate intervention.

Similar to improvements in the metabolic comorbidities listed earlier, Faulconbridge et al[43] have shown improvements in binge eating disorder, depression, and self-reported quality of life scores in post-surgical patients compared to patients treated with lifestyle modification alone. However, Sarwer et al[39] also caution that although these factors may improve, pre-existing body dysmorphic disorder may not. These are patients that are less likely to be satisfied with their postoperative results. It is therefore of paramount importance to screen patients for this prior to agreeing to performing body contouring surgery, and also to continually paint realistic expectations about their anticipated results.

POST-BARIATRIC BODY CONTOURING

Anatomy and Timing

Massive weight loss (MWL) from diet, exercise, medications, or bariatric surgery leaves patients with ongoing body issues, mostly related to skin excess. This skin excess causes two major functional problems: difficulty maintaining hygiene and difficulty exercising due to the obtrusive skin. Patients can present with dermatitis, intertrigo, and skin infections. The functional and cosmetic consequences of the skin laxity and excess can be more disheartening to these patients than their previous obese state. Many of these patients wish to start or continue an exercise program, but the functional impediments posed by the hanging skin may preclude them from performing many types of cardiovascular exercises. In turn, this can cause the patient to regain the weight that he or she had lost. The patient should be evaluated not only for loose and excess skin but also for residual deposits of adipose tissue. These areas can be viewed as areas that require excision or areas that can be utilized and transposed for auto-augmentation of other nearby regions.

The timing of body contouring surgery and the necessity for it is patient-specific. Contouring procedures should not commence until weight loss is complete and has been stable for a minimum of 6 months. This will usually not occur until at least 12 months after bariatric surgery. Patients must also have had the time to meet the nutritional requirements discussed above and should undergo a complete pre-operative medical evaluation.

There are six major areas of the body that are considered for surgical correction after MWL: the mid-body; breasts and chest; arms and axillae; back; thighs; and the face and neck. Staging of these procedures is often performed, but more than one region may be addressed during the same operation.[44] The most important consideration used to determine which area is approached first is the patient's complaints and desires. Many factors are used in deciding which procedures to combine. These include operative time, opposing vectors of tension, recovery time from each

operation, cumulative recovery time from multiple operations, intraoperative blood loss, surgeon fatigue, and financial burden. Of course, patient safety is the foremost concern and combined procedures must be evaluated in this light. The authors prefer to limit operative time to 6 hours and only combine areas that will not apply opposing vectors of tension on each other. We also wait a minimum of 3 months between stages. Revisions from previous surgeries can also be added to the plan of the upcoming operations.

CONTOURING PROCEDURES BY REGION

Abdomen, Back, Thigh, and Gluteal Region

For the purposes of this article we will discuss the anatomical distortion of the abdomen, back, thigh, and gluteal region in one section. The reason for this is that these areas tend to overlap into each other. For instance, the abdominal pannus will blend into the lower back rolls and the back rolls will neighbor the gluteal region. The abdomen and the lower back are in direct connection with the upper thigh. The correction of one of these areas in the absence of the others requires careful planning for future operations. Alternatively, many of these areas can be addressed in one operation, as described below.

The structural elements of the abdomen include the skin, subcutaneous fat, muscle, fascia, umbilicus, and pubis. All of these structures contribute to the contour of the anterior torso following MWL. Many classification systems have been devised to describe abdominal deformities. However, no single classification to date has been able to completely capture the variations in abdominal contour following MWL. The skin tends to be loose, with poor quality and tone. It is often quite thin and striae are often present. The pannus can hang over the pubis and thighs. There may be areas of adhesion that cause additional areas of overhang. The subcutaneous tissues can contain variable amounts of fat as well as pockets of fat that have settled irregularly. The muscle has usually lost its tone and the fascia has stretched significantly. There can also be ventral hernias present, some of which can be related to the previous surgeries. The shape and tone of the umbilicus is often altered after MWL. The pubis frequently demonstrates marked descent.

The back can be subdivided into upper and lower regions. The upper region is continuous with the breasts and chest. The lower back is continuous with the abdomen anteriorly and the buttocks and thigh inferiorly. All of these associations should be carefully noted prior to surgery so as to place incisions from the abdomen that will meet up with the incisions of the back so that those incisions will end up in cosmetically appropriate places. After MWL, the buttock appears flattened and lacks shape. Lower body lift procedures without gluteal augmentation can accentuate this flattening.[45]

The thighs can often be the most pronounced deformity following MWL. It can be difficult to achieve a good cosmetic result. The patient can have significant functional concerns related to their thighs, including rashes, chafing, and skin breakdown as well as cosmetic concerns. It has been noted previously by the senior author (Dr Herman) that there are two different basic shapes to the MWL thigh: conical and cylindrical.[46] In short, conical thighs have excess proximal thigh tissue with tapering distally toward the knee. There is little excess at this lower level. The cylindrical form has excess thigh tissue from the proximal to the distal extent, at least to the knee. The distinction is important for determining the proper operation to perform (Figure 1).

Belt Lipectomy

The belt lipectomy is a very important procedure in massive weight loss patients. The abdomen is often the area of most concern and results in the most hygiene problems (Figure 2). Patients often seek to have this corrected at the first stage. The role for traditional abdominoplasty in MWL patients is limited to a very select group because the traditional abdominoplasty fails to address the other nearby regions of concern. The circumferential operation does address these areas, namely the ptotic lateral thighs, hips, and buttocks. These can be elevated at the time of belt lipectomy. The lower back roll is also released and excised during the posterior portion of the operation. The belt lipectomy allows the surgeon to address the laxity of the abdominal wall musculature and fascia. The midline anterior rectus sheath can be plicated and the lateral abdomen can be assessed and plicated in an oblique fashion, if necessary.[47] Many approaches have been described for lower body contouring in these patients, including patient positioning and sequencing. Hurwitz[48] described a “total body lift” in which thighplasty, as well as extremity and breast contouring, may be incorporated in the same setting. De la Torre and Cerio[49] have described combining the lower body lift with liposuction and gluteal flap surgery. The operation is commenced in the prone position with the gluteal surgery performed first before the patient is then rotated into a supine position to complete anterior truncal surgery. Shestak[50] has described a modification of the belt lipectomy in which the skin excision is carried to the posterior hip area, with the remainder of the posterior truncal contouring performed with liposuction. We prefer to address the abdomen first with the patient supine, perform the anterior resection as far laterally as possible, then close and dress the anterior incisions before turning the patient into the prone position for the remainder of the operation. Back incisions are made and tissue undermining is limited to

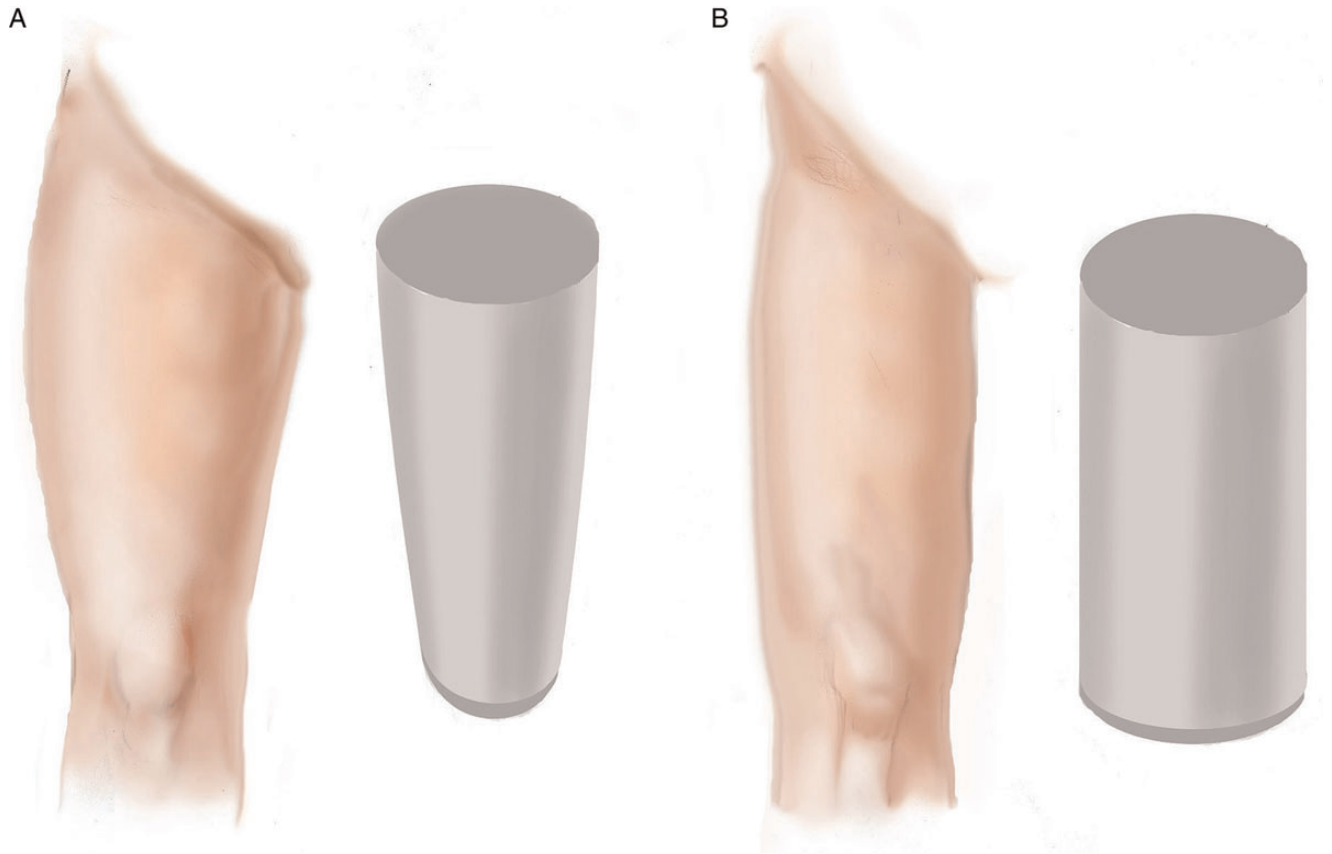

Figure 1. Typical shapes of the thigh encountered in the massive weight loss patient. (A) Cone-shaped thigh; (B) cylinder-shaped thigh.

that which is necessary to release and advance the lower back rolls, hip rolls, and buttocks. Limited undermining reduces the dead space that can lead to seroma formation. Gluteal augmentation is considered pre-operatively and performed at this point when deemed appropriate.

Lower Body Lift

The lower body lift is essentially the same operation as the belt lipectomy, with one major difference. The lower body lift places the incisions, both anteriorly and posteriorly, in a significantly lower position than those of the belt lipectomy. This improves the surgeon's ability to lift the thighs in a single stage. It also places the final scar at a more inconspicuous position. Adversely, it places the scar through the buttock and not in the natural plane between the buttock and lower back. It also has less improvement of the waistline. Although commonly used synonymously with the term lower body lift, belt lipectomy originally was described by Gonzalez-Ulloa[51] as an operation involving the circumferential excision of skin and fat without significant undermining of flaps and abdominal wall reconstruction.

Abdominoplasty

In a select group of patients who have skin laxity limited to the anterior trunk and abdomen without a back or buttock component, a traditional abdominoplasty can be considered. This procedure is performed in a similar manner to the standard abdominoplasty performed in non-MWL cosmetic cases. It addresses the anterior abdominal contour and pannus. The rectus sheath can be plicated in vertical and horizontal planes, depending on the patient's laxity. The ability to re-inset the umbilicus is also provided. In the MWL population, the procedure is typically performed as an "extended abdominoplasty," requiring the surgeon to extend the incisions laterally and posteriorly to avoid a "standing cone" deformity.

Fleur-De-Lis Abdominoplasty

In an effort to address the lax and expanded horizontal component of the abdominal wall following MWL, the fleur-de-lis technique was developed. This is a technique of abdominoplasty that has both a horizontal and vertical component. The pattern is marked in the shape of a fleur-de-lis. The tissue within the marks is resected and the

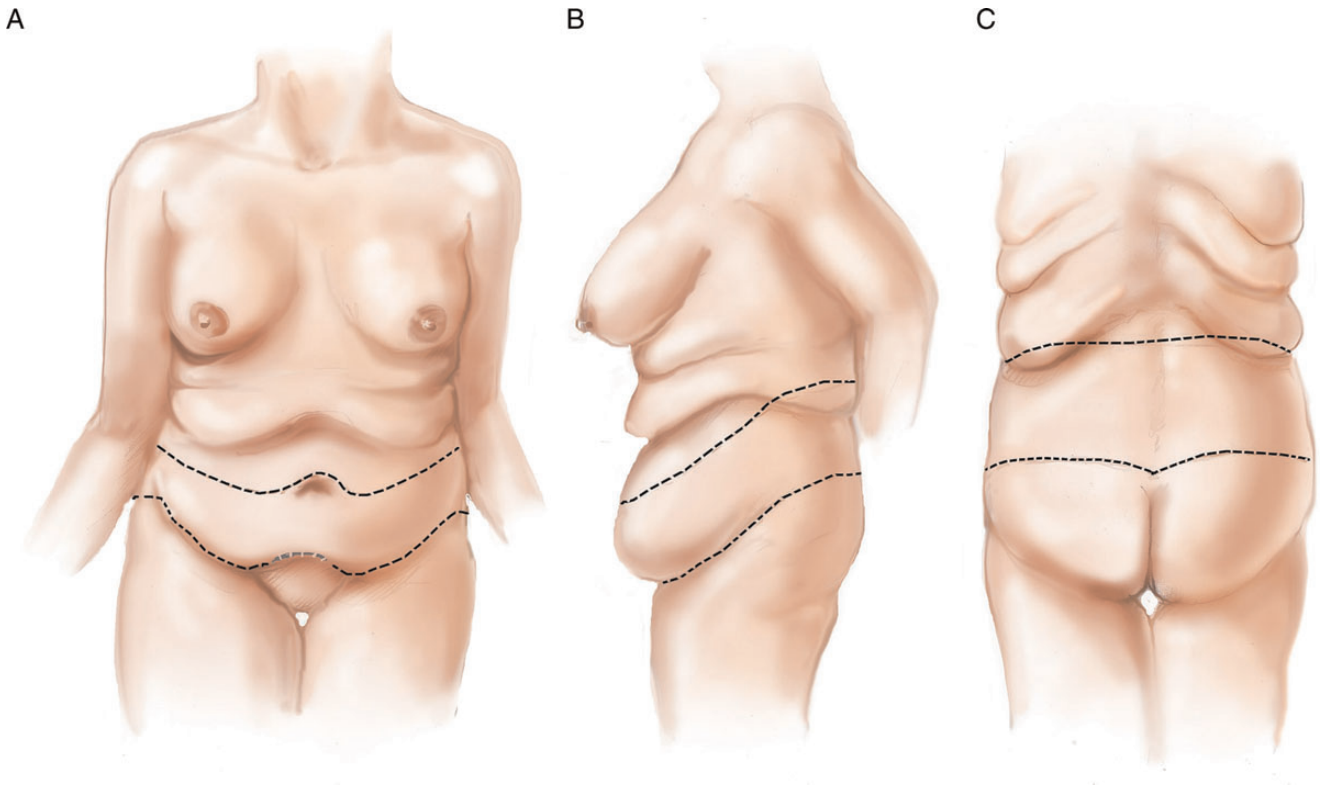

Figure 2. Markings for lower body lift. (A) Anterior markings include a pubic lift by placing the medial lower marking into the pubic hair; (B) lateral markings include excision of the hip fold; (C) back markings include extension of the upper marking to include the lower thoracic fold.

incisions are closed in an inverted T formation. This allows the surgeon to gather excess horizontal tissue at the flanks and draw it medially, thus creating an aesthetically pleasing waistline. This, of course, comes at the expense of the additional scar. The complication rate of the fleur-de-lis has been shown to be comparable to traditional abdominoplasty.[52]

Buttock Lift and Gluteal Augmentation

Buttock lift is usually included as part of a belt lipectomy and lower body lift. Augmentation of the buttocks is necessary to correct the flattened, shapeless appearance of the buttocks following MWL, as described earlier. The options for gluteal augmentation include autologous augmentation with local flaps, fat transfer, and implant placement. Auto-augmentation is well described and is the current mainstay of treatment for gluteal deformities following MWL.[53] This procedure involves using a portion of the skin flap from the back that would otherwise be discarded and de-epithelializing it for use more caudally in the gluteal region. If done well, this can restore an aesthetically pleasing contour to the buttocks.

Autologous fat transfer is a popular method of gluteal augmentation in the non-MWL population. In the right patient, it can provide a significant amount of volume of augmentation with good long-term results. In the MWL patient, fat transfer can be an approach to gluteal augmentation; however, it is limited to the patient who has adequate fat stores elsewhere that are accessible by suction lipectomy. The other caveat to this procedure in the MWL group is that the skin laxity will often still be present following grafting and the likelihood of the patient needing a skin resection procedure is quite high. In carefully selected patients, fat transfer for gluteal augmentation can accompany a belt lipectomy and lower body lift.

Gluteal implants have had their successes and failures in the past in the general cosmetic population. They have been used in MWL patients with limited success. It is the authors' preference not to use implants for gluteal augmentation in the MWL patient due to their higher rate of complications compared with the other methods described.

Thigh Lift

The thighs, as mentioned above, can be assessed and categorized into either conical or cylindrical deformities. Based on this assessment, the proper surgical procedure can be chosen. In the conical type of thigh deformity, the excess

skin is primarily proximal. This group can usually be treated with a horizontal resection alone. This avoids a vertical scar down to the knee, a scar that is less cosmetically appealing. The cylindrical variant of thigh deformities usually requires a vertical resection in addition to a horizontal skin resection. This is due to the fact that the deformity contains both a horizontal and vertical component down to the level of the knee.

Upper Body Lift

The upper back will frequently have pendulous rolls after MWL that require surgical resection (Figure 3). These are usually in continuity with the deformities of the anterior chest. The technique for correction of back rolls involves direct excision. The upper marking is made pre-operatively with the patient's bra (in females) of choice used as a guideline. Keeping the upper incision in this position and raising the lower flap to meet the upper incision will provide a hidden scar. The incisions need not cross the midline in all cases.

Liposuction

Liposuction can be an adjunct to any of the above procedures, as well as to some of the procedures below. Again, it is at the surgeon's discretion and experience to determine what areas still possess excess adiposity and are amenable to suction lipectomy. Most importantly, when suctioning areas of the body that will not have a concomitant skin resection, the skin tone and quality must be evaluated and scrutinized. Care must be taken to only liposuction an area with good skin quality that has the potential to retract over time. Failure to adhere to this principle will cause additional excess ptotic skin, the very problem the surgeon is attempting to correct. Consideration should be given to fat grafting into areas of deflation, including the face, buttocks, and breasts.

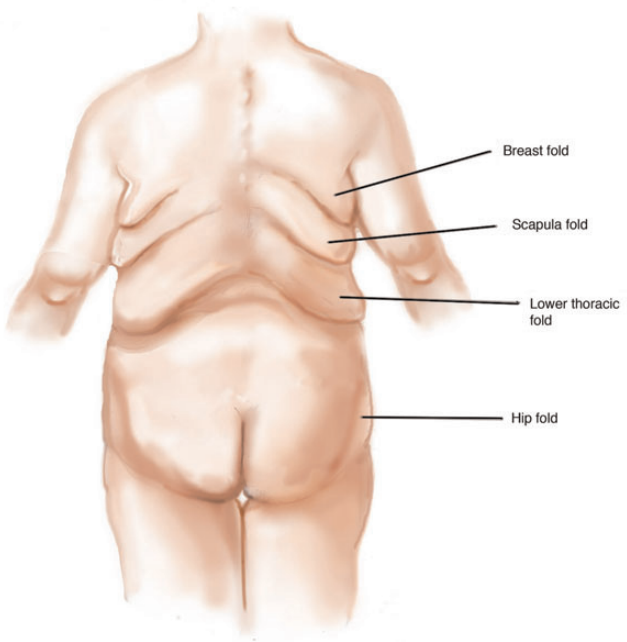

Figure 3. In the massive weight loss patient, characteristic folds encountered on the posterior trunk include the breast fold, scapula fold, lower thoracic fold, and hip fold.

ARM CONTOURING

Anatomy

After patients undergo a bariatric procedure and are in the process of massive weight loss, the subcutaneous fat in the arms can often be involved along with the rest of the body. Combined with decreased skin elasticity that accompanies advancing age, patients can present with excess skin laxity, a deformity that will not improve with diet and exercise alone. This is often colloquially referred to as a "bat's wing deformity."[54]

This deformity can have a wide range of presentations. El Khatib[55] proposed a classification of brachial ptosis with suggested treatment of each stage. For example, he defined stage 1 as minimal adipose tissue deposits and minimal ptosis, which could be treated with circumferential liposuction alone. In contrast, stage 4 is defined as minimal adipose tissue with severe skin ptosis: these patients would benefit from a brachioplasty procedure. Patients classified as stage 2 or 3 would benefit from combination brachioplasty and liposuction procedures. Similar to El Khatib's classification system, Appelt et al[56] developed a classification system also based on skin and fat excess, but additionally accounting for the location of the skin excess.

Post-bariatric deformities of the upper arm can be broken down into four anatomic zones, dividing the upper extremity, axilla, and superolateral chest wall: zone 1 extends from the wrist to the medial epicondyle, zone II extends from the medial epicondyle to the proximal axilla, zone III contains the axilla, and zone IV extends from the inferior axilla to the chest wall (Figure 4).[57]

Brachioplasty

Several techniques for brachioplasty have been described. A traditional brachioplasty involves a longitudinal incision along the entire arm from the axilla to the elbow, with the scar placed anteriorly, medially, or posteriorly.[58] As the skin is excised, it is advanced from a distal to proximal direction, thereby working the skin into the axilla. A tailor-tacking technique is used to avoid over-resection. In patients with extensive bat's wing deformities involving the lateral chest wall, Strauch et al[59] describe an incision

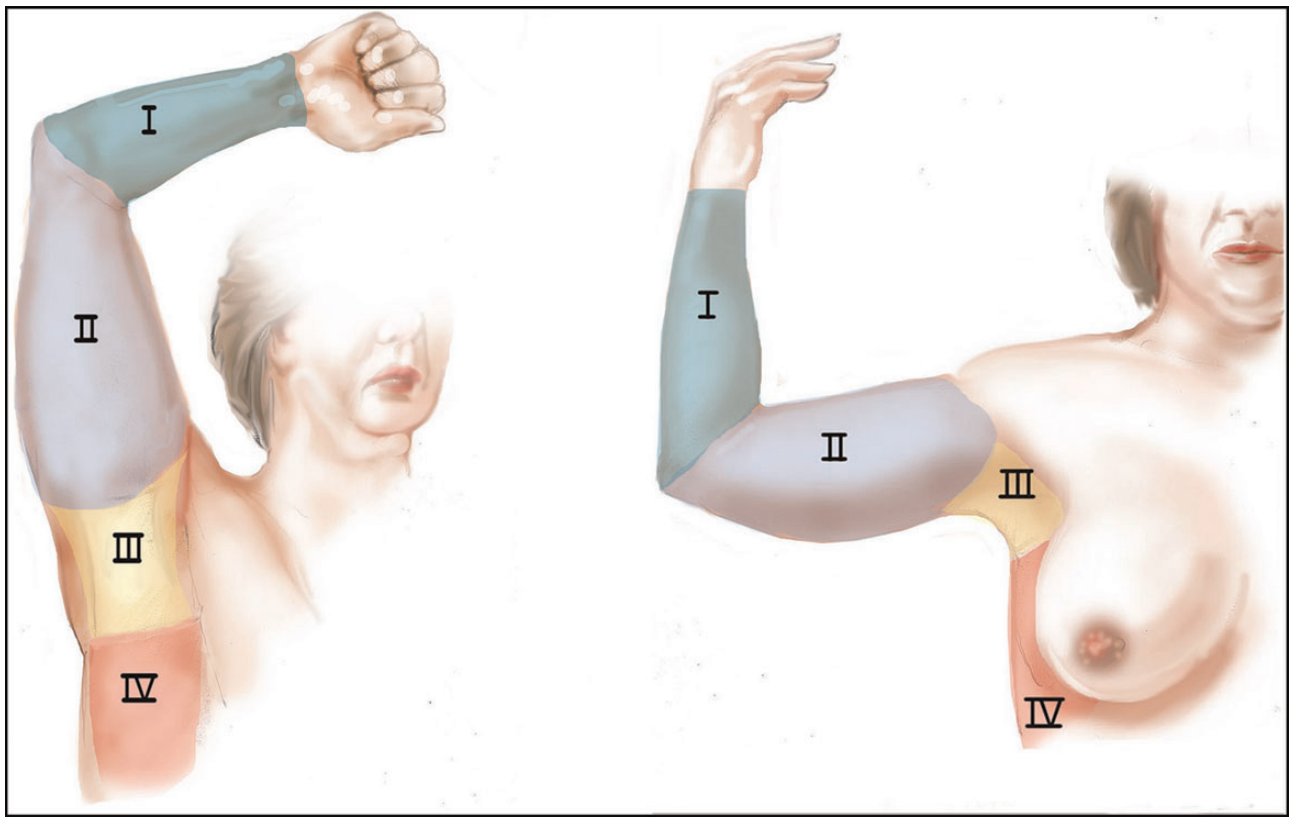

Figure 4. Zones of the upper arm are comprised of Zone I (forearm), Zone II (upper arm), Zone III (axilla), and Zone IV (chest wall). Deformities of the upper arm can be anatomically classified according to the zone(s) involved.

extending into the axilla with an axillary Z-plasty to lengthen the scar and to preserve axillary contour. In cases of moderate upper-third lipodystrophy and moderate skin excess, liposuction combined with a limited incision medial brachioplasty may be used. Cannistra et al[60] have described use of an inferiorly-placed scar with an axillary Z-plasty. Rubin and Michaels[61] utilize a medial bicipital scar with an L-shaped extension perpendicular to the arm incision placed along the axilla and lateral chest wall to address proximal deformity.

The selection of a brachioplasty technique should be indicated by the location of the anatomic deformity and relative amount of excess skin and fat. Patients with excess skin limited to the upper arm may benefit from a short-scar brachioplasty incision placed into the axilla and/or extending along the upper arm only. If there is also an excess of adiposity, liposuction can be combined with the short-scar resection. In patients with excess fat and skin extending the full length of the arm to the elbow, a traditional brachioplasty is indicated. In these cases, liposuction may also be indicated if a severe excess of fat is noted. Many weight loss patients present with additional deformities of the axilla and chest wall. In these cases, the resection should be extended into the axilla and onto the lateral chest wall.[62]

BREAST AND CHEST CONTOURING

Female Breast

Anatomy

After MWL, the female breast becomes deflated and ptotic. Additional changes to the breast that occur after MWL include medialization of the nipple-areola complex (NAC), lateralization of the breast mound, extension of the breast into the axillary fold, inferior displacement of the infra-mammary fold (IMF), skin laxity, and deflation of the upper pole.

Nearly all patients with MWL will have some degree of breast ptosis. Ptosis was graded in 1976 by Regnault, and that grading system is still used today.[63]

- *Normal*. The nipple sits above the IMF.
- *Grade 1: Mild Ptosis*. The nipple is at the level of the IMF and above most of the lower breast tissue.
- *Grade 2: Moderate Ptosis*. The nipple is located below the IMF but above, not at, the most dependent portion of the breast.
- *Grade 3: Severe Ptosis*. The nipple is located at the most dependent portion of the breast.
- *Pseudoptosis*. The nipple is located at or above the IMF but the majority of breast tissue resides below the IMF.

Contouring Procedures

Patients with sufficient breast volume and ptosis will benefit from mastopexy. The mastopexy can be performed using a periareolar, vertical, or Wise-type skin pattern. We often use the grade of ptosis as a guide to help decide which of these skin excision patterns is appropriate. Grade 1 can usually be treated with a periareolar mastopexy. Grade 2 ptosis can be treated with vertical mastopexy. Grade 3 ptosis will usually require a Wise-type pattern skin excision. The authors prefer a superior or superomedial pedicle when performing a vertical mastopexy and an inferior pedicle when performing a Wise-pattern mastopexy. Because MWL patients often have skin folds extending laterally into the back folds, a Wise-type pattern often is more advantageous.

Patients with ptosis and insufficient breast volume comprise a difficult group of patients. A variety of techniques have been described that redistribute the patient's own tissue to "autoaugment" the upper pole of the breasts (Figure 5). Mastopexy with implant augmentation has historically demonstrated high complication and revision rates. A revision and complication rate as high as 20% has been reported by Spear et al.[64] In addition, this combination surgery has been the source of a high rate of malpractice claims.[65] A more recent study on mastopexy with implant augmentation with a very large series has found a revision rate similar to breast augmentation alone or mastopexy alone, which suggests that changes in technique over time have alleviated some of the difficulties introduced by combining these operations.[66] This is a good technique for the properly-selected patient in this category.

Patients with ptosis and excess volume are rarely encountered in the MWL population. These patients will benefit from a reduction mammaplasty. The type of reduction mammaplasty, including the pedicle location and pattern of skin resection, are left to the surgeon's discretion.

There have been many novel approaches to dealing with the volume depletion and ptosis without the need for an implant. Rubin[67] describes an excellent technique for just this purpose. Patients that are good candidates for breast contouring following massive weight loss should be assessed for the possibility of utilizing this technique. The technique incorporates the native breast tissue from the lateral and medial pillars at the inferior margin of the breast for use in the superior pole. This operation consists of a Wise-pattern skin incision with preservation of a central pedicle. The nipple will be raised and lateralized. The vertical limbs are typically 5 cm in length. Often these patients have excess axillary tissue and this can be included in the autologous tissue that will be used for augmentation. After marking and incising around the NAC, the entire area of the Wise pattern is de-epithelialized. Following this, the superior skin flaps are elevated with 1 cm thickness down to the pectoralis fascia. The lateral and medial portions of the de-epithelialized Wise pattern are now raised as lateral and medial flaps. The central mound is secured to the pectoralis fascia superiorly. The lateral and medial flaps are medialized and tacked superiorly to the central mound. The de-epithelialized tissue is then plicated to the shape of an aesthetically pleasing breast. The skin can then be re-draped, the nipple can be repositioned, and the incisions closed.

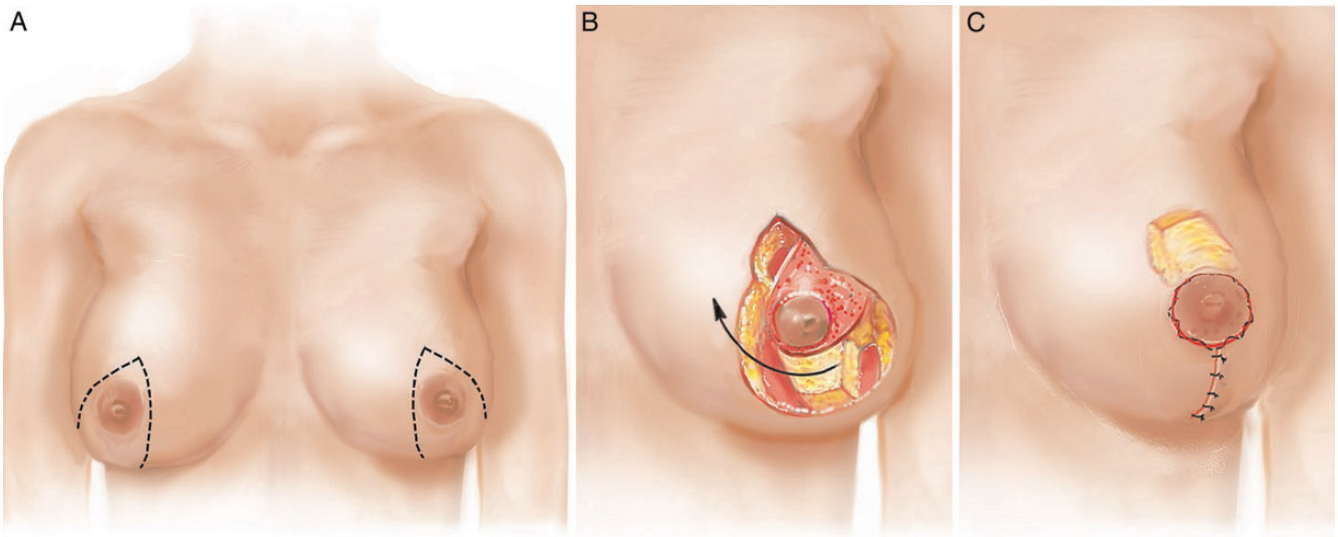

Figure 5. Vertical mammaplasty markings. (A) The markings are made by assessing the excess tissue. (B) The pedicle is rotated as a dermoglandular flap (arrow) into the superior pole of the breast. (C) Closure with the rotated breast gland secured in the superior breast to improve superior pole fullness.

Male Chest

Anatomy

The changes seen with the male breast following MWL are similar to those seen in the female breast and include skin and soft tissue redundancy, medialization of the NAC, inferior displaced IMF, deflation, lateral chest rolls, and areolar enlargement. A grading system for male breast deformities with treatment guidelines was developed by Gusenoff et al.[68] They propose three grades based on ptosis of the NAC in relation to the ideal position.

- *Grade 1*: Minimal excess skin and fat, minimal alteration of NAC, normal IMF.
  - A: No lateral skin roll.
  - B: Lateral skin roll.
- *Grade 2*: NAC and IMF below the ideal IMF, lateral chest roll, minimal upper abdominal laxity.
- *Grade 3*: NAC and IMF below the ideal IMF, lateral chest roll, significant upper abdominal laxity.

Contouring Procedures

Grades 1A and B can be approached with a combination of ultrasound-assisted and suction-assisted lipectomy with the addition of direct excision of lateral rolls for Grade 1B. Grade 2 can be corrected with a pedicled nipple reconstruction. Grade 3 usually requires a pedicled nipple reconstruction or, in severe cases, a free nipple grafting procedure.

The pedicled nipple reconstruction is performed utilizing a dermoglandular flap. This procedure involves excising an elliptical area of skin from the ideal IMF position while maintaining the NAC attachment using a thin dermal pedicle with a broad base. The new nipple should be placed between the fourth and fifth ribs. After determining the position for the nipple, the upper incision can be extrapolated by measuring 4-5 cm below the proposed NAC location. This will become the new IMF. The native IMF will serve as the lower incision. These two incisions will meet medially and laterally.

FACIAL REJUVENATION

Anatomy

Following massive weight loss, patients will often complain of premature aging. The patient may not be able to completely verbalize what it is that bothers them. It is, therefore, up to the surgeon to perform a complete facial analysis and determine the deformities from an objective standpoint. In general, the forehead, brow, and eyelids do not undergo marked change related to weight gain and weight loss. This is likely secondary to the relative paucity of subcutaneous fat in these areas. Additionally, the nose does not change significantly during weight fluctuation. Should these areas demonstrate contour deformities, it is likely due to facial aging in general and not related to the MWL. As such, these areas should be treated with standard treatments for facial aging.

The midface and neck, however, do suffer from the changes associated with MWL. The midface can be affected by volume loss and facial soft tissue descent, including both skin and fat. Descended fat pads and midface deflation should be addressed by midfacial repositioning, suspension, and fat grafting.[69] The neck can also undergo severe alterations from MWL. Excess skin is almost universally present. Platysmal banding can also be prominent. The authors have noted that the deformities are not as severe in younger patients, typically those younger than 40 years of age, but can be quite severe in older patients.

Facial Contouring

As stated above, the forehead, brow, eyelid, and nose are rarely affected by the changes from weight gain and MWL. Standard plastic surgical rejuvenation techniques should be employed for these areas. Particularly in an older patient, the midface usually demonstrates obvious descent and requires lifting. This can be performed with a skin resection, superficial musculoaponeurotic system elevation via plication or dissection, malar fat pad elevation, and/or fat grafting (Figure 6). The neck can also be included in the facelifting procedure. This often requires a separate incision in the submental position for access to the central neck and platysma. Excess neck skin can be removed laterally in the postauricular region. The platysmal bands can be corrected via the submental incision. The medial edges of the splayed platysma are dissected free, medialized, and sutured to each other. A platysmal incision can be made distally,

Figure 6. A key component of facial rejuvenation surgery includes elevation of the midface (dotted lines), including the malar fat, along a superoposteriorly-oriented vector (arrows).

perpendicular to the muscle, to allow the platysma to drape more anatomically.

RISKS AND COMPLICATIONS

Introduction

No surgery is without potential risks, and post-bariatric contouring is no exception. Complications can range from scarring or asymmetry to hematoma, seroma, wound dehiscence, infection, and deep venous thromboembolism.[70] The possibility of complications must be discussed with the patient during the pre-operative visits, as patients will be more likely to be accepting of complications if they are adequately prepared and counseled prior to undergoing surgery.[62] The incidence of complications also appears to be linked to both pre-weight loss BMI and BMI at the time of contouring.[71]

Complications

Complications are commonly encountered after body contouring in the post-bariatric surgery patient. In fact, wound healing problems have been reported to occur in as many as 46% of nonsmokers and 69% of smokers under this type of surgery.[72] Partial wound dehiscences have been reported in 16-33% of patients.[73] Poor skin elasticity that contributes to the deformities being addressed by the body contouring surgery also leads to a high rate of scar migration and recurrent contour deformities. Therefore, it is recommended that bony landmarks and stable fixation points be utilized as much as possible during planning of the surgical procedures. As described by Lockwood,[73] suspension of the superficial fascial system was a significant advancement towards optimizing scar healing and location.

Hematoma

The risk of hematoma depends on the procedure performed. In Coon et al's[71] study of 511 post-bariatric patients who underwent contouring, 4.7% developed a hematoma. As with all operations, meticulous hemostasis is critical. In addition, some surgeons recommend injecting incision lines with 1:100 000 epinephrine to decrease the risk of bleeding. To confirm the diagnosis of a hematoma, an ultrasound or CT scan may be helpful. Depending on the size of the hematoma, the patient should be drained either at the bedside or in the operating room setting.

Seroma

The formation of seromas is quite common following post-bariatric contouring, with an average of around 13%[74] and higher rates found in smokers (22%) and patients undergoing multiple procedures compared to a single procedure (18.6% compared to 4.1%).[75] Although not every seroma needs to be drained, large seromas may be uncomfortable or become infected. If a Jackson-Pratt drain is intact and effectively draining the seroma, this may be left in place. If the output continues to be high (> 50 mL per day), doxycycline and bleomycin have been used to help sclerose the seroma cavity. If the drain has already been removed, the patient may benefit from percutaneous drainage, either with serial aspirations at the bedside for smaller seromas or with an ultrasound-guided catheter left in place to drain larger seromas. Seromas are most commonly associated with lower body procedures, including abdominoplasty. Injudicious undermining of the back during back and buttock lifting can also contribute to seroma formation.

Infection

Infections have been reported to occur in less than 10% of cases, ranging from 3.5% to 7.7%.[62] Most surgeons will try to prevent infection with a prophylactic pre-operative dose of a first-generation cephalosporin or clindamycin but, as Shermak[62] points out, there is little agreement on postoperative antibiotics. Many surgeons prescribe no postoperative antibiotics at all, while many others treat patients for at least a week after surgery. If cellulitis is identified, the extent should be marked and the patient should be frequently examined for worsening or for resolution with oral antibiotics. If the patient fails to improve, worsens, or develops systemic signs of infection such as fever, the patient should be admitted for intravenous antibiotics. Comorbidities such as diabetes and immunocompromise should clearly lower the threshold for hospital admission and intravenous antibiotics. If an abscess is identified, it should be drained, either at the bedside or in the operating room. Following drainage, the space may be treated with packing changes if it is small; for larger defects, a wound vacuum-assisted closure may be indicated.

Skin Necrosis

Skin necrosis can also be common after contouring procedures, ranging anywhere from 6 to 10%. As in seroma formation, the incidence can be higher in smokers (19.4%) and in patients undergoing multiple procedures (9.5% vs. 2.4%).[62] Although abdominoplasties with a vertical component, such as the fleur-de-lis, have been reported with a higher rate of skin necrosis, Friedman et al[52] reported similar rates of necrosis between fleur-de-lis and traditional abdominoplasties (4.6% vs 3.3%). Superficial areas of necrosis may be treated with bacitracin or silver sulfadiazine.[3] Although not specifically studied for treatment of skin necrosis after body contouring procedures, there is growing evidence that topical collagenase may be a safe and cost-effective method of enzymatic debridement.[76] Full-thickness areas of necrosis would need to be debrided, excised, and packed using the same methods as described following drainage of abscesses. Prolonged immobilization after surgery can lead to pressure ischemia.

Venous Thromboembolism

Of all possible complications, deep venous thromboembolism (DVT) and pulmonary embolism (PE) are two of the most feared, and for good reason. These can be the deadliest, and given that obesity already lends itself to a hypercoagulable state, patients are at a higher risk for developing these outcomes. Prophylaxis is therefore of paramount importance. These measures include sequential compression devices for the lower extremities placed prior to induction and a pillow under the knees to improve venous return.[77] Early ambulation should also be encouraged as soon as possible following surgery.

Prophylactic anticoagulation is somewhat controversial, as the concern is that administration of pre-operative unfractionated heparin or low–molecular weight heparin will lead to higher rates of postoperative bleeding. Consequently, some authors recommend giving heparin only after the procedure if the patient is to be admitted, beginning 8 hours after the operation is complete or during the night following the procedure. However, there is also evidence that preoperative unfractionated and low–molecular weight heparin does not lead to a significantly increased rate of postoperative bleeding.[78] Certainly, if the patient has a much higher risk of developing a DVT or PE or has had one of them in the past, a pre-operative inferior vena cava filter may be beneficial.

Swelling after surgery is common in post-bariatric contouring. Therefore, distinguishing between postoperative edema and deep venous thrombosis in the lower extremities can be challenging. The threshold for diagnostic work-up should be low. Venous duplex ultrasound is indicated for asymmetric swelling or pain in the lower extremity, as well as a chest computer tomography angiogram for postoperative dyspnea and tachycardia. If positive, the patient should be treated with an intravenous heparin drip with a pulmonary embolism protocol based on the partial thromboplastin time, or a low–molecular weight heparin. The patient should be bridged to warfarin therapy and may discontinue heparin once the international normalized ratio has reached therapeutic levels.[79]

CONCLUSION

The increasing rate of bariatric surgical procedures has led to an increasing popularity of post-bariatric contouring procedures. These procedures are extremely important for the patient. With proper management of the post-bariatric medical, psychological, and surgical issues, the patient can get back on the road to a healthier and happier lifestyle.

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