

Outcomes of Incorporating Customized Plication in Lipoabdominoplasty Procedures

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Abstract

Lipoabdominoplasty has evolved into one of the most frequently performed body contouring procedures worldwide, combining the principles of liposuction with advanced musculoaponeurotic repair to achieve superior aesthetic and functional outcomes. While traditional vertical plication effectively addresses rectus diastasis, it often fails to correct complex deformities or enhance waist definition. This has driven the development of customized plication techniques including transverse, oblique, L-shaped, and crossbow configurations that allow for individualized treatment based on anatomical classification systems and deformity severity. Preservation of abdominal wall perforators and Scarpa's fascia underpins the safety of these procedures, maintaining robust vascularity while reducing ischemic complications and seroma formation. Contemporary evidence demonstrates that tailored plication improves waist contour, core stability, and long-term patient satisfaction without significantly increasing complication rates when performed by experienced surgeons. This review synthesizes the anatomical foundations, vascular considerations, classification of musculoaponeurotic deformities, surgical refinements, and outcome analyses of customized lipoabdominoplasty techniques, highlighting the importance of personalized approaches. Future directions include integration of advanced imaging, biomarker-based tissue assessment, and technological innovations to further optimize durability, precision, and safety.

Keywords: Lipoabdominoplasty, musculoaponeurotic plication, waist contouring, oblique plication, crossbow technique, abdominal wall reconstruction

Introduction

The landscape of abdominal contouring surgery has undergone dramatic transformation since Kelly's pioneering abdominal wall procedure in 1899, evolving through Thorek's umbilicus-preserving technique in 1924 to Vernon's modern abdominoplasty incorporating umbilical transposition and musculoaponeurotic plication in 1957 (1,2). The integration of liposuction in the 1980s and Dellon's fleur-de-lis resection pattern in 1985 further advanced the field, setting the foundation for contemporary lipoabdominoplasty techniques (3).

According to the International Society of Aesthetic Plastic Surgery (ISAPS) 2023 Global Survey, approximately 1,153,539 abdominoplasty procedures were performed worldwide, representing a 434% increase since 1997 and establishing abdominoplasty as one of the most commonly performed body contouring procedures globally (4). This exponential growth has driven continuous innovation in surgical techniques, with particular focus on optimizing aesthetic outcomes while minimizing complications.

The fundamental principle underlying modern lipoabdominoplasty involves preservation of abdominal wall perforators at the rectus abdominis muscle level through selective undermining combined with comprehensive liposuction (5). This approach maintains approximately 80% of the abdominal flap's vascular supply compared to traditional abdominoplasty, significantly reducing ischemic complications and enabling more extensive contouring procedures (6).

However, traditional vertical plication alone often proves insufficient for addressing complex musculoaponeurotic deformities and achieving optimal waist definition. Musculoaponeurotic laxity correction through standard midline plication from xiphoid to pubis, while effective for diastasis recti correction, fails to improve contour deformities of the entire musculofascial layer, particularly in the waist region (7). This limitation has prompted the development of various advanced techniques including horizontal plication, oblique vectors, aponeurotic release and repair, and combination approaches (8).

The anatomical understanding of abdominal wall deformities has evolved to recognize the relationship between extracellular matrix composition and surgical outcomes. The ratio of collagen type I to type III in aponeurotic tissue represents a genetic determinant of tissue strength, with high type III fiber concentrations associated with weaker aponeuroses and increased deformity susceptibility (9). Additionally, the correlation between skin excess severity and musculoaponeurotic deformity complexity supports the need for individualized treatment approaches based on comprehensive anatomical assessment (10).

Contemporary practice patterns reflect this evolution toward customized approaches. Institutional audits demonstrate that while vertical plication remains universal (100% of cases), transverse plication is performed in 55% of cases, oblique/lateral vector plication in 30%, and cross-pattern plication in 15%, particularly in patients with severe diastasis or requiring enhanced waist contouring (11,12). These statistics underscore the growing recognition that optimal outcomes require tailored surgical planning based on individual anatomical presentations.

The classification of abdominal deformities has become increasingly sophisticated, with skin excess categorized into Types I-III based on severity and umbilical positioning, while musculoaponeurotic deformities are classified as Types A-D based on etiology and anatomical patterns (13). This dual classification system guides surgical decision-making and technique selection, enabling personalized treatment plans that address specific anatomical challenges.

This comprehensive review examines the current state of customized musculoaponeurotic plication in lipoabdominoplasty, analyzing anatomical foundations, classification systems, surgical techniques, and clinical outcomes to provide evidence-based guidance for optimizing patient care and aesthetic results.

Anatomical Foundations and Vascular Considerations

Abdominal Wall Vascularization

The arterial supply of the anterolateral abdominal wall comprises two primary systems: the superolateral division including intercostal, subcostal, musculophrenic, and superior epigastric arteries, and the inferior division encompassing deep circumflex iliac and inferior epigastric arteries from the external iliac system (14). This dual arterial network forms the foundation for understanding surgical approaches and complication prevention.

Huger's classical description divides the abdominal wall into three distinct vascular zones. Zone I extends from xiphoid to pubis between the lateral rectus sheath margins, supplied primarily by superior and inferior epigastric arteries. Zone II spans between the anterior superior iliac spines in the upper region and extends into the inguinal area below, vascularized by superficial and deep arterial systems including superficial circumflex iliac, superficial epigastric, and external pudendal arteries. Zone III encompasses the lateral regions above the anterior superior iliac spines to the lateral rectus margin, supplied by intercostal, subcostal, and lumbar arteries (15).

The perforating arterial system represents the critical vascular component for lipoabdominoplasty success. Approximately six perforating vessels arise from the deep epigastric system, located 2-3 cm from the medial rectus muscle edges (16). These perforators create two distinct supply patterns: smaller caliber vessels primarily nourish the deep subcutaneous tissue through the deep arterial plexus, while larger diameter perforators extend to the subdermal plexus, supplying skin and superficial subcutaneous layers (17).

During traditional abdominoplasty, extensive flap undermining damages perforating branches in Huger zones I and II, compromising vascular supply and increasing complication risks. Lipoabdominoplasty's limited undermining preserves most perforating vessels, maintaining approximately 80% of blood supply compared to conventional techniques (18). This preservation enables safe execution of extensive plication procedures while minimizing ischemic complications.

Doppler flowmetry studies in lipoabdominoplasty patients demonstrate preservation of periumbilical and upper quadrant perforators, with preoperative averages of 4.92 vessels in the left upper quadrant and comparable numbers on the right, reducing to 3.10 and 3.0 respectively postoperatively (19). This data confirms significant vascular preservation following lipoabdominoplasty with reduced flap displacement.

Subcutaneous Tissue Architecture

The subcutaneous tissue demonstrates distinct layering divided by Scarpa's fascia into superficial areolar and deep reticular layers. The superficial layer contains abundant fibrous septa with turgid globular cells and high compaction, creating small interstitial spaces traversed by small-caliber vessels. The deep layer exhibits fewer septa with loose, smaller globular cells, higher fat accumulation, and larger intercellular spaces accommodating higher-caliber vessels (20).

Scarpa fascia preservation has emerged as a critical component of modern lipoabdominoplasty, offering multiple advantages including reduced bleeding through inferior perforator preservation, homogeneous abdominal flap support, and improved scar containment with enhanced adherence between flap and deep layers (21). Additionally, Scarpa fascia reconstruction reinforces continuity and prevents cephalic retraction toward the umbilical scar, which can cause transverse suprapubic depression and scar migration (22).

Computed tomography analysis reveals that the umbilical region subcutaneous tissue measures approximately 5 mm thicker than the suprapubic region, with the deep layer being approximately 9 mm thicker umbilically than suprapubically (23). These findings support selective deep layer resection to prevent postoperative protrusion above suture lines.

Musculoaponeurotic System Structure

The anterolateral abdominal wall comprises three flat muscles (external oblique, internal oblique, transversus abdominis) and two vertical muscles (rectus abdominis, pyramidal muscle), all arranged in bilateral pairs. The lateral rectus borders create linea semilunaris depressions corresponding to the transition where flat muscle fibers become aponeurotic, converging to form the rectus sheath (24).

The rectus sheath demonstrates complex layering with anterior and posterior components. The posterior layer forms from transversus abdominis aponeurosis and posterior internal oblique aponeurosis in the superior three-quarters, while the inferior quarter lacks posterior coverage, being lined only by transversal fascia. This transition point represents the arcuate line, a potential weakness zone (25).

The linea alba represents the medial convergence of bilateral aponeuroses, forming a natural weakness area susceptible to diastasis during tissue tension states such as pregnancy. Diastasis recti abdominis involves aponeurotic fiber weakening and midline separation without hernia formation, requiring correction through rectus sheath plication (26).

Classification of Musculoaponeurotic Deformities

Contemporary understanding recognizes four distinct musculoaponeurotic deformity patterns requiring specific surgical approaches:

Type A deformities represent rectus diastasis secondary to pregnancy with fusiform patterns and close medial rectus insertion at costal margins. These cases respond optimally to anterior rectus sheath plication alone (27).

Type B deformities demonstrate persistent musculoaponeurotic bulging following diastasis correction, often with vertical abdominal wall elongation. These patients benefit from combined anterior rectus sheath plication and L-shaped external oblique aponeurosis plication (28).

Type C deformities involve congenital rectus diastasis with lateral rectus muscle insertion at costal margins, requiring rectus muscle advancement for effective correction (29).

Type D deformities present poorly defined waistlines with strong external oblique aponeurosis, necessitating external oblique muscle advancement in addition to anterior rectus sheath plication (30).

This classification system provides a framework for individualized treatment planning, ensuring appropriate technique selection based on specific anatomical presentations and functional requirements.

Advanced Surgical Techniques and Plication Methods

Preoperative Planning and Patient Selection

Contemporary lipoabdominoplasty with customized plication requires meticulous preoperative assessment and patient selection. Ideal candidates present with body mass index below 35 kg/m², demonstrating lipodystrophy with abdominal skin laxity while maintaining reasonable tissue quality (31). Special considerations apply to post-bariatric patients due to poor skin retraction capability, smokers with compromised healing potential, and patients with previous abdominal surgery including prior liposuction (32).

The degree of anatomical definition achievable depends critically on patient factors including BMI, skin quality, and underlying musculature. Patients with BMI exceeding 27 kg/m² and poor skin quality typically achieve moderate rather than high-definition results, emphasizing the importance of realistic expectation setting during consultation (33).

Comprehensive preoperative marking involves systematic anatomical delineation with the patient performing muscular contraction to identify rectus borders and diastasis extent. The costal margin, iliac crests, and anticipated umbilical positioning require precise marking to guide subsequent surgical steps (34).

Liposuction zones are categorized based on vascular anatomy and safety considerations. Red zones over rectus muscles require controlled deep liposuction with perforator preservation. Yellow zones represent flap perfusion risk areas requiring moderate approach. Light green zones permit safe intense deep liposuction, while dark green zones (linea alba and semilunaris lines) undergo superficial and deep liposuction for anatomical definition (35).

Fundamental Lipoabdominoplasty Technique

The procedural sequence begins with super-wet infiltration using saline solution with adrenaline (1:500,000) throughout the designated treatment areas, with particular attention to regions planned for intensive liposuction. Infiltration pumps and specialized cannulas significantly reduce infiltration time and improve efficiency (36).

Selective liposuction commences in dark green definition areas, starting with the linea alba between rectus medial edges and over the planned umbilical pedicle location. Sequential treatment of semilunaris lines and subcostal inverted triangle using 3-4mm conventional cannulas removes superficial then deep layer fat while preserving the subdermal plexus (37).

The procedural endpoint targets pinch test measurements of approximately 1.5 cm, adjusted based on patient BMI, skin quality, and musculature. Horizontal rectus lines are deliberately avoided as flap transposition may displace these markings from anatomical muscle locations, potentially compromising vascularization (38).

Light green areas including flanks and posterior regions undergo deep and selective superficial liposuction until achieving natural, harmonious abdominal wall contours with pinch test measurements between 1.5-2.0 cm (39). This selective approach creates natural curves while avoiding artificial muscular hypertrophy appearance.

Scarpa fascia preservation extends to the anterior superior iliac spines, based on theoretical benefits including lymphatic preservation, pubic suspension, scar shortening, dead space reduction, and seroma prevention. The central Scarpa fascia portion overlying the diastasis requires removal for complete plication access (40).

Advanced Plication Techniques

Vertical Plication: The Cornerstone Technique

Vertical plication remains essential for central abdominal reinforcement and diastasis correction, with robust evidence supporting its functional and aesthetic efficacy (41). The technique employs interrupted 1-0 Prolene figure-of-eight sutures placed 2 cm apart, followed by running Vicryl 1 reinforcement from xiphisternum to symphysis pubis (42).

Long-term efficacy studies using CT scan evaluation demonstrate no diastasis recurrence with average follow-up of 84 months when plication targets the medial rectus muscle edges in pregnancy-related cases (43). However, studies by van Uchelen and colleagues reported 40% recurrence rates with average 64-month follow-up, attributed to plication extending beyond medial rectus edges and potential measurement methodology limitations (44).

The discrepancy in outcomes emphasizes the importance of precise technique, with plication confined to actual diastasis areas rather than extending into normal tissue. Excessive tension during aponeurotic approximation may contribute to failure and should be avoided (45).

Oblique Plication: Enhanced Waist Definition

Oblique plication involves angled rectus sheath suturing to address asymmetrical laxity patterns commonly seen following pregnancy or abdominal surgery. Comparative studies demonstrate significant enhancement in waist narrowing and epigastric bulging reduction, though with moderately extended operative times (46).

The technique demonstrates superior contouring capabilities in patients with diagonal muscle laxity, promoting more symmetrical force distribution across the abdominal wall. Clinical applications show particular benefit in cases where standard vertical repair proves inadequate (47).

Technical execution involves upper oblique plication extending from below the mid-costal margin downward and medially toward the umbilicus, while the lower oblique limb starts from the umbilicus and extends downward and laterally to a point 5 cm above the midinguinal point (48). All plications target the rectus sheath and external oblique muscle with 2 cm width, secured using interrupted 1-0 Prolene figure-of-eight sutures and reinforced with running Vicryl 1 sutures.

L-Shaped Lateral Plication

The L-shaped plication technique addresses cases where isolated medial plication fails to provide adequate lateral tightening or waist definition. This approach involves strategic folding of the external oblique aponeurosis in an L-configuration, reinforcing the abdominal wall across both vertical and transverse vectors (49).

Clinical applications demonstrate particular value in patients with significant musculoaponeurotic laxity localized to flanks and hypogastrium. The vertical limb addresses midline diastasis while the horizontal extension targets lateral laxity, enhancing waistline contour and reducing apparent abdominal length (50).

Controlled studies comparing L-shaped external oblique plication with traditional approaches demonstrate significant waist circumference reduction (mean 87.4 ± 1.1 cm vs. 96.8 ± 1.8 cm) and superior patient satisfaction rates exceeding 85% (51). The technique creates a corset-like effect through strategic external oblique aponeurosis modification without requiring mesh reinforcement.

Technical execution involves rectus muscle undermining and posterior rectus sheath exposure, representing the congenital lateral rectus insertion at costal margins. The vertical limb measures approximately 8 cm height while the horizontal limb extends 3 cm, secured with interrupted 1-0 Prolene figure-of-eight sutures 2 cm wide (52).

Crossbow Plication: Multidirectional Reinforcement

Crossbow plication represents the most comprehensive approach, combining vertical and horizontal reinforcement through coordinated folding of both rectus sheath and external oblique aponeurosis in cross-like patterns (53). The Type I approach involves marking from xiphoid process to pubis with an arc connecting the anterior superior iliac spines for horizontal reinforcement.

The procedure sequence begins with standard vertical plication addressing linea alba diastasis, followed by horizontal external oblique muscle plication from midline to anterior superior iliac spines. Aponeurotic flaps are secured with interrupted figure-of-eight 1-0 Prolene sutures, reinforced with overlying running Vicryl 0 sutures (54).

Since Farouk and Askar's introduction of crossed plication in 2013, the technique has evolved into three variants (Types I-III) applicable to both cosmetic and post-bariatric patients. Clinical series of 22 cases demonstrate

excellent aesthetic definition in hypogastric and iliac regions with no serious complications or revision requirements (55).

Comparative studies show patients undergoing horizontal oblique plication with abdominoplasty achieve superior hypogastric contour and waist definition compared to midline-only repairs, with higher excellent ratings and patient satisfaction scores (56).

Postoperative Management

Comprehensive postoperative care involves two-layer abdominal closure using polyglactin 0 for deep connective/fascial tissue and monocryl 3-0 for subdermal layers (57). Continuous aspiration drainage continues until output falls below 50 mL per 24-hour period, typically occurring within 5-7 days postoperatively.

Thromboembolic prophylaxis includes elastic stockings and intermittent pneumatic compression until active mobilization, with low-molecular-weight heparin for high-risk patients continued for 5-7 days postoperatively (58). Antibiotic prophylaxis utilizes first-generation cephalosporin maintained 24 hours after drain removal.

Pain management incorporates nonsteroidal anti-inflammatory drugs for 5 days, with celecoxib 200 mg daily and acetaminophen with codeine (500/30 mg every 8 hours) as needed. Compression garments and medical-grade polyurethane foam pads are utilized for 20-30 days to optimize healing and contouring (59).

Clinical Outcomes and Evidence Analysis

Aesthetic Outcomes and Patient Satisfaction

Contemporary lipoabdominoplasty with customized plication demonstrates superior aesthetic outcomes compared to traditional single-vector approaches. The ability to tailor plication patterns based on individual anatomical assessment and deformity classification enables predictable results with high patient satisfaction rates (60).

Studies evaluating combined vertical and oblique plication techniques show patients achieve significantly better waist-to-hip ratios and satisfaction scores compared to vertical plication alone. The customization capability allows for natural abdominal contours while avoiding the artificial appearance associated with overly aggressive approaches (61).

Patient satisfaction correlates strongly with the degree of waist definition achieved and the naturalness of final contours. The preservation of rectus muscle bulges while correcting laxity maintains physiological appearance, contributing to higher satisfaction rates compared to overly flattened results (62).

Long-term aesthetic durability studies demonstrate maintained results at 2-year follow-up in patients with appropriate tissue quality and stable weight. The key factors influencing longevity include proper patient selection, appropriate technique selection based on deformity classification, and adherence to postoperative care protocols (63).

Functional Outcomes and Core Stability

Musculoaponeurotic plication provides both aesthetic and functional benefits through restoration of midline muscular support and intra-abdominal pressure optimization (64). By anatomically correcting muscolofascial laxity, the procedure restores juvenile abdominal wall appearance while maintaining physiological muscle function.

However, plication techniques increase intra-abdominal pressure, which may cause temporary complications including reduced pulmonary function, particularly in patients with chronic obstructive pulmonary disease (65). This effect results from diaphragmatic elevation secondary to increased intra-abdominal pressure, with spirometric studies showing significant value reduction on postoperative day two, normalizing by day fifteen.

Studies indicate that additional plication techniques beyond vertical correction do not significantly alter spirometric values, possibly due to loose connective tissue between internal and external oblique muscles

permitting slip between layers (66). This finding supports the safety of advanced plication techniques when properly executed.

Functional outcome assessments demonstrate improved core stability and reduced back pain in patients undergoing comprehensive musculoaponeurotic repair compared to skin-only procedures (67). The restoration of anatomical relationships contributes to improved posture and reduced compensatory mechanisms.

Complication Profiles and Safety Analysis

Lipoabdominoplasty with customized plication maintains the favorable safety profile of standard lipoabdominoplasty while potentially offering enhanced outcomes through improved technique precision (68). The preservation of vascular perforators significantly reduces ischemic complications compared to traditional approaches.

Comparative analyses between classic abdominoplasty and lipoabdominoplasty demonstrate significant seroma reduction with lipoabdominoplasty, attributed to smaller supraumbilical flap displacement creating reduced dead space and enhanced lymphatic drainage preservation (69). Quantitative studies show 86.7% reduction in seroma formation rates with lipoabdominoplasty compared to conventional techniques.

The additional complexity of customized plication requires enhanced surgical expertise and thorough anatomical understanding. However, when properly executed by experienced surgeons, these techniques do not significantly increase complication rates beyond standard lipoabdominoplasty levels (70).

Specific complications associated with advanced plication techniques include temporary sensory changes, particularly in the lateral femoral cutaneous nerve distribution when incisions extend toward the anterior superior iliac spine. Careful anatomical awareness during lateral dissection minimizes these risks (71).

Comparative Effectiveness Studies

Multi-institutional studies comparing different plication approaches provide evidence for technique selection based on patient characteristics and desired outcomes. The TULUA multicenter study of 845 cases demonstrated excellent safety profiles with customized plication approaches, showing reduced complication rates compared to traditional methods (72).

Comparative effectiveness research indicates that patient-specific technique selection based on musculoaponeurotic deformity classification yields superior outcomes compared to standardized approaches. The ability to match technique complexity to deformity severity optimizes results while minimizing unnecessary intervention (73).

Cost-effectiveness analyses suggest that while customized plication techniques may require increased operative time, the improved outcomes and reduced revision rates provide favorable economic profiles over extended follow-up periods (74).

Quality of life assessments demonstrate significant improvements in body image, self-confidence, and physical comfort following customized plication procedures, with benefits maintained at long-term follow-up in appropriately selected patients (75).

Future Directions and Technological Advances

Personalized Medicine Integration

The evolution toward customized musculoaponeurotic plication represents broader trends toward personalized medicine in aesthetic surgery. Individual assessment incorporating genetic markers of tissue quality, metabolic factors affecting healing, and biomechanical analysis may further refine patient selection and technique optimization (76).

Advanced imaging modalities including three-dimensional surface analysis, magnetic resonance imaging, and ultrasound elastography may enhance preoperative planning and outcome prediction. The integration of artificial intelligence algorithms could assist in technique selection based on comprehensive patient data analysis (77).

Biomarker assessment of collagen types I and III ratios may predict tissue quality and appropriate plication techniques. Patients with high type III collagen concentrations may benefit from modified approaches or adjunctive treatments to optimize outcomes (78).

Technological Innovations

Emerging technologies including ultrasound-assisted liposuction, radiofrequency-assisted techniques, and energy-based devices may enhance precision and outcomes in customized plication procedures (79). These modalities offer potential advantages in tissue tightening and collagen remodeling.

Robotic surgical systems and computer-assisted planning may improve precision in plication placement and tension adjustment. Three-dimensional modeling could enable virtual surgical planning with outcome prediction capabilities (80).

Advanced suture materials including absorbable mesh reinforcement and bioactive sutures promoting tissue integration may enhance plication durability and reduce long-term recurrence rates (81).

Research Priorities

Long-term durability studies with extended follow-up periods are essential for establishing the permanence of customized plication results. Factors affecting longevity including patient age, tissue quality, lifestyle factors, and hormonal influences require systematic investigation (82).

Biomechanical studies analyzing force distribution patterns across different plication configurations may optimize technique selection and suture placement. Understanding the mechanical properties of various approaches could guide evidence-based technique refinement (83).

Standardization of outcome measurement tools and reporting criteria would enhance comparative effectiveness research and enable meta-analyses of plication techniques. Development of validated assessment instruments specific to abdominal contouring would improve research quality (84).

Conclusions

Customized musculoaponeurotic plication represents a significant evolution in lipoabdominoplasty technique, enabling enhanced waist contouring and body reshaping through anatomically-guided, patient-specific surgical approaches. The integration of vertical, oblique, lateral, and crossbow plication patterns provides comprehensive solutions for complex musculoaponeurotic deformities while maintaining the established safety profile of lipoabdominoplasty. The classification system for musculoaponeurotic deformities (Types A-D) provides an evidence-based framework for surgical decision-making, enabling individualized treatment plans that optimize outcomes while minimizing unnecessary intervention complexity. The correlation between deformity type and optimal plication technique selection has been validated through multiple clinical studies and represents current best practice.

Clinical outcomes demonstrate superior aesthetic results, enhanced patient satisfaction, and improved functional outcomes with customized approaches compared to standardized vertical plication alone. The preservation of vascular perforators through limited undermining enables safe execution of extensive plication procedures while maintaining favorable complication profiles. The future of customized musculoaponeurotic plication lies in continued refinement through technological integration, extended durability studies, and biomechanical optimization. The principles of anatomical understanding, individualized assessment, and technical precision will remain fundamental to achieving optimal outcomes in this evolving field.

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