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Lipedema Reduction Surgery Improves Pain, Mobility, Physical Function, and Quality of Life: Case Series Report

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Background: Lipedema is a chronic inflammatory subcutaneous adipose-rich connective tissue disease affecting millions of women worldwide. Disproportionate fat accumulation on the extremities characterized by heaviness, tenderness, and swelling can affect function, mobility, and quality of life. Treatments include conservative measures and lipedema reduction surgery (LRS). Here, we report lipedema comorbidities and surgical techniques, outcomes measures, and complications after LRS.
Methods: This is a single outpatient clinic retrospective chart review case series of comorbidities and complications in 189 women with lipedema. Bioelectrical impedance analyses, knee kinematics, gait, physical examinations, Patient-Reported Outcomes Measurement Information System, and RAND Short Form-36 questionnaires collected before and after LRS were analyzed for 66 of the 189 women. Hemoglobin levels were measured by transdermal hemoglobin monitor (Masimo noninvasive hemoglobin monitoring; Irvine, Calif.).
Results: Common comorbidities in 189 women were hypermobile joints (50.5%), spider/varicose veins (48.6/24.5%), arthritis (29.1%), and hypothyroidism (25.9%). The most common complication in 5.5% of these women after LRS was lightheadedness with a 2-g reduction or more in hemoglobin. After conservative measures and LRS in 66 women, significant improvements ($P \leq 0.0009$) were found for: (1) knee flexion (10 degrees); (2) gait; (3) Patient-Reported Outcomes Measurement Information System T-score (16%); (4) mobility questions: gait velocity, rising from a chair, stair ascent; (5) RAND Short Form-36 scores: physical functioning, energy/fatigue, emotional well-being, social function, general health; (6) and Bioelectrical impedance analyses total and segmental body fat mass.
Conclusion: LRS provided significant improvements to women with lipedema using direct physical measurements and validated outcome measures, comparable to those seen after total knee replacement. *(Plast Reconstr Surg Glob Open 2023; 11:e5436; doi: 10.1097/GOX.0000000000005436; Published online 30 November 2023.)*

INTRODUCTION

Lipedema is a subcutaneous adipose-rich connective tissue (SAT) disease estimated to affect 6%–19% of women.[1–3] Signs and symptoms of lipedema include limb heaviness and pain.[4] Affected limbs can become bulky and heavy, which can make daily tasks such as walking, cleaning, or shopping difficult or impossible. Disproportionate accumulation of lipedema tissue on the inner leg causes valgus stresses (increasing the risk of meniscus damage and osteoarthritis),[5] restricts knee flexion,[6] and alters gait mechanics, which is a risk factor for falls.[7]

Lipedema tissue can grow and present in three stages: stage 1 is thickening and disproportionate accumulation of SAT in the extremities with smooth skin; stage 2 is increased fibrous SAT with skin indentations; stage 3 lipedema tissue forms lobules of skin and SAT. Women with stage 2–3 lipedema often have swelling on physical examination and most have evidence of impaired lymphatic function (Fig. 1).[8–10]

There is no cure for lipedema. Treatment focuses on symptom management, improving patient outcomes, and

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Received for publication June 21, 2023; accepted October 5, 2023.

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DOI: 10.1097/GOX.0000000000005436

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prevention of complications. Two treatments are (1) nonsurgical conservative measures and (2) lipedema reduction surgery (LRS).

Women with lipedema have been treated with LRS, including suction lipectomy, in Europe for years.[11,12] LRS is the only method for removing large amounts of fibrotic tissue with a single treatment, has extensive published data showing it slows the progression of lipedema, and can be performed before complications and disability from lipedema occur.[13,14] Women with lipedema are at increased risk for secondary lymphedema.[15] The principal superficial lymphatic collecting ducts have been well described and run in or adjacent to the great and small saphenous sheaths.[17,18] There are no clinical trials that examine whether presurgical mapping of venous and lymphatic structures improves the safety of LRS. However, lymphatic vessels are dilated and tortuous in the legs of women with lipedema, even in early stages of the disease.[16,17] Lymphedema is a comorbidity,[18] and lymphatic injury can occur after liposuction.[19–21] Up to 50% of women with lipedema also have venous disease.[22–24] In this study, LRS uses suction lipectomy with techniques to protect lymphatic structures and can include manual extraction of fibrous tissues that remain after maximal debulking of tissue. Although both liposuction and LRS use cannulas attached to suction, they are distinctly different surgical procedures. Liposuction is one of the most common cosmetic surgical procedures performed,[25] and focuses on fat removal for maximal aesthetic results. LRS focuses on pain relief and functional improvement. Lipedema patients on average have a higher body mass index (BMI) and disproportionately larger areas need treatment with longer procedure times to remove greater SAT volumes.

The purpose of this article is to describe the benefits experienced by women in the USA after LRS, using techniques to protect lymphatics.

Takeaways

Question: How effective is lipedema reduction surgery (LRS)?

Findings: In this retrospective chart analysis, LRS improved knee mechanics, range of motion, and gait. Patient-Reported Outcomes showed decreased pain and improved walking speed, stair ascent, sit to rise functions, and emotional and social well-being. LRS resulted in tissue changes consistent with regression of stage in some patients.

Meaning: LRS is at least as effective in treating lipedema as total knee arthroscopy is for treating arthritis using the same outcome measures.

MATERIALS AND METHODS

Subjects were sequential patients diagnosed with lipedema in an outpatient clinic seen by a single surgeon (TW) from July 2016 to December 2022 who presented for LRS. (**See table, Supplemental Digital Content 1,** which displays the physical assessment and diagnostic criteria. **http://links.lww.com/PRSGO/C891**.)

This study was considered exempt from institutional review board oversight because it is an analysis of data collected during usual medical and surgical treatment. Over the years, the data collected evolved. BMI, lobules (subcutaneous tissue extrusions extending beyond the normal contour), and complications after LRS have been documented since 2016. Outcomes questionnaires and knee mechanics (Fig. 2) were integrated into the evaluation in 2019 and added to postoperative assessments in 2021; gait was integrated into the evaluation in 2020 and added to the postoperative assessment in 2021; transdermal hemoglobin monitoring was added

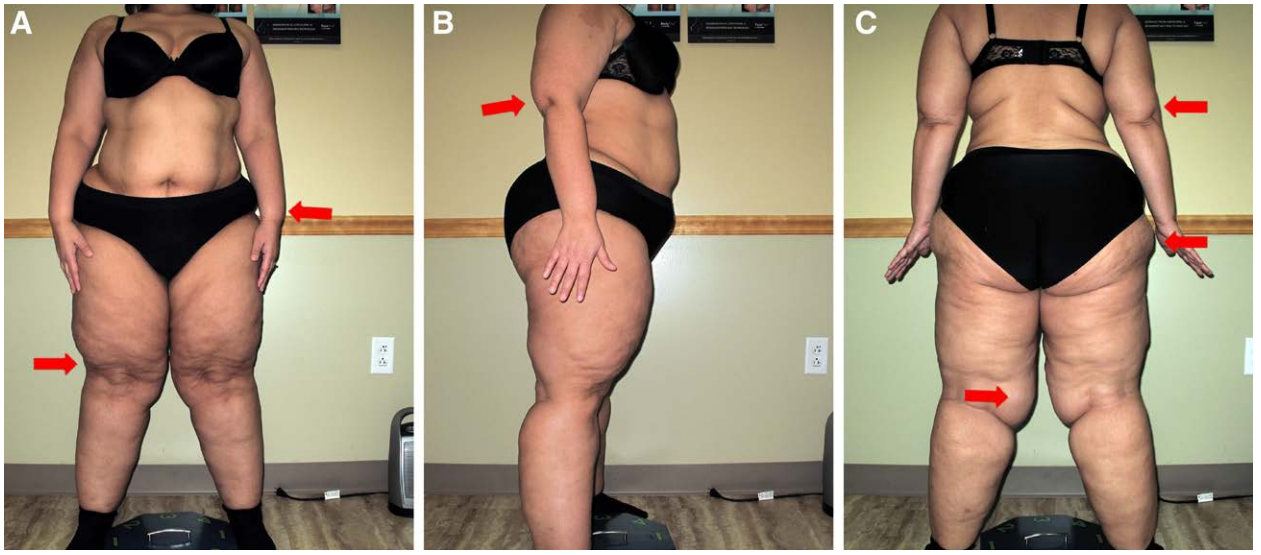

Fig. 1. Characteristic lipedema phenotype. Photographs of a woman with lipedema type 3 stage 3 view from front, back, and side, showing characteristic skin changes. In the first frontal view (A), notice the mattress changes in the thighs; the red arrows are pointed at the wrist cuff and tissue overhanging the knees. In the second panel (B), arrow is pointed at arm lobule. In the third panel (C), the red arrows are pointed at lobules on the upper arms, hips, and inner knees.

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Fig. 2. Demonstration of measuring knee joint ROM and angles. Photographs showing Q-angle, knee flexion, and valgus measurements with a long arm goniometer. A, Q angle or Quadricep angle from mid patella to inferior iliac spine. The Q-angle is measured by extending a line through the center of the patella to the anterior superior iliac spine and another line from the tibial tubercle through the center of the patella. B, Valgus measured in the anterior plane, the angle of knee joint alignment. This patient with lipedema demonstrates nearly 10 degrees of valgus angulation. Valgus/varus is the angle of deviation of the knee from normal in the sagittal plane while standing. A normal knee is neutral (no varus or valgus angulation). In lipedema, valgus deviation can be caused by bulky lipedema tissue on the medial leg and is associated with lateral tibiofemoral knee arthritis. C, Knee flexion with arms aligned over the femur and fibula and center of the goniometer over the center of the knee joint; the red arrow over the calf shows the measured flexion of 90 degrees in this patient with lipedema, and an additional arm was added for this demonstration and marked with a green arrow for the expected position of the calf with normal flexion of 140 degrees. The difference between measured knee flexion of about 90 degrees and the expected 140 degrees is caused by limitations imposed by the bulky lipedema tissue.

in 2020. Charts from 189 patients who underwent 507 surgical cases were reviewed. See Figure 3 for inclusion and exclusion criteria. The number of patients included in each outcome measure is listed in the text, figure legends or tables.

LIPEDEMA REDUCTION SURGERY

LRS in this study was designed (by TW) to protect lymphatic (and venous) vessels and improve patient outcomes as follows: (1) Patients were asked to follow conservative lipedema management, as published

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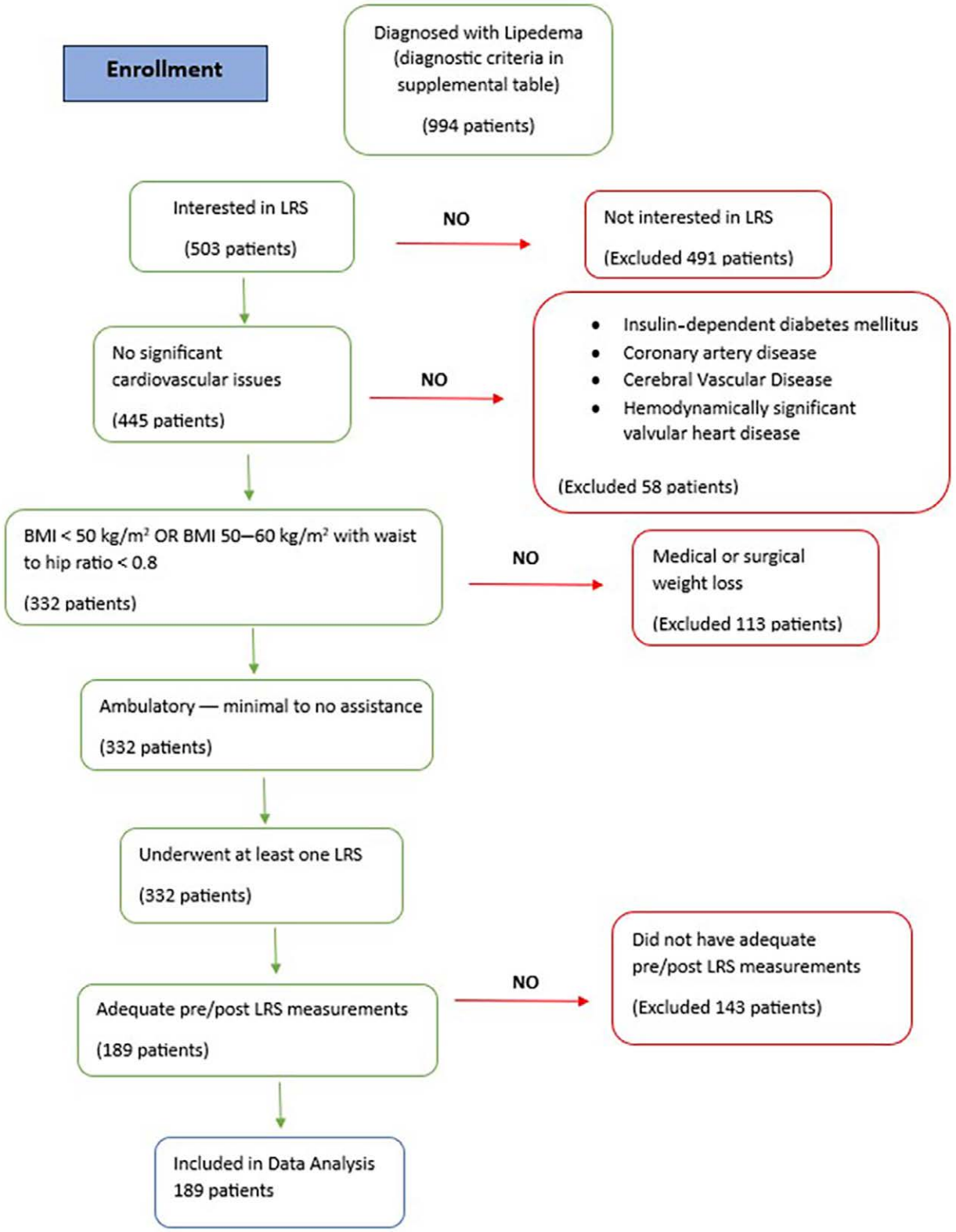

Fig. 3. Enrollment flowchart. A flowchart showing the inclusion and exclusion criteria used.

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(**See table, Supplemental Digital Content 2, http://links.lww.com/PRSGO/C892**).[26] (2) Presurgical mapping of the principal superficial veins and lymphatic structures in surgical sites (arms or legs) was performed using vascular Doppler ultrasound (Terason 3000) with a 12-20 MHz linear probe[16,17] or indocyanine green direct lymphography.[27] (3)The patients were given 2mg oral lorazepam 2 hours before arrival and upon arrival, oral narcotic pain medication, and additional lorazepam and nitrous oxide/oxygen gas mixture if needed; an intravenous line was started after preoperative oral sedation. (4) Tumescent anesthesia followed published recommendations.[28] (5) Lidocaine dosage was limited to 35–55mg per kg per procedure. 6) Each patient was risk stratified for DVT using Caprini scoring.[29,30] Prophylactic oral Xa inhibitors were prescribed for patients with increased DVT risk. **(See table, Supplemental Digital Content 2,** which displays the compression and conservative treatment. A table showing pre- and postoperative conservative treatment protocol including compression garment type and strength used for each surgery, diet recommendations, lymphatic therapy, and exercise recommendations. These were ordered pre-LRS and recommended to be continued postsurgery. These nonsurgical recommendations and their benefits and limitations were published in 2022. **http://links.lww.com/PRSGO/C892**.)

LRS was performed with the patient initially in a supine position. The patient's position was frequently adjusted to ensure longitudinal suction cannula strokes around superficial venous and lymphatic structures to reduce the risk of transection. Sterile prepping was repeated as the patient was repositioned.

Procedures were staged after distributions of lymphotomes, so extremities were paired with adjacent areas of the trunk: anterior/inner thighs in one surgery, lateral thighs/buttocks in a second surgery, calves/ankles in a third surgery, arms/midback (if needed) in a fourth surgery, and the abdomen/flanks were treated last in patients who had lipedema of the torso. The tumescent solution was infiltrated using a 16-gauge Monty tip infiltration cannula and Klein tumescent pump. Microaire Power Assisted Liposuction 650 system was used with 3-mm and 4-mm multi-hole cannulas. The cannula was directed to the plane of least resistance, not too superficial or deep, especially in mapped areas of lymph collectors to minimize the risk of injuring the ducts that lie on top of the deep subcutaneous fascia. Manual lipedema extraction was performed for lipedema nodules not removed during liposuction by massaging along the long axis of limbs to gently mobilize nodules. Nodules are typically removed through liposuction incisions; however, these may need to be enlarged or another incision may be needed to accommodate larger nodules. Before discharge, patients were able to ambulate to the bathroom, and they were discharged in the care of a responsible designate.

Patients were seen 2–4 days postoperatively with a postoperative hemoglobin (HgB) check and then at 6- to 8-week intervals. Most patients have four to five follow-up visits (range of ≥2–10) over 6 months to 3 years.

PROMIS

Patient-Reported Outcomes Measurement Information System (PROMIS) is a set of person-centered measures to evaluate and monitor physical, mental, and social health in adults. PROMIS raw scores were rescaled into a standardized T-score and then compared with a large sample of the US general population; the normalized mean is 50 with an SD of 10.[31] Each PROMIS physical function (PF) question has been individually validated.

RAND Short Form (SF)-36 Medical Outcomes Study

The SF-36 was developed and validated for clinical practice and research to follow eight health domains, with each domain contributing to overall quality of life (QOL) and health.[32]

Statistics

Data are reported as total values, percentages, or average ± SD (GraphPad Prism version 10.0.0, Boston, Mass.). Shapiro-Wilk test for normality was performed before statistical analyses with nonparametric tests. Differences between stages were evaluated by nonparametric testing (Kruskal-Wallis test with multiple comparisons) due to large differences in numbers between groups: Paired *t* tests were used to evaluate individual changes before and after LRS. Values of *P* less than 0.05 were considered significant.

RESULTS

A total of 189 women who underwent a total of 507 procedures were evaluated for comorbidities, surgery volumes, times, and surgical complications (Tables 1 and 2).

Comorbidities

A common medical condition in our population was arthritis (29%). We also observed a high prevalence of generalized joint hypermobility in this study (50.5%) along with additional comorbidities (Table 1).

Lipoaspirate Volume and Times

The average LRS time was 5.2 hours, and average total aspirate was 5.0 L. The anterior thighs had the highest average total aspirate (7 L) [1.8–13.8 L]. The surgical area with the smallest total aspirate was the calves and ankles at 3.8 L [1.2–7.8 L] (Table 2; Figs. 4–6). The average amount of SAT removed increased with stage; combining all LRS volumes per patient, a maximum of 38.5 L was removed from a single patient over four procedures (Fig. 7).

Complications

In 507 procedures (189 women), the following complications after LRS were identified: one patient had postoperative anemia that required overnight hospitalization and a blood transfusion of two units of packed RBCs, and one patient with lupus was noncompliant with prescribed DVT prophylaxis and subsequently experienced a DVT.

In the 401 procedures, the average preoperative hemoglobin was 14.64g per dL and the average postoperative hemoglobin was 12.8g per dL; 5.5% experienced lightheadedness with a greater than or equal to 2-g drop in hemoglobin from their preoperative measurement

Table 1. Demographics and Comorbidities in 189 Women with Lipedema

Demographic	Stage 1	Stage 2	Stage 3	Total or Average ± SD	
No. patients	**7**	**80**	**102**	**189**	***P***
Age (y)	48 ± 16.7	48 ± 16.7*	52.4 ± 10.1	51.2 ± 11.3	0.223
BMI (kg/m^2)	23.7 ± 5.9**	30.9 ± 5.2**	38.1 ± 7.1	34.5 ± 7.5	<0.0001
No. Subjects with Limbs of Different Stages and Types					
	Stage 1	**Stage 2**	**Stage 3**	**Total**	
Arms (type 4)	44	83	47	174	
Leg type 1	0	0	0	0	
Leg type 2	0	27	5	32	
Leg type 3	7	52	95	154	
Leg type 5	0	1	1	2	
Comorbidity	**Number Affected**			**Total Affected (%)**	***P***
	Stage 1	**Stage 2**	**Stage 3**		
Flat feet	0	13	20	17.7	0.36
Hypermobile joints	3	44	47	50.5	0.56
Lymphedema	3	58	78	74	0.13
Knee arthritis	0	11	19	15.8	0.34
Arthritis	0	20	35	29.1	0.56
Hypothyroid	0	15	34*	25.9	0.13
Asthma	1	12	24	19.5	0.34
Anxiety	0	9	14	12.1	0.089
Depression	0	19	24	22.8	0.3
Diabetes	0	2	8	5.3	0.2
Migraine	1	11	4	8.4	0.5
Anemia	0	51	6	11.1	0.34
Varicose veins (%)	0	23.5 ± 43	25.7 ± 44	24.5 ± 43	0.2
Spider veins (%)	42.9 ± 53	49.4 ± 50	48.5 ± 50	48.6 ± 50	0.05

SD=standard deviation; Significance by Wilcoxon matched pairs signed rank test between
*P<0.05 vs. Stage 3;
**P=0.0007 vs. Stage 3

within 96 hours postoperatively. No other complications occurred.

Knee Kinematics and Mechanics

In 26 women, the average preoperative range of motion (ROM) of the left (115.8 ± 13 degrees) and right knee (114.5 ± 14 degrees) were below normal and significantly improved after surgery with a gain of flexion of 9 degrees in the right and 10 degrees in the left knee. Preoperative average valgus deviation in the left and right knees was 6 degrees, which reduced to 3 degrees bilaterally postoperatively. There was no significant postoperative change in the average Q-angle. Gait improved after LRS (Fig. 8).

Bioelectrical Impedance Analysis

Average total body and segmental body fat mass (BFM) decreased significantly postoperatively (Fig. 9). There was also a decrease in percentage body fat (47% ± 7.5% to 43% ± 8.5%, respectively $P < 0.0001$).

PROMIS

The mean PROMIS T-score improved significantly FROM 40 ± 6 before LRS to 46 ± 9 after surgery ($P < 0.0001$; Fig. 10). There were improvements in all PF questions relating to mobility. Improvement in three areas correlates with future disability and mortality, including the ability to walk with normal gait, speed, and distance ($P < 0.0001$), ascend and descend stairs ($P < 0.0001$) and get up from a chair ($P < 0.009$; Table 3).

SF-36

There was a statistically significant improvement in all eight domains of the SF-36 questionnaire (Fig. 11; Table 4). The average of each domain started below the validated population mean and improved towards or surpassed it.

Lobules

Lobules of tissue define stage 3 lipedema. After LRS, 69 of 101 (68%) stage 3 patients no longer had lobules (Fig. 12).

DISCUSSION

In the case series before and after LRS, we observed improvements in QOL and pain that mirror improvements after LRS in Germany, Spain, and the United Kingdom.[33–36] In addition, our data show improvements in multiple outcomes after LRS for women with stage 1, 2, and 3 lipedema, including knee flexion, knee alignment, gait, body fat, and tissue lobules.

LRS is not aesthetic surgery; it is reconstructive surgery to improve function. Knee function is critical for ambulation and activities of daily living (ADL), including walking,

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Table 2. Locations, Average Fluid Volumes, and Times of Lipedema Reduction Surgery

Locations	Total Fluid Volumes Removed (Liters ± SD)					Surgery Time			Tumescent Used/Infused (L)		
	Total Aspirate*	Supernatant	Infranatant	Minimum†	Maximum†	Average	Minimum	Maximum	Average	Minimum	Maximum
Inner/anterior thighs (n = 164)	6.1 ± 2.1	4.7 ± 2	1.4 ± 0.6	1.8	13.8	5.5 ± 1.0	3.4	9.1	8.5	3.9	13
Lateral thighs/buttocks (n = 125)	5.6 ± 2.1	4.6 ± 2.0	0.93 ± 0.7	1.2	12.2	5.1 ± 0.9	3.32	8.0	8.3	4.3	14.9
Calves (n = 121)	3.2 ± 1.5	2.6 ± 1.3	0.74 ± 0.6	0.3	7.6	4.9 ± 1.0	3.5	7.13	5.7	2.2	14.0
Arms (n = 60)	3.5 ± 1.3	2.5 ± 1.0	1.0 ± 0.4	1.0	7.2	5.2 ± 0.9	3.4	8.0	7.1	3.7	9.8
Abdomen/flanks (n = 61)	5.2 ± 1.7	3.4 ± 1.5	1.8 ± 0.7	1.6	8.4	5.0 ± 0.8	3.88	6.67	8.2	5.1	10.5

*Total aspirate is the volume collected during the entire surgical procedure (supranatant + infranatant). Fat and other tissue components are located within the supernatant, and the infranatant is primarily tumescent fluid with blood, blood products, and dissolved proteins.
†Minimum and maximum refer to total aspirate. Data from 189 women with lipedema who underwent a total of 507 procedures with an average 2.7 procedures per patient.

climbing stairs, and getting in and out of a car or a chair. In the USA, total knee arthroplasty (TKA) is one of the most expensive surgical procedures in adults, with average total costs ranging from $31.6–37.4K.[37,38] One published systematic review and meta-analysis found the complication rate of TKA was 3.3% at 30 days and 9.7% at 90 days,[39] with an average cost of $39K ($4.8–104.8K).[40] These data suggest preserving knee function with LRS could reduce operational and rehabilitation costs after TKA.

In the orthopedic literature, the average increase in knee flexion after TKA is 4.8 degrees, approximately half the 10 degrees improvements after LRS reported here.[41] Improvements in knee kinematics allow women with lipedema to perform ADL that they could not before LRS due to bulky lipedema tissue on the thigh and calf (Tables 3 and 4; Figs. 8–10). The increased prevalence of knee arthritis before LRS could have blunted the improvement in knee flexion seen in this report. Direct physical observations of improved knee flexion after LRS were confirmed by improvements in responses to mobility questions on the PROMIS and SF-36 questionnaires (Tables 3 and 4).

In total, 16% of the subjects in this case series underwent TKA before LRS. TKA is the most frequent orthopedic joint surgery performed[42] with estimates of 4.2%–5.2% of women in the general population undergoing this procedure;[43] our observed rate is three to four times higher, likely related to mechanical factors affecting the knee in women with lipedema, including excess tissue on the legs.

Most women with lipedema have a valgus angulation at their knee caused in part by increased hip and thigh tissue. Even a slight degree of valgus misalignment can increase the risk of meniscus damage and osteoarthritis.[5] Consideration should be given to performing LRS to reduce the progression of arthritis.

Gait abnormalities limit mobility and ADL and are a risk factor for falls.[7] Gait improved in women with lipedema after LRS through clinical assessment and the PROMIS and SF-36 questionnaires. We are not aware of previous reports of gait changes measured in women with lipedema after LRS.

INDIVIDUAL PROMIS PF OUTCOMES

Individual PROMIS PF questions improved significantly after LRS, providing examples of functional improvements in ADL. For example, the average response to PFA-21 (are you able to go up and down stairs at a normal pace?) before LRS was “with some difficulty” and after was “with little difficulty.” PFA-21 has been correlated to timed stair ascent.[44] Stair negotiation time was a significant predictor of functional decline.[45] Improvements in PFB-24 (are you able to run a short distance, such as to catch a bus?) and PFA-15 (are you able to stand up from an armless straight chair?) also correlate with objectively measured physical performance tests.[44]

These outcomes also corroborate objectively measured improvements on the clinical examination. A change in

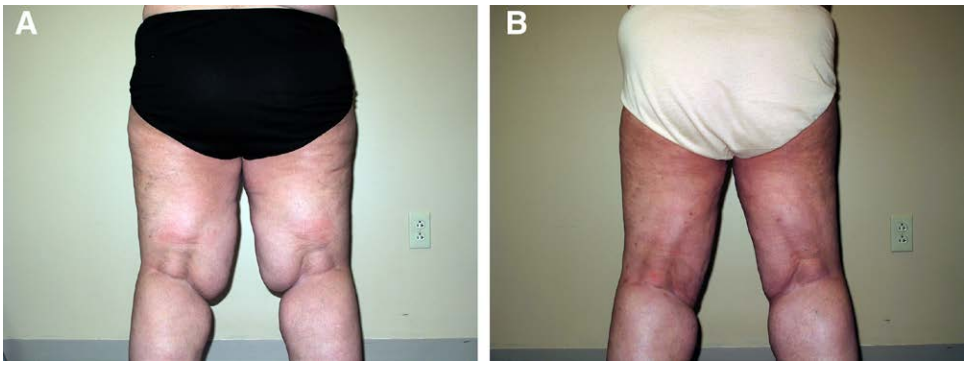

Fig. 4. Before and after LRS on the thighs. Photographs showing a woman with lipedema type 3 stage 3 before (A) and after LRS (B), view from behind. Notice the lobules just above the knee have been reduced postoperatively and can be restaged to stage 2.

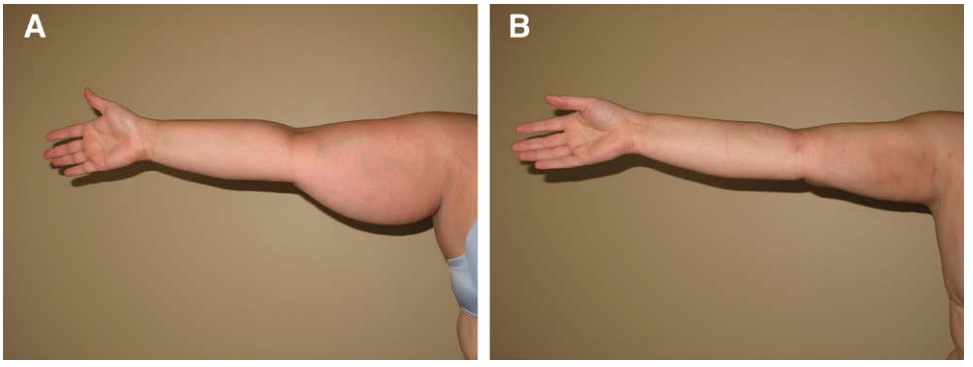

Fig. 5. Before and after LRS on the arms. Photographs showing a woman with lipedema type 4 stage 3 before (A) and after LRS (B) on arms, frontal view.

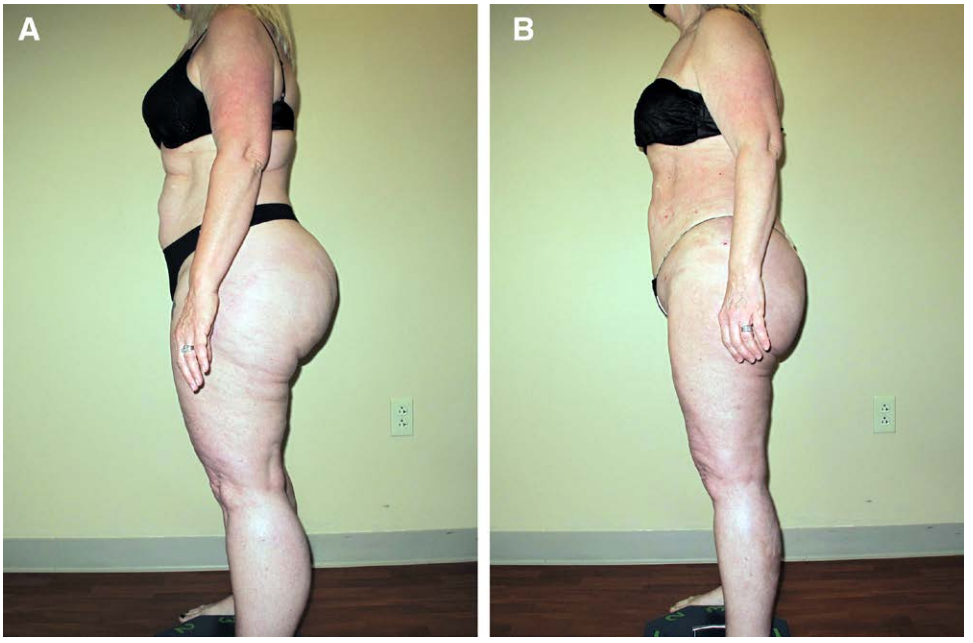

Fig. 6. Before and after LRS on the full legs. Photographs showing a woman with lipedema type 3 stage 2 before (A) and after LRS (B), lateral view.

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rating measurements of two to three points is considered to be a minimally clinically important difference in health.[46] Other publications report 1.5–5-point improvements in PF after TKA.[47,48] Changes in PROMIS mobility observed in this study are at least of magnitude similar to PROMIS measures after TKA.

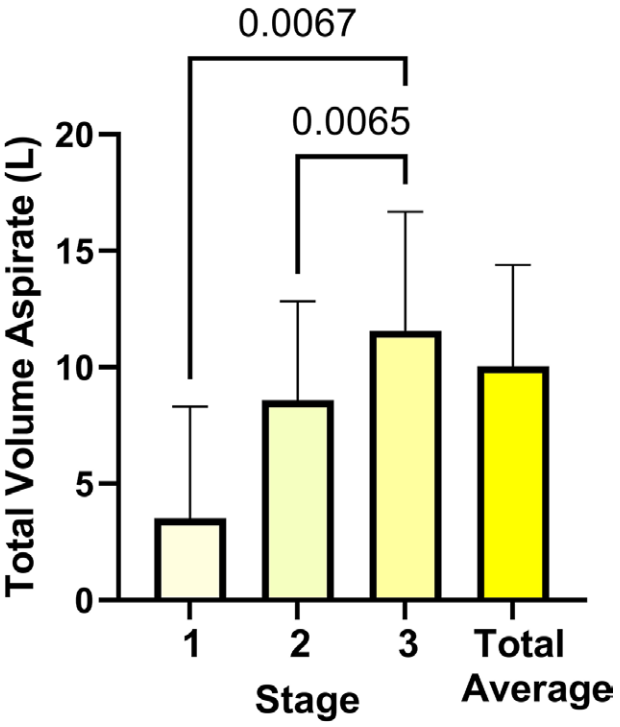

Fig. 7. Suction aspirate totals by stage and average aspirate. The average suction aspirates are graphed by lipedema stage 1–3. Medians with interquartile ratios for total suction aspirate removed when all procedures for each woman with lipedema are combined (n = 189). The aspirate volume increased by stage. Significance was assessed by Kruskal-Wallis test with multiple comparisons.

RAND SF 36 MOS

Overall health and QOL for women with lipedema significantly improved after LRS, as demonstrated by SF-36. Amitkumar reported similar improvement in SF-36 domains from spine surgery.[49]

Bioelectrical Impedance Analysis

Total and segmental BFM decreased after LRS, as expected.

Lobule Changes

Over 68% of women with stage 3 lipedema had a reduction in the presence of lobules, which likely contributed to an improved gait. The absence of lobules suggests that these women could be clinically diagnosed as having stage 2 lipedema. Regression in stage has been reported previously[50] and is an important clinical improvement in this disease.

COMPLICATIONS

The most common complication of LRS was lightheadedness with a hemoglobin drop of greater than 2 g per day (5.5%). We recommend following hemoglobin levels post-LRS.

There are abnormalities and impairments in lymphatic function in lipedema, and lymphatic injury can occur during suction lipectomy.[16] Using high-frequency ultrasound to identify venous and lymphatic structures is a straightforward and relatively inexpensive addition to LRS; once identified and mapped, it follows naturally that extra care would be taken not to transect these structures. Using

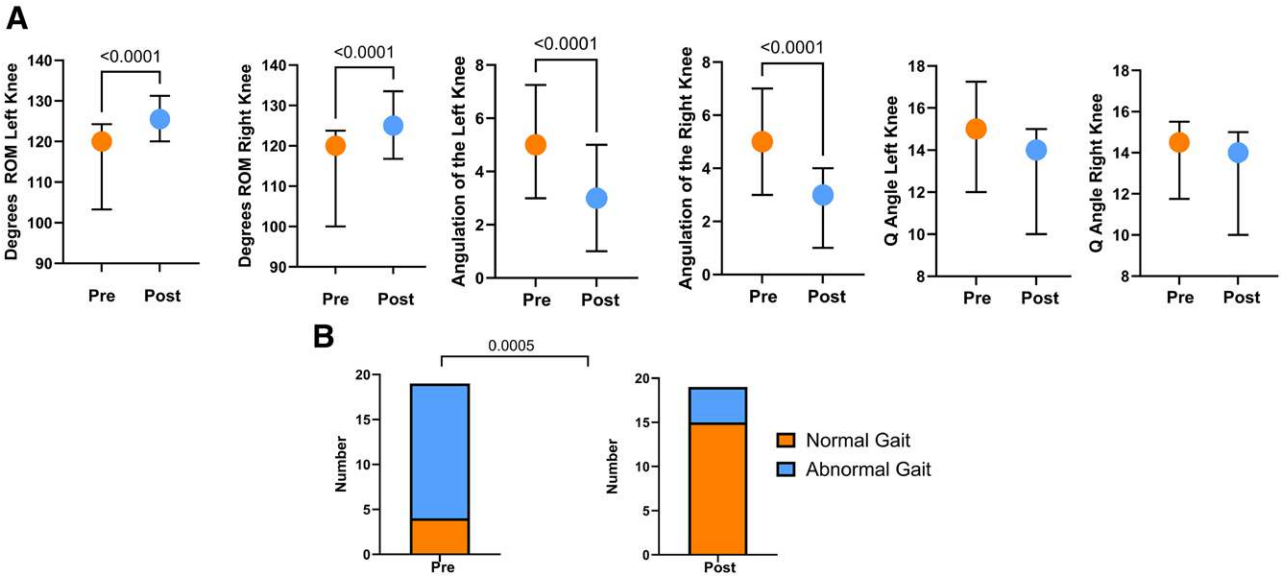

Fig. 8. Knee kinematics, knee ROM, knee joint angulation in degrees, quadriceps (Q) angle, and gait pre- and post-LRS. A, Median values with interquartile range for ROM, angulation, and Q-angle of the right and left knee pre- and post-LRS (N = 26). B, Normal (orange) and abnormal (blue) gait pre- and post-LRS (N = 19). Significance was assessed by Wilcoxon matched pairs sign rank test.

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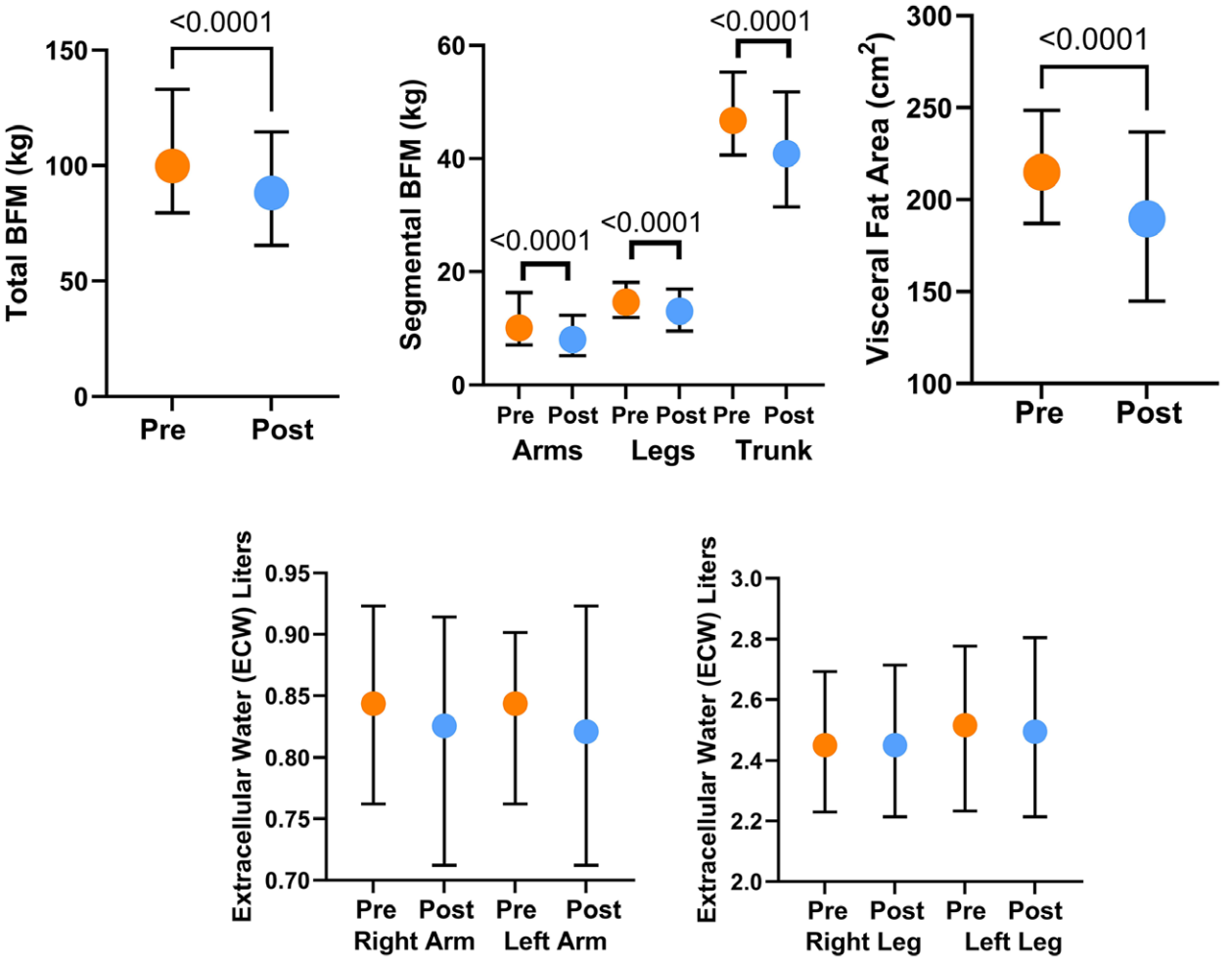

Fig. 9. Tissue bioimpedance. Median and interquartile ranges for bioelectrical impedance analysis values for BFM, visceral fat area, and extracellular water in the limbs pre- and post-LRS (N = 64). Significance was assessed by Wilcoxon matched pairs signed rank test.

bioelectrical impedance analyses to assess tissue fluid, and ultrasound to look for signs of lymphatic injury after LRS, no evidence of lymphatic injury was found in 507 procedures using LRS techniques described in this article. The availability and low risk of ultrasound guidance of vascular mapping is a safe and reasonable addition to LRS.

Comorbidities

Because arthritis was common in our population, frequent assessment of joints and symptoms of knee arthritis in women with lipedema may be warranted since earlier treatment with LRS could prevent further knee damage and possible TKA. Joint hypermobility prevalence was also increased in our population and should be assessed.

LIPOASPIRATE VOLUMES AND FUNCTIONAL GAINS

The average total aspirate for all LRS was over 5 L (2.8–13.8 L). Women with higher stages had larger volumes removed. LRS is considered a large-volume reconstructive surgery,[51] distantly related to cosmetic suction lipectomy. The goal of LRS is to remove SAT, precipitated solids, and fibrous nodules between the skin and deep fascia to improve function. Adequate debulking of SAT results not only in pain relief but improvements in QOL and mechanical and mobility benefits.

The American Society of Plastic Surgery expressed concerns about large-volume liposuction and its derivatives. Several states in the United States have enacted limits of 5 L for these procedures. Chow et al showed no difference in major complications between the non–large-volume (≤5000 mL) and large-volume (>5000 mL) liposuction cohorts.[52] Chow further showed lower complications in larger volume lipoaspirates in patients with higher BMI. We agree with Chow that there should not be an arbitrary aspirate volume limit, and rather, each patient's health history, risk factors, and goals should be individually considered, and the surgical aspirate modified accordingly. In our study, large volumes were safely removed, allowing treatment of patients with advanced lipedema in fewer procedures.

There is currently no CPT code that accurately describes LRS. Moreover, the 15877-79 suction lipectomy CPT codes

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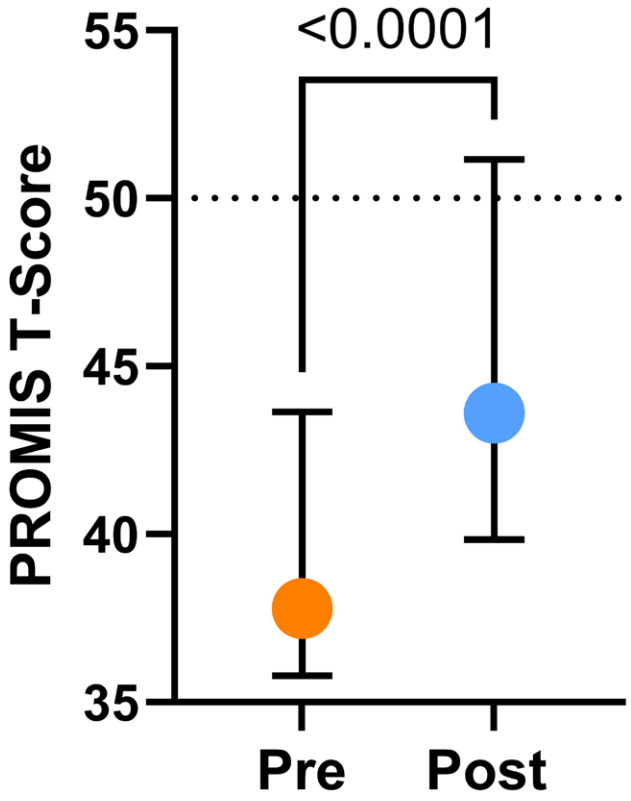

Fig. 10. Change in median with interquartile ranges for PROMIS T-score pre- and post-LRS (N = 53). The average population mean is represented by a dotted line. Significance was assessed by Wilcoxon matched pairs signed rank test.

do not have a full description in the coding manual because they are placeholders for cosmetic procedures.

SURGERY TIME

The average time for LRS was ~5 hours, and the maximum time was 9 hours, much longer than for cosmetic liposuction. Increased time was the result of the preoperative mapping of venous and lymphatic structures/landmarks, larger volumes of aspirate removed, techniques to limit the risk of lymphatic injury, manual removal of fibrous tissue, super wet tumescent technique, use of small blunt cannulas, which are safe but remove tissue slowly, and frequent repositioning to allow for safer cannula strokes.

STRENGTHS AND LIMITATIONS

The following are the strengths of this study:

1. Improvements in knee mechanics, mobility, and QOL add new information about the benefits of LRS and corroborate with observed improvements in gait.
2. The study adds additional data on the prevalence of lipedema comorbidities.
3. LRS with conservative measures improved mobility, whereas conservative measures alone did not.[26]

Limitations of the study are as follows:

1) Data reported in this study are from a single site and surgeon (TW).
2) The number of patients is small to moderate.
3) Patient-reported outcome measures are subject to recall bias.
4) This is not a randomized placebo-controlled clinical trial, which would not be ethical.[53]

CONCLUSIONS

LRS using lymphatic sparing techniques for debulking of fibrotic SAT in women with lipedema resulted in significant improvements in mobility, knee ROM, gait, QOL, social function, and pain. Improvements in movement, knee mechanics, and QOL outcomes are equivalent to or better than published data for TKA. Objectively assessed PF improvements align with patient-reported outcome improvements, and importantly, should lower the risk of

Table 3. Individual PROMIS Physical Function (PF) Question Scores ± SD Pre- and Post surgery

PROMIS Item	Question	Score ± SD		*P**
		Presurgery	Postsurgery	
PFC38	Are you able to walk at a normal speed?	3.6±0.9	4.4±0.8	$P < 0.0001$
PFA15	Are you able to stand up from an armless straight chair?	4.1±1	4.6±0.7	0.0009
PFA21	Are you able to go up and down stairs at a normal pace?	3.0±1.0	3.9±1.0	<0.0001
PFA23	Are you able to go for a walk of at least 15 minutes?	3.8±1.0	4.4±0.8	0.0002
PFA31r1	Are you able to get up from the floor from lying on your back without help?	3.0±1.2	3.8±1.2	<0.0001
PFB9	Are you able to jump up and down?	2.9±1.4	3.6±1.2	0.0009
PFB10	Are you able to climb up five steps?	4.1±0.9	4.5±0.8	0.0122
PFB24	Are you able to run a short distance, such as to catch a bus?	2.5±1.5	3.5±1.4	<0.0001
PFB32	Are you able to stand up unsupported for 10 minutes?	4.1±0.9	4.5±0.8	0.0163
PFA10	Are you able to stand for one hour?	3.1±1.4	3.8±1.3	<0.0001
PFB40	Are you able to stand up on tiptoes?	3.7±1.2	4.2±1.0	0.0088
PFB42	Are you able to stand unsupported for 30 minutes?	3.7±1.1	4.2±1.1	0.0010
PFC37	Does your health now limit you in climbing one flight of stairs?	3.8±1.2	4.3±0.8	<0.0001
PFB49	Does your health now limit you in going for a short walk (less than 15 minutes)?	4.1±0.9	4.5±0.8	0.0025
PFC10	Does your health now limit you in climbing several flights of stairs?	2.8±1.3	3.8±1.1	<0.0001

*Significance by Wilcoxon matched pairs signed rank test. N = 53.

Table 4. SF-36 Data Pre- and Post-LRS (N = 53)

Scale	Preoperative Score	Postoperative Score	*P*	Population Mean[32]
Physical functioning	57.4	72.9	<0.0001	70.6
Role limitations due to physical health	39.4	61.3	<0.0089	53
Role limitations due to emotional problems	56.6	76.7	<0.0001	65.8
Energy/fatigue	35.9	53.9	<0.0001	52.1
Emotional well-being	66.4	75.5	<0.0001	70.4
Social functioning	62.7	77.4	<0.0001	78.8
Pain	48.1	65.7	<0.0001	70.8
General health	52.6	65.0	<0.0001	57.0

RAND SF-36 is a Patient-reported medical outcome that measures eight principal domains of health and QOL.

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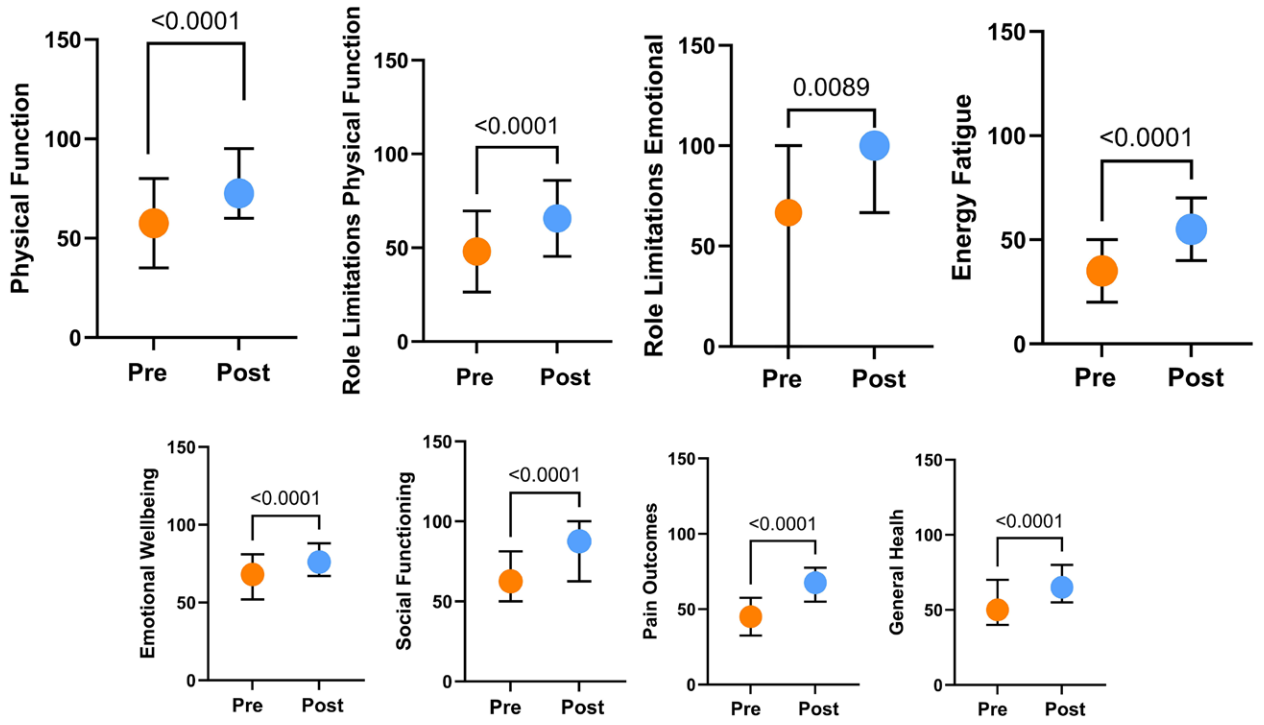

Fig. 11. Outcomes data of SF-36 and PROMIS scores. SF-36 graphed by the eight component health domains. Median and interquartile ranges for SF-36 outcome scores pre- and post-LRS (n = 53). Significance was assessed by Wilcoxon matched pairs signed rank test.

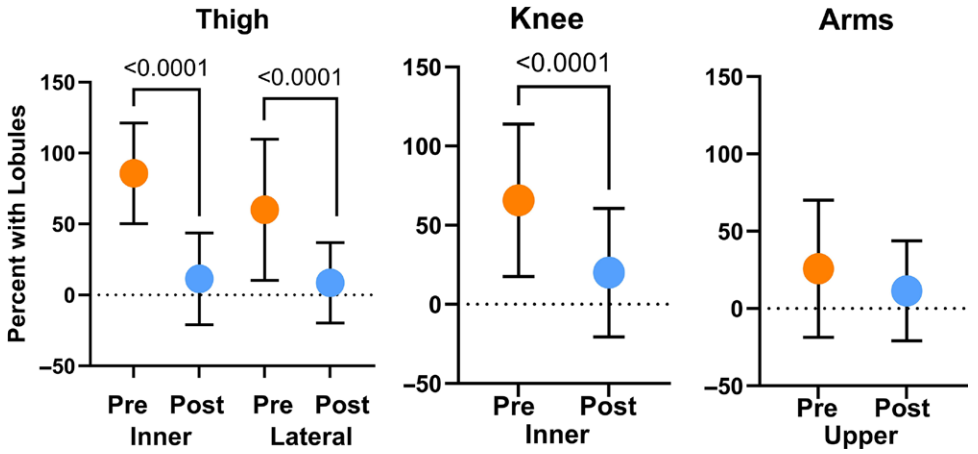

Fig. 12. Lobules on legs and arms. Median and interquartile ranges for the percentage of women with lipedema stage 3 with lobules pre- and post-LRS (N = 101). Significance was assessed by Wilcoxon matched pairs signed rank test.

future functional decline and mortality in women living with lipedema.

DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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