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Complete Reduction of Leg Lymphedema after Liposuction: A 5-Year Prospective Study in 67 Patients without Recurrence

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Background: Lymphedema leads to adipose tissue deposition that cannot be removed using conservative methods. Previous studies have shown a complete reduction in excess volume in limbs with lymphedema when treated with liposuction and controlled compression therapy (CCT). We present the long-term outcomes of all patients treated with liposuction and CCT for lower extremity lymphedema (LEL) who were followed up for 5 years.

Methods: Sixty-seven LEL patients underwent liposuction and CCT. Thirty-six patients had primary lymphedema and 31 patients had secondary lymphedema. The outcomes included excess leg volume over a follow-up period of 5 years. Any association between patient characteristics and treatment outcomes was analyzed.

Results: The preoperative excess volume prior was 3515 mL [interquartile range (IQR): 2225–5455 mL], and the volume ratio to the unaffected leg was 1.35 (IQR: 1.25–1.53). One year after treatment, the excess volume decreased by 101% (IQR: 84–116). The decrease in excess volume continued during the 5-year follow-up, and at the end of the study, the excess volume had decreased by 115% (IQR: 98–124). No major complications were noted.

Conclusions: Liposuction and CCT are safe and effective procedures for removing excess adipose tissue and normalizing the leg volume in patients with late-stage LEL. When no satisfactory results are obtained with conservative methods, such as complex decongestive therapy, and there is no or minimal pitting on limb examination, excess adipose tissue is present, and liposuction can be considered.
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INTRODUCTION

Lower extremity lymphedema (LEL) is a well-known complication after surgical procedures in the inguinal area, caused by damage to lymphatic vessels during cancer resections, and lymph node removals.[1] The postoperative incidence of LEL in gynecological cancers is assessed to be 20%.[2] Cervical cancer is the fourth most common cancer in women worldwide, having affected 570,000 women in 2018.[3] Another common cause of lymphedema is infection with the nematode *Wochereria bancrofti*, called lymphatic filariasis.[4] Globally, this infection is of such magnitude that the World Health Organization implemented a program that was initially planned to eliminate lymphatic filariasis by 2020, and has administered drugs to millions of people in endemic areas.[5]

In contrast to the above-mentioned causes of lymphedema, collectively called secondary lymphedema, the primary forms are genetic and caused by anatomical malformations.[1]

LEL is a problematic condition that causes symptoms such as heaviness, pain, social challenges, and dermatological concerns.[6] Successful surgery leading to complete reduction in large nonpitting lymphedema has only been described for liposuction.[7–11] Adipose tissue hypertrophy starts when lymphedema induces chronic stasis and inflammation.[12–15] Over time, the smooth vasculature in the lymph vessels becomes fibrotic and loses its contractile

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function.[16] Complex decongestive therapy (CDT) is the basis for conservative lymphedema treatment consisting of manual lymphatic drainage, bandaging, compression garments, skin care, and lymph-reducing exercises to remove interstitial free fluid.[17,18] Recent research has shown that manual lymphatic drainage has a negligible effect, and it is the bandaging that reduces the fluid component of lymphedema.[19,20] At the stage where adipose tissue is present, CDT cannot completely normalize limb volume. Therefore, surgical approaches have been used to reduce limb swelling. Historically, different surgical techniques have been used, including inserting silk threads to increase lymphatic drainage,[21] or to excise skin and adipose tissue down to the underlying fascia with subsequent split-thickness skin grafting.[22] The latter technique, although greatly reducing limb volume, has many disadvantages, including infections, scarring, eczema, and leakage of lymph.[23] More recent surgical approaches include microsurgical techniques such as vascular lymph node transplantations (VLNT),[24–26] lymph vessel transplantation,[27–29] and lymphovenous anastomosis (LVA).[30–33] Reported reduction rates of excess volume are between 40% and 51%[26,34] after VLNT and 42% after LVA.[31] One reason these modalities cannot achieve a full reduction is the presence of adipose tissue. The benefits of microsurgery include the theoretical possibility of eliminating the need for CDT.[30] However, there is a risk of postoperative complications and donor-site lymphedema after VLNT[35,36] as well as occluded lymphovenous anastomoses.[37,38]

The introduction of liposuction for lymphedema combined with controlled compression therapy (CCT) has shown a complete reduction in the excess volume in upper extremity lymphedema, with a postoperative volume decrease of 107% ± 22% after 6 months.[11] These improvements remained stable at the 5-year follow-up. Multiple studies on liposuction in LEL have shown satisfactory results[10,39–41]; however, the number of patients analyzed with long-term follow-up has been low. This study aimed to evaluate the 5-year results of liposuction combined with CCT in patients with LEL.

Takeaways

Question: Does liposuction for leg lymphedema lead to complete reduction without recurrence after 5 years' follow-up?

Findings: Sixty-seven patients with large chronic leg lymphedemas and no or minimal pitting were operated on with liposuction. All were followed up for 5 years. Liposuction led to complete reduction without recurrence. When no satisfactory results are obtained with conservative methods and there is no pitting or minimal pitting on examination of the limb, this indicates that excess adipose tissue is present and liposuction can be considered.

Meaning: Liposuction followed by compression is safe and leads to long-lasting complete reduction.

MATERIALS AND METHODS

Patients

Patients treated with liposuction for LEL between September 1993 and May 2017 at the Department of Plastic and Reconstructive Surgery, Skåne University Hospital, Malmö, Sweden were included in this study. The inclusion criteria for the study were unilateral primary and secondary lymphedema with a 10% greater volume in the affected leg than in the contralateral leg; conservative treatment alone not leading to satisfactory reduction; edema with no or minimal pitting (<6–7 mm)[42–44] due to fat deposition; and a positive attitude toward continuous use of garments after liposuction. The exclusion criteria were bilateral lymphedema, active cancer, wounds, or ongoing infection. All patients were followed up for 5 years. The contralateral leg is routinely evaluated with the pitting test at the first visit in our clinic to exclude bilateral lymphedema. This is done routinely throughout the duration of the follow-up.

Measurements

The leg volume was measured using plethysmography. The limb was lowered into a container filled with water, and the overflow was collected and measured to the nearest 5 g, corresponding to 5 mL.[45–47] Measurements were carried out by the same physiotherapist/lymph therapist and occupational therapist. Volumes were measured from the foot to the groin for both legs. Both leg volumes were measured using plethysmography at each visit to avoid the influence of excess volume due to weight change or time of day when measured.

Compression Garments

Compression garments were used both preoperatively to reduce the amount of free fluid in the leg and postoperatively to maintain the results over time. Garments were ordered 2 weeks preoperatively using measurements of the unaffected limb and included three panties with a leg [JOBST Elvarex, compression class (CCL) 3, compression range 33–46 mm Hg] and two leg-long stockings (JOBST Elvarex, CCL 2, compression range 23–32 mm Hg). One panty with a leg was sterilized for immediate application at the time of surgery. This garment was used for only 2 days and discarded because of the decreased compression capability after sterilization.

Liposuction

From 1998, power-assisted liposuction (Lipomatic, Nutational Infrasonic Liposculpture, Euromi, Andrimont, Belgium) was performed using a combination of tourniquet and the tumescence technique. The "dry technique" (no tourniquet or tumescence) was used in two patients operated on before 1998. A tourniquet was placed on the proximal thigh. About 15–20 small incisions (3–4 mm) were made along the leg, and aspiration was performed using 15- and 25-cm-long cannulas with diameters of 3 and 4 mm. Using measurements from the healthy leg as the control, aspiration was continued until the contralateral circumference was achieved, as measured using

Fig. 1. A patient with lymphedema of the left leg in the operating theater. Images depicting before (with an excess volume of 4940 mL; A), and after liposuction (B) up to the tourniquet (placed proximal on the thigh). An instant reduction in the excess volume was achieved, and complete reduction was achieved at 1 year (C).

a sterile tape measure. Liposuction was performed from the ankles to the tourniquet (Fig. 1). A sterilized compression garment was applied before the tourniquet was removed. Tumescence was achieved by injection of 1000 mL saline mixed with 1 mg adrenaline and 20 mL lidocaine 2% (Xylocaine, AstraZeneca PLC, London, United Kingdom). A total of 2000 mL was infused subcutaneously into the area where the tourniquet was applied. Liposuction was then performed on the proximal part of the thigh and the garment was fitted to cover this part as well.[48] Aspirated fluid was collected in canisters of 2000 mL, where aspiration from the use of the tourniquet and tumescence were collected separately. The amounts of fat and fluid were measured after 24 hours of sedimentation at room temperature. The incisions were left open for drainage and secondary healing. Postoperative antibiotics were administered to reduce the risk of infection. Isoxazolyl penicillin was administered intravenously for 1 day and orally for 10 days. Clindamycin was administered to patients with a penicillin allergy. The patient was mobilized as soon as possible, often in the afternoon on the day of the surgery.

CCT and Follow-up

The compression garment was removed on the second postoperative day when taking a shower. Patients were informed about the importance of skin care and a lotion was applied before a new garment with a panty was placed. A second layer with a leg-long compression garment was added, which was removed at night and placed again the next morning. The second change in compression garments was performed on the fourth postoperative day with the same routine, including lubrication of the skin, before a new set of garments was placed. The patient was discharged from the hospital and the compression garments were changed every second day during the following week. Thereafter, garments were changed daily. Thus, clean garments can be applied daily after the patient has showered and lubricated the leg. Patients were instructed to use compression garments for 24 hours a day, with only short interruptions when needed.

After liposuction, patients were scheduled for visits at 2 weeks, 1, 3, 6, 9, and 12 months postoperatively, and then every 12 months (every third month if complete reduction was not achieved 12 months postoperatively). Follow-up visits were conducted at our outpatient clinic until two years after surgery and thereafter by the patient's ordinary lymph therapist if complete reduction of lymphedema was achieved. Because plethysmography is not always available to lymph therapists, volume calculations using circumference measurements every 4 cm along the legs were used, and volumes were calculated according to the formula for the truncated cone, which correlates well with plethysmography.[49,50] New garments were ordered with measures taken at the first 3-month visit and every third month during the first year. Garments could be taken in at our clinic using a sewing machine if needed, whereas new garments were ordered. If complete reduction was seen on the 6-month visit, the 9-month visit was canceled, and garments for the following 6 months were ordered. A combination of two sets [one set equals two layers (CCL 3 and 2)] of compression garments typically lasts 3–6 months. If a complete reduction in excess volume was reached after 1 year, garments were ordered for an entire year, which would normally entail six to eight sets of garments. This

Table 1. Demographics of the Studied Population

Demographics	Years (Median, IQR)	Range
Age (y)	50 (37–60)	17–76
Lymphedema onset after cancer surgery (y)	1 (0–3)	0–26
Duration of lymphedema (y)	12 (7–18)	2–63
	Number	**Percent**
Primary lymphedema	36	54
Secondary lymphedema	31	46
Male sex and primary lymphedema	5	7
Male sex and secondary lymphedema	3	4
Female sex and primary lymphedema	31	46
Female sex and secondary lymphedema	28	42
Cause (secondary lymphedema)		
Gynecological cancer	21	68
Malignant melanoma	4	13
Other	6	19
Irradiation	16	24
Chemotherapy	11	16
Removal of lymph nodes	27	40
Conservative treatment (other than compression garments)	66	99
Compression garments	66	99

means that two sets were always ordered at the same time, so that one set was used when the other was being washed. Physically active patients require more care. Otherwise, visits were scheduled every third month for new measurements and the ordering of new garments.

Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics for Macintosh, version 27.0 (IBM Corp., Armonk, N.Y.) released in 2020. The normality of all data points was tested using the Shapiro-Wilk test, but most variables did not follow a normal distribution; thus, nonparametric tests were used. The results are presented as median and interquartile range (IQR). The Wilcoxon matched-pair signed rank test was used to analyze differences between preoperative and postoperative excess volumes, and the Mann-Whitney test was used for subgroup analysis. The postoperative reduction in excess volume was tested for associations with variables such as age, preoperative excess volume, and chronological number of patients using Spearman rank-order correlation. Correlations were considered exploratory; therefore, nominal P values were presented without any adjustment for multiple comparisons, and P values less than 0.05 were considered statistically significant.

Ethics

This study was approved by the Swedish Ethical Review Authority (2020-03102). Information regarding the study was sent to all patients who had previously agreed to be included in the local database, and an opt-out method was used for inclusion in the study.

RESULTS

Demographics

Ninety-six patients with leg lymphedema underwent liposuction between September, 1993 and May, 2017. Most of the patients underwent surgery after 2003 (n = 90). Of the 96 patients, 13 patients did not yet have a full 5 years of follow-up measurements (mostly international patients), five patients died during the study period from recurrence of cancer diseases, six could not/did not want to attend follow-up, four patients did not want their data to be used, and one had bilateral lymphedema. Therefore, 67 patients were included in this study. The demographic characteristics of patients are presented in Table 1. The group consisted mainly of middle-aged women, with a median age of 50 years (IQR: 37–60) and lymphedema duration of 12 years (IQR: 7–18). The most common causes of secondary lymphedema were gynecological cancer (n = 21) and malignant melanoma (n = 4).

Liposuction

The preoperative excess volume in the affected leg was 3515 mL (IQR: 2225–5455 mL; Fig. 2), corresponding to a volume ratio (affected to nonaffected leg) of 1.35 (IQR: 1.25–1.53). At 6 months, the excess volume was 380 mL (IQR: -35 to 870 mL) with a ratio of 1.03 (IQR: 1.00–1.09), which corresponds to a reduction of 90% (IQR: 75–101), $P < 0.001$). One year after liposuction, the excess volume was –20 mL (IQR: –430 to 540) and the ratio was 1.00 (IQR: 0.96–1.05), which corresponds to a reduction of 101% (IQR: 84–116), $P < 0.001$. The results were consistent throughout the study, and the excess volumes at 2, 3, and 4 years after liposuction were –85 mL (IQR: –565 to 370), –149 mL (IQR: –795 to 283), and –268 mL (IQR: –868 to 250), respectively. The last follow-up at 5 years showed an excess volume of –394 mL (IQR: –798 to 126) and the ratio was 0.96 (IQR: 0.92–1.01), which equals a reduction of 115% (IQR: 98–124), $P < 0.001$. Thus, the affected leg decreased in size to a smaller size than the unaffected leg. An example of postoperative results for a patient with leg lymphedema is shown in Figure 3. A cumulative sum control chart is shown in Figure 4, which

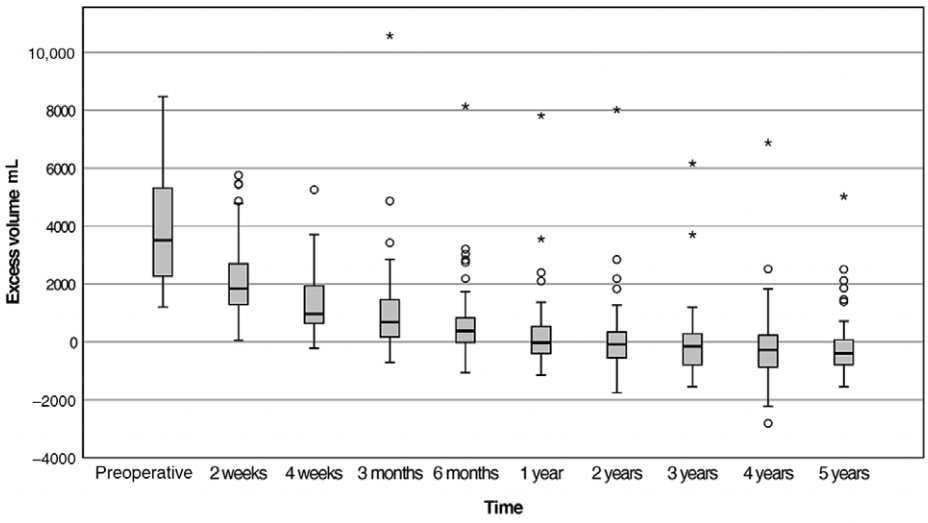

Fig. 2. Boxplot illustrating the excess volumes of the affected leg before and after liposuction. The line within the box represents the median value, the border of the box represents IQR, and the whiskers represent the lowest and highest values without outliers (circles) and extreme outliers (stars). The reductions in excess volume from preoperative to 2 weeks and from 2 weeks to 5 years were statistically significant ($P < 0.001$ and $P < 0.001$, respectively). One patient representing an extreme outlier lies outside the visualized field in the graph. Preoperatively, the missing values for this patient in the graph are: 20805 mL; 2 weeks: 12575 mL; 4 weeks: 12695 mL.

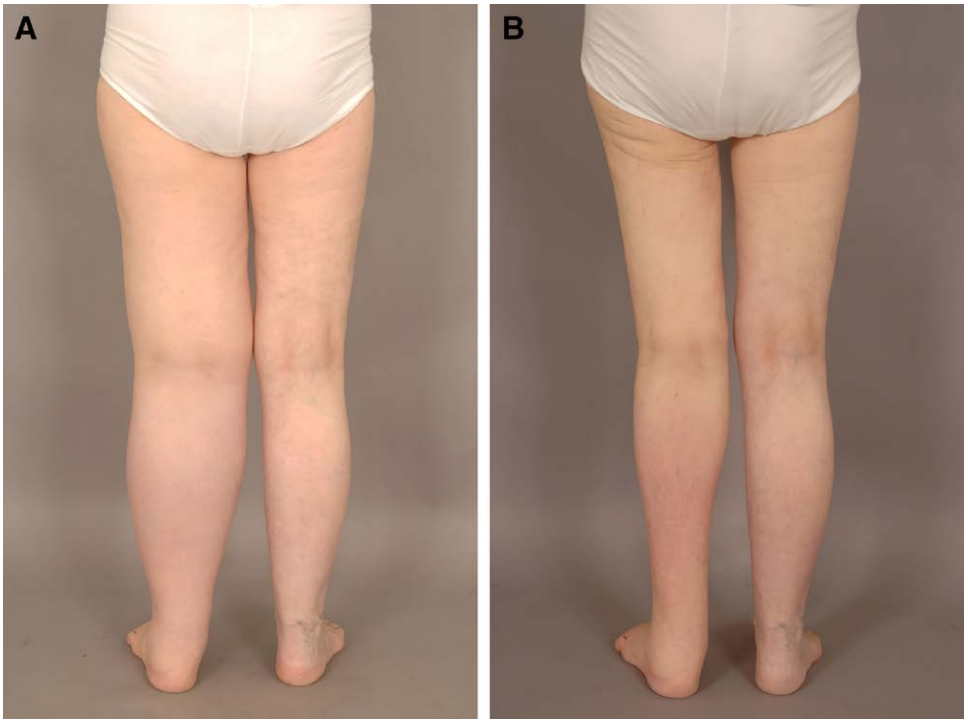

Fig. 3. A 73-year-old woman with primary leg lymphedema of 5790 mL that had been present for 50 years. A, Preoperative image. B, Complete reduction 6 months after liposuction.

illustrates the number of patients with a 90% reduction in the excess volume during the study period.

In the subgroup analysis, there was no difference in the excess volume reduction percentage between primary and secondary lymphedema after 1 and 5 years ($P = 0.11$ and $P = 0.89$, respectively). Similarly, no difference was found in postoperative excess volume reduction in percentage between men and women after 5 years ($P = 0.36$),

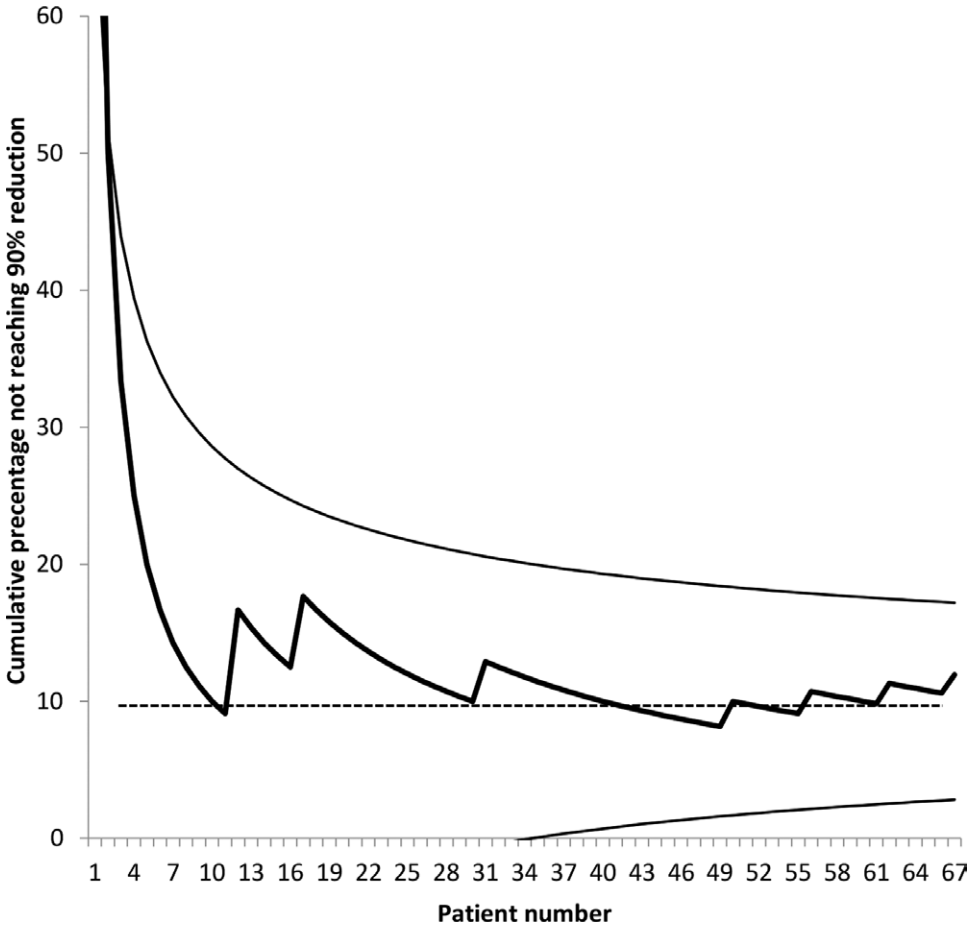

Fig. 4. A cumulative sum control chart of the percentage of patients in serial order who did not reach at least 90% reduction of excess volume after surgery (thick line) with a 95% confidence interval (thin line). The dashed line indicates a 90% success rate over the study period. At the end of the study, eight patients did not reach 90% reduction.

but the difference was significant after 1 year ($P = 0.014$), where women had a median reduction of 101% (IQR: 86–116) and men had a 74% reduction (IQR: 65–108). No correlations were found for the three variables, age, duration of lymphedema, and chronological surgery number, with the postoperative excess volume reduction in percentage after one year ($r_{Spearman} = -0.15$, $P = 0.21$, $r_{Spearman} = 0.057$ and $P = 0.65$, $r_{Spearman} = -0.041$ and $P = 0.74$, respectively). However, the preoperative excess volume of the affected leg (lymphedema size) had a moderate negative correlation with the postoperative excess volume reduction in percentage after both 1 and 5 years ($r_{Spearman} = -0.33$, $P = 0.006$, $r_{Spearman} = -0.49$, and $P < 0.001$, respectively). Thus, patients with smaller lymphedema are more likely to have a greater reduction in excess volume after liposuction. A scatter plot of this correlation is shown in Figure 5. The procedure resulted in cosmetically acceptable results, without the need for skin excision.

Aspirated Volumes

Of the 67 patients, 64 underwent liposuction with the tourniquet and tumescence technique, two patients were operated on in 1993–1994 with the dry technique, and one additional patient had distal lymphedema and did not need proximal tumescent liposuction and had only tourniquet liposuction. Figure 6 shows the aspirated volumes. For one patient operated on with the "dry technique" the amount of fat and fluid was not calculated. The total aspirated volume for all patients (n =66) was 3770 mL (IQR: 2240–5140 mL), containing 85% fat (IQR: 79–91%). When the tourniquet was used (n = 65), the aspirate volume was 2080 mL (IQR: 1150–3205 mL), containing 100% fat (IQR: 90–100 mL). Aspiration from proximal liposuction using tumescence (n = 64) was 1400 mL (IQR:1075–2020 mL), with 75% fat (IQR:65–83%).

Complications

No major complications were noted. Three units of blood were administered to one patient who underwent surgery using the dry technique. Eight units were administered to one patient with the largest lymphedema (20.8 L) despite using the combined technique. An additional three patients needed between two and four units of blood transfusion. Since October 2006, none of the patients have received blood transfusions. Postoperative skin numbness disappeared within a few weeks.

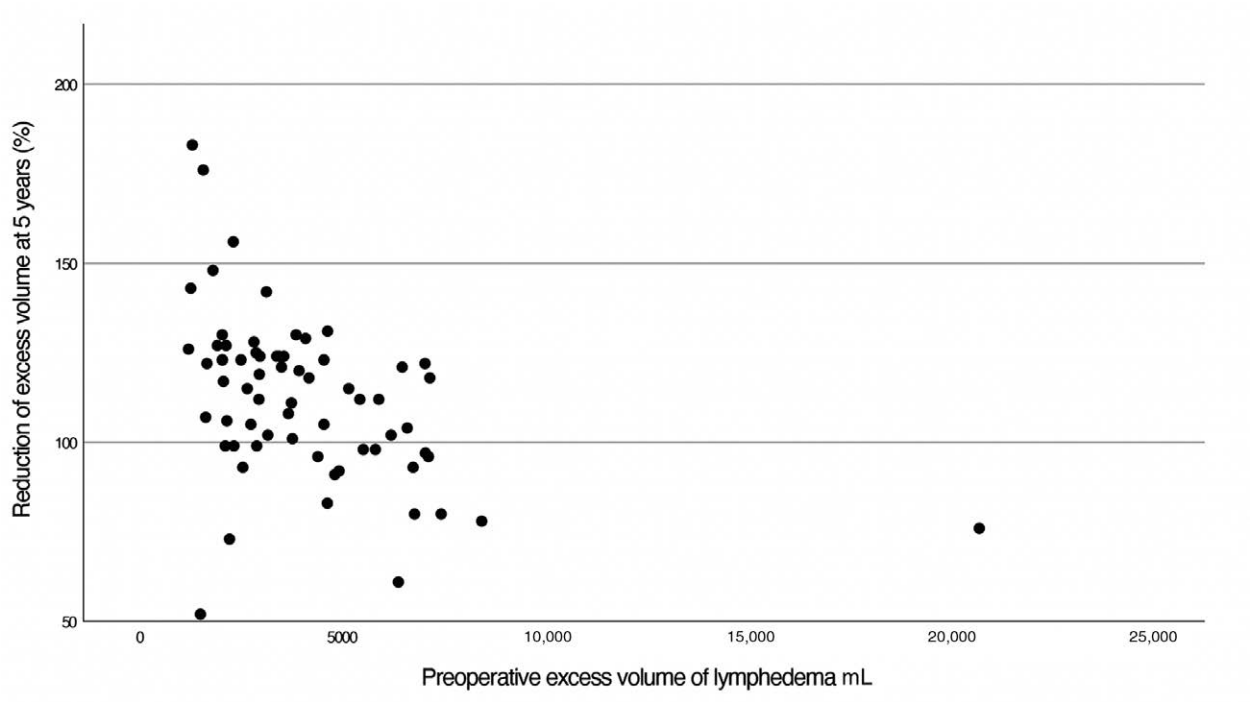

Fig. 5. Scatterplot of the reduction in excess volume at 5 years with the preoperative excess volume of lymphedema. The Spearman correlation ($r_{Spearman} = -0.49$ and $P < 0.001$) indicates that patients with the largest excess volumes might have a lesser reduction after surgery.

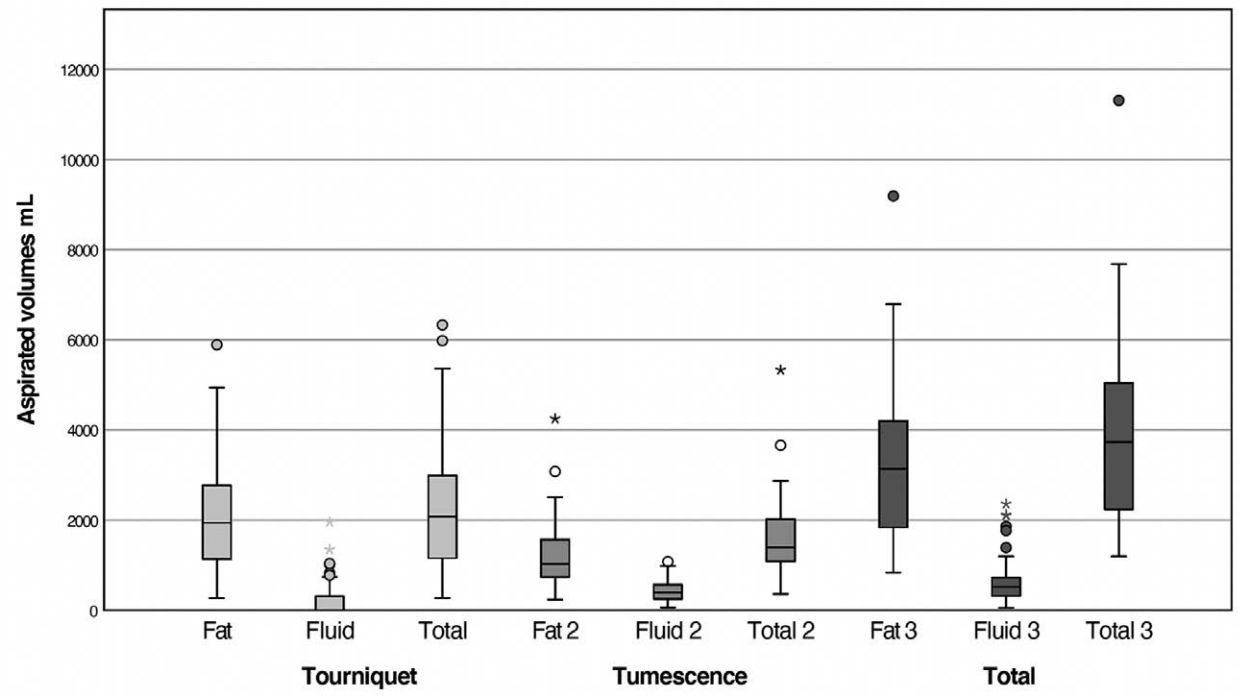

Fig. 6. Boxplot illustrating the aspirate volumes in mL. Light gray represents aspirated volumes with tourniquet (n = 65), medium gray represents aspirated volumes with tumescence (n = 64), and dark gray represents total aspirated volumes (n = 66). For each method, fat volume, fluid volume, and total aspirate volumes are presented. The line within the box represents the median value, the border of the box represents IQR, and the whiskers represent the lowest and highest values without outliers (circles) and extreme outliers (stars).

DISCUSSION

This study showed a total reduction in excess volume of LEL after 1 year with sustained results during a 5-year follow-up. The main reason for this is the removal of adipose tissue, which is not possible with conservative treatments. To date, the best results for late-stage lymphedema have been obtained with liposuction.[7,9,11] The disadvantage of this approach is the need for lifelong use of compression garments and continuous follow-up by lymph therapists once a year. The strict compliance required could possibly exclude some patients from receiving this treatment, such as those not willing to use compression garments continuously and those unable to pay for the expenses related to compression garments in some countries. In addition, the climate of tropical countries presents a challenge to the continuous use of compression garments. The benefits of liposuction include complete reduction of excess volume, reduced incidence of infection, and improved quality of life, especially in terms of average daily life and sensations of pain and heaviness.[51–53]

In this study, we showed a continuous reduction in excess volume for 5 years after liposuction. This is in accordance with a previously published study evaluating patients with breast cancer-related lymphedema using dual-energy X-ray absorptiometry.[54] Adipose tissue as well as lean tissue (muscle, fluid, skin, etc) were seen to gradually decrease for 1 year after liposuction. One possible explanation is that an enlarged limb is heavy, and therefore, muscle mass increases due to the added load.[14] After liposuction, the weight of the leg decreases, leading to a continuous loss of muscle mass. No major complications were observed in this patient cohort. Despite the invasive nature of this procedure, it has been shown that liposuction does not damage or further compromise the already decreased lymph transport.[55]

One extreme outlier in Figure 1 was a male patient from abroad with a preoperative excess volume of 20805 mL (aspirated volume 11310 mL). The postoperative follow-up for this patient and three other patients (one man and two women) from abroad was not optimal due to travel difficulties, resulting in excess volumes of 5025 mL (76% reduction), 2509 mL (61% reduction), 1392 mL (80% reduction), and 1465 mL (80% reduction) at 5 years, respectively. One reason for not achieving complete reduction may be that fibrosis and muscle hypertrophy hindered complete liposuction, as suggested by smaller aspirate volumes. All four patients had very large lymphedema with aspirated volumes that were significantly smaller than the preoperative excess volume.

One limitation of the study design is the lack of a control group with no treatment/only CCT, and an optimal study design would be a randomized controlled trial; however, this is questionable from an ethical perspective. A previous comparative study showed that liposuction and CCT is substantially more effective than CCT alone.[8] Microvascular procedures are more suitable for earlier stages of lymphedema, but are still performed in combination with liposuction, and could in combination with liposuction be an alternative treatment when testing liposuction in an randomized controlled trial. Indications for improved lymph flow or lymphangiogenesis after liposuction might support this treatment combination.[56–58] Difficulties of comparing studies for surgical management of lymphedema include a wide variety of follow-up schemes and measurements, different clinical grading systems, and different settings (healthcare systems, financial aspects, climate). A consensus for standardized preoperative management, routines for long-term follow-up, and comparable measurement techniques would reduce these obstacles and help surgeons guide their practice toward the best clinical outcome.

CONCLUSIONS

This study showed that treatment with liposuction and CCT for nonpitting LEL is a safe and effective procedure to achieve normalization of leg volume, with sustained results over time. Liposuction is suitable for lymphedema resistant to conservative treatment with CDT, indicating the presence of adipose tissue that cannot be removed by other means; thus, it must be surgically removed.

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DISCLOSURES

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