Liposuction combined with controlled compression therapy reduces arm lymphedema more effectively than controlled compression therapy alone.

Brorson, Håkan; Svensson, Henry

Published in:
Plast Reconstr Surg

1998

LIPOSUCTION COMBINED WITH CONTROLLED COMPRESSION THERAPY REDUCES ARM LYMPHEDEMA MORE EFFECTIVELY THAN CONTROLLED COMPRESSION THERAPY ALONE

IV

Håkan Brorson and Henry Svensson

Plastic and Reconstructive Surgery 1998;102: 1058-1067.

Liposuction Combined with Controlled Compression Therapy Reduces Arm Lymphedema More Effectively than Controlled Compression Therapy Alone

Håkan Brorson, M.D., and Henry Svensson, M.D., Ph.D.

Malmö, Sweden

Arm lymphedema after breast cancer therapy has been treated with various forms of conservative and surgical treatment during recent years. The clinical results usually have been modest or, in some instances, even disappointing. In a previous series of patients treated with the new liposuction technique combined with controlled compression therapy, we found, however, an overall edema reduction of 106 percent after 1 year. The purpose of this study was both to investigate how much the surgical procedure contributes to the outcome and to clarify the importance of controlled compression therapy. Twenty-eight patients were, therefore, prospectively matched into two groups. One group received liposuction combined with controlled compression therapy, and one group received the therapy alone. Additionally, the therapy group was compared with our complete group of patients treated thus far with liposuction combined with therapy ($n = 30$). The prospective study using matched pairs ($n = 14$) showed that liposuction combined with controlled compression therapy is significantly more effective than the therapy alone ($p < 0.0001$), with a mean difference of about 1000 ml during the entire 1-year observation period. The beneficial effect of liposuction was confirmed by the comparison between the controlled compression therapy group and our complete group of patients treated with liposuction combined with the therapy, as the edema reduction figures after 1 year were 47 percent and 104 percent, respectively ($p < 0.0001$). In six patients who had surgery and a complete reduction of the edema, the compression garments were removed for 1 week, 1 year postoperatively. A marked increase in the arm volume was observed, which was immediately remedied by reapplying the garments. We conclude that liposuction combined with controlled compression therapy reduces arm lymphedema more efficiently than the therapy alone. Continued use of compression garments is, however, important to maintain the primary surgical outcome. (*Plast. Reconstr. Surg.* 102: 1058, 1998.)

The incidence of lymphedema of the arm after mastectomy ranges between 8 and 38 percent, depending on whether axillary lymph nodes are excised and radiation is used.[1] Prophylaxis by wearing garments seems to be a worthwhile adjunct, but more active therapeutic intervention is required in cases of established edema. Examples of such interventions include manual lymph therapy and pneumatic compression therapy. Nevertheless, the condition often may progress slowly but steadily, eventually causing disability. Surgical treatment becomes necessary for patients who, probably because of progressive hypertrophy of the adipose tissue and later fibrosis, fail to respond to conservative treatment. The mechanism behind the adipose tissue hypertrophy is probably that macrophages and adipose cells take up lipids from the lymph, which because of the interrupted lymph flow cannot be transported further. The subcutaneous adipose tissue thickens, and a chronic swelling ensues, which consists of lymph and hypertropied adipose tissue.[2–4] Later, an ingrowth of fibrosis is

From the Department of Plastic and Reconstructive Surgery, Malmö University Hospital. Received for publication September 8, 1997; revised January 13, 1998.

Presented in part at the following meetings: IPRAS meetings in Yokohama, Japan, in May 1995, Phuket, Thailand, in April 1997, and Lisbon, Portugal, in June 1997; winner of First Prize for best paper presented at the Annual Meeting of the Swedish Society of Medicine, Stockholm, Sweden, in November 1994, the XXVth Meeting of the Nordic Society of Plastic Surgery, Stockholm, Sweden, in June 1996, and the IXth EURADS Meeting, Verona, Italy, in May 1998; awarded the Presidential Prize at the 16th International Congress of Lymphology, Madrid, Spain, in September 1997.

seen in the subcutaneous adipose tissue, which makes the condition more difficult to treat. The cause of the fibrosis is probably that the fibroblasts are stimulated by the high protein concentration in the lymph.[5,6]

Nonsurgical ways to treat lymphedema were first used by Winiwarter, who introduced physical therapy.[7] He used the classical massage techniques, such as pétrissage, effleurage, frictionement, and tapotement, which were introduced by the founder of physiotherapy, Pehr Henrik Ling of Sweden, in 1813.[8] Winiwarter also emphasized the complex decongestive treatment, consisting of meticulous cleanliness, bed rest, elevation of the swollen arm, exercises, and compression bandages.[9] His massage technique was rather crude compared with that introduced by Vodder in 1932; Vodder used a specific light massage technique, manual lymph drainage, to improve lymph flow, especially in patients with primary lymphedema.[11,12] The edema reduction achieved by these methods could not be maintained, however, because suitable compression garments were not available at that time.[12,13] In 1969, Stillwell developed a variant of complex decongestive treatment without knowing of Winiwarter's published work. He mainly advocated firm massage and pneumatic compression.[9,14–16] Vodder's technique was refined further by Asdonk in 1963.[8,17] He called the improved technique *manuelle Lymphdrainagetherapie* (manual lymph drainage therapy). In 1978, Földi, after collaborating with Asdonk, further developed Vodder's original technique, combining it with Winiwarter's complex decongestive treatment, and introduced *komplexe physikalische Entstauungstherapie* [9,14,15,18] (complex decongestive physiotherapy). This technique combines manual lymph drainage, skin care, remedial exercises, and compression bandaging complemented by compression garments. Földi also defined two treatment phases: stage I, the primary intervention, and stage II, repeated follow-up treatments. The technique is also known as combined physiotherapy.[19] In Australia, the Casley-Smiths adopted the concept and called it complex physical therapy.[12,13] Finally, pneumatic compression therapy, which uses various pneumatic pumps, also has gained widespread acceptance.[16,20–27]

Since 1908, when Handley placed silk threads subcutaneously in an attempt to reduce lymphedema by capillary forces,[28] a variety of surgical methods have been used to treat lymphedema. To create drainage channels, surgeons have inserted different materials subcutaneously, including tubes of rubber,[29] polythene,[30] and polyvinylchloride (Portex).[31]

Interventions in the underlying fascia have been made to create functional lymphatic communications from the superficial to the deeper tissues.[32–35] The same principle lay behind the idea of implanting shaved dermal flaps.[36] By using microvascular techniques, anastomoses have been established between lymph collectors and the venous system.[37,38] Transplantation of lymph vessels also has been tested.[39–41] Promising results have been reported recently after the creation of various forms of lymphatic venous anastomoses.[42,43] Although attractive in concept, none of these methods gives consistently satisfactory results. Wide excision with skin grafting remains an option in severe cases,[44–46] but these patients often develop troublesome skin conditions such as papillomatosis, eczema, lymph fistulas, keloids, ulceration, and erysipelas.

Reduction of the volume of the lymphedema by using the less traumatic liposuction constitutes an interesting new approach, and preliminary clinical reports, although not impressive,[47–50] warranted further refinement and evaluation of the procedure. We recently reported a prospective study of 28 patients with fibrotic arm lymphedema, grade II, after treatment for breast cancer. All patients had undergone manual lymph therapy and/or pneumatic compression therapy, but the results were considered unsatisfactory both objectively and subjectively. Treatment by liposuction and controlled compression therapy, as described below, provided a 106-percent overall reduction of the edema after 1 year.[51]

Because of our encouraging results with liposuction, we wanted to study how much the surgery contributes to the edema reduction. Therefore, in this prospective study, patients were randomly selected either for liposuction combined with controlled compression therapy or for the therapy alone. The same monitoring procedure was used for both groups. To further clarify the importance of controlled compression therapy, six patients temporarily removed their compression garment for 1 week, 1 year postoperatively.

Materials and Methods

Patients

Patients are regularly referred to our lymphedema team by general surgeons, oncologists, and general practitioners. Thirty-two such patients, consecutively recruited during an 18-month period, participated in the present prospective study. The indication for further intervention was based on the subjective discomfort caused by the heavy arm and on the fact that previous treatment with manual lymph therapy and/or pneumatic compression therapy had produced unsatisfactory results.

Sixteen patients were selected for liposuction combined with controlled compression therapy, and 16 for the therapy alone. Selection was done in such a way that patients having the most similar edema volumes were paired off. Because our daily clinical work is with patients in urgent need of care, we would not postpone treatment for ethical reasons. The matching procedure, therefore, had to be done continuously throughout the trial. One patient did not adhere to the treatment protocol and was excluded after 3 months. One patient had an extraordinarily large edema volume, more than 3.2 liters, and could not be matched satisfactorily. Thus, 14 pairs of patients remained for analysis. Detailed data on the two groups are shown in Table I.

Neither of the two groups had received any conservative treatment preceding the trial. Therefore, lymphedema was firm in all cases and showed clinical signs of grade II fibrosis with adipose tissue hypertrophy. None of the patients had generalized disease or local wound complaints. All patients, except one in the controlled compression therapy group, had received radiotherapy immediately after the breast cancer operation, which included the excision of lymph nodes in all cases.

Measurements

Before treatment began and 0.5, 1, 3, 6, and 12 months afterward, both arm volumes were recorded for each patient using the water displacement technique. The displaced water was weighed on a balance to the nearest 5 g (corresponding to 5 ml). Hence, both arms were measured at each visit, and the difference in arm volumes was designated as the edema volume.[52–55] The decrease in the edema volume was calculated in percent, thus:

$$\text{Percent reduction of edema volume} = \frac{\text{initial edema volume} - \text{present edema volume}}{\text{initial edema volume}} \times 100$$

TABLE I
Patient Profile

	All Liposuction + CCT	CCT	Liposuction + CCT	Δ [CCT − (Liposuction + CCT)]
Number of patients	30	14	14	—
Age at cancer operation				
Mean	55	56	54	2.1
SD	12.7	11.8	12.8	−1.0
Range	39–79	28–72	40–78	—
Duration of lymphoedema (years)				
Mean	7.2	7.9	7.8	0.1
SD	6.7	5.1	6.8	−1.7
Range	1–27	1–19	1–23	—
Age at start of treatment				
Mean	64	66	63	2.9
SD	9.9	13	10	3.2
Range	46–81	30–89	46–80	—
Interval between breast cancer operation and treatment start (years)				
Mean	8.3	9.9	8.6	1.2
SD	6.6	5.4	6.7	−1.3
Range	1–27	1–19	1–24	—
Edema volume before treatment (ml)				
Mean	1790	1680	1745	−65
SD	800	628	603	25
Range	570–3915	670–3320	570–2950	—

SD, standard deviation; CCT, controlled compression therapy.

Controlled Compression Therapy

The compression therapy is crucial, and its use and effects were described in detail and discussed with the patient at the first clinical evaluation. If she had any doubts about continuous controlled compression therapy, she was not enrolled for participation in the study.

We took measurements for each patient for a custom-made compression sleeve-and-glove garment that provided 32 to 40 mmHg of compression (Jobst-Elvarex, compression class 2 and 3, Beiersdorf, Sweden). For temporary use, an interim dressing was worn for 2 weeks; thereafter, a custom-made garment was fitted. The custom-made compression garment was taken in at each visit (using a sewing machine) to compensate for reduced elasticity and reduced arm volume. This was most important during the first 3 months when the most notable changes in volume occurred, particularly in the surgery group. At the 3-month visit, the arms were measured for new custom-made compression garments. This procedure was repeated at 6 and 12 months. It was important, however, to take in the garment continuously to compensate for wear and tear. This required additional visits in some instances, although such adjustments could often be made by the patient herself. When the edema volume had decreased as much as possible and a steady state was achieved, new garments could be prescribed using the latest measurements. In this way, the garments were renewed three or four times during the first year. Two sets of sleeve-and-glove garments were always at the patients' disposal, one being worn while the other was being washed. Thus, a garment was worn permanently, and treatment was interrupted only briefly when showering and, possibly, for formal social occasions. The patient was informed about the importance of hygienic measures and skin care. This rigorous method of compression therapy as instituted in both groups is referred to as "controlled compression therapy."

Liposuction

Our surgical technique has been described in detail in a previous paper.[5] Briefly, liposuction was effected by means of 20 to 30 3-mm-long incisions, and the hypertrophied and edematous fat was removed by vacuum aspiration as completely as possible. During the subsequent postoperative course, controlled compression therapy was maintained exactly as described above for the nonsurgical group.

Statistical Analysis

Measurements are presented as mean, standard deviation (SD), and range. Standard error of the mean (SEM) is used in Figures 1 and 2 for practical reasons. The reduction in the volume of edema after 12 months was compared with that recorded before treatment. The significance of differences was assessed with Student's t test for paired matched observations.

Additionally, the outcome of the group that received controlled compression therapy alone was compared with the outcome for all patients thus far who had liposuction and a follow-up of at least 1 year ($n = 30$). Consequently, this latter group includes the 14 patients who participated in the present study. The significance of differences here was assessed with Student's t test for unpaired observations.

RESULTS

In the group that received controlled compression therapy alone ($n = 14$), the mean volume of edema before treatment was 1680 ml (range, 670 to 3320 ml). After compression therapy, a substantial step-by-step reduction was observed. After 12 months, the mean volume of edema had decreased to 873 ml (range, 340 to 2275 ml), corresponding to an average relative reduction of 47 percent (range, −2 to 80 percent; Fig. 1).

In the surgical group ($n = 14$), there were no major complications. The mean volume of edema before liposuction was 1745 ml (range, 570 to 2950 ml). The immediate effect of liposuction followed by controlled compression therapy was obvious, and during the postoperative course, a further reduction was seen in the mean volume of edema. After 12 months, the volume was −122 ml (range, −655 to 820 ml), corresponding to an average relative reduction of 113 percent (range, 66 to 179 percent). The statistical analysis of the paired groups showed that liposuction is significantly more effective than compression therapy alone ($p < 0.0001$; Fig. 2).

In the group of all patients thus far who have had surgery ($n = 30$), the mean volume of edema was 1790 ml (range, 570 to 3915 ml) preoperatively, and 52 ml (range, −655 to

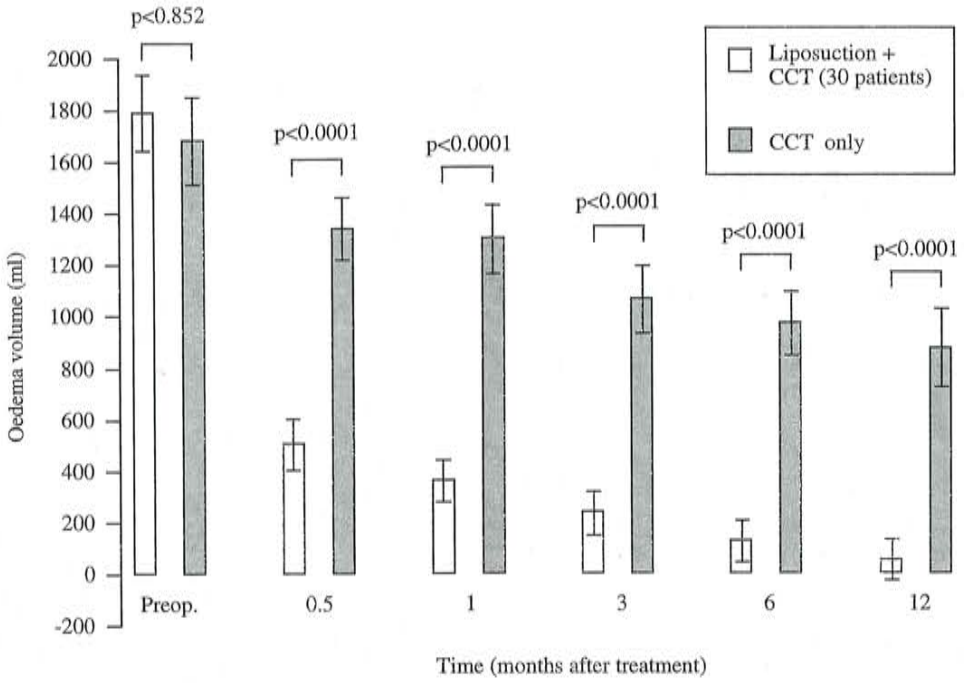

FIG. 1. Mean (SEM) volumes of edema before and after treatment. Note the pronounced effect of liposuction and that significant improvement continues during the subsequent postoperative course.

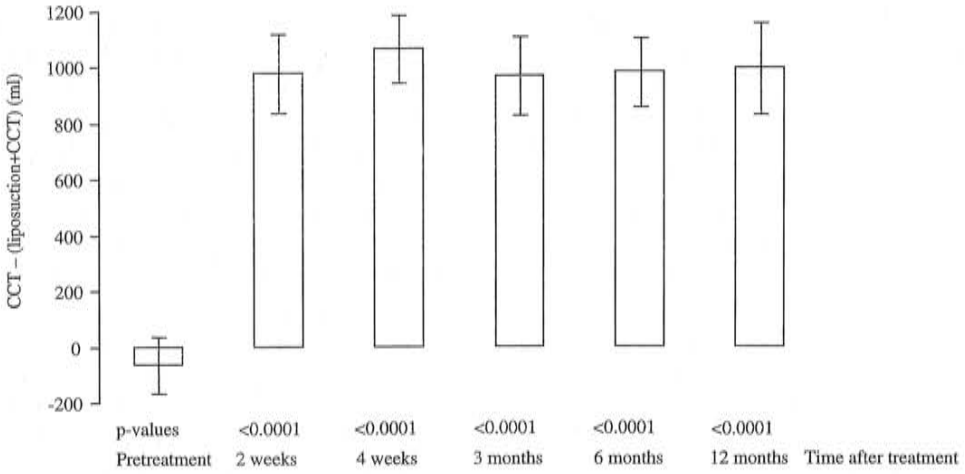

FIG. 2. Mean (SEM) edema volume difference [CCT − (liposuction + CCT)] showing a significant difference after 2 weeks. *p* values show posttreatment values compared with pretreatment ones. The significant difference remains for the entire 12-month period, and it represents approximately 1000 ml.

1135 ml) after 12 months, corresponding to a relative reduction of 104 percent (range, 66 to 179 percent; Fig. 1).

Removing the compression garment for 1 week, after 1 year, showed a mean increase of the arm volume difference of 370 ml (range, 135 to 775 ml; $n = 6$). The increase of the edema was completely reversed by reinstituting compression (Fig. 3).

DISCUSSION

Estimation of the edema volume in the arm can be accomplished by measuring the arm circumference, or girth. Measurements made at 10-cm intervals have been used for this purpose[12,13,56,57] but give a rather crude approximation of the arm edema volume. A more accurate estimation can be achieved by reducing

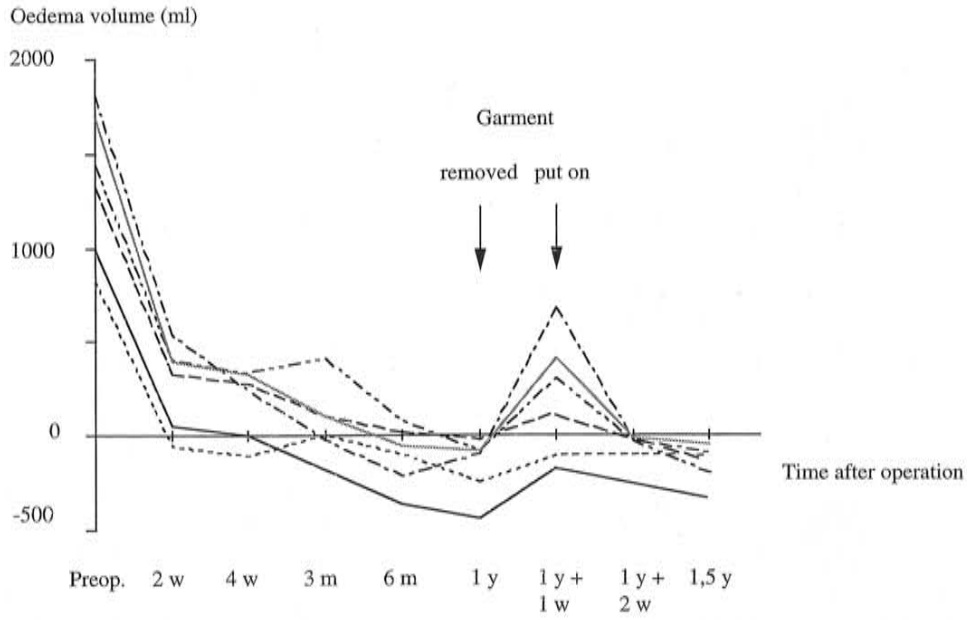

FIG. 3. The detailed clinical course in six patients, all with complete reduction of the edema, showing both the prompt effect of liposuction with controlled compression therapy and the importance of the compression garment. After removing the garment for 1 week after 1 year, the edema volume increased markedly but could be remedied again using the garment.

the measuring intervals, for instance, to 4 cm, as described by Kuhnke.[58,59] However, the method of measurement we prefer is the water displacement technique, with which the arm edema volume is reliably measured directly in ml. As in this study, both arms should be measured simultaneously so that the arm edema volume can be monitored, with the contralateral arm serving as a control, thus avoiding the effect of casual variations in the general body mass.

Manual lymph therapy is the primary method for treatment of lymphedema. Its direct beneficial effect on long-standing, pronounced edema with fibrosis and adipose tissue hypertrophy is uncertain, however, because complete and convincing reports of long-term follow-up studies are sparse. It is beyond the scope of this article to go into details, but these treatment regimes seem to produce only moderate long-term results, despite considerable efforts. This same qualification applies to pneumatic compression therapy. Furthermore, patients treated with these methods all seem to be prone to recurrence, necessitating repeat treatment or additional measures.

The effects of conservative treatment are detailed in a study by Boris et al.[56] This article is a 1-year follow-up with a fairly detailed presentation of the study material, and nonresponders were not excluded from the analysis of the results. The effects of complex physical therapy given 4 hours a day for 30 days followed by the

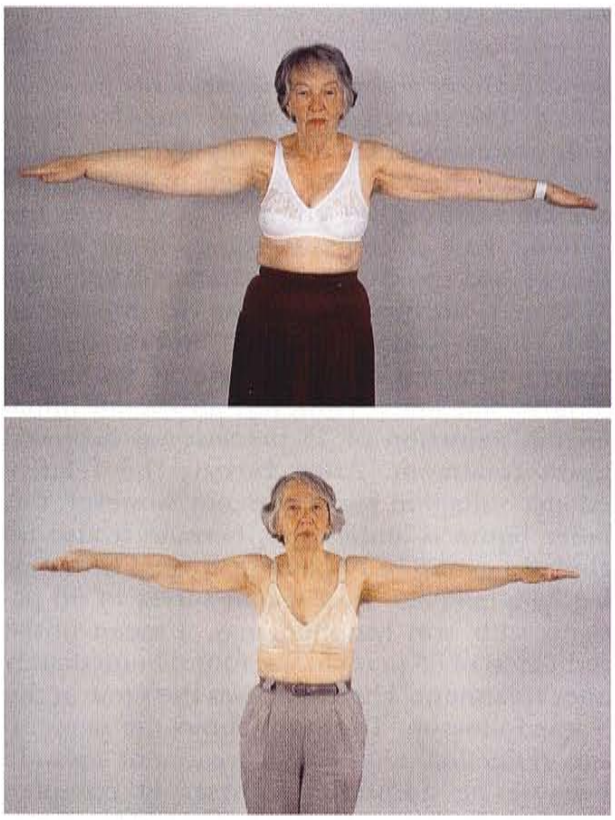

FIG. 4. A 64-year-old woman with a preoperative edema of 2140 ml in the right arm (*above*). Clinical result 1 year after liposuction (*below*).

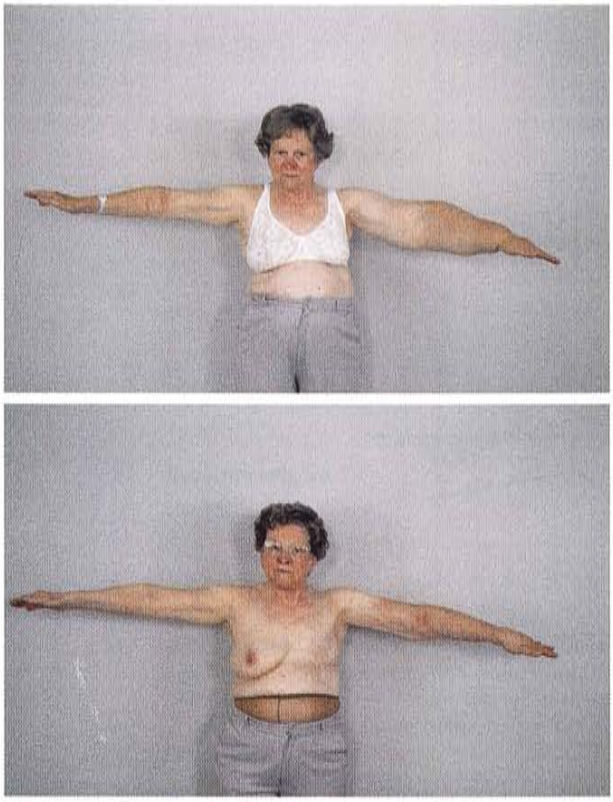

FIG. 5. A 74-year-old woman with a preoperative edema volume of 3100 ml in the left arm (*above*). Clinical result 1 year after liposuction (*below*).

application of compression garments were analyzed. The study participants were 16 women with postmastectomy arm lymphedemas; 13 of the lymphedemas were judged to be fibrotic. No information was given as to whether the patients had undergone axillary node dissection or had received postoperative irradiation. Moreover, the lymphedemas were rather small, with a mean volume of 690 ml, and the healthy control arm was measured only at the beginning of the study. However, an overall initial edema reduction of 73 percent was achieved upon treatment. After 1 year, the relative edema reduction was 86 percent; however, this latter figure is ambiguous, because it also included a group of 17 patients treated for lower leg lymphedema. In a recent survey of 56 patients with arm lymphedemas, a mean initial reduction of 63 percent was found immediately after treatment. This figure was the same at the 3-year follow-up. The study shows the percentage reduction of a single treatment episode because no additional courses of complex physical therapy were administered. However, no information of the quantitative edema volumes before and after treatment was given.[57] Furthermore, 12 patients had only grade I lymphedema, and nine patients were lost to follow-up.

The result of the present study clearly shows that the use of simple compression garments remains an interesting alternative to manual lymph therapy and pneumatic compression therapy. After controlled compression therapy, a stepwise reduction in the mean volume of edema was seen, and after 12 months, the average reduction was 47 percent. This outcome was very good, particularly considering that all the patients had heavy edemas with marked signs of adipose tissue hypertrophy and fibrosis. Although our controlled compression therapy requires a careful follow-up, preferably with a lymphedema team, it seems to be a cost-effective method. It is done purely on an outpatient basis, and it is not associated with prolonged intervention by therapists. Furthermore, no expensive technical devices of any kind are used.

The uncertainty regarding the long-term results of conservative treatment makes a surgical approach seem logical. This seems particularly true in patients with long-standing, massive, and fibrotic edemas with adipose tissue hypertrophy. Another reason for surgery is that the removal of edematous tissue may reduce the risk of developing malignant lymphosarcoma.[60] However, previous surgical methods intended either to simply reduce the edematous tissue or to create favorable conditions for alternative drainage, did not always give satisfactory results. The concept of combining the more recent liposuction technique with controlled compression therapy has proved to be very promising.[51] In our complete series of patients ($n = 30$) treated in this way, with a follow-up of 1 year, we have managed to remove the edema volume completely, by 104 percent on average. This means that the tissue volume removed sometimes was greater than the initial edema volume, a finding that we have encountered in 18 patients. Consequently, not only a normalization, but even an overcorrection, of the lymphedematous condition can be achieved after 1 year. Because only normalization is intended, Bernas et al.[55] have suggested using 100 percent as an upper limit for reporting results to make the interpretation of results more comprehensive. Taking this into consideration, the mean relative reduction in our series was 93 percent (range, 66 to 100 percent).

Our wish to ascertain how much liposuction contributed to our favorable results indicated the need for a prospective study, with patients receiving controlled compression therapy alone serving as matched controls based on the volume of edema. Although the matching procedure could not be done in an optimal way for clinical and ethical reasons, the paired patients seemed to match one another very closely (Table I). Coincidentally, other parameters of interest showed only slight divergences.

The results clearly show that liposuction gives an instant and significant reduction of the edema volume compared with controlled compression therapy alone (Figs. 1 through 3). The unequivocal effect of surgery is because of the removal of the lymphatic load, consisting of both edematous and hypertrophied fatty tissue and accumulated proteins (Figs. 4 through 6). Although controlled compression therapy may afford complete relief during prolonged treatment, the accelerated temporal course achieved by liposuction is important when considering quality of life, particularly in view of the patients' malignant ground disease and their age. On the other hand, this study also shows that controlled compression therapy becomes an important complement in the treatment to maintain the primary surgical outcome (Figs. 1 through 3). The importance of maintaining compression is also indicated by our observation of the one patient in the controlled compression therapy group who showed poor compliance, probably because of reduced intellectual capacity caused by an operation for two brain aneurysms 9 years before compression therapy. She did not respond at all to the therapy. If her data are excluded from the calculations, the overall result in the compression therapy group is 51 percent.

CONCLUSIONS

Controlled compression therapy reduces arm lymphedema to a certain degree and may well constitute an interesting alternative to manual lymph therapy. It is less time-consuming, does not interfere with the activities of daily living, and is cost-effective. This study clearly shows, however, that liposuction combined with controlled compression therapy reduces arm lymphedema significantly more effectively than compression therapy alone.

Håkan Brorson, M.D.
Department of Plastic and Reconstructive Surgery
Malmö University Hospital
SE-205 02 Malmö
Sweden

FIG. 6. Liposuction has been performed on the distal half of the forearm (*left*). Clinical result immediately after the operation (*right*).

ACKNOWLEDGMENTS

We thank occupational therapist Karin Ohlin and physiotherapist and certified lymph therapist (Földi) Gaby Olsson for assistance in the measurement and adjustment of garments.

The clinical work was supported by the Swedish National Board of Health and Welfare (local grants for habilitation and rehabilitation). The scientific evaluation was supported by Malmö University Hospital and the Foundation Against Cancer at Malmö University Hospital.

REFERENCES

1. Kissin, M. W., Querci della Rovere, G., Easton, D., and Westbury, G. Risk of lymphoedema following the treatment of breast cancer. *Br. J. Surg.* 73: 580, 1986.
2. Vague, J., and Fenasse, R. Comparative Anatomy of Adipose Tissue. In A. E. Renold and G. F. Cahill, Jr. (Eds.), *American Handbook of Physiology*, Section 5. Washington, D.C.: American Physiology Society, 1965. Pp. 25–36.
3. Ryan, T. J., and Curri, S. B. Blood vessels and lymphatics. *Clin. Dermatol.* 7: 25, 1989.
4. Ryan T. J. Lymphatics and adipose tissue. *Clin. Dermatol.* 13: 493, 1995.
5. Gaffney, R. M., and Casley-Smith, J. R. Excess plasma proteins as a cause of chronic inflammation and lymphoedema: Biochemical estimations. *J. Pathol.* 133: 229, 1981.
6. Casley-Smith, J. R., and Gaffney, R. M. Excess plasma proteins as a cause of chronic inflammation and lymphoedema: Quantitative electron microscopy. *J. Pathol.* 133: 243, 1981.
7. von Winiwarter, A. Die chirurgischen Krankheiten der Haut und des Zellgewebes. *Dtsch. Chirurg. (Lief.)* 23: 356, 1892.
8. Asdonk, J. Über Wirksamkeit, Indikationen und Kontraindikationen der "Manuellen Lymphdrainagetherapie" bei "Schmerzödemen." *Z. Lymphol.* 19: 16, 1995.
9. Földi, E., and Földi, M. Komplexe physikalische Entstauungstherapie des chronischen Gleidmassenlymphödems. *Folia Angiol.* 29: 161, 1981.
10. Vodder, E. La drainage lymphatique, une nouvelle méthode thérapeutique: Revue d'hygiène individuelle. *Santé pour Tous.* Paris, 1936.
11. Vodder, E. Lymphdrainage ad modum Vodder. Eine neue Behandlungsart in der Chirotherapie zu aesthetischen, prophylaktischen und kurativen Zwecken. *Asthet. Med. (Berl.)* 14: 190, 1965.
12. Casley-Smith, J. R., and Casley-Smith, J. R. Modern treatment of lymphoedema I. Complex physical therapy: The first 200 Australian limbs. *Australas. J. Dermatol.* 33: 61, 1992.
13. Morgan, R. G., Casley-Smith, J. R., Mason, M. R., and Casley-Smith, J. R. Complex physical therapy for the lymphoedematous arm. *J. Hand Surg. (Br.)* 17: 437, 1992.
14. Földi, E., and Földi, M. Komplexe physikalische Entstauungstherapie des chronischen Gleidmassenlymphödems. *Physikalische Therapie* 2: 16, 1981.
15. Földi, E., Földi, M., and Weissleder, H. Conservative treatment of lymphoedema of the limbs. *Angiology* 36: 171, 1985.
16. Stillwell, G. K. Treatment of postmastectomy lymphedema. *Mod. Treat.* 6: 396, 1969.
17. Hutzschenreuter, P. O., Wittlinger, H., Wittlinger, G., and Kurz, I. Post-mastectomy arm lymphedema: Treated by manual lymph drainage and compression bandage therapy. *Arch. Phys. Med. Rehabil.* 1: 166, 1991.
18. Földi, E., Földi, M., and Clodius, L. The lymphoedema chaos: A lancet. *Ann. Plast. Surg.* 22: 505, 1989.
19. Földi, M. Treatment of lymphedema (Editorial). *Lymphology* 27: 1, 1994.
20. Zelikovski, A., Manoach, M., Giler, S., and Urca, I. Lympha-press: A new pneumatic device for the treatment of lymphedema of the limbs. *Lymphology* 13: 68, 1980.
21. Alexander, M. A., Wright, E. S., Wright, J. B., and Bikowski, J. B. Lymphedema treated with a linear pump: Pediatric case report. *Arch. Phys. Med. Rehabil.* 64: 132, 1983.
22. Swedborg, I. Effects of treatment with an elastic sleeve and intermittent pneumatic compression in post-mastectomy patients with lymphoedema of the arm. *Scand. J. Rehabil. Med.* 16: 35, 1984.
23. Zanolla, R., Monzeglio, C., Balzarini, A., and Martino, G. Evaluation of the results of three different methods of postmastectomy lymphedema treatment. *J. Surg. Oncol.* 26: 210, 1984.
24. Kim-Sing, C., and Basco, V. E. Postmastectomy lymphedema treated with the Wright linear pump. *Can. J. Surg.* 30: 368, 1987.
25. Klein, M. J., Alexander, M. A., Wright, J. M., Redmond, C. K., and LeGasse, A. A. Treatment of adult lower extremity lymphedema with the Wright linear pump: Statistical analysis of a clinical trial. *Arch. Phys. Med. Rehabil.* 69: 202, 1988.
26. Yamazaki, Z., Idezuki, Y., Nemoto, T., and Togawa, T. Clinical experiences using pneumatic massage therapy for edematous limbs over the last 10 years. *Angiology* 39: 154, 1988.
27. Pappas, C. J., and O'Donnell, T. F., Jr. Long-term results of compression treatment for lymphedema. *J. Vasc. Surg.* 16: 555, 1992.
28. Handley, W. S. Lymphangioplasty: A new method for the relief of the brawny arm of breast cancer and for similar conditions of lymphatic œdema. Preliminary note. *Lancet* i: 783, 1908.
29. Walther, C. Note sur une nouvelle méthode de traitment de l'éléphantiasis des membres. *Bull. Acad. Natl. Med.* 3 (Sér. 79): 195, 1918.
30. Hogeman, K. E. Artificial subcutaneous channels in draining lymphoedema. *Acta. Chir. Scand.* 110: 154, 1955.
31. Jantet, G. H., Taylor, G. W., and Kinmonth, J. B. Operations for primary lymphoedema of the lower limbs: Results after 1 to 9 years. *J. Cardiovasc. Surg. (Torino)* 2: 27, 1961.
32. Lanz, O. Eröffnung neuer Abfuhrwege bei Stauung in Bauch und unteren Extremitäten. *Zentralbl. Chir.* 38: 153, 1911.
33. Kondoléon, E. Die operative Behandlung der elephantiastischen Ödeme. *Zentralbl. Chir.* 30: 1022, 1912.
34. Lexer, E. Erworbener Elephantiasis. *Munch. Med. Wochenschr.* 66: 1274, 1919.
35. Sistrunk, W. E. Contribution to plastic surgery. *Ann. Surg.* 85: 185, 1927.
36. Thompson, N. Surgical treatment of chronic lymphoedema of the lower limb. With preliminary report of new operation. *B.M.J.* ii: 1566, 1962.
37. Nielubowicz, J., and Olszewski, W. Surgical lymphaticovenous shunts in patients with secondary lymphoedema. *Br. J. Surg.* 55: 440, 1968.

38. O'Brien, B. M., Mellow, C. G., Khazanchi, R. K., Dvir, E., Kumar, V., and Pederson, W. C. Long-term results after microlymphaticovenous anastomoses for the treatment of obstructive lymphedema. *Plast. Reconstr. Surg.* 85: 562, 1990.
39. Baumeister, R. G., Seifert, J., Wiebecke, B., and Hahn, D. Experimental basis and first application of clinical lymph vessel transplantation of secondary lymphedema. *World J. Surg.* 5: 401, 1981.
40. Baumeister, R. G., and Siuda, S. Treatment of lymphedemas by microsurgical lymphatic grafting: What is proved? *Plast. Reconstr. Surg.* 85: 64, 1990.
41. Baumeister, R. G. Treatment of Lymphoedemas by Microsurgical Autogenous Lymph Vessel Transplantation. Presented at the Annual Meeting of the European Association of Plastic Surgeons, Strasbourg, France, May 11–13, 1995.
42. Campisi, C., Boccardo, F., Alitta, P., and Tacchella, M. Derivate lymphatic microsurgery: Indications, techniques, and results. *Microsurgery* 16: 463, 1995.
43. Campisi, C., Boccardo, F., and Tacchella, M. Reconstructive microsurgery of lymph vessels: The personal method of lymphatic-venous-lymphatic (LVL) interpositioned grafted shunt. *Microsurgery* 16: 161, 1995.
44. Charles, H. Elephantiasis of the Leg. In A. Latham and T. C. English (Eds.), *A System of Treatment*, Vol. 3. London: Churchill, 1912. P. 516.
45. Macey, H. B. A new surgical procedure for lymphedema of the extremities. Report of a case. *Proc. Staff Meetings Mayo Clin.* 15: 49, 1940.
46. Poth, E. J., Barnes, S. R., and Ross, G. T. A new operative treatment for elephantiasis. *Surg. Gynecol. Obstet.* 84: 642, 1947.
47. Illouz, Y. G. Lymphedema. In Y. G. Illouz and Y. T. de Villers (Eds.), *Body Sculptoring by Lipoplasty*. Edinburgh: Churchill Livingstone, 1989. Pp. 384–388.
48. Louton, R. B., and Terranova, W. A. The use of suction curettage as adjunct to the management of lymphedema. *Ann. Plast. Surg.* 22: 354, 1989.
49. O'Brien, B. M., Khazanchi, R. K., Kumar, P. A. V., Dvir, E., and Pederson, W. C. Liposuction in the treatment of lymphoedema: A preliminary report. *Br. J. Plast. Surg.* 42: 530, 1989.
50. Sando, W. C., and Nahai, F. Suction lipectomy in the management of limb lymphedema. *Clin. Plast. Surg.* 16: 369, 1989.
51. Brorson, H., and Svensson, H. Complete reduction of lymphoedema of the arm by liposuction after breast cancer. *Scand. J. Plast. Reconstr. Surg. Hand Surg.* 31: 137, 1997.
52. Swedborg, I. Voluminometric estimation of the degree of lymphedema and its therapy by pneumatic compression. *Scand. J. Rehabil. Med.* 9: 131, 1977.
53. Swedborg, I. Effectiveness of combined methods of physiotherapy for post-mastectomy lymphoedema. *Scand. J. Rehabil. Med.* 12: 77, 1980.
54. Casley-Smith, J. R. Measuring and representing peripheral oedema and its alterations. *Lymphology* 27: 56, 1994.
55. Bernas, M., Witte, M., Witte, C., Belch, D., and Summers, P. Limb Volume Measurements in Lymphedema: Issues and Standards. In R. C. Mayall, M. F. C. Andrade, M. H. Witte, and C. L. Witte (Eds.), *Progress in Lymphology XV. Proceedings of the 15th International Congress of Lymphology*, Brazil, 1995. *Lymphology* 29 (Suppl): 199, 1996.
56. Boris, M., Weindorf, S., Lasinski, B., Boris G. Lymphedema reduction by noninvasive complex lymphedema therapy. *Oncology (Huntingt.)* 8: 95, 1994.
57. Boris, M., Weindorf, S., Lasinski, B. Persistence of lymphedema reduction after noninvasive complex lymphedema therapy. *Oncology (Huntingt.)* 11: 99, 1997.
58. Kuhnke, E. Volumbestimmungen aus Umfangsmessungen. *Folia Angiol.* 24: 228, 1976.
59. Kuhnke, E. Die Volumenbetimmung entrundeter Extremitäten aus Umfangsmessungen. *Z. Lymphol.* 2: 37, 1978.
60. McConnell, E. M., and Haslam, P. Angiosarcoma in post-mastectomy lymphedema. *Br. J. Surg.* 46: 322, 1959.