THE FACTS ABOUT LIPOSUCTION AS A TREATMENT FOR LYMPHOEDEMA

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There is some controversy regarding liposuction for late-stage lymphoedemas. While it is clear that conservative therapies such as complex decongestive therapy (CDT) and controlled compression therapy (CCT) should be tried in the first instance, options for the treatment of late-stage lymphoedema that is not responding to treatment is not so clear. Liposuction has been used for many years to treat lipodystrophy. Some results have been far from optimal, however, improvements in technique, patient preparation and patient follow-up, has led to a greater and a wider acceptance of liposuction as a treatment for lymphoedema. This paper outlines the benefits of using liposuction and presents the evidence to support its use.

Key words
Liposuction
Controlled compression therapy
Lymphoedema
Adipose tissue

There is an increasing body of evidence, based on well-controlled clinical trials and long-term follow-up, that liposuction can result in significant objective and subjective benefit to patients who have long-term chronic lymphoedema (Bronson et al. 2007a,b). There are, however, different views on the immediate, short- and long-term benefits of liposuction for treating lymphoedema, with a strong dichotomy between those who support surgical and conservative treatments.

Excess subcutaneous adiposity and chronic lymphoedema
The incidence of postmastectomy arm lymphoedema varies between 8% and 80%, depending on part in whether axillary lymph nodes have been removed and postoperative irradiation has been given (Kissin et al. 1966; Segerstrom et al. 1992).

The outcome of the surgical procedure as well as the irradiation of the tissue often results in the destruction of lymphatic vessels. When this is combined with the removal of lymph nodes and tissue scarring, the lymphatic vessels that remain are likely to be unable to remove the load of lymph. The remaining lymph collectors become dilated and overloaded and their valves become incompetent, preventing the lymphatics from performing their function. This failure spreads distally until even the most peripheral lymph vessels, draining into the affected system, also become dilated (Olzæwski, 1991).

In a parallel process, the cells of the mononuclear phagocytic system of the mesenchymal tissues begin to lose their capability to remove the protein that accumulates. The accumulated interstitial proteins, as cosmotically active molecules, attract fluid to the area. This accumulation of protein and fluid is usually a transitory phase, lasting between one and three weeks (Olzæwski, 1991).

In the latent phase, there may still be no clinical signs initially of any discernable lymphoedema. The latent phase normally varies from about four months to 10 years. At the end of the latent phase, pitting of the oedematous arm on pressure can be observed. This can be objectively measured by plethysmography and by decreased tissue compressibility using a tissue tonometer (Olzæwski, 1991; Bagheri et al. 2005).

The enlargement of the arm leads to discomfort and complaints in the form of heaviness, weakness (Johansson and Filler, 2007), pain tension and a sensory deficit of the limb, as well as anxiety, psychological morbidity, maladjustment and social isolation (Richter, 2005; Pillar and Thelander, 1998) and increasing hardness of the limb (Bronson et al. 2006a). In time, there is also an increase in the adipose tissue content of the swollen arm. The author has observed this clinically since 1987, when the first lymphoedema patient in his department was operated on (Bronson and Svensson, 1997a,b). Bronson and Svensson, 1998).

There are various possible explanations for the adipose tissue hypertrophy. There is a physiological imbalance of blood flow and lymphatic drainage, resulting in the impaired clearance of lipids and their uptake by macrophages (Vague and Fenasse, 1965; Ryan, 1995). There is increasing support, however, for the view that the fat cell is not simply a container of fat, but is an endocrine organ and a cytokine-activated cell (Mattacks et al. 2005; Pond, 2005) and chronic inflammation plays a role here (Borley et al. 2000, Sadler et al. 2005). The same pathophysiology goes for primary and secondary leg lymphoedema.

For more information about investigational advances and the relationship between slow lymph flow and adiposity, as well as that between structural changes in the lymphatic system and adiposity, see Harvey et al. 2005 and Schneider et al. 2005.

Other indications for adipose tissue hypertrophy include:

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Consecutive analyses of the content of the aspirate removed under bloodless conditions using a twentygauge, showed a high content of adipose tissue in 44 women with postmastectomy arm lymphoedema (mean 90%, range 58–100) was found (Broson et al, 2004a).

Analyses with dual X-ray absorptiometry (DXA) in women with arm lymphoedema following mastectomy showed a significant increase of adipose tissue in the non-pitting swollen arm before surgery (Broson 2004b).

Preoperative investigation with volume rendered computer tomography (VR-CT) images in eight patients showed a significant preoperative increase of adipose tissue in the swollen arm, the excess volume consisting of 11% (range 68–96) fat (Broson et al, 2006).

Tonometry findings in 20 women with postmastectomy arm lymphoedema showed postoperative changes in the upper arm, but not in the forearm, which also showed significantly higher absolute values than in the upper arm. This is probably caused by the high adipose tissue content with little or no free fluid, just like the situation in the normal arm. The thinner subcutaneous tissue in the forearm may also play a part. Tonometry can distinguish if a lymphoedematous arm is harder or softer than the normal one. If a lower tissue tonicity value is recorded in the oedematous arm, it indicates that there is accumulated lymph fluid in the tissue, and these patients are candidates for conservative treatment methods. In contrast, patients with a harder arm compared with the healthy one, have an adipose tissue excess that can successfully be removed by liposuction (Bagheri et al, 2005).

The findings of increased adipose tissue in intestinal segments in patients with Crohn's disease, known as fat wrapping, have clearly shown that inflammation plays an important role (Jones et al, 1986; Sheehan et al, 1992; Borley et al, 2000).

In Graves' ophthalmopathy, a major problem is an increase in the intraocular adipose tissue volume leading to exophthalmus. Adipocyte related immediate early genes (IEGs) are overexpressed in active ophthalmopathy and cysteine-rich angiogenic inducer 61 (CYR61) may have a role in both orbital inflammation and adipogenesis and serve as a marker of disease activity (Lantz et al, 2005).

The common understanding among clinicians is that the swelling of a lymphoedematous extremity is due purely to the accumulation of lymph fluid, which can be removed by use of non-invasive conservative regimens such as complex decongestive therapy (CDT) and controlled compression therapy (CCT). These therapies work well when the excess swelling consists of accumulated lymph, but do not work when the excess volume is dominated by adipose tissue (Broson et al, 1998). The same may go for microsurgical procedures using lymphovenous shunts and lymph vessel transplantation (Baumeister and Suda, 1990; Baumeister and Frick, 2003; Campisi et al, 2006).

The outcome of liposuction

Today, chronic non-pitting arm lymphoedema of up to four litres in excess can be effectively removed by use of liposuction, without any further reduction in lymph transport. Long-term results have not shown any recurrence of the arm swelling (Figures 1a, b and 2) (Broson and Svensson, 1997a; Bronson and Svensson, 1998; Bronson et al. 1998; Bronson, 2003; Bronson et al. 2007a). Promising results can also be achieved for leg lymphoedema (Figures 3a and 3b) (Broson et al. 2007a, d).

Liposuction

Liposuction is the most common procedure in plastic surgery and is mainly performed for cosmetic purposes. To a lesser extent it has been used for reconstructive surgery, for example, in the treatment of lymphoedema (Broson and Svensson, 1997a; Bronson et al. 1998), problems of leakage around colostomies and urostomies caused by bulging fatty skin folds (Sandal et al, 1991; Sandal and Myrvold, 1992), 'insulin tumours' caused by the injection of insulin into the subcutaneous fat (Sandal et al, 1993), multiple familial angiooedematosis (Kanter and Wollfort, 1988), gynecomastia (Courtiis, 1987), and benign symmetrical lipomatosis (Broson et al, 1995).

Initially, liposuction was done as a 'dry' technique, no dilute adrenaline or anaesthetics being injected into the adipose tissue beforehand (Clayton et al, 1989). A disadvantage of the 'dry' technique was the large amount of blood lost (Courtiis et al, 1992). Most surgeons recommended that no more than 1500 ml of blood be lost or removed to avoid the need for blood transfusions.

Illoz was the first to infiltrate the subcutaneous fatty tissue when doing liposuction (Illoz, 1983). In the early 1980s most surgeons used the 'wet' technique (Goodpasture and Bunkis, 1986), which involves infiltration of 200–300 ml of normal saline with or without lignocaine, adrenaline, or a combination, into the surgical area before liposuction.

In 1986 the superwet technique was introduced, which involves infiltration of a solution of normal saline containing adrenaline and lignocaine in an amount equal to that of the fat that is to be removed (Rohrich and Mathes, 1990).

The following year Klein described the 'tumescent' technique, which involves somewhat larger amounts of saline containing both low-dose adrenaline and lignocaine in a ratio of 2:3 ml (infiltrate: aspirate) being injected (Klein, 1987).

These techniques enabled surgeons to remove large quantities of adipose tissue by
infiltrating dilute adrenaline and lignocaine into subcutaneous fat, both the excessive loss of blood and the need for general anaesthesia with its associated risks are reduced (Wojnikow et al, 2007).

According to other authors, more than 3000ml of fat can be removed during liposuction under local anaesthesia without sedation (Klein, 1987; Klein, 1993). Sandal et al (1995) reported the amount of whole blood contained in the aspirate is roughly 2% (volume/volume) when supravetor or tumescent techniques are used, whereas in the dry technique it is 25% (Goodpaster and Bunkis, 1986), and in the wet technique 15% (Clayton et al, 1989).

When our team started to treat arm lymphoedema following breast cancer treatment, we used the ‘dry technique’. Later, to minimise blood loss, a tourniquet was used in combination with tumescence. Liposuction was performed up to the distal edge of the tourniquet. A sterile compression garment was put on and the tourniquet was released. The area covered by the tourniquet was infiltrated with dilute adrenaline before the liposuction was completed (Wojnikow et al, 2007) (figure 1).

How to perform liposuction for lymphoedema
Surgical technique
Liposuction technique for leg lymphoedema is similar to that for the arm. By the use of liposuction the excess hypertrophied adipose issue is removed under bloodless conditions (figure 1). General anaesthesia is used in most cases but some patients with arm lymphoedema prefer nerve blockade in the combination of a plexus and scalenus block. Neither local anaesthetic nor epinephrine is injected distal to the tourniquet, hence the ‘dry technique’ is used. Through around 15–20, 3mm long incisions, the shoulder and arm — and even the hand when indicated — are treated (figures 4 and 5).

Cannulas are connected to a vacuum pump giving a negative atmospheric pressure of 0.9. The cannulas are 15cm long with an outer diameter of 3 and 4mm, and they have three openings at the tip. The finer cannula is mainly for the hand and the distal part of the forearm, and also when irregularities are remedied. The openings differ from normal liposuction cannulas in that they take up almost half of the circumference to facilitate the liposuction, especially in lymphoedemas with excess fibrosis.

Made-to-measure compression garments (two sleeves and two gloves) are ordered two weeks before surgery. The size of the garments is measured according to the size of the healthy arm and hand. In stock we always have standard interim gloves and gauntlets (= a glove without fingers, but with a thumb), used as described below. Liposuction is executed circumferentially step-by-step from hand to shoulder, and the hypertrophied fat is removed as completely as possible (figures 4, 5 and 6).

When the arm distal to the tourniquet has been treated, a sterilised made-to-measure compression sleeve is applied (Jobst® Evarex BSN medical, compression class 2) on the arm to stem bleeding and postoperative oedema. A sterilised, standard interim glove (Gicatrex interim, Thasne®, France), where the tips of the fingers have been cut to facilitate gripping, is put on the hand. The tourniquet is removed and the most proximal part of the upper arm is treated using tumescent technique. Finally, the proximal part of the compression sleeve is pulled up to compress the proximal part of the upper arm. The incisions are left open to drain through the sleeve. The arm is tightly wrapped with a large absorbent compress covering the whole arm (60 x 60cm, Cover-Dri, www.wattles.co.uk). The arm is kept at heart level on a large pillow. The compress is changed when needed.

The following day a standard gauntlet (Jobst® Evarex BSN medical, compression class 2) is put over the interim glove after the thumb of the gauntlet has been cut off to ease the pressure on the thumb. If the gauntlet is put on straight after surgery, it can exert too much pressure on the hand when the patient is still not able to move the fingers after the anaesthesia.

Operating time is, on average, two hours. An isoxazolylenicillin or a cephalosporin is given intravenously for the first 24 hours and then in tablet form until incisions are healed, about 10–14 days after surgery.

Postoperative care
The arm is held raised by the patient herself during the hospital stay. Garments are removed two days postoperatively so that the patient can take a shower. Then, the other set of garments is put on and the used set is washed and dried. This is repeated by the patient herself after another two days before she is discharged. The standard glove and gauntlet is usually changed to the made-to-measure glove at the end of the stay (figure 7).

The patient alternates between the two sets of garments (two sleeves and two gloves) during the first two postoperative weeks, changing them daily or every other day so that a clean set is always put on after showering and lubricating the arm. After the two-week control, the garments are changed every day after being washed. Washing activates the garment by increasing the compression due to shrinkage. It also removes perspired salt, that can cause dry and irritated skin. During the subsequent course, this rigorous compression regime, referred to as
controlled compression therapy (CCT), is maintained exactly as described below.

**Controlled compression therapy (CCT)**
A prerequisite to maintaining the effect of liposuction, and, for that matter, conservative treatment, is the continuous use of a compression garment (Brorson and Svensson, 1998). Compression therapy is crucial, and its application is therefore thoroughly described and discussed at the first clinical evaluation. If the patient has any doubts about continued CCT, she is not accepted for treatment. After initiating compression therapy, the custom-made garment is taken in at each visit using a sewing machine, to compensate for reduced elasticity and reduced arm volume. This is most important during the first three months when the most notable changes in volume occur. At the one- and three-month visits the arm is measured for new custom-made garments. This procedure is repeated at six (nine) and 12 months. If complete reduction has been achieved at six months, the nine-month control may be omitted. If this is the case, remember to prescribe garments for six months, which normally means double the amount that would be needed for three months. It is important, however, to take in the garment repeatedly to compensate for wear and tear. This may require additional visits in some instances, although the patient can often make such adjustments herself.

When the excess volume has decreased as much as possible and a steady state is achieved, new garments can be prescribed using the latest measurements. In this way, the garments are renewed three or four times during the first year. Two sets of sleeve and glove garments are always at the patient’s disposal, one being worn while the other is washed. Thus, a garment is worn permanently, and treatment is interrupted only briefly when showering and, possibly, for formal social occasions. The patient is informed about the importance of hygiene and skin care, as all patients with lymphoedema are susceptible to infections and keeping the skin clean and soft is a prophylactic measure (Brorson and Svensson 1997a, 1998).

The life span of two garments worn alternately is usually four to six months. After complete reduction has been achieved, the patient is seen once a year when new garments are prescribed for the coming year, usually four garments and four gloves (or four gauntlets). In active patients, six to eight garments and the same amount of gauntlets/gloves a year are needed. Patients without preoperative swelling of the hand can usually stop using the glove/gauntlet after 6–12 months postoperatively.

For legs, the authors’ team often uses up to two to three compression garments on top of each other, depending on what is needed to keep pitting away. A typical example is Jobst Bellava® compression
class 2, Elvarex® compression class 3, Forte and Elvarex® compression class 2 (ISSN Medical). The latter can be a leg-length or a below-the-knee garment. Thus, such a patient needs two sets of 2–3 garments. One set is worn while the other is washed. Depending on the age and activity of the patient, two such sets can last for 2–4 months. That means that they must be prescribed 3–6 times during the first year. After complete reduction has been achieved, the patient is seen once a year when all new garments are prescribed for the coming year.

CCT can also be used primarily to effectively treat a pitting oedema as an alternative to CDT, which, in contrast to CCT, comprises daily interventions (Bronson and Svensson, 1998).

Arm volume measurements
Arm volumes are recorded for each patient using the water displacement technique. The displaced water is weighed on a balance to the nearest 5 g, corresponding to 5 ml. Both arms are always measured at each visit, and the difference in arm volumes is designated as the oedema volume. The decrease in the oedema volume is calculated in a percentage of the preoperative value (Bronson and Svensson, 1997a).

The lymphoedema team
To investigate and treat patients with lymphoedema, a team comprising a plastic surgeon, an occupational therapist, a physiotherapist and a social welfare officer is needed. An hour is reserved for each scheduled visit to the team when arm volumes are measured, garments are adjusted or renewed; the social circumstances are assessed, and other matters of concern are discussed. The patient is also encouraged to contact the team whenever any unexpected problems arise, so that these can be tackled without delay. In retrospect, a working group such as this one seems to be a prerequisite both for thorough preoperative consideration and informing patients and for successful maintenance of immediate postoperative improvements. The team also monitors the long-term outcome, and the authors' experience so far indicates that a visit once a year is necessary, in most cases, to maintain a good functional and cosmetic result after complete reduction.

Other liposuction techniques
Newer techniques involve ultrasonic-assisted liposuction (UAL), laser-assisted liposuction (LAL), and power-assisted liposuction (PAL). UAL and LAL generate energy that is transformed into heat that can damage the skin. The authors do not use these techniques for lymphoedema. On the other hand, PAL is of great benefit as the vibrating cannula facilitates the liposuction, especially in the leg.

How liposuction helps
For many people conservative treatment does not work well or come up to their expectations, and no matter what therapy they receive, neither conservative treatment nor microsurgical procedures can remove excess adipose tissue (Andersen et al. 2000; Campisi et al. 2006; Baumeister and Sluda, 1990; Baumeister and Frick, 2003). Subcutaneous tissue debulking seems the only option to reduce the limb volume and lead to an improvement in the patient's quality of life (Bronson et al. 2006).

Lymph transport system and liposuction
All surgery can lead to postoperative swelling due to tissue trauma and damage to the lymph and vascular systems. This swelling, depending on the type of surgery performed (ankle fractures take three to six months before the swelling disappears), free flaps tend to regenerate quickly after a rhinoplasty, swelling can persist for more than one year, and, naturally, minor surgery, e.g. after excising a mole, leads to no swelling at all, usually disappears within a few weeks when the lymphatics regenerate.
When a patient has been treated conservatively and shows no pitting, liposuction can be performed. If quality of life is low, this can be especially effective. The cancer itself is a worry, but the swollen and heavy arm introduces an additional handicap for the patient from a physical, psychosocial and psychological point of view. Physical problems include pain, limited limb movement and physical mobility and problems with clothing, thus interfering with everyday activities. Also, the heavy and swollen arm is impractical and cosmetically unappealing, all of which contribute to emotional distress (Borson et al, 2006a).

When liposuction should never be used
Liposuction should never be performed in a patient that shows pits on pressure (Figure 8a) (see above). In a patient with an arm lymphoedema, the authors accept around 4–5mm of pitting, and in a leg lymphoedema 6–7mm. Patients with more pitting should be treated conservatively until the pitting has been reduced. The reason for not doing liposuction in a pitting oedema is that liposuction is a method to remove fat, not fluid, even if theoretically it could remove...
all the accumulated fluid in a pitting lymphoedema without excess adipose tissue formation.

**Benefits to the patient**

Liposuction improves patients’ quality of life, particularly qualities associated with everyday activities, hence those that can be directly related to the complete arm oedema reduction (Bronson et al, 2006a). CCT is also beneficial, but the effect is less obvious than when combined with surgery conceivably because the reduction of excess volume is less (Bronson and Svensson, 1998).

**Skin blood flow and cellulitis after surgery**

Liposuction reduces the incidence of erysipelas; the annual incidence of cellulitis was 0.4 before liposuction and 0.1 after (Bronson and Svensson 1997b). Improved local skin blood flow may be an important contributing factor to the reduced episodes of arm infection (Bronson and Svensson, 1997b). The point of bacterial entry may be a minor injury to the oedematous skin, and impaired skin blood flow may respond inadequately to counteract impending infection. Reducing the excess volume by liposuction increases skin blood flow in the arm, and decreases the reservoir of adipose tissue, which may enhance bacterial overgrowth.

**Potential negative effects to the patient**

Liposuction typically leads to a numbness in the skin, which disappears within three to six months. Continuous, i.e. lifelong, wearing of compression garments is a prerequisite of maintaining the effect of any lymphoedema treatment and should not be considered as a negative effect.

**When to perform liposuction**

In all patients with arm lymphoedema treated so far at our department (n=94), the mean age of the patient at the time of surgery was 64 years (range 41–89), with a mean duration of arm swelling of nine years (range 1–38). Mean age at breast cancer operation and mean interval between breast cancer operation and onset of lymphoedema was 52 years (34–80), and three years (0–32) respectively. The preoperative mean excess arm volume was 1729 ml (570–3195) (Bronson et al, 2007c).

In short, there is no age limit for performing surgery. Any patient with a non-pitting swelling that causes a considerable decreased quality of life can be a candidate for surgery. Surgery should not be performed if the patient has active cancer or wounds.

**Conclusion**

There need be no tension between those who favour conservative treatment and proponents of liposuction. Accumulated lymph should be removed using the well-documented conservative regimen until minimal or no pitting is seen. If there is still a significant excess volume, this can be removed by the use of liposuction. In some patients increased fibrous tissue can be present, especially in male patients and in women with a male distribution of body fat. When seen, fibrous tissue is more common in leg than in arm lymphoedema. Continuous wearing of a compression garment prevents recurrence.

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**References**


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Key points

- Excess arm or leg volume without pitting implies that excess adipose tissue is present.
- Excess adipose tissue can be removed by the use of liposuction. Conservative treatment and microsurgical reconstructions cannot remove adipose tissue.
- As in conservative treatment, the lifelong use (24 hours a day) of compression garments is mandatory for maintaining the effect of surgery.
- Patients that are happy with an excess volume in the arm or leg are not candidates for liposuction.
- To date, the author has trained and approved five teams to perform liposuction for lymphoedema (Veje Hospital, Denmark; Ninewells Hospital Dundee, Scotland, UK; Nij Smellinghe Hospital, Drachten, Holland; Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, USA; Center for Lymphatic and Venous Disorders, Stanford University School of Medicine, Falk Cardiovascular Research Institute, Stanford, USA).