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Waterjet-assisted liposuction to treat lipoedema. Experiences, results and comparisons to tumescent liposuction

Summary

Background. Lipoedema is a chronic disease characterised by an increase in subcutaneous adipose tissue in the legs, pain, oedema and a tendency to develop haematoma. Waterjet-assisted liposuction (WAL) is becoming increasingly important for surgical treatment of this condition.

Objective. The safety and effectiveness of WAL were analysed and compared to tumescent liposuction (TL).

Materials and methods. A total of 141 patients with lipoedema were surgically treated by WAL (Body-Jet Evo[®], Human Med, Schwerin) between 1 July 2010 and 31 July 2016 and 71 were re-evaluated after an average follow-up period of 35.9 months.

Results. In each case a significant reduction in the subcutaneous fat layer and an improvement of the proportions were achieved. The control showed a significant improvement in all 10 symptoms (score reduction on a 10-point scale from 6.1 to 3.1; Wilcoxon test, $p < 0.05$). In 38.3% of cases conservative therapy was no longer necessary, could be reduced or was found to be more effective.

Conclusion. Liposuction of lipoedema ensures positive and lasting results when the surgical technique focuses on preserving the lymphatic system. Compared to TL, WAL provides the advantage that adipocytes are selectively removed while protecting the vessels to the greatest extent. The anaesthesia solution is selectively administered to the area to be aspirated, which results in optimal analgesia and vasoconstriction. Additionally, there is less swelling and the liposuction can be assessed more precisely during surgery. Impressive results can very often be achieved using WAL in terms of reduction in pain and the tendency to develop oedema, improvement in body shape and an increase in the quality of life.

Keywords

Adipose tissue • Body-jet • Liposuction • Lymph vessels • Oedema

Experiences, results and comparisons to tumescent liposuction

Lipoedema, a fat distribution disorder causing disproportionate fat accumulation between trunk and extremities, cannot be causatively treated by conservative means. Therapies using 'dry' liposuction methods led to fatal results and only the tumescent technique enabled substantial progress to be made. Waterjet-assisted liposuction is a surgical procedure that is gentle to tissues, is characterised by effective analgesia and vasoconstriction, reduces stress placed on the patient due to volumes and high concentrations of drugs and shortens surgery times and convalescence periods.

Lipoedema: Definition, pathophysiology, symptoms

Lipoedema is a chronic and usually progressive disease that is characterised by a symmetrical fat distribution disorder on the legs and in 30% of cases also on the arms. Along with the localised increase in subcutaneous fatty tissue, there is a tendency to develop orthostatic oedema, a tendency to bruise easily after minor trauma and an increased sensitivity to touch while patients also experience feelings of tightness and painful responses to pressure [19]. Fatty bulges on the insides of the thighs can lead to skin irritation or gait disorders. The quality of life of lipoedema patients can be very adversely affected by their appearance and the disproportionate relationship between the upper body and the legs and often leads to frustration and psychological problems. Invariably women are affected by lipoedema and there are often familial clusters. Lipoedema generally starts after puberty, after a pregnancy or in association with menopause. Concomitant obesity that aggravates the symptoms occurs in about 50% of lipoedema patients [14].

» Invariably women are affected by lipoedema

Along with the increase in the fat volume, there is a capillary permeability disorder: The increased fragility of the capillary walls leads to the increased tendency to bruise and also causes an increase in fluid moving from the vascular system to the interstitial space resulting in orthostatic oedema [20]. The lymphatic system compensates for this increased fluid accumulation initially by increasing the lymph transport but the constant stress leads to changes in the walls of the lymph vessels and a reduction in their transport capacity [2]. The consequences are oedema and an increase in subcutaneous adipose tissue.

Clinically, lipoedema is divided into 3 stages [5, 13].

- In stage 1 of the disease, the skin surface is smooth, the subcutaneous tissue is thickened, soft and has small nodules.
- In stage 2 the skin becomes uneven and larger nodules form.
- Stage 3 is characterised by grossly nodular connective tissue and large disfiguring fat lobules.

Over the course of years fibrosis of the lymphatic pathways leads to the development of secondary lymphoedema.

» There is no known causal conservative therapy for lipoedema

Lipoedema is diagnosed by the medical history (symptoms, time of onset, familial clusters), inspection (disproportion, skin surface) and palpation (painful to touch, fatty structure) [19]. Additional parameters such as body weight, body-mass index, 'waist-hip / waist-height ratio' and measurements of circumference are recommended for monitoring during follow-up [12]. There is no known causal conservative therapy for lipoedema. The aim of conservative treatment, in addition to weight control, is to eliminate the increased accumulation of interstitial fluid using complete decongestive therapy (CDC). This includes manual lymphatic drainage, the wearing of compression stockings, movement therapy and skin care [5]. A permanent reduction in the subcutaneous adipose tissue can be achieved by liposuction, a low-risk and well-established method.

Objective

The aim of this study is to analyse the safety and effectiveness of waterjet-assisted liposuction (WAL) for the treatment of lipoedema regarding symptoms and improvement of body shape.

Based on the literature and the author's experience of 4000 tumescent liposuction (TL) and 1500 WAL operations, the fundamental and clinically relevant differences between the two methods are described and compared.

Patients and methods

Between 1 July 2010 and 31 July 2016 141 lipoedema patients were operated on using WAL, 61 of which were performed in 2 sessions, with a total of 202 procedures performed (Body-Jet Evo[®], Human Med, Schwerin). (Fig. 1). If the entire lower extremity was affected, as a rule 2 procedures were performed separated by about 3 months: 1st operation: thigh circular and inside knee, 2nd operation: calves and, if necessary, upper arms and/or hips. The average patient age was 37.2 years (18–65; standard deviation [SD] 9.68), the average pre-operative weight was 72.5 kg (47–136; SD 13.96) and the average body-mass index (BMI) was 26.6 kg/m² (18.6–44.9; SD 5.14).

Pre-infiltration

All operations were performed as outpatient procedures under local anaesthetic with pre-operative sedation with 7.5 mg midazolam (Dormicum[®]). Additional sedation was with Entonox[®] (50% nitrous oxide / 50% oxygen, 'laughing gas') as needed. Entonox[®] has analgesic effects, is simple to administer and can be readily controlled. The patient remains responsive and can rotate independently into the optimal position, which enables precise operating. Prophylactic antibiotics were administered as ciprofloxacin 500 mg twice over 3 days, while for thrombosis prophylaxis, depending on the patient's risk profile, low-molecular Liquemin was taken over 5 days.

The 2.5 mm infiltration cannula is inserted through small incisions into the subcutaneous fatty layer of the treatment zones that were marked beforehand with the patient standing. The anaesthesia liquid (Klein solution) is preheated to 37°C and is delivered from the end of the cannula through an opening that is angled at 30° to the longitudinal axis in a fan shape to ensure uniform distribution in the fatty layer. The pressure achieved in the tissue is less than 1 bar, comparable to a powerful shower jet. The infiltration of the solution is pulsed with a flow of 188 mL/min and the penetration depth of the solution in the adipose tissue is 40–50 mm. The cannula is slowly moved back and forth in a fan shape, following the irrigation jet, and at the same time rotated around the longitudinal axis. This enables pain-free and gentle infiltration of the subcutaneous fatty layer; the adipose tissue is gently dissected by the waterjet and made ready for the subsequent liposuction. The tissue is not filled until swollen as in the typical tumescent technique because this could damage the lymph vessels and because precise aspiration is made difficult by the bloated surface shape. The aim is to

achieve effective analgesia and vasoconstriction by means of a profound infiltration of the subcutaneous adipose tissue layer.

Waterjet-assisted liposuction

Because penetration of the anaesthetic solution into the adipose cells is not necessary, there is no need for the waiting time that is typical of TL: immediately after completing the pre-infiltration, the aspiration is performed with the double-lumen irrigation/aspiration cannula with a length of 30 cm (Fig. 2). Depending on the aspiration zone, the thickness of the subcutaneous fatty layer and the consistency of the adipose tissue, cannulas with different diameters (3.5/3.8/4.2/4.6 mm) and variously shaped cannula ends (blunt/sharp bevel, 2/4 multi-hole cannulas, circular/single-sided holes) are available. Analogous to the previous infiltration phase, the anaesthesia solution, with the same composition, is distributed in a fan shape in the tissue to continuously maintain the anaesthetic and haemostatic effect throughout the aspiration phase as well. The pulsation options for the waterjet are set either as short/fast, uniform and long, depending on the tissue consistency and aspiration zone, and the flow rates are set between 100 and 188 mL/min.

The continuous irrigation reduces the burden for the patient caused by the medications present in the solution. The vacuum has an adjustable level of up to 0.8 bar and is generated and controlled by closing a bypass hole with the thumb on the handpiece of the cannula. Using slow, regular back and forth movements, the enlarged adipocytes are gently flushed out of their extracellular matrix by the waterjet, a technique that protects the surrounding connective tissue, and particularly the lymphatic pathways, to the greatest degree. The cannula movements must not be made using a criss-cross technique but are instead made parallel to the body's longitudinal axis, an appropriate aspiration technique that also ensures that lymph vessels are not damaged [16].

Unlike cosmetically indicated liposuction, for lipoedema the legs are suctioned in a circular pattern, that is, also on the back and front of the thigh. This achieves maximum volume reduction and accordingly also optimal improvement in the symptoms. Thanks to the local anaesthesia, the patient can also rotate at any time to the optimal position. This allows precise guidance of the cannula. At the end of the operation, the incision sites are left open; after the remaining irrigation solution has drained out, the incisions spontaneously close up within 24 h. The average duration of surgery including pre-infiltration was 1 h 36 min and the mean fat volume removed per patient was 4200 mL (Fig. 3).

Follow-up treatment

Postoperatively, the patient is fitted with a compression suit. The aspiration zones are chilled to 16° (Hilotherm Clinic®, Hilotherm GmbH, Argenbühl-Eisenharz). We prescribe the use of a local heparin gel and a paracetamol preparation as rescue medication. We recommend that the compression garment is worn for 24 h for 2 weeks and then during the day for the following 6 weeks.

Complications

No postoperative complications such as infections, abscesses, necrosis, haemorrhage, thromboembolic incidents or skin irritation such as erysipelas developed after any of the procedures. More or less pronounced haematomas, swelling and local indurations occurred in practically every case. Using conservative measures such as rest, elevation, wearing compression garments and the application of heparin preparations, these adverse effects regressed completely in a few weeks in all cases, however.

Results

A definitive evaluation of the operated zones is only possible after 6 to 8 months. For all patients, a considerable improvement in the symptoms and a significant increase in the quality of life was noted often after just a few weeks. The reduction in the subcutaneous fatty layer resulted in every case in a reduction in circumference and a permanent normalisation of the overall proportions (Fig. 4 and 6). The disease-related pain symptoms, the tendency to develop oedema, the painful responses to pressure and the increased tendency to bruise declined significantly or disappeared altogether. Orthopaedic symptoms improved and the number and intensity of conservative treatments was reduced or stopped. A new clothing size was often required and sporting activities that were previously disallowed were once again possible.

For 71 patients whose questionnaires could be analysed, the self-assessment of individual symptom criteria was recorded using a visual analogue scale from 0 (= not present) to 9 (= very severe) (Fig. 5). For all symptom parameters and regarding the physical proportions as well as the quality of life, significant improvements were achieved (Wilcoxon test; $p < 0.05$). The mean follow-up period was 35.9 months (5–84; SD 14.09).

Postoperatively a reduction in the weight was achieved of 3.4 kg on average (-4–17; SD 4.62); 42.1% of the patients were able to go down 1 size in clothing and 10.5% were able to go down 2 sizes (Fig. 4 and 6). Lymphatic drainage or compression treatments were no longer needed for 5.3% of the patients, while the use of such measures could be reduced for 23.4% of patients and were found to be more effective for 9.5% of patients.

Discussion

Conservative therapy

Conservative measures can to a limited degree alleviate the symptoms of lipoedema, prevent complications and improve the quality of life of patients. Although physical activity and low-calorie diets reduce weight, the disproportionate fat distribution is not affected by these measures. There is no lipoedema-specific diet. Diuretics are contraindicated because they lead to a withdrawal of fluid from the interstitial spaces with consecutively increased protein concentration, which causes a secondary increase in the oedema [12]. Reducing the pathologically increased adipose tissue is not possible with conservative measures and likewise the increased capillary permeability and thus the tendency to oedema are also unaffected by these measures. Lipoedema requires ongoing conservative treatment, and these measures are also time consuming, have a limited effect and, particularly for younger patients, are a considerable burden.

Dry liposuction technique

Until the late 1980s lipoedema was treated using large-scale liposuction with the 'dry' technique under general anaesthesia. The surgery was performed using thick and sharp cannulas without prior infiltration. The consequences included haemorrhaging, infections, damage to lymphatic vessels and swelling that persisted postoperatively, often combined with unacceptable cosmetic and functional results. Due to these high rates of complications, these methods must be considered to be obsolete [4, 13, 16].

Wet liposuction technique

The wet technique in tumescent anaesthesia reduces these risks [3, 6, 11, 14]: this technique involves filling the subcutaneous adipose tissue with a 0.9% saline solution that contains lidocaine and adrenaline. A fat-solution mixture is removed by aspiration. This method is an improvement in terms of safety compared to the 'dry' technique and enables the procedure to be performed under

local anaesthesia. The addition of adrenaline and the tissue pressure improve the haemostasis, and the drainage effect of the irrigation solution discharging through the incision sites over a longer period protects against infections.

Waterjet-assisted liposuction

WAL, a technique that has been in clinical use since 2007, is a methodological refinement and led to a paradigm shift in liposuction treatment [17]: With this technique the cannula follows the waterjet, and the adipose cells are selectively flushed out of the tissue while protecting the lymphatic vessels, nerves and blood vessels and at the same time they are suctioned off with the irrigation solution (Fig 2).

Unlike conventional liposuction, the waterjet is more respectful of anatomical structures and causes no trauma to these structures [1, 7, 8, 16]. Full tumescence is not necessary because the continuous spray jet continually replaces the fluid that is suctioned off with the adipose cells.

Comparison between tumescent liposuction and waterjet-assisted liposuction

The disadvantage of TL compared to WAL is that the tissue is filled tight beforehand with a large volume of anaesthesia solution, which places stress on the circulatory system and can lead to a critical dosage of medications. The massively swollen tissue also makes precise aspiration and visual inspection of the liposuction outcome difficult. The consequences may be uneven results and a subsequent need for correction. The tumescence leads to membrane penetration of the adipocytes due to the pressure of the fluid and the osmotic gradients. This and the subsequent liposuction can cause destruction of the cells [8, 16]. In contrast, the WAL aspirate largely contains intact adipose cells [9]. It can thus be assumed that WAL as a tissue-preserving technique potentially has a less traumatising effect on the lymphatic vessels. Furthermore, damage to the tissue and particularly the lymphatic vessels by more aggressive mechanical aspiration methods cannot be ruled out: vibration cannulas, ultrasonic devices or laser-assisted lipolysis procedures traumatise the tissue more than the gentle waterjet, which creates a natural path through the tissue starting from the tip of the cannula and thus does not damage blood vessels, lymphatic vessels and nerves [1]. For these reasons, WAL has become established as a successful method for gently harvesting intact fat particles for autologous fat transfer [10, 18].

Another disadvantage of TL is that the effect of the anaesthesia and the vasoconstriction wanes toward the end of the liposuction and thus the procedure has to be ended prematurely due to pain or bleeding. With WAL fresh fluid is continuously supplied directly to the aspiration site and additional anaesthesia can be easily applied at any time at sensitive sites. This ensures safe analgesia even toward the end of the procedure and reduces the intra- and postoperative tendency to develop haematoma.

» With WAL effective analgesia is achieved by the continuous supply of anaesthesia solution

Studies have also shown that the pain during and after surgery with WAL is significantly less than with TL [1, 7]. WAL also has benefits in terms of haematoma formation and skin retraction [8]. The unpleasant drainage of the anaesthesia solution with TL often lasts several days while with WAL it takes a maximum of 24 h. Another benefit of WAL is also the duration of surgery: pre-infiltration is achieved more quickly than full tumescence, and there is no need to wait for up to 1 h for the tumescence anaesthesia to take effect [3, 7]. Due to the greater fluid stress, treating lipoedema with

tumescence requires 3 sessions on average [11] while the use of WAL means that the same treatment can be carried out in only 2 operations in practically all cases (Tab. 1).

Summary evaluation of tumescent liposuction versus waterjet-assisted liposuction

Unlike conservative measures, the use of liposuction for the purpose of a causal therapy enables a sustainable reduction in the pathologically increased adipose tissue although the capillary permeability is not affected [14]. The pain symptoms along with the tendency to develop oedema and haematoma therefore cannot be completely eliminated but can be greatly reduced. The reduction in the adipose tissue deposits also prevents skin irritation, normalises mobility and improves the gait. Conservative therapies can be reduced or stopped completely after liposuction. Monitoring during follow-up over more than 8 years shows that these results can largely be considered to be permanent [3, 15].

Conclusion for clinical practice

- **Lipoedema is a fat distribution disorder of unknown cause that occurs in women symmetrically on the lower extremities and in 30% also on the upper arms. The patients suffer enormously due to their appearance and from the symptoms.**
- **Because the pathogenesis has not yet been explained, there is no causal therapy.**
- **Conservative therapies can improve the symptoms but are time consuming and not sustainable.**
- **Tumescent liposuction has become established as a safe procedure for adipose cell reduction in lipoedema under local anaesthesia.**
- **Waterjet-assisted liposuction offers additional benefits in terms of protection of anatomical structures, less stress due to volume and medications, more precise liposuction and shorter surgery times.**
- **Waterjet-assisted liposuction improves the symptoms associated with lipoedema conclusively and sustainably. Those affected gain considerable quality of life compared to the use of conservative measures, meaning that the indication for surgery should be made generously.**

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Compliance with ethical guidelines

Conflict of interest. D. Münch states that there is no conflict of interest.

This article does not include any studies conducted on humans or animals by the author. All patients who can be identified by photographic material or other information in the manuscript have provided their written consent to this. In the case of patients who are not of age, the consent of the guardian or legal representative has been provided.

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Figures and tables

Fig. 1 Device for waterjet-assisted liposuction, Body-Jet Evo[®], Human Med (© Human Med AG, Schwerin, with kind permission)



Fig. 2 Double-lumen cannula for simultaneous infiltration and aspiration (© Human Med AG, Schwerin, with kind permission)

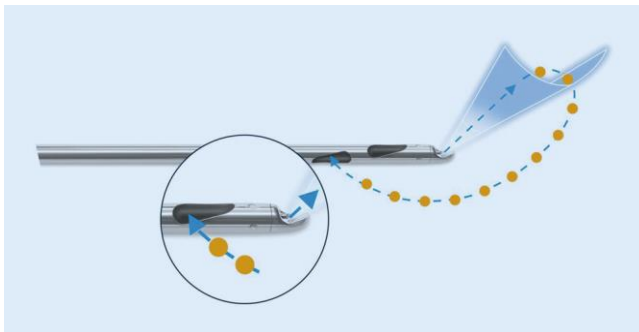


Fig. 3 Example of a WAL (waterjet-assisted liposuction) aspirate: approx. 5500 mL of fat removed from a lipoedema patient, minimal blood inclusion; surgery time including pre-infiltration: 1 3/4 h



Fig. 4 Example of a 33-year-old patient with lipoedema, body-mass index of 31.2 a. Preoperative findings and b 8 months after waterjet-assisted liposuction. (Photo: D. Münch, with kind permission)

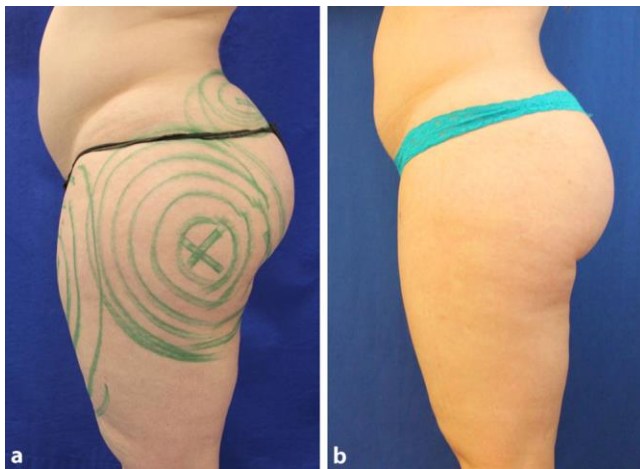


Fig. 5 Symptom score (mean) pre- and postoperative. WAL Waterjet-assisted liposuction

Deutsch	English
Intensität Beschwerdekriterium	Intensity of the symptom criterion
Schmerzen	Pain
Berührungsempfindlichkeit	Sensitivity to touch
Druckschmerzen	Pain on pressure
Spannungsgefühl	Feeling of tension
Schwere Beine	Heavy legs
Schwellneigung	Tendency to swell
Hämatomneigung	Tendency to haematoma
Einschränkung beim Gehen	Restriction when walking
Störende Körperproportionen	Disruptive physical proportions
Eingeschränkte Lebensqualität	Limited quality of life
Vor der WAL	Before WAL
Nach der WAL	After WAL

Fig. 6 Example of a 31-year-old patient with lipoedema, body-mass index of 25.4 a. Preoperative findings and b 1 year after waterjet-assisted liposuction. (Photo: D. Münch, with kind permission)



Tab. 1 Comparison between tumescent liposuction (TL)/waterjet-assisted liposuction (WAL)

Criterion	TL	WAL
Equipment required	Minimal	Greater
Stress to the body due to medications and volume	Greater, because tumescence requires large volume	Minimal, because continuous simultaneous irrigation and aspiration of the fluid take place precisely at the surgical site
Trauma to the tissue and the lymphatic vessels	Increased because fluid pressure / osmosis can potentially cause cell damage; cannula with no waterjet instead causes tissue lesions	Minimal because tissue is not swollen and cannula follows the natural path of the waterjet
Precision of the liposuction	Frequently irregular results because tumescence swells surface structure and the ability to evaluate the working area is limited	Corrective procedures are rarer because the shape obtained enables precise liposuction
Possibility of subsequently infiltrating sensitive or previously insufficiently anaesthetised zones	Laborious due to time-consuming instrument change	Simple because with the running irrigation jet only the vacuum must be temporarily deactivated
Intraoperative pain, particularly toward the end of the operation	Pronounced because toward the end of the liposuction the effective level of the anaesthetic becomes unsatisfactory	Uniformly good analgesia because the continuous supply of fresh anaesthesia solution at the site of action until the end of the procedure ensures an effective level
Duration of surgery	Longer because more time needed for infiltration/waiting phase until the onset of action of the tumescence anaesthesia	Shorter because pre-infiltration is performed more quickly and there is no waiting time
Duration of the postoperative fluid discharge	Often several days because large volumes remain in the body	Maximum 24 h because less residual fluid remains in the body
Convalescence phase	Longer	Shorter
Postoperative haematoma	Increased	Less pronounced
Postoperative pain	Pronounced	Less
Skin retraction	Often unsatisfactory	Pronounced due to the tightening effect due to the waterjet, depends on age and connective tissue
Number of procedures required for complete liposuction	Often more than 2	As a rule 2