Post-Tumescent Liposuction Care
Open Drainage and Bimodal Compression
Jeffrey A. Klein, M.D.

The goals of postliposuction care must be to minimize edema, bruising and patient discomfort. The postoperative pain and edema resulting from sutured incisions and prolonged postliposuction compression is an irrational remnant from the days before the tumescent technique.

Antediluvian (before tumescent technique) liposuction resulted in such extensive blood loss that patients often had to donate and bank their own blood before surgery and receive an autotransfusion afterward. Prior to the advent of tumescent vasoconstriction, providing hemostasis and preventing hematomas or seromas were the primary goals of postliposuction external compression. Prolonged high-grade compression was thought necessary to prevent or diminish the size of hematomas and seromas. With the advent of the tumescent technique, and with its profound vasoconstriction and surgical hemostasis, imperatives of postliposuction care have changed. Some surgeons, however, are still unfamiliar with the technique of open-drainage and bimodal compression. The goal of postliposuction care is to optimize patient recovery, which in turn requires an objective comparison of available alternatives.

Liposuction Edema

Extracellular postliposuction edema occurs when there is excessive fluid postoperatively within the extracellular space. The two factors responsible for extracellular edema are impaired lymphatic drainage and excess capillary filtration. Lymphedema is distinctly different from venous capillary edema.[1] Treatments of these conditions are also distinctly different. If one's perverse goal is to produce the maximum degree of postliposuction edema, one must prevent the egress of subcutaneous fluid (1) by trapping the maximum amount of bloody fluid within the subcutaneous space and (2) by simultaneously blocking all lymphatic drainage. This goal can be achieved by closing incisions with sutures and then applying a high degree of external compression to collapse lymphatic capillaries.

In contrast, open drainage with bimodal compression minimizes postliposuction edema. Open drainage refers to an expedited drainage of blood-tinged anesthetic solution via incisions not closed by sutures. Bimodal compression refers to two sequentially applied degrees of postoperative compression. The first degree is a relatively high-grade compression that accelerates the drainage via open incisions. The second is a low-grade compression, employed after drainage has ceased, that is mild enough not to collapse the lymphatic capillaries, but adequate to increase interstitial hydrostatic pressure.

Lymphatic Drainage

The surgical effect of liposuction upon the lymphatics is unique in several respects. First, liposuction disrupts or destroys most lymphatic capillaries within the targeted adipose tissue. Second, lymphatic damage from liposuction is not permanent. Lymphatic capillaries regenerate within a few weeks after being torn by a liposuction cannula. In contrast, after surgical lymph node dissection, damage to lymphatics is permanent.

Damaged lymphatics are not able to transport excess interstitial fluid back to the blood. Lymphatic insufficiency can cause especially severe swelling and edema. The persistence of extravasated plasma proteins increases the interstitial fluid osmotic pressure and draws even more fluid out of the capillaries.

Excess Capillary Filtration

Excessive capillary filtration or fluid shift from the intravascular to the interstitial space is influenced by increased capillary permeability, decreased plasma colloid osmotic pressure, and increased capillary hydrostatic pressure. Decreased plasma colloid osmotic pressure occurs after liposuction because of loss of plasma protein through ruptured capillaries, consumption of hemostatic procoagulant proteins, and iatrogenic hemodilution with unnecessary IV fluid crystalloids, and possibly hemorrhage. Increased capillary hydrostatic pressure may occur after liposuction as a result of general anesthesia, secondary immobilization of limbs, and loss of sympathetic vascular tone.

Lymphedema

Lymphedema is edema caused by inadequate lymphatic function resulting from agenesis, destruction or obstruction of lymph vessels or lymph nodes. On a molecular level, lymphedema is the result of a failure of the lymphatics to remove large molecular proteins from the interstitial space. Although both hematic and lymphatic capillaries reabsorb interstitial water, the lymphatic capillaries are responsible for reabsorbing large proteinaceous molecules.

Although lymph capillary injury is an inevitable consequence of liposuction, the extent and duration of liposuction lymphedema can be significantly reduced by rational postoperative care. Early and aggressive efforts to expel as much blood-tinged anesthetic fluid as possible give immediate results. Once the drainage fluid is allowed to become trapped within interstitial microloculations, the edema becomes persistent and will only resolve once the injured lymphatic capillaries have been regenerated.

Normal Lymphatic Function

Proteins and other large molecules are too large to be absorbed into the blood directly across capillary membrane. Lymphatic capillaries have large gaps between adjacent endothelial cells that permit passage of large-molecular-weight substances. Lymphatic endothelial cell edges overlap each other slightly, forming minute unidirectional endothelial valves into the lumen of the lymphatic capillary. In addition, some lymphatic capillary endothelial cells overlap to a much greater degree than usual endothelial cell overlap and form internal bivalve flaps that act as one-way valves inside the lymphatic capillary. This valve structure inhibits retrograde lymph flow.

Microscopic Structure of Lymphatics

The wall of a terminal lymphatic capillary has an interior layer formed by a single thin endothelial cell and an external basal lamina that is widely fenestrated. In many places there are wide gaps between adjacent endothelial cells. These holes in the lymphatic capillaries facilitate the uptake of macromolecules, proteins, bacteria, blood cells, and tumor cells.[2]

Effects of Edema and Compression on Lymphatics

There is an important distinction between the effects of increased interstitial pressure owing to edematous fluid overload compared to the effects of compression on the external surface of the body, which elevates interstitial hydrostatic pressure.

In the first instance, the expansion of the swollen interstitial tissue causes the inside diameter of the lymphatic capillary to dilate. From the perspective of mathematical topology, edema causes every point within the tissue compartment to move further apart from every other point. This includes the lymphatic endothelial cells. The expanded lymphatic capillary inside diameter increases lymph flow, which tends to reduce the edema.

In the second instance, external compression squeezes the interstitial tissue and can compress the capillary lumen. This constriction limits the lymph flow and ultimately impairs the lymphatic capillary ability to reduce edema.

The Lymphatic Pump Mechanism

The rate of lymphatic flow is determined by the lymphatic pump mechanism and interstitial fluid pressure. The one-way lymphatic capillary valves allow a degree of lymphatic pumping when capillaries are compressed *intermittently* by an external force, such as by large muscles of a limb, movement of the body, arterial pulsations, and external massage. When larger lymphatic vessels become stretched with lymph fluid, the smooth muscle in the wall of the vessels contracts automatically and forces the lymph fluid through the proximal valve and into the next segment of the lymphatic vessel. This lymphatic pump mechanism generates the negative interstitial fluid pressure.

For the liposuction patient, excessive external pressure from compressive postoperative garments may be counterproductive. Continuous external compression, for example, from high-compression postoperative garments may cause the delicate lymphatic capillaries to collapse, impede lymph flow, and effectively block lymphatic drainage.

Lymph Flow and Interstitial Fluid Pressure

The normal interstitial fluid pressure is subatmospheric and ranges between -6 mm Hg to 0 mm Hg (atmospheric pressure). Experimental measurements in dogs show

that the rate of lymph flow varies as a function of interstitial fluid pressure.[3] There is very little lymph flow below -6 mm Hg. Between -6 mm Hg and 0 mm Hg the rate of lymph flow increases exponentially until it reaches a maximum between 1 or 2 mm Hg. The rate of flow at 0 mm Hg is 20 times greater than at -6 mm Hg; however, when interstitial pressure exceeds 1 or 2 mm Hg, the lymph flow rate reaches a plateau. Lymph flow fails to increase with higher interstitial fluid pressures. One can conclude that a high compression postoperative garment is unlikely to increase the rate of lymph flow after liposuction.

Wound Fluid Osmolality

The clinical laboratory measurement of a serum osmolality requires that a serum sample be frozen as soon as possible after it is obtained. A long delay in freezing the sample exposes the serum proteins to temperature-dependent proteolysis. By effectively multiplying the number of solute particles in solution, proteolysis amplifies the osmolality of a sample. The trauma from tumescent liposuction allows plasma proteins to leak out of injured capillaries and into the subcutaneous wound space. Once a protein molecule has entered the subcutaneous wound space it can only re-enter the blood by way of lymphatic absorption.

Fresh wound fluid has an osmolality of approximately 10 mmol greater than serum. This osmotic pressure gradient will tend to draw water from intravascular space, across the capillary wall and into the wound space. Incubating residual blood-tinged tumescent fluid at body temperature increases the osmolality of fluid over time. This exacerbates postliposuction edema by an osmotic amplification by incubation.

Iatrogenic hemodilution by infusion of IV crystalloid fluids will increase intravascular hydrostatic pressure and therefore augment edema. External compression will counteract the effects of intravascular hydrostatic pressure but hinder the lymphatic uptake of would fluid containing protein molecules.

Antique Postliposuction Care

Liposuction causes a certain amount of subcutaneous bleeding as well as damage to the subcutaneous lymphatic capillaries. The combination of subcutaneous bleeding and

impaired lymphatic drainage entraps large osmotically active molecules and produces an osmotic edema. Any technique for postliposuction care that contributes to this osmotic edema will increase the degree of postliposuction edema, pain, and bruising.

The traditional liposuction and postliposuction techniques often consort to produce an unnecessary degree of prolonged healing and edema. Incomplete tumescent infiltration will lead to subcutaneous bleeding, encourage a postoperative subcutaneous inflammation, and augment postoperative edema. The super-wet technique is an example of suboptimal tumescent liposuction. Sutured liposuction incisions prevent percutaneous drainage of residual blood-tinged anesthetic solution and encourage subcutaneous edema. Long-term use of a high-compression postliposuction elastic garment will compress and impair subcutaneous lymphatic capillaries and further block lymphatic uptake of large osmotically active molecules. There is a more efficient and effective method for postliposuction care.

An ideal method for postliposuction care prevents problems before they occur. Prolonged edema, excessive bruising, and persistent inflammation are the most bothersome and most common undesirable sequella of liposuction. To a large extent these problems can be avoided with a rational and scientific approach to postliposuction care. One successful method of postliposuction care uses open drainage, special super-absorbent pads that provide distributive compression, and bimodal compression.

Open Drainage and Compression Sponges

Open drainage after tumescent liposuction refers to the technique for maximizing the drainage of blood-tinged anesthetic solution by using adits (1.5 mm or 2 mm punch excisions for microcannula access to subcutaneous fat) to facilitate postoperative drainage, locating adits in strategic locations in order to encourage gravity-assisted drainage, and allowing the adits to remain open instead of being closed with sutures. Open drainage demands the use of comfortable, high-capacity absorptive pads, also known as compression sponges.

Compression sponges are a functional combination of absorptive sponges and compression pads. Absorptive sponges are required for the containment of the objectionable postoperative blood-tinged drainage. Containing the drainage avoids

alarming the patient and prevents staining of clothing and furniture. Complete absorption and containment of the drainage allows the patient to mobile and sociable. The copious drainage that occurs after tumescent liposuction demands absorptive pads with a special design.

Compression pads are postoperative cushions place over liposuctioned areas in order to distribute the compression provided by an elastic compression garment in a smooth and uniform manner. Uniform, gentle compression of subcutaneous tissue after liposuction collapses the gaps within the interstitial collagen of the dermis. Therefore, dermal compression prevents bruising by blocking the outward percolation of red blood cells up toward the epidermis.

An effective and practical way of applying the compression-absorption pads over the targeted areas is to use a combination of a few strips of paper tape and elastic tube netting, similar to the method of applying dressings over burn wounds. After the compression-absorption pads are well positioned, one can apply the elastic compression garment. The optimal garment in this regard must be able to accommodate the bulk of the pads, and the pads must be easy for the patient to take off and put on again without assistance.

Bimodal compression refers to the sequential use of two different degrees of postliposuction compression. First, a high degree of compression is maintained while drainage persists and for an additional 24 hours past the time when all the drainage has ceased. Twenty-four hours after all drainage has ceased only a relatively mild degree of compression is required.

In the Old Days Sutures were Necessary

In the days of antediluvian liposuction, surgeons were compelled to close liposuction incisions with sutures. Before the tumescent technique and microcannulas, liposuction cannulas were large and required large incisions, which required sutures for proper healing. With the modern tumescent technique (including the use of microcannulas and adits), postliposuction healing is better when incisions are not closed with sutures.

In the past, using sutures to close an incision was seen as necessary to prevent infections. In fact, with the advent of nearly bloodless tumescent liposuction, many of the problems that necessitated the closure of liposuction incisions with sutures no longer exist. Without tumescent vasoconstriction there was a relatively high incidence of hematomas and seromas. Hematomas and seromas provide an avascular medium for bacterial growth and infection. An open incision had the potential for being a port of entry for an infection.

With the tumescent technique, hematomas are rare, and the incidence of seromas is virtually eliminated by open drainage and good compression. Tumescent lidocaine further reduces the risks of infection, because residual interstitial lidocaine is bacteriocidal in the sense that it appears to prevent infections after tumescent liposuction. Therefore, the tumescent technique appears to have reduced the risk factors for infection, and open drainage probably reduces the risk of infection even further.

Adits

An adit is a technical engineering term that describes a horizontal opening by which a mine is entered or drained. A micro-adit used in tumescent liposuction is a small circular hole made by a tiny (1.5 mm or 2 mm) skin biopsy punch. Adits facilitate and promote the open drainage of residual blood-tinged anesthetic solution associated with tumescent liposuction.

It is common knowledge that 1.5-mm and 2-mm skin biopsy punches leave virtually no scars. Therefore, 1.5-mm or 2-mm punch excisions can be placed over a liposuction area with minimal risk of scarring. Adits are especially helpful areas, such as the thighs and the abdomen, where postoperative edema and bruising can be more pronounced and bothersome than in other areas.

A 16- or 14-gauge microcannula can easily pass through a 1.5 mm adit. These size microcannulas can enter through a 1.5-mm round hole with virtually no epidermal friction as the microcannula is pushed and pulled through the skin. A 12-gauge microcannula often requires a 2-mm adit. With a careful and skilled liposuction technique, especially in areas of the skin such as the inner thigh, a 1.5-mm adit can often accommodate a 12-gauge microcannula with minimal epidermal trauma.

For the outer thigh the best site for an adit is the most dependent margin of the targeted area. Insert a 16- or 14-gauge microcannula through the tiny hole and create multiple liposuction tunnels in order to funnel the postoperative drainage to the adit opening.

The most important advantage to using round adits is that round holes remain patent for a longer time than a slit incision. Round 1.5-mm and 2-mm adits allow better drainage than simple incisions. The edges of a microincision may close and heal before the blood-tinged anesthetic has been completely drained, therefore entrapping blood-tinged anesthetic solution in the subcutaneous space.

Several 2-mm punch excisions placed along the lower margin of the abdomen, above the pubic area, allow more drainage than tiny slit incisions. Adits placed along the lower abdomen plus firm, uniform compression will virtually eliminate postliposuction ecchymosis and seromas and dramatically reduce postoperative swelling and tenderness.

Even with the use of a large cannula and the closure of incisions with sutures, the judicious use of adits can provide all the advantages of open drainage. The strategic use of surgical adits significantly improves the rate of recovery by decreasing the duration of postoperative bruising, swelling, tenderness, and significantly reduces the incidence of seromas and hematomas.

Eliminating Sutures

The most significant advantage of placing adits or eliminating sutures is the dramatic acceleration of recovery and reduction of postliposuction edema. There is a striking contrast between closing incisions with sutures compared to allowing the adits or incisions to remain open. Sutures do not benefit from a 4-mm microincision. Some surgeons close incisions with sutures because of a concern that the profuse drainage will alarm the patient and necessitate increased nursing care[4]; however, with super-absorptive compression sponges, there is no longer any need for concerns about messy postliposuction drainage.

The advantages of not using sutures include (1) more complete drainage, leading to less edema, less tenderness, and less ecchymosis; (2) adits and microincisions (≤ 5 mm) heal better without sutures because there is no suture-induced inflammation, no

foreign-body reactions, and no cross-hatch scars; (3) patients need not return for suture removal, therefore saving the patient time and avoiding inconvenience. Patients become less apprehensive about the disconcerting appearance of blood-tinged drainage once it has been explained that the greater the drainage the less the postliposuction bruising, swelling, and soreness.

Compression Sponges

Compression sponges or pads have two distinct functions. They completely absorb the copious tumescent drainage and therefore improve patient comfort and hygiene. Containing SAP and cellulose, a 25 cm x 50 cm (10 inch x 20 inch) compression sponge can absorb up to 1,000 mL of watery fluids. Secondly, these compression sponges or pads distribute the compressive force of an elastic garment over the treated area in a smooth, uniform fashion. By uniformly compressing the dermal interstitial collagen, the interstices between the dermal collagen bundles are narrowed and red blood cells are prevented from moving toward the skin surface. Therefore, bruising is prevented.

Super-absorbent compression sponges eliminate postoperative bruising in a fashion similar to adhesive-backed, closed-cell foam when applied postoperatively over an area of the body that has been treated by liposuction. Compression pads are superior to adhesive closed-cell foam for postliposuction care. Adhesive foam applied to the skin after liposuction can crimp and cut off dermal vascular dermal supply, and therefore cause focal avascular dermal bullae. Adhesive foam must remain on the skin for several days, which precludes the possibility of showering. In contrast, the compression sponges are replaced once or twice daily, permitting patients to shower. Whereas adhesive foam only reduces bruising, super-absorbent compression pads both reduce bruising by compression and reduce osmotic edema by facilitating open drainage.

History of Postliposuction Compression

The tradition of long-term use of high-compression garments after liposuction is a vestige of the earliest days of liposuction during the late 1970s and early 1980s. In the days before the tumescent technique, antediluvian liposuction created a proteinaceous mélange of grumous clotted blood, inflammatory cytokines, prostoglandins, and

fragmented adipose tissue. By closing incisions with sutures, this inflammatory detritus was trapped within the subcutaneous wound. The patient was required to endure weeks of being wrapped in special plastic adhesive "French" tape in the manner of a mummy. Taking a normal shower or bath was not an option. Removing the tape could be so dreadful that some patients required systemic narcotic analgesia. Eventually surgeons replaced the use of "French tape" with high-compression elastic postoperative garments. With either type of compression, there was a high rate of seroma formation, massive bruising, prolonged swelling and tenderness, and significantly delayed return to normal activity.

Chronic venous edema and acute postliposuction edema are distinctly different pathophysiologic processes. Leg edema owing to venous disease is best treated and prevented by providing graduated leg compression beginning at 15 mm Hg to more than 30 mm Hg distally, and decreasing proximally. In contrast, local edema owing to tumescent liposuction can be largely prevented by open drainage and uniform (non-graduated) bimodal compression. It is a misconception that the pathophysiology of acute postliposuction leg edema resembles chronic post-phlebitic venous disease. Chronic venous insufficiency is due to venous hypertension and a hydrostatic pressure gradient that favors chronic leakage of intravascular fluid into the interstitial tissues. Acute postliposuction edema is due to acute posttraumatic hemorrhage, inflammation, and an osmotic pressure gradient.

Excessive Compression

Prolonged high compression is only necessary when drainage is impeded by closing incisions with sutures. With old-fashioned liposuction, the subcutaneous voids and tunnels were filled with blood, clot, or hematoma. Constant compression applied externally to the skin has the tendency to squeeze the delicate subcutaneous lymphatic capillary, causing the lumen to collapse upon itself and preventing interstitial fluid from entering the lymphatic capillary lumen. Therefore, excessive continuous external compression may actually impede lymphatic drainage and exacerbate postoperative edema. Without open drainage, the compression delivered by traditional postliposuction garments may be detrimental.

Graduated Verses Bimodal Compression

Therapeutic compression after liposuction is qualitatively different from the type of compression used to treat leg vein disease. Varicose vein treatment requires compression to overcome venous hypertension, and prevention of perioperative deep vein thrombosis requires compression to prevent the venostasis associated with the general anesthesia-induced loss of sympathetic vascular tone. In contrast, compression after tumescent liposuction is intended to expel the subcutaneous fluid containing a mélange of blood, fragmented adipocytes, and trauma-induced inflammatory exudates.

Lower extremity venous stasis is treated by a graduated compression garment. Graduated compression is necessary to counter the hydrostatic (gravitational) forces within veins having incompetent valves.[5] Because the hydrostatic force exerted by a vertical column of fluid increases as a function of the column's length, venous pressure in leg veins with incompetent valves increases distally when the patient is in an upright posture. In this setting, graduated compression is necessary to counteract the progressive increase in physical forces exerted by fluid contained within the "closed" hydraulic system of the lower extremity.

Graduated compression is not necessary after tumescent liposuction. Open drainage and bimodal compression are more efficient and more comfortable, and the compression garments are easier to put on and take off compared to graduated compression garments.

Optimal Compression is Bimodal

Proper postoperative compression after tumescent liposuction requires two degrees of compression applied sequentially (i.e., the compression after tumescent liposuction is bimodal). Bimodal compression involves two distinct therapeutic phases: the drainage phase and the post-drainage phase.

During the drainage phase, high compression is applied immediately after liposuction to encourage drainage from adits and open microincisions. Uniform high compression will maximize the drainage out of the suctioned subcutaneous adipose tissue onto the absorptive dressings and minimize postliposuction edema. With open drainage

and high compression, the tumescent drainage usually ceases in 24 to 72 hours. After liposuction of an unusually large abdomen or thighs, drainage may persist for several additional days. Once all the drainage has ceased, external compression is no longer essential. The ultimate cosmetic result does not depend on continued compression after all tumescent drainage has ceased.

During the post-drainage phase, after all the drainage of blood-tinged anesthetic solution has ceased, only a mild degree of compression is needed. Once external drainage has ceased, lymphatic uptake is the only means of clearing the subcutaneous tissue of protein-laden edema fluid. The function of mild compression is to augment the interstitial fluid hydrostatic pressure just enough to counterbalance the increased interstitial fluid osmotic pressure, and thereby slow the rate of transudation of intravascular water. Mild compression also provides a sense of security during physical activity and seems to provide a moderate degree of analgesia and comfort.

---

[1] Majino G, Joris I: Cells, Tissues, and Disease: Principles of General Anesthesia. Cambridge, MA, Blackwell Science, 1994.
[2] Odland GF: Structure of Skin. *In* Goldsmith LA (ed): Physiology, Biochemistry, and Molecular Biology of the Skin, ed. 2. New York, Oxford University Press, 1991, pp 19-20.
[3] Guyton AC, Hall JE: The microcirculation and the lymphatic system: Capillary fluid exchange, interstitial fluid, and lymph flow. *In* Guyton AC, Hall JE (eds): Textbook of Medical Physiology, ed. 9. Philadelphia, WB Saunders, 1996, pp 193-196.
[4] Pitman GH: Liposuction and Aesthetic Surgery. St. Louis, Quality Medical Publishing, Inc., 1993, p 67.
[5] Straudinger P: Compression therapy: Low or short stretch bandage and graduated compression stockings for leg edema [letter]. Dermatol Surg 21:106, 1995.