Special Topic

Liposuction of the Legs and Ankles: A Review of the Literature

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A Taboo Procedure

Lipodystrophy of the legs and ankles presents a particularly challenging problem in aesthetic surgery. This is true both historically and presently. Anatomic peculiarities and technical challenges delayed the development of treatment for this condition. Today, attempts to overcome these same obstacles continue to rapidly change the face of liposuction in this anatomical area.

Lipodystrophy of the legs and ankles is distressing to patients for several reasons. This condition, which is mostly limited to female patients and usually appears during the emotionally vulnerable time of adolescence,[1,2] tends to make patients look heavier than they are. The problem is seen in all ethnic groups.[3] The appearance of the leg may be so ill defined as to cause the patient severe psychological pain and loss of self-esteem. Legs and ankles are frequently not camouflaged by clothing and are therefore among the more conspicuous areas of lipodystrophy.[3–5] These factors combine to make this an emotionally frustrating cosmetic deformity. Frustration is exacerbated by the fact that lipodystrophy in this area appears to be largely genetically predetermined and is especially resistant to exercise and diet.[1,2,6]

Despite a need for therapy, liposuction of the legs and ankles was slow to develop. The earliest attempt at treatment of these areas in the literature dates to the 1920s, when Dujarrier in France attempted to remove fat by curettage in the lower legs of a well-known ballerina. He transected a major artery, and this eventually resulted in amputation.[7] Thus began the long-lived stigma surrounding lipectomy of the leg. In 1964, another surgeon, Schrudde of Cologne, attempted to remove such fat in his patients by curettage. Despite several good results, he reported skin necrosis in four of 15 patients in his series.[4,1] In 1977, Fischer and Fischer presented the new lipectomy technique of suction curettage.[8] This technique was attempted in the trochanteric areas but was abandoned because it left lymphorrhea, large cavities filled with lymph and serum, and terrible secondary sagging deformities over the affected areas.[9]

After disappointing experiences with closed curettage and closed suction curettage in the early 1970s, the modern era of lipectomy began in 1977 with Illouz in Europe.[7,9,10] The first U.S. experience was in 1981, when American physicians of various specialties observed the new technique of suction lipectomy in France.[2] Liposuction is now one of the most common cosmetic procedures,[2] but the growth of this modality in the specific areas of the legs and ankles lagged behind. By the late 1980s, the legs and ankles were being treated more frequently, but large numbers of successful cases were not reported until 1989 and 1990.[4]

The ignition of the lipectomy wildfire by Illouz's development of blunt liposuction techniques in 1978 resurrected the stigmata associated with circumferential lipectomy of the legs and ankles.[7] The procedure had been portrayed as "fraught with complications and of limited benefit."[2] Others have said that lipoplasty of these areas frequently combines high expectations with, at best, modest results.[4,11] Thus, early on, it became clear that liposuction

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of the legs and ankles represented an entity far different from liposuction in other anatomic areas, with unique anatomical and technical challenges to be overcome. Feared complications then and now include poor patient satisfaction, persistent pigmentation, contour irregularity, ulceration, and especially persistent edema.[1,2,7] For these reasons, liposuction of the legs and ankles was slow to develop.

As early as 1983, Illouz was finding much of this stigma of liposuction of the calves and ankles to be well-founded. In his report of 3000 cases of liposuction that year, he included 159 patients who had liposuction of the ankles.[12] Although he described good early results in the ankle region, he recognized and warned that the postoperative edema in this area was much greater than in any other anatomical zone, lasting up to 6 months. As is discussed in more detail, efforts to overcome this seemingly inevitable edema have been a major front in the battle to treat lipodystrophy in the legs and ankles. Even cases of eventual good outcomes are tainted by the fact that the edema, which persists in the legs longer than in other body areas, often makes patients prematurely feel that they had a poor result.[13]

Illouz also found other major complications to include long-term postoperative pigmentation and contour irregularities.[14] Such predisposition to hyperpigmentation is attributable to the dependent location.[4] Irregularities, which have been claimed to be the most common complication, are more common in this area because the fat is relatively thin. These irregularities are more commonly palpable than visible.[4]

In 1990, Watanabe's study of 166 cases of liposuction of the legs and ankles showed that patient dissatisfaction was secondary to these and multiple other factors. In addition to the aforementioned edema, irregularities, and prolonged postoperative pigmentation, these complaints included legs that appeared less slender than anticipated by the patient, asymmetries in shape, hypesthesia, and unexpectedly severe postoperative pain.[13] In fact, liposuction of these areas may be one of the most painful cosmetic procedures, and this discomfort often remains for many weeks.[7] When the legs and ankles are treated with liposuction, the recovery will also be longer than for most other areas because of factors such as edema. The reality of these complications in the context of a recovery period that can be challenging to both the patient and the physician explains the continued hesitancy of many surgeons to attempt this procedure.

Still, with advances in technique over the last 15 years, complication rates seem to have dramatically improved. Newer literature suggests that good results usually can be expected. Despite prolonged postoperative edema, after 6 months these patients are some of the most grateful.[2] Watanabe showed 84 percent satisfaction in this patient population, although this is compared with 98 percent satisfaction with liposuction in other areas of the body.[13] Nonetheless, cautious attitudes toward this procedure have been slow to change. As of 1997, there were still virtually no published articles or textbooks emphasizing the significant benefit, high patient satisfaction, and progressively lower complication rates of liposuction in these areas.[2] Recently, more investigators have discussed new techniques that have contributed to overcoming some of the aforementioned obstacles. This review presents the anatomic basis for the challenges of liposuction of the legs and ankles and examines recent authors' strategies for successful liposuction in these difficult areas. It is intended to provide clinicians with an overview of the developing state of the art, and to assist in sorting through the multiple techniques that have been presented. Table I summarizes the individual authors' differing strategies.

Anatomic Considerations of the Legs and Ankles

Illouz felt that the legs and ankles required special attention because of their unique anatomic features.[7] He described this area as relatively taboo for liposuction because of these characteristics.[13–15] Understanding of these unique anatomic considerations elucidates the basis for most of the unique challenges of liposuction in the legs and ankles. First, many authors describe this area as having only one layer of fat, with dense fibrous tissue and many lymphatics.[7,13–15] This is thought to be largely responsible for easily caused postoperative skin irregularities.[7] Also, because of this thin subcutaneous fat layer, postoperative hematomas or ecchymosis may result in pigmentation of the skin itself.[13] In addition, the dependent nature of the lower legs, the fibrous nature of the fat,[13–15] and possibly the disruption of the dense lymphatics from certain techniques[16] engender a constant tendency toward postopera-

tive edema. A delay in the absorption of this swelling may cause a tendency for more fibrous tissue to form, thereby threatening permanent "woody" induration of the subcutaneous layer.[13]

Anatomically, the larger, less sculptured leg is rarely the result of undesirable fat distribution alone, and usually is also the product of bone and muscle configuration.[11] This important anatomical consideration is addressed later in the discussion of preoperative evaluation. The heterogeneic character of the fat throughout the lower leg also presents a challenge. For example, the subcutaneous fat in the medial lower calf is softer and easier to suction than that more laterally.[13] This tends to lead to a greater reduction and resultant overall concavity medially if this anatomic factor is not taken into account.

Because of the neurovascular structures, liposuction at the popliteal fossa should never be performed.[6] Although the motor nerves and deep vascular structures of the leg lie deep to the investing fascia, the greater and lesser saphenous veins and the anatomically associated saphenous and sural nerves, respectively, live within the fat. Although one must take care not to injure these structures with stab wounds for cannulas, Grazer claimed no serious hematomas, superficial vein thromboses, or other complications from suctioning around the saphenous system.[5]

Within this anatomic setting, the pattern of lipodystrophy of the calves and ankles can be considered. Women tend to present with a common pattern of lipodystrophy of the legs and ankles. Chamosa presents a thorough review of the aesthetic ideals in the legs, and explains the typical adiposities that deviate from this form.[17] In brief, the knee should normally be bony, with some medial convexity and mild lateral concavity. More inferiorly, a concavity should also occur between the knee and the medial protrusion of the gastrocnemius. This area is commonly deformed by adiposities that exaggerate the medial convexity of the knee and that fill in the aesthetic concavities of the lateral knee and the area between the medial knee and the calf. In lipodystrophy of the leg, there is also proportionally more fat accumulation over the lower half of the leg than the upper areas.[13] Again, these aesthetic ideals and their common dystrophic deviations are well presented graphically by Chamosa.[17]

In 1997, Chamosa presented a uniquely different conceptualization of the lipodystrophies of this area by representing the cross-sectional anatomy of the leg and ankle as a rhomboid, the points of which were the anterior edge of the tibia, the Achilles tendon, and the two malleoli.[18] In this model, fat tends to accumulate along the lines between these points and thus obscures these prominences. He found the anterolateral and posterolateral aspects to be the most frequent areas of lipodystrophy. Interestingly, Chamosa suggested using liposuction to visually camouflage malalignment of the knee, claiming that the aesthetic impact of a varus or valgus knee can be decreased by concentrating liposuction toward the lipodystrophic areas on the convex side of the leg.[18]

Most patients' concerns regard areas of excessive fat distally over the medial and lateral malleoli.[1] In addition, excess fat often blunts the definition of the inferior bellies of the gastrocnemius muscles, especially medially.[1,2] Such an obscure transition between the gastrocnemius muscles and the more inferior leg contributes to a columnar appearance. Special attention toward the contouring of this "transition zone" is a focus of Mladick's recent work,[19] and is further discussed.

Another localized excess of fat commonly exists distally on either side of the Achilles tendon, creating medial and lateral fullness at the ankle.[4] These normally concave areas present a unique technical challenge.

Despite these common foci of lipodystrophy in the legs and ankles, specific fat distributions in this area of the body may be generally less well defined than in other commonly lipodystrophic areas.[14] Lipodystrophy of the legs and ankles is often more circumferential than in other locations, which presents special technical problems secondary to the unique and complex contours of these zones. There are two important exemptions to the commonly circumferential nature of this lipodystrophy. First, excess fat rarely becomes confluent between the perimalleolar regions across the pretibial region.[1,5] This paucity of fat extends superiorly over the anterior tibia.[4] Second, significant fat is never present over the Achilles tendon distally.[1,4,5] The consequence is that liposuction rarely changes the anteroposterior dimension of the lower leg or ankle, which is instead determined by the distance between the anterior tibia and the posterior surface of

TABLE I

Authors and Their Published Techniques for Liposuction of the Calves and Ankles

Author	Year	Positioning and Anesthetic	Incisions	Wetting Technique	Operative Strategy	Postoperative Management	Comments
Teimourian	1985, 1987	Prone; general anesthetic	Above ankles; medial and lateral to popliteal space	Tourniquet at midthigh	Circumferential technique; 2- to 4-mm metal or No. 7 plastic cannulas	Drains, stockinette, Ace, massage, medium pressure Jobst stockings; elevation	Tourniquet enhances contouring/decreases edema (not released until compressive dressings on)
Asken	1988	Prone or supine	Not specified	Not specified	2-, 3-, and 4-mm blunt-tipped cannulas	Supportive stockings for several weeks, self-massage after 7–10 days	
Illouz and Villers	1989	Position varies with isolated areas to be treated	On either side of Achilles tendon	Wet technique	Noncircumferential, tapering; 5- or 6-mm cannulas; leave 5 mm thickness of fat	Criss-cross tape dressing <1 wk; elastic stockings 1–2 mo	
Reed	1989	Prone; sedation, epidural, or GA with some local	Midposterior at T-zone, two lower lateral and medial calf incisions, and two posterior incisions above ankles	20–30 cc/leg of specialized mixtures depending on general or local with sedation	1.6- and 2.4-mm "Mercedes-type" cannulas; circumferential technique	Full exercise and activities on POD 1; previously fitted support hose for 4–5 wk	Notes "transition zone" at midposterior calf
Watanabe	1990	Usually prone with epidural or local using 0.5% lidocaine and 1:200,000 epinephrine	Not specified	Local infiltration of 0.5% lidocaine and 1:200,000 epinephrine	Size 5 cannula, 2-mm cannula at Achilles tendon; criss-cross suctioning; subcutaneous fat shaving without suction; pinch test 5–7 mm	1 cm foam, elastic bandage; minimize standing for 3 weeks; twice daily massage; tight stockings first postoperative week; dilute dexamethasone injection every 2 wk to treat edema	Focus on lateral fat; medial fat softer; pretunneling with cannula before suction; local double-diluted dexamethasone for prolonged edema
Aiche	1990	Prone position; local or general anesthetic depending on extent of procedure	Incisions at Achilles tendon at malleoli, mid-Achilles incision; sometimes need anterior ankle incision or incision beside popliteal fossa	0.25% lidocaine with 1:400,000 epinephrine	4- and 6-mm cannulas; 1 cm thickness goal; not circumferential but emphasis on feathering; wounds either flushed with saline or dependent drains left for 2 days	Criss-cross elastic tape to posterior leg or TED stocking; supine for several days with legs elevated; start massage 10 days postoperatively; compressive stockings for 6 mo	Key to striking result is aggressive anterior and ankle defatting
Stallings	1990	Not specified	Not specified	No preinjection of fluid, does use tourniquet	4-, 5-, and 6-mm cannulas	Bulky pressure dressing of Dacron fluffs and Ace wrap before tourniquet released; no drains; dressing down in 24 hr, then heavy support hose for 6 mo	No distortion from tumescent fluid and no bleeding
Grazer	1992	Prone, then supine; general or local anesthesia	Prone; medial and lateral popliteal areas, medial and lateral to Achilles tendon Supine: incision above retinaculum of ankle for ankle area and anteromedial calf	0.3% lidocaine with 1:320,000 epi	Cannulas no larger than 3 mm, usually 2.4 mm, incisions closed	Reston foam, then TED stockings, then occasionally Ace bandage in addition; Reston removed at 24 hr, then keep legs elevated and supportive stockings until edema resolves, walk as much as possible	
Pitman	1993	General or spinal; left lat decub then right lat decub	Upper, lower, and middle leg incisions on both medial and lateral surfaces of leg	Not specified	2.4-, 3.0-, or 3.7-mm cannulas; usually circumferential technique; attention to definition of lower border of gastrocnemius and Achilles tendon	Overnight stay with feet elevated and bed rest, then staples out and home in the morning with custom 40-mmHg compression stockings for 3–6 wk and legs elevated at night	Compare measured fat removed from four quadrants; right and left medial and lateral

TABLE I
Continued

Author	Year	Positioning and Anesthetic	Incisions	Wetting Technique	Operative Strategy	Postoperative Management	Comments
Ersek and Salisbury	1996	Sedation; local anesthesia by tumescence	Incision "in the crease behind the knee" and incision just above Achilles tendon	0.15% lidocaine with epi in LR infused with infiltrator system	4- to 6-mm blunt-tipped cannulas; incisions closed	Tight Ace wrap from toes wrapped in graded fashion left in place for 1 wk; legs elevated; massage and custom tight support hose at 1 wk, hose at all times for 6 wk	
Toledo	1999	Supine or prone; sedation and local tumescence	Medial and lateral popliteal area, medial and/or lateral subpatellar, and medial and lateral malleolar incisions	1:1 proportion	2- and 3-mm pyramid-tip cannulas on 60 cc Toomey syringes; mostly localized treatments, rarely circumferential	Avoid much walking on POD 1; sleep with legs elevated; mild compressive stockings for 3 wk; manual lymphatic drainage after POD 2	
Lillis	1997, 1999	Sedation and tumescent local; bilateral decubitus and prone positions	Superior, middle, and inferior medial and lateral incisions, and any necessary posterior incisions	0.05 or 0.1% lidocaine, 1:100,000 epi, Na bicarb, triamcinolone fully tumesced	2.5- and 3-mm accelerator cannulas; remove all but thin layer (2–3 mm) of fat circumferentially	35- to 40-mmHg compression hose; strict leg elevation for 3 days, then continue compression stockings whenever upright for 8 wk	
Mladick	1990, 1994, 1997, 1999, 1999	General anesthetic	Anterior and posterior to each malleolus, medial and lateral to transition zone	"Superwet," approximately 1 cc injected for each 1 cc anticipated aspiration (700–800 cc/leg); fluid is 1 amp epi, 50 cc 1% lidocaine in 1 liter saline	Slightly bent triple-holed 2- to 4-mm Accelerator cannulas; machine liposuction; longitudinal suctioning except transition zone; circumferential approach with attention to transition zone	35- to 40-mmHg medical grade compression hose; 1/2-inch soft foam, 6-inch Ace; SCDs begun in recovery room; elevation except bathroom; dressings off in 4 days, stockings with SCDs for 2 mo	External ultrasound assist for 5 min to each leg
Rohrich	1999	Not specified	Anterior and posterior lateral incisions, and two medial incisions	Superwet solution into midfat layer	2- and 3-mm malleable triple-lumen cannulas; circumferential technique; separate attention to T-zone; internal ultrasound used in some areas	Silicone foam under compression garments, then surgical compression garment and SCDs for 3 wk; external ultrasound/ manual massage two to three times per wk for 3–4 wk with compression garments for 3 mo	
Klein	2000	Local only by tumescence; modified lateral decubitus position with top leg on "thigh aside" pillow	Not specified	Local injection with spinal needle until anesthesia complete	Suction along long axis to avoid veins and lymphatics; circumferential technique in some patients, others need only discrete areas	Wraps in absorbent pads, then elastic bandages until drainage stops; further compression is optional; no bed rest or leg elevation; encourages early ambulation	

GA, general anesthetic; T-zone, transition zone; POD, postoperative day; TED, thromboembolic disease; lat, lateral; decub, decubitus; epi, epinephrine; LR, lactated Ringer's solution; Na bicarb, sodium bicarbonate; SCD, sequential compression devices.

the Achilles tendon.[4] This is an important preoperative consideration.

Whether "circumferential" or more localized, lipodystrophy in the legs and ankles must be considered in the context of the whole lower extremity. As Chamosa stressed, "beauty is based on the different body regions being in proportion to one another. . .correcting a single area usually leads to an imbalance in the contour of the lower limbs."[17] The aesthetic goal is the achievement of normal leg and ankle contour, but this must be in proportion to neighboring body regions. Watanabe noted that the medial knee should be addressed at the same time as the leg, if needed, to give an overall balanced shape.[13] Although liposuction of the knees is not further discussed here, much literature exists on this topic and such treatment should be considered when it applies to the achievement of well-proportioned leg contour in a given patient.

Preoperative Evaluation

Understanding the patterns of lipodystrophy and the unique relevant anatomy of the leg, one can assess individual candidates for surgical treatment. When evaluating patients for liposuction of the legs and ankles, certain contraindications should be respected. Because of the high risk of embolism from this procedure, patients with a history of deep venous thrombosis, phlebitis, hypercoagulability, or any history of a previous thrombotic event should be excluded.[7,11] In addition, the procedure should not be performed on patients with circulatory insufficiency.[1,2] The procedure should also be avoided in patients with chronic edema, trophic anomalies, and severe varicosities.[14] Mild varicosities do not preclude liposuction, and these patients are not subject to increased postoperative morbidity.[4] Active phlebitis, though, is an absolute contraindication to this procedure. If vein stripping is planned for severe varicosities, this should precede liposuction by 3 months.[4]

The problem of skin laxity and draping after liposuction of the legs and ankles is not as great a concern as in other areas.[3] Originally, it was felt that patients with good skin elasticity (younger patients) should be the best candidates, but experience has shown that the great elasticity and the limited amount of skin in this area allows for very large volumes of fat to be removed in almost all patients without concern for postoperative skin laxity.[1,3,10] Still, Teimourian claims his best results to be in patients under the age of 40, although most patients requesting this procedure are in their 20s and 30s.[20]

Patients who may be candidates must be examined to determine whether their complaints can in fact be addressed appropriately by this procedure. Visual inspection should not be considered sufficient to assess fat deposits. In general, patients with lipodystrophy of the calves and ankles will show blunting of definition of the gastrocnemius muscles and the ankles as previously described. If the legs have a large circumference but the gastrocnemius muscles are actually well defined, the "problem" is likely that of increased muscle tissue, often in the soleus.[1,2] Older literature endorsed the use of xerograms to evaluate fat thickening.[14] Most authors, though, use only the pinch test to determine whether the excess tissue is actually removable fat. Recommendations for surgical treatment vary between authors, but pinch tests of 1.5 to 2 cm of fat at the calf and 1 to 1.5 cm at the ankle are felt by many to represent an indication for surgery.[4,10,13] Despite the fact that fat can usually be distinguished from muscle in this way, at times patients with firm pinch tests suggestive of increased muscle tissue over both calf and ankle areas have had a surprising amount of fat at surgery.[1]

Most authors perform the pinch test while the patients stand on a stool. Usually, it is performed with the patient standing flat-footed, and then standing on the toes.[1,3,4,10,11,14] The thought is that standing on the toes will flex and therefore help to define the edges of the gastrocnemius muscle bellies for marking. These authors perform the final preoperative evaluation and marking in this manner. Recently, Mladick proposed the benefits of marking the patient in the sitting position with the legs dangling, claiming that "dangling legs are more supple, which makes it easier to differentiate the thickness of the fat bulges from the underlying muscles and tendons."[19] Klein suggests using the pinch test while the patient is resting her leg in the horizontal position on a chair or stool with the ipsilateral knee bent at approximately 90 degrees while standing on the contralateral leg.[6] Rohrich espoused a combination of dangling, standing, and sitting, citing that the relaxed tone of the muscles allows better differentiation of tissues in the sitting position.[21] We also feel that the combination of all three positions is useful, with the benefit of the dangling position or Klein's resting posi-

tion coming not so much from the decreased tone of the muscles, but from the decreased tension on all of the soft tissues—especially skin and subcutaneous tissue—as the foot is allowed to naturally plantar flex, thus facilitating distinction between relaxed tissue types during the pinch test.

Klein recommends that contour lines should be drawn in the preoperative evaluation position because distinct concentrations of fat can be subtle and can be lost when tumid.[6] Most authors mark areas of relatively greater or lesser fat deposits as would be done in other areas of the body to intraoperatively demonstrate areas of fat requiring intensive resection. Mladick's markings emphasize the contours of the transition zone, where the leg narrows posteriorly at the inferior edge of the gastrocnemius muscles and then tapers down to the ankle, approximately midway between the popliteal crease and the maleoli.[19] Areas of fat are often difficult to document with photographs, and this fact should be discussed with the patient and the discussion documented in the chart, as it may be hard to show postoperative changes in the photographs.[6] Toledo notes that results are usually subtle; therefore, some authors recommend measuring preoperative and postoperative leg circumferences for this reason.[5,22] He does mention, though, that patients are often very pleased with even the most subtle objective changes, which may be imperceptible to others.[22]

As will be discussed further, many surgeons put their patients in compressive garments for extended periods postoperatively. Some surgeons require fitted garments. Authors suggesting the use of these garments recommend that the patient be fitted preoperatively for a properly fitting garment.[4,10,11] It is unclear what effect the operative change in size has on the accuracy of such planning.

The final preoperative concern after evaluating the patient is that of patient selection and counseling. Because the outcome of this procedure eventually relies heavily on postoperative management, this operation should be reserved for patients who are responsible enough to follow postoperative instructions closely.[1,2]

TECHNIQUE

Positioning and Anesthesia

Over the past decade, the progression of the literature concerning liposuction of the calves and ankles has demonstrated changes in techniques, but there are still many disagreements. In 1990, Watanabe and others described liposuction in the prone position.[3,13] Others have championed the idea of an awake patient able to change positions between both sides and prone, to better visualize and assess the circumferential fat.[1,2,23] In contrast, Mladick in 1994 described the technique using a supine position, which he still recommends.[10,19] Klein places most patients in the lateral decubitus position and turns the patient to the other side during the procedure.[6]

The literature has shown no real trend over time among these alternatives toward a preferred type of positioning. Most authors tend to endorse their technique on the basis of its convenient marriage with a certain type of anesthesia, as some combinations tend to work better together.

Opinions also differ on the type of anesthesia used. In 1985, Teimourian described using only general anesthesia.[24] Klein used straight local tumescent infiltration of anesthetic into the tissue with a spinal needle.[6] Watanabe used epidurals in his patients and infiltrated 0.5% lidocaine and 1:200,000 epinephrine but did not describe actual tumescing.[13] Many others have used sedation with "tumescent-type" infiltration of a solution usually consisting of dilute local anesthetic (lidocaine), epinephrine, and sometimes bicarbonate in saline or lactated Ringer's solution.[1,7] Lillis described liposuction, using only lidocaine as a tumescent fluid, on an awake patient who was therefore able to change positions.[2] This was also reported by Mladick, who then used only local anesthetic for touchups.[2,10] In 1996, Chamosa claimed to perform liposuction in a two-stage procedure. In the first stage, liposuction of only half of the circumference on each leg and ankle was performed under general anesthesia. The second stage was performed at 3 weeks, which involved completion of the procedure under local anesthesia.[17] From these diverse possibilities, one can understand that the best anesthetic may depend on such factors as the extent of the procedure and whether it is to be combined with other procedures.

The Role of Tumescence and Tourniquets

Most authors use some form of tumescent liposuction of the legs and ankles. There have been multiple techniques described that use tumescent infiltration of local anesthetic. The

various compositions of the actual tumescent fluids are presented in Table I. Here, some of the arguments that have been presented in the literature for and against tumescent infiltration will be reviewed to provide the reader with a context in which to balance these suggestions and make his or her own decisions.

In 1995, Hunstad discussed the advantages of the tumescent technique for liposuction in general as described by Klein,[25] adding that tumescence magnifies areas to be treated and that it not only improves safety but decreases cost.[26] Hunstad suggested the use of warm solutions to avoid shivering or heat loss in the patient. He found that his tumescent technique resulted in less ecchymosis and apparently less pain, citing a survey showing that patients felt overwhelmingly that general anesthesia was unnecessary for their procedures. He also endorsed the use of lactated Ringer's solution over normal saline because lactated Ringer's solution gave a lower acidity without requiring the addition of bicarbonate. Finally, Hunstad suggested that lactated Ringer's solution, being more physiologic, may be less traumatic to adipocytes. He recognized that this may prove important in the context of grafting the aspirated fat.[26] In 1989, Illouz and de Villers espoused many of these same advantages of tumescence, claiming benefits of the "wet technique" to be hydrodissection and magnification of the fat layer in which to work, thus facilitating staying in the proper plane. They stated that the dry technique is rougher, being merely "curettage."[14] In 1993, Klein showed that the tumescent technique improved safety in large-volume liposuction by eliminating the need for general anesthesia, intravenous sedation, and narcotic analgesia, and by also virtually eliminating surgical blood loss.[25] Neither of these authors discussed the application of these techniques specifically in the area of the legs and ankles.

With these benefits in mind, Ersek and Salisbury[7] in 1995 described a superwet technique in the legs and ankles. They too claimed that this helped to provide adequate analgesia and to reduce bleeding and subsequent bruising. Mladick also championed a superwet technique in this anatomical area, claiming the advantages of making the fat more turgid, magnifying fat accumulations, and decreasing blood loss through the use of tumescence fluid.[19] Lillis specified that the lower legs require a reduced infiltration rate compared with other anatomical locations, citing that the tissue is naturally more taut in this area and therefore becomes more uncomfortable with distention compared with other areas. Therefore, less volume should be used to maximally tumesce this area, which he notes causes severe but expected blanching and tautness of the skin.[1,2] Mladick indeed clarifies that the volume of fluid used for strictly defined tumescence (specifically, the infusion of twice the volume of expected fat aspirate) is "unnecessary and excessive and makes the leg excessively tight." Instead, he uses approximately 1 cc of tumescent fluid per 1 cc of expected fat to be removed. In his technique, approximately 1000 cc is injected per leg through multiholed fine injecting needles.[19]

Lillis added another goal to tumescing, adding triamcinolone to his tumescent fluid.[1] Chamosa also reported this technique and claimed less edema since his addition of triamcinolone to the tumescent solution.[18]

Although most authors champion some version of tumescing, there are those who have described liposuction of the legs and ankles without the use of tumescent fluid infiltration. The dry technique was described by Fournier and Otteni in 1983 for use in general liposuction.[9] It was championed because it saved time, left the tissues less distorted for evaluation, and left the aspirated tissue mostly unchanged histologically. Because of the lack of local anesthetic, they used mostly general anesthesia with some regional blocks. They admitted that this technique had the disadvantage of requiring volume resuscitation, sometimes with colloid use in large-volume cases.

The variation of dry liposuction of the lower leg with a tourniquet inflated at the midthigh was first reported by Teimourian in 1985 and in 1987.[20,24] Although he did not describe his cases or technique in much detail, he claimed to have experienced no intraoperative blood loss and minimal bleeding afterward, having placed drains overnight through the incisions. The legs were wrapped with Ace wrap before the tourniquet was released to minimize edema formation.[24] In 1990, Stallings suggested that a dry technique under tourniquet could give very precise sculpting. He also explained that the technique causes almost no bleeding and therefore no hemosiderin tissue staining, and that this technique resulted in less postoperative swelling. The longevity of these benefits was ensured after the tourniquet

was released by placing a large bulky pressure dressing of Dacron fluffs and an Ace wrap before the tourniquet was released. No drains were used.[27] In that same year, Watanabe argued against such use of a tourniquet, reasoning that although the lower leg is more subject to persistent edema than other areas of the body, it is also one of the least vascularized areas.[3] The basis for this argument, which was not explained in more detail, remains unclear.

In 1998, Karacalar and Ozcan described liposuction of the kneecap area with a "superdry" technique under tourniquet.[28] Then, in 2000, they reported the use of this technique for liposuction of the leg.[29] They too felt that this technique should give the best intraoperative prediction of a final result because the end result on the table is not distorted by swelling from trauma or by injection of fluid. They reported first exsanguinating the leg with an Esmarch bandage from toes to upper thighs. Although they did not tumesce, they did pretunnel with a 3-mm, single-hole, blunt rod. These authors also firmly wrapped the legs from the toes to above the knee with an elastic bandage before the tourniquet was let down, as was done by Teimourian.[24] They point out that such dressing application under tourniquet is a common, safe technique in hand surgery. Very little bruising was noted in these patients, which was conjectured to be secondary to having applied pressure to the tiny injured vessels before the tourniquet was released. They noted that the only patient in their series who developed significant bruising was the single one in whom the Esmarch bandage had been prematurely released during the procedure.[28] Thus, it appeared that liposuction and compressive dressing application under tourniquet control may be helpful in preventing both bruising and edema from ever developing.

Of interest, Karacalar and Ozcan histologically studied the fat aspirated using this dry technique. Using as controls the contralateral legs with wet technique and no tourniquet, they found the fat from the dry, tourniquet side to be almost bloodless and far more intact than the control tissue.[28,29] This may have great significance as the practice of lipoaugmentation becomes more commonplace and the need for harvesting reliable autograft material is realized.

Intraoperative Techniques

Authors differ slightly in their incision location, but fat removal always takes precedence over attempts to limit the number of scars from incisions.[1,2,22] Ersek and Salisbury used only incisions in the posterior knee crease and in the crease above the Achilles tendon both medially and laterally.[7] Pitman[4] and Lillis[1,2] both described starting with three incisions both medially and laterally on each leg—one just below the knee, one midleg, and one just above the ankle. Lillis stressed the point that additional incisions are often required, especially on the posterior calf.[2] Grazer described access to the ankle and posterior calf through stab incisions on either side of the Achilles tendon.[5] Most authors use one or a combination of these groups of incisions. Most importantly, the consensus stands that incisions should be added as needed to achieve a good contour.

Watanabe claimed that, before beginning suctioning, the use of a 5-mm feathering rod to create an artificial double layer of fat is necessary to prevent the suctioning of the most superficial fat.[13] Mladick also endorsed pretunneling without suction.[10,19,30] Rohrich[21] reported the use of internal ultrasound to assist suctioning, whereas Klein[6] felt that this is contraindicated in the legs and ankles.

One of the most significant differences in techniques between liposuction in the legs and ankles and liposuction in other areas of the body is the small cannulas used in this area. This trend has developed among authors over the past dozen years, and many authors discuss how they came to realize this necessity. Table I shows the choices of various authors and the year in which their work was published. In general, most authors currently use cannulas in the range of 2 to 5 mm, often using the smallest for refinements around the ankles.

The type of cannula also differs between authors, but with no consensus. Lillis, for example, favors smaller cannulas in the range of 2 to 3 mm with openings recessed from the tip on the underside to avoid traumatizing the underside of the dermis and to leave 2 to 3 mm of subdermal fat.[1,2] In contrast, Mladick favors the use of triple-holed cannulas.[10,19,30]

Some authors endorse the use of bent and straight cannulas to deal with the anatomic complexities of this area. In his earlier work, Mladick recognized that the delicate curves of the legs make liposuction with straight cannulas difficult.[13] Mladick described the use of 2-, 3-, and 4-mm triple-holed cannulas, adding the use of both convexly and concavely curved cannulas.[10,19,30] He claimed these curved cannulas

to be requisite to following the contours in these tight areas. Chamosa also uses slight bends to the cannulas as needed to allow easier contouring of the complex curves of the leg and ankle.[19]

In 1995, Hunstad promoted the use of syringes in liposuction in general. He cited that the use of syringes was quieter, less expensive, easier, faster, more lightweight, gave more control and precision, avoided the awkward tubing, and caused less surgeon fatigue. It also allowed for multiple surgeons and made the suction more immediately adjustable. In addition, he claimed less trauma, bleeding, and bruising with this technique, and felt that syringes allowed for better quantitative assessment of the fat removed.[26]

Toledo preferred syringes also, and used 60-cc Toomey-tip syringes with 2- and 3-mm cannulas.[22] Chamosa[18] also preferred the use of syringes, whereas Mladick[31] disagreed and uses machine-generated suction because it is hard to maintain a seal around the cannulas when working in these small areas near the incisions. Most authors have not specified which type of suction they prefer.

Many surgeons differ on the endpoint of liposuction in the calves and ankles. Most surgeons believe that some thickness of fat should be left behind. Authors such as Klein feel that attempting to remove all the fat is a mistake because an incongruously muscular, masculine leg on a woman is generally undesirable. In addition, if skin is adherent to muscle in all areas except where small bits of fat were left behind, future weight gain will accentuate these areas.[6] Ersek and Salisbury felt that it was very important to ensure that some subcutaneous fat be left to provide shape to the calves and ankles.[7]

Aiche suggested thinning to a pinchable 1 cm.[3] In 1989, Illouz also suggested leaving 0.5 cm of fat or a pinchable 1 cm.[14] Watanabe first pretunneled to artificially create a double layer of fat, and attempted to leave 3 to 5 mm of fat in this top layer, for a final postoperative pinch test of 5 to 7 mm (except at the Achilles area).[13] He felt that a thinner layer of fat would make irregularities more noticeable. Lillis favors small cannulas with openings recessed from the tip on the underside to avoid traumatizing the underside of the dermis and to leave 2 to 3 mm of subdermal fat.[1,2] Lillis also pointed out that the aggressive use of the opposite hand through downward pressure or grasping of the cannula is contraindicated. Some mild downward pressure may sometimes be necessary, and in fibrous pockets of fat around the malleoli, grasping and lifting fat and more aggressive cannula use is warranted.

Other authors strive to leave little or no fat. Mladick espoused very superficial work with 2- and 3-mm cannulas around the ankle, originally specifying a single-holed cannula for this area,[10] with no attempt to preserve any subdermal fat in the ankles to approximately 5 cm above the malleoli. He noted that the most frequent postoperative problem was, in fact, persistent ankle thickness in 10 percent of his patients, which he attributed partly to persistent edema and partly to underresection.[19] He noted that "The degree of success is usually determined by the improvement of the ankle region."[10]

Pioneers of liposuction of the calves and ankles suggested that hypertrophy is often asymmetrical—often being more medial or lateral—and that isolated treatment was all that was required.[14] This preference for local treatments corresponded with an old belief that there are colliding zones in the dorsal calves and ankles that should not be crossed to avoid irregularities.[22] It was felt that the circumferential technique should be avoided so that venous and lymphatic return would not be severely altered.[14] Mladick presented the concept of circumferential liposuction in 1994.[19] Over the past several years, an understanding of the need to blend the appearance of the entire leg has developed. Aiche stressed the importance of feathering between the junctions of defatted and nondefatted portions of the leg with a 4-mm cannula.[3] Chamosa pointed out that one single area must never be done alone,[17] and Lillis encouraged an organized approach to avoid skipped areas.[2] Klein felt that there are some individuals who can benefit from circumferential work in all areas, but that other patients should have work limited to discrete areas.[6] Most recent authors, though, have accepted Mladick's concept of circumferential liposuction. Still, Toledo feels many if not most patients only need localized treatments.[22]

Although Mladick was one of the first to encourage circumferential liposuction, he more recently stresses the importance of sculpting the transition zone, previously described as the area where the leg narrows posteriorly at the inferior edge of the gastrocnemius muscles and then tapers down to the

ankle, approximately midway between the popliteal crease and the malleoli. This transition zone had already been alluded to by Reed in 1989.[11] Mladick claimed, "The importance of the Transition zone cannot be understated; it is a major aesthetic improvement." He stressed medial transition zone suctioning more aggressively than lateral on the posterior leg. This area is suctioned transversely and obliquely through stab wounds placed posteriorly and 3 cm medial and lateral to the posterior midline.[19]

In contrast, Lillis claims that this concern over defining the inferior gastrocnemius muscle so that it can be sculpted is no longer warranted. He claims that with his technique of removing all but a thin layer of subdermal fat circumferentially in all areas, the shape of the gastrocnemius will naturally define itself.[1,2]

In addition to the transition zone conceptual modification to the circumferential model of liposuction of the leg and ankle, other variations have been suggested. Chamosa feels that reproducing the shape of the ankle by concentrating on the reduction of fat in the four facets of this aforementioned rhomboid produces a better result than the circumferential liposuction approach championed by Ersek, Mladick, and Watanabe.[18] Earlier in the literature, because of what he saw as a tendency to aspirate more of the softer medial fat, Watanabe recommended focusing on removing more fat laterally.[5] This concept has not been revisited by other authors.

Recently, the optimal direction to suck with the cannula has also come into question. Chamosa specified working in most areas longitudinally.[17,18] In 1999, Frick studied the effect of liposuction of the lower legs on epifascial lymphatics.[16] He examined the effect of dry liposuction with 4-mm blunt cannulas both in parallel and perpendicular to the long axis of the leg. He found severe or moderate lymphatic injury in approximately half of all transversely suctioned areas, whereas no severe injury and only a few moderate injuries were seen in areas suctioned parallel to the long axis. Importantly, Frick claimed that "the flexibility and quality of the lymph vessels visualized and tested after lipectomy seem to be comparable to those of the lymph vessels harvested during lymph vessel transplantation."[16,31]

Klein works mostly in the longitudinal direction for exactly this reason.[6] Mladick recognized the value of this study but claimed to not have seen an increase in postoperative edema from his transverse suctioning of the transition zone. He suggests that this may be because of his use of 2- and 3-mm cannulas or because these lymphatics may regenerate in the normal leg.[32] Lillis also felt that cross-tunneling is desirable.[2]

The studies by Frick are difficult to interpret in the setting of tissue that has been infiltrated with tumescent fluid, especially with the superwet and tumescent techniques. The results of previous authors do not show any significant prolonged edema with aggressive transverse liposuction at the transition zone from the gastrocnemius and soleus muscle bellies to the tendon of Achilles. One must postulate that the increased volume of interstitial fluid provides a protective effect on the lymphatics. Also, the cannula size used by the majority of authors is less than 4 mm. Of course, there is also the unknown importance of injury response of live tissue versus cadaveric tissue. In addition, it is difficult to provide any data regarding the strength, mobility, and elasticity of live versus cadaveric tissue in these operative situations. These factors, which have not been studied, and the clearly documented favorable results of authors that do use transverse strokes during liposuction make it difficult to draw any conclusions from Frick's study.

One of the more recent techniques described is the use of ultrasound assistance with liposuction of the leg and ankle. Mladick feels that the use of external ultrasonic assisted liposuction may help to disperse the tumescence fluid, soften the fat, and possibly increase postoperative skin contracture.[19] Rohrich commented that although he does not find external ultrasonic assisted liposuction helpful, he has begun using internal ultrasound to improve results, especially in the transition zone.[21]

No consensus has developed in the literature regarding the management of the stab wounds for the cannulas. Many authors mention closing the wounds with nonabsorbable sutures, whereas some authors leave the wounds open to drain.

Dressings and Postoperative Care

As postoperative edema is one of the most daunting hurdles of liposuction of the legs and ankles, postoperative care to prevent this problem has proven to be fundamental to improvements in this treatment modality. The specific

modalities used by the authors is presented in Table I. Most authors use some form of compressive therapy and attention to postoperative leg elevation. Despite agreement on the need for attention to postoperative care, no clear preferred regimen has developed, and the suggested postoperative treatments continue to vary from the simple to the most complex protocols. The various interventions described at progressive stages of the procedure to combat edema are presented.

Aiche[3] felt that the fluid and blood from surgery would collect in dependent areas, leading to continued tender swelling. He thought that this could be addressed in two ways. First, one can flush the wounds with saline to remove debris that could produce an oncotic load and leave pigments. Second, drains can be placed dependently for 2 days, after which the wounds can be closed with delayed sutures. Teimourian placed one Jackson-Pratt and three Penrose drains in each leg for 24 hours.[20,24] Mladick described milking excess fluid out through incisions after suctioning each leg.[10]

Another concept described to battle the formation of edema is the prevention of its formation even before the patient leaves the operating room. Chamosa wraps the first leg in an Esmarch strap elastic tourniquet while working on the second leg. This is not removed until the definitive postoperative dressing is applied, a strategy that he feels also prevents postoperative hematomas.[18] Similarly, after finishing the first leg, Mladick tightly wrapped it with a 6-inch Ace wrap to above the knee while the contralateral leg was contoured and likewise bandaged. When both legs were done, the first was unwrapped and the incisions closed, followed by the second leg. Mladick claimed that this "maintains continuous firm compression on the legs to avoid accumulation of blood. The compression has also been successful in minimizing bruising."[19]

Techniques involving pneumatic tourniquet use focus specifically on this goal of minimizing edema formation in the operative and immediate postoperative periods. Application of a compressive dressing before the release of the tourniquet prevents edema and bleeding before it has the chance to develop because the traumatized tissues are never exposed to blood flow without a compressive dressing in place. After placing his drains, Teimourian applied stockinette and then an elastic bandage from midfoot to above the knee before the tourniquet was released. The procedure was then performed on the other leg.[20] Karacalar and Ozcan described a similar technique.[28,29]

Even without the use of a tourniquet, the cornerstone of postoperative care is compressive therapy. The simplest form of compressive therapy is the use of criss-crossed elastic tape placed posteriorly on the legs.[14] More commonly, postoperative care includes compressive stockings, and some authors feel the use of medical grade graduated compression stockings in the range of 35 to 40 mmHg to be imperative. Such proponents suggest that these support hose be fitted and purchased preoperatively.[4,11] Other authors use an Ace wrap instead of, or in addition to, compressive stockings.[5,7,10,19,20,24,27,31]

Foam padding has been placed beneath the elastic dressing to provide more compression. Watanabe[13] placed a 1-cm-thick urethane sponge on the fossa created lateral to the Achilles tendon to prevent blood accumulation. Over this, he wrapped the leg with an elastic bandage. Postoperatively, tight stockings were initiated during the first week after the pressure bandages were removed. Grazer described placing a Reston sponge more circumferentially under thromboembolic disease stockings and occasionally applying an Ace bandage over top in addition. Reexamination after removing the foam at 24 hours showed reduction in ecchymosis where the Reston foam was.[5] Mladick applies tight surgical hose to above the knee, and then circumferentially covers the areas from the ankles to the calves with soft nonadhesive foam wrapped with a 6-inch Ace wrap over top.[10,19,31] These authors suggest leaving compressive dressings in place for varying lengths of time, as shown in Table I.

Several authors endorse the use of massage in the postoperative period to decrease edema while the body repairs its ability to remove this excess fluid. Chamosa considered the "use of body support therapy wear and massage for lymph drainage to be fundamental."[17]

Mladick modernized the concept of postoperative massage to reduce edema through the application of sequential compression devices in the postoperative period. He claimed that the use of sequential compression devices markedly decreased the period of postoperative edema compared with his early experience, with most patients using sequential compression devices being almost edema-free by 2 months.[19] He begins the use of sequential com-

pression devices in the recovery room, and the original dressings are not changed until the fourth postoperative day. Mladick requires that his patients use the sequential compression devices as much as possible, at least at night, with firm stockings during the day for 2 months.

Varying authors differ in their opinions on the need for postoperative leg elevation and rest. Lillis felt strongly that "strict attention to leg elevation especially in the first three days will greatly decrease the amount and duration of peripheral edema." Although he admits to one patient who went mountain climbing 1 week postoperatively and still had an excellent result, he enumerates complications that can be expected with noncompliance, such as huge recurrent bilateral seromas.[2] Other authors suggest widely varying activity restrictions, which are listed in Table I.

Several other modalities have been used to combat postoperative edema. Chamosa added triamcinolone to his tumescent fluid,[18] as did Lillis.[1] Watanabe claimed that local injection of 1 to 2 cc of double-diluted dexamethasone acetate every 2 weeks was very effective in combating edema.[13] Rohrich reported the use of external ultrasound two to three times per week for 3 or 4 weeks combined with manual massage in the office to facilitate edema resolution.[21]

Despite this shift toward aggressive means of edema prophylaxis, some surgeons remain minimalists. Klein wraps the legs with the incisions left open with absorbent pads and then elastic bandages that are kept on until the drainage stops. He considers further compression to be optional, and feels that bed rest and elevation are unnecessary. His patients are encouraged to ambulate as of the first postoperative day.[6]

Our Preferred Technique

We prefer a combination of the aforementioned techniques to achieve the best possible result with the fastest recovery and the least postoperative edema. The use of a tourniquet and compression dressings is thought to be essential to the success of this technique. Aggressive manual massage and thromboembolic disease hose are also emphasized.

Preoperative Evaluation and Markings

The patient is marked in a seated position. The transition zone from calf to ankle is marked for aggressive suctioning and easy identification intraoperatively. Other areas that will be reduced by suctioning are also marked, and care is taken to identify the area overlying the tibia, as this will not be violated by suction cannulas.

Operative Technique

The patient is placed in the supine position and either general anesthesia or spinal anesthesia with sedation is used. Prophylactic antibiotics are given 1 hour before coming to the operating room. The lower extremities are prepared and draped in the usual sterile fashion, and sterile tourniquets are applied to the thighs. One of the legs is elevated for 5 minutes and the tourniquet is inflated to 300 mmHg. The areas to be suctioned are infiltrated with a solution containing 1 mg of epinephrine and 20 cc of 0.25% bupivacaine per liter of lactated Ringer's solution. This will provide pain reduction long after the operative anesthetic has worn off. A wet technique is used.

Incisions are made laterally and medially to address the lower leg fat along the Achilles tendon and up to the transition zone. Incisions are made medial and lateral to the palpable tibia at the middle third of the lower leg to address the transition zone. At the proximal third of the leg, less liposuction is performed, to create the appearance of a muscular calf transitioning to a thinner ankle. A combination of 2- and 3-mm suction cannulas are used, and the tip configuration is generally varied according to the thickness of the fat layer being suctioned. After completion of the first leg liposuction, attention is turned to the other leg, where the same procedure is performed. The tourniquet is not deflated on either limb until the conclusion of the procedure.

Postoperative Dressings

With the tourniquets still inflated bilaterally, the dressings are applied. Wounds are dressed with 2 × 2-inch gauze pads, and the legs are wrapped with Reston foam and 6-inch Ace bandages over the foam. Care is taken to make the foam circumferential in nature up to the level of the knees. The adhesive side is placed definitively away from the patient's skin. The tourniquets are then deflated and the patient taken to recovery.

Postoperative Care and Management

The patient is to minimize the activity of standing and walking for 1 week. Preferably,

they should take 1 week off from work or travel and remain supine with their legs elevated the majority of the first week postoperatively. Full bed rest is not recommended. The dressings are removed at 1 week and the patient is placed in thromboembolic disease hose for the next 3 to 6 months. Leg elevation is strongly emphasized, with two pillows every evening, and manual massage is started as soon as the patient is able to tolerate this maneuver. The patient is able to remove the thromboembolic disease hose completely when all residual edema is eradicated from the lower extremities (Fig. 1).

CONCLUSIONS

Liposuction of the calves and ankles is certainly an important operation to offer the appropriate patients. Many authors have approached the problem in many different ways, which indicates that there is no one best way to handle the problem of lipodystrophy of this difficult region. The most important point is to develop a technique that is safe and reliable and produces excellent results. The extensive review presented here will help one formulate an approach that is customized to the surgeon and to the patient. When the "best" technique

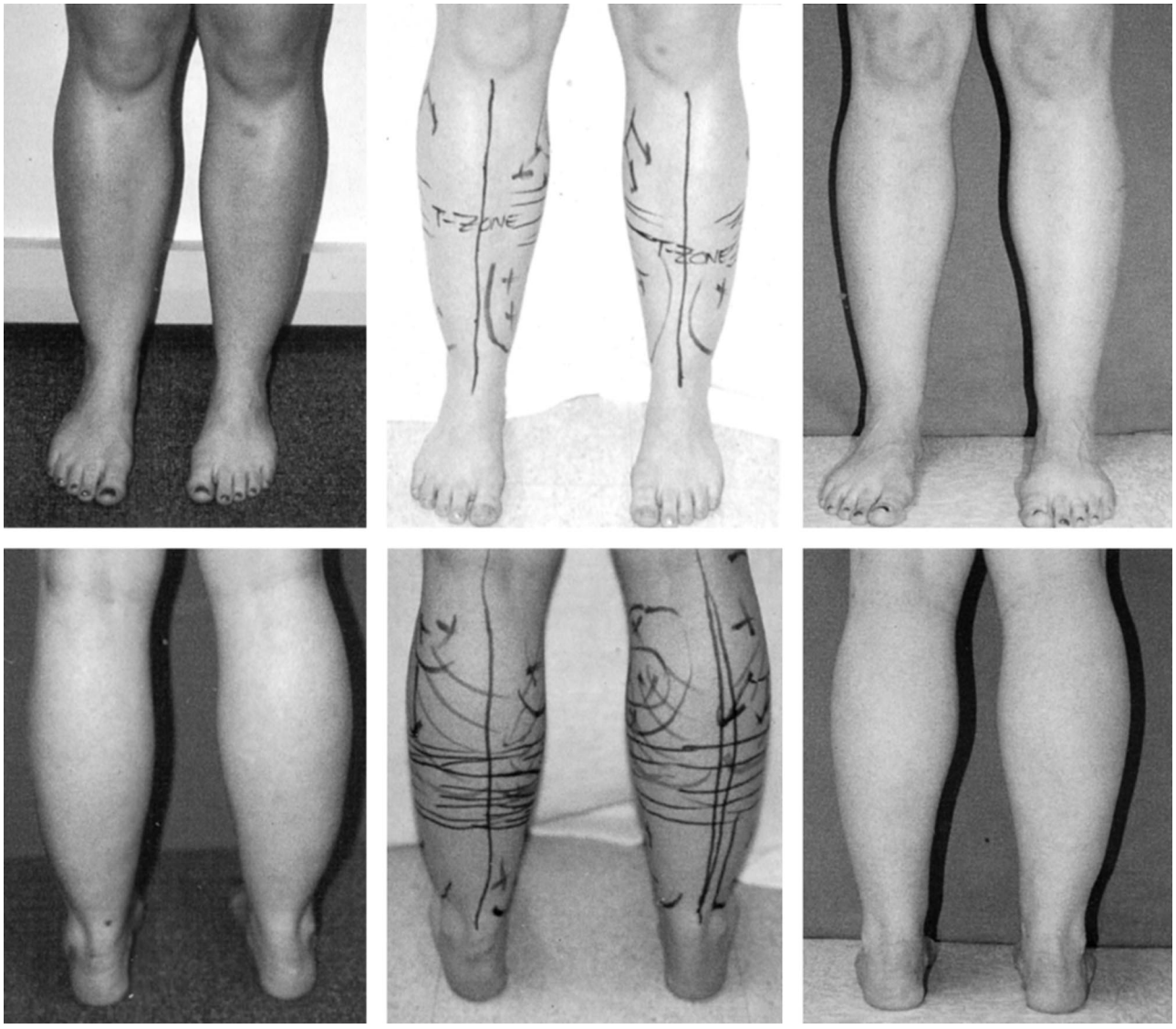

FIG. 1. Preoperative views (*left*), preoperative markings (*center*), and postoperative views (*right*) of a patient with lipodystrophy. Notice the poor definition of the gastrocnemius muscles and the thickness around the malleoli preoperatively. The transition zone is marked and a total of six incisions are planned: one medial and one lateral at the knees, one medial and lateral at the central portion of the transition zone, and one medial and one lateral just above the malleoli. Anterior and posterior views of postoperative result at 1 year show definition retention and no edema.

is not immediately obvious, it is important to keep in mind the principles of excellent surgical patient care and synthesize the best approach that generates the best results in your hands.[33]

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