Calf Augmentation

8

Introduction

Men and women alike wish to have a more muscular and toned physique, and the calf region is not exempt from this. Despite vigorous exercise and body building, some people are unable to attain the definition that they desire in the calf. Many patients who present for consultation want to look good in shorts and skirts but due to a hypoplastic calf say that they are unable to do so. To that end, calf implants of various shapes and sizes have been created to increase volume in the calf. In addition to calf implants, there has been increasing interest in the use of fat to augment the calf in order to avoid foreign body placement [1].

Calf Aesthetics

While the perception of an aesthetic calf may vary from culture to culture and time period to time period, the anatomy is consistent and ultimately gives the basis for calf aesthetics. The shape of the calf is defined primarily by the volume of the gastrocnemius and soleus muscles. In addition, the crural bones and the subcutaneous fat work in tandem with the muscles to further define the calf. While the bones cannot be altered easily to adjust the aesthetics of the calf, there is liposuction available to treat the subcutaneous fat and implants to address the muscle volume.

Over the years multiple physicians and mathematicians have tried to define beauty and what constitutes a beautiful human form. It was Howard [2] who first described the ideal length proportions of the calves, basing his paper's findings on the drawings of Leonardo da Vinci. Howard defined the golden ratio of calf aesthetics to exist when the distance between the ankle and the lower border of the gastrocnemius muscle was equal to the distance between the knee and the most prominent point on the medial curvature of the gastrocnemius muscle; and the entire length of the gastrocnemius should be 1.6 times the former value. This golden ratio correlated to the golden section of 1:1.618 as defined by the Italian mathematician Bonacci or what German astronomer and physicist Johannes Kepler called the "divine proportion" (Fig. 8.1) [3].

Szalay [4], based on his 12 years of experience with calf augmentation, also helped to define the aesthetics of the calf by determining that the attractive range for female calf circumference is between 33 and 36 cm. Values outside this range were considered aesthetically unattractive [4, 5].

History of the Procedure

Over the course of the last 40 years since the introduction of calf augmentation for reconstructive purposes, there have been various surgeons that have proposed novel implant shapes and sizes along with varying locations for the placement of the implants [3–13]. The implant most commonly used today is largely based on the silicone gel implants of Glitzenstein [2]. However, Carlsen [14] was the first to use calf implants

N.V. Chugay et al., *Body Sculpting with Silicone Implants*,
DOI 10.1007/978-3-319-04957-1_8, © Springer International Publishing Switzerland 2014

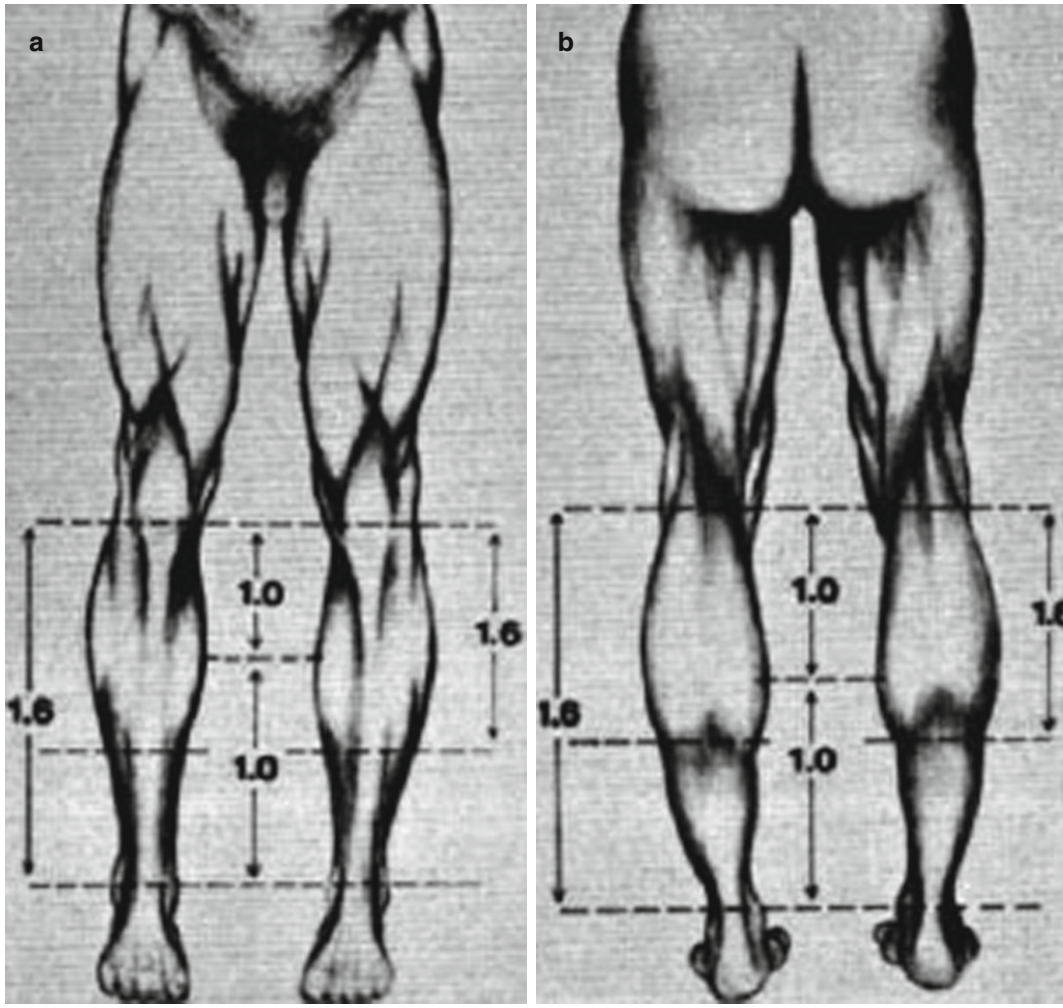


Fig. 8.1 Golden ratio of calf aesthetics [6]

back in 1972. His initial implant was made out of Silastic foam. Glitzenstein, in 1979 [2], used calf implants for patients with atrophy of the leg and muscular aplasia. Unlike Carlsen, his implants were designed from silicone gel. In 1984, Szalay [4] introduced torpedo-shaped implants that were placed beneath the fascia. In his technique, however, he did recommend the use of relaxing incisions in the fascia. Aiache in 1991 [13] introduced lenticular-shaped implants. In 2006, Gutstein [9] described a new silicone prosthesis that enhances the curved medial lower leg which he termed a "combined calf-tibial implant."

The early pioneers of the procedure, Carlsen and Glitzenstein, introduced the implant into a subfascial plane. However, in 2003 Kalixto and Vergara [8] described a calf augmentation with placement of the implant in a submuscular pocket, between the gastrocnemius and soleus muscles. The dissection that they proposed was done far away from the union of the gastrocnemius muscles where there were no vessels or nerves that could be damaged. It was noted however that these patients had a more tedious dissection and prolonged recovery than the patients who had undergone subfascial implant placement as described in previous reports. The use of muscle relaxants was paramount in these patients. The rationale for submuscular placement, according to the authors, was that they were able to gain better camouflaging of the implant. In 2004, Nunes described a method for calf augmentation

that placed the implant in a supraperiosteal plane associated with fasciotomies. Ultimately, it is at the surgeon's discretion where to place the implant; however, based on anatomic studies it seems that the subfascial plane is a safe plane that allows for reproducible results with minimal risk of postoperative complications and significantly less pain from the patient's perspective [12]. It is for this reason that the authors favor a subfascial plane in the medial aspect of the calf.

Indications

Calf augmentation was originally designed to fill defects left following oncologic surgery, after trauma or infection, or due to genetic abnormalities. There are many causes for unilateral or bilateral calf deformities, and they include but are not limited to the following: (1) congenital hypoplasia due to agenesis of a calf muscle or adipose tissue reduction; (2) as a sequelae of clubfoot (talipes equinovarus), cerebral palsy, polio, and spina bifida; (3) due to poliomyelitis or osteomyelitis; and (4) following fractures of the femur and as a result of burn contractures [2, 6, 7, 14]. While calf implants do not improve function of the affected extremity, patients are pleased with the improved aesthetic appearance of the leg after implantation.

Since its initial introduction, calf augmentation surgery has become a widely popular aesthetic procedure to help patients gain more shapely legs. Whether it is a body builder that is looking to "bulk up" the leg despite a vigorous exercise regimen or the average patient who wants a more shapely calf region, there are implants of various shapes and sizes to help add volume to a hypoplastic calf.

Contraindications

Contraindications to the calf augmentation procedure are few. The first is unrealistic expectations on the part of the patient. The patient must be fully aware of the amount of augmentation that can be safely achieved. Patients that desire a more substantial augmentation may be candidates for serial operations but must be prepared for this fact up front. Secondly, patients with severe medical conditions that place the patient in a high ASA classification and at significant surgical risk are not good candidates for elective calf augmentation surgery. The surgeon must always be cognizant of the patient's circulation to the lower extremity. Compromised circulation in the postoperative period can be disastrous and cause limb loss. A patient who already has preexisting arterial or venous insufficiency may be at an increased risk of limb loss and may be a poor candidate for surgery.

Limitations

Some authors have noted that calf prostheses have the disadvantages of being unable to adequately correct ankle deformities, having a risk of displacement, having a risk of capsular contracture, and potentially having problems with extrusion. While the authors do agree that calf augmentation does not correct ankle deformities, they feel that this can be addressed with judicious fat grafting to the ankle region via small stab incisions at the medial and lateral malleoli.

Relevant Anatomy

As a result of anatomic studies [12] and operative dissections, the anatomy of the calf region is well understood. The calf is made up of two muscle groups: the gastrocnemius and the soleus (Fig. 8.2). The gastrocnemius has two heads and lies superficial to the deeper soleus muscle. The two heads of the gastrocnemius are connected to the condyles of the femur by strong tendons. The medial and larger head originates from a depression at the upper and back part of the medial condyle and from the adjacent part of the femur. The lateral head arises from an impression on the side of the lateral condyle and from the posterior surface of the femur immediately above the lateral part of the condyle. The fibers of the two heads unite at an angle in the midline of the muscle in a tendinous raphe, which expands into a broad aponeurosis. The aponeurosis, gradually contracting, unites with the tendon of the soleus and forms the calcaneal tendon (Achilles tendon). In performing

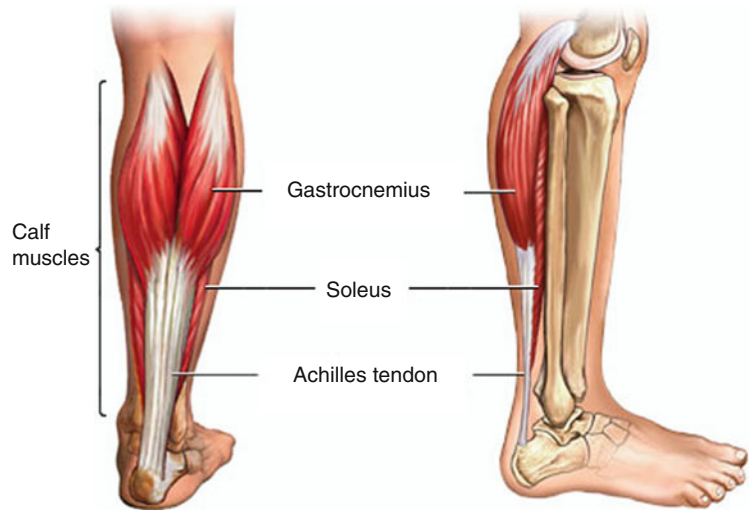


Fig. 8.2 Major muscles of the calf region: gastrocnemius and soleus

the dissection to attain a subfascial plane, the lateral and medial cutaneous nerves, branches of the peroneal nerve and tibial nerve, respectively, are potentially encountered. These nerves provide sensory innervation to the skin (Fig. 8.3). The medial sural cutaneous nerve originates from the tibial nerve of the sciatic and descends between the two heads of the gastrocnemius. It can be identified prior to diving between the heads of the gastrocnemius in the upper midline calf region. The lateral sural cutaneous nerve supplies the skin on the posterior and lateral surfaces of the leg and travels in a subcutaneous plane alongside the small (short) saphenous vein, joining with the medial sural cutaneous nerve to form the sural nerve. Major arterial, venous, and nerve structures are deep within the calf and remain undisturbed during a routine calf augmentation procedure (Fig. 8.4). The subfascial plane in the medial calf region is relatively avascular, allowing for creation of a relatively bloodless plane. Care must be taken to avoid injury to the short saphenous vein which lies deep to the investing fascia of the leg and superficial to the gastrocnemius in the midline posteriorly. This vein drains into the popliteal vein in the popliteal fossa.

Consultation/Implant Selection

The consultation begins with a thorough medical history on the patient. Special attention is taken to ask specifically about trauma to the extremity, history of surgery to the foot or ankle, history of vascular insufficiency which may put blood flow at risk, history of venous insufficiency or leg swelling which may prolong postoperative edema in the lower extremity, and any history of nerve damage or sensory deficits as may be seen in patients with diabetes mellitus. At the time of consultation, the patient is asked what specifically about their calf bothers them. Preoperative goals are assessed at this point. A patient who has unrealistic expectations and is unable to comply with the strict postoperative instructions is deemed a poor candidate for augmentation. Patients who have congenital anomalies, a significant size disparity between the two calves, or bilateral hypoplasia are informed that several surgeries may be required to attain symmetry and achieve the augmentation they desire. In the typical consultation, patients are asked if their deficiency lies primarily in the medial aspect of the calf, the lateral aspect of the calf, or whether they would like a larger calf size overall. The reason for this distinction is to help the surgeon plan the right implant style for surgery.

After completion of the history, the patient's calves are evaluated. The symmetry of the two sides is assessed and any disparity is brought to the attention of the patient. Although the majority of patients present with a preexisting asymmetry of the calves, not many patients note the difference and this can be a source of medicolegal matters in the future. If the patient suffers from

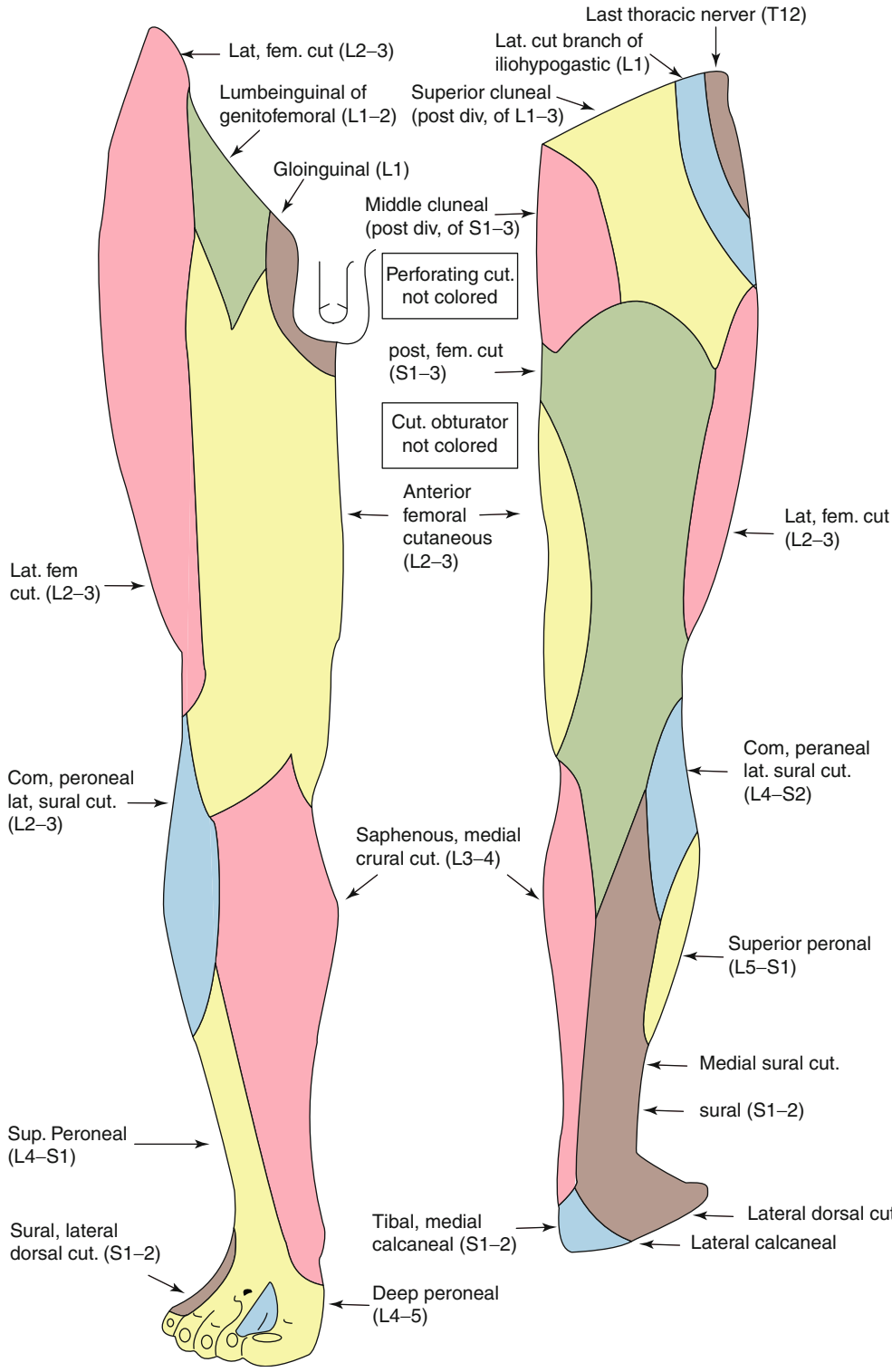


Fig. 8.3 The lateral and medial cutaneous nerve dermatomes are seen here. These are branches of the peroneal nerve and tibial nerve, respectively, and are potentially encountered in dissection for calf augmentation. These nerves provide sensory innervation to the skin in the area

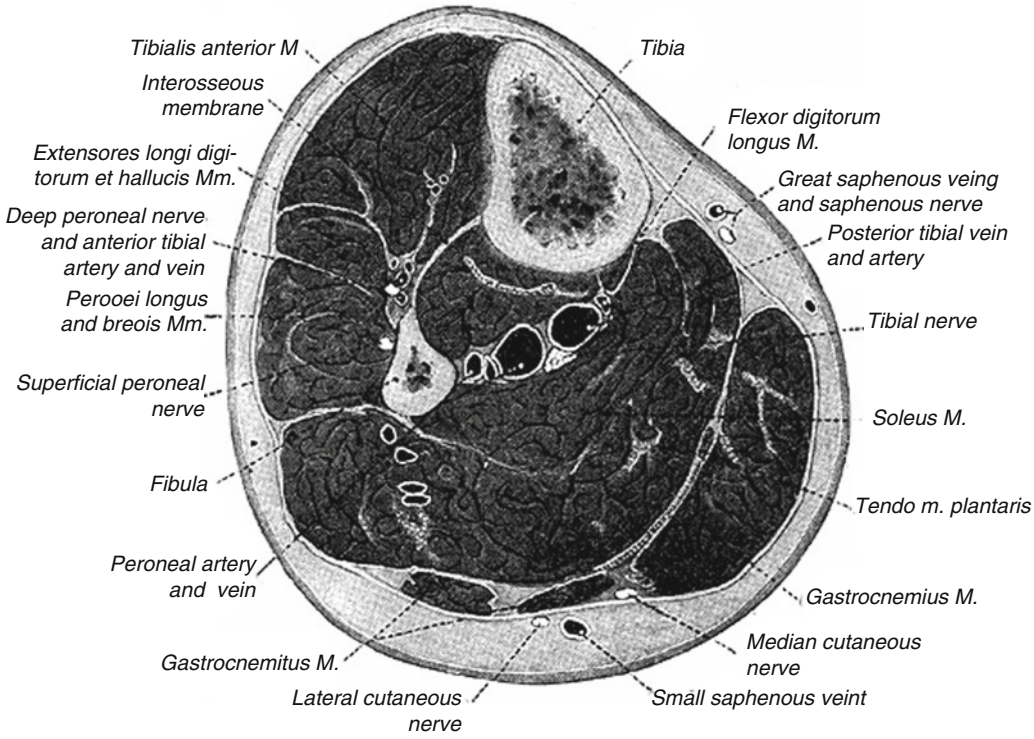


Fig. 8.4 Major neurovascular structures are seen in this cross section of the midportion of the calf. When performing a subfascial augmentation, these structures are relatively safe from injury

clubfoot deformity or a previous bout of polio, leg asymmetry is noted. The physician then evaluates the quality of the skin, subcutaneous tissue, and muscle. A person who has very thin tissues or significant hypoplasia of the calf may not be able to adequately accommodate a large implant. The patient's calves are measured in circumference at the midportion of the calf. A second measurement, from the popliteal fossa (proposed incision line) to the insertion of the Achilles tendon, is also taken. Having this second measurement allows one to assess the maximum length of implant that can be accommodated in the calf.

When determining the type of implant to use, the determination is based on the desires of the patient. However, the authors also take into account the length from the popliteal fossa to the insertion of the Achilles tendon to better define the length that will be accommodated. If the patient merely wishes to have more definition in the calf, then the style 2 implants will be used in most cases. With the style 2 calf implant, there is a greater enhancement of the medial calf muscle (Fig. 8.5). If, however, the patient wishes to have more overall volume to the calf region and is looking for more of a blocklike appearance to the calf, then the style 1 implant is favored (Fig. 8.5). With the style 1 implant, there is a greater enhancement of the entire calf region, which in our practice is best suited for patients who already have a great deal of muscle volume (e.g., body builders) and just want an overall increase in volume. Style 3 is used for lateral head augmentation and is rarely used. Each of the different style implants has a range of sizes to fit each patient need. Regardless of the implant chosen, the position of the implant is still in the subfascial plane and minimizes dissection around key neurovascular structures. With experience, the surgeon will be better able to determine the best implant for each patient.

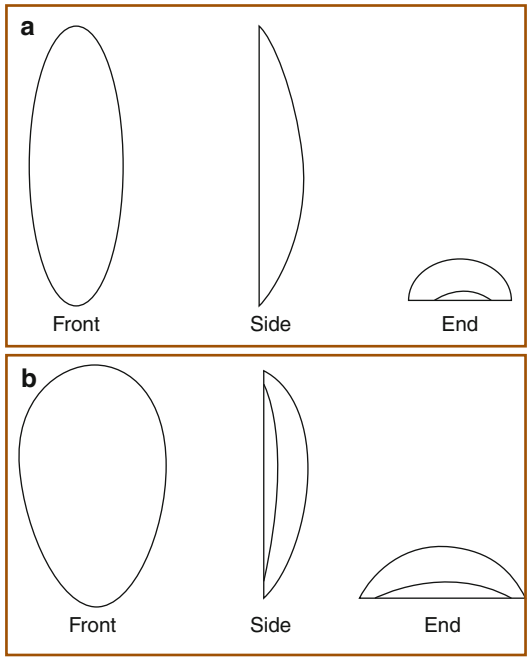


Fig. 8.5 (**a**) Calf implant style 2 (Courtesy of AART (Aesthetic and Reconstructive Technologies, Inc., Reno, NV)). (**b**) Calf implant style 1 (Courtesy of AART (Aesthetic and Reconstructive Technologies, Inc., Reno, NV))

Available Implants

Style 1 is the authors' preference for bulky calf augmentation (Table 8.1). Style 2 is the authors' preference for medial calf augmentation (Table 8.2). Style 3 is the authors' preference for lateral calf augmentation (Table 8.3).

Preoperative Planning and Marking

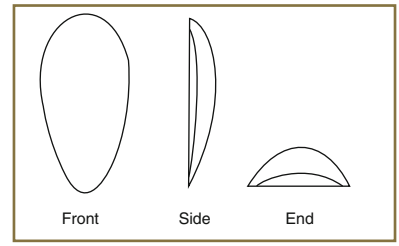
On the day of the surgery, the patient is met in the preoperative holding area. It is here that the patient's consent is verified and again risks, benefits, and alternatives are reviewed with the patient. With the patient in the erect position, the proposed site of incision is marked, measuring approximately 5 cm. The site of incision should be in line with the patient's natural crease in the popliteal fossa. To help accentuate this crease and make marking easier, the patient may be asked to hold on to a stationary object and flex at the knee. Once the site of the incision is marked, the site of the proposed implant is marked taking into account the patient's anatomy and existing deficit along with the desires of the patient (Fig. 8.6).

Operative Technique

Medial Calf Augmentation

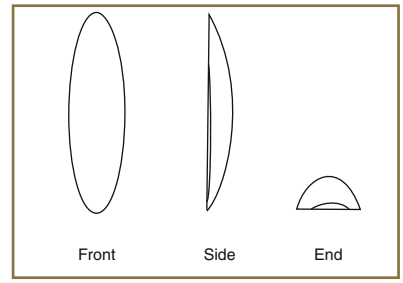
The surgery can be performed under general anesthesia or under simple local anesthesia; however, our preference is to use monitored anesthesia care with propofol and ketamine. Two grams of Ancef are administered prior to the incision for prophylaxis (if allergic to penicillin or cephalosporin, then intravenous (IV) clindamycin 300 mg is administered). The patient is repositioned in the prone position after administration of anesthesia. The calves are then prepped with Betadine, and each calf is injected with a total of 50 mL of 1 % lidocaine with epinephrine in the area of proposed implant placement. The patient is then reprepped and draped in sterile fashion. A 5 cm incision is made in the popliteal fossa in line with preoperative markings (Fig. 8.7). Dissection is performed through the subcutaneous tissues using a combination of blunt dissection with gauze and a hemostat. Further dissection and hemostasis can be achieved with electrocautery (Fig. 8.8). Dissection is carried to the level of the popliteal fascia (Fig. 8.9). On reaching the fascia, a #15 blade scalpel is used to make a transverse incision. This is extended with Metzenbaum scissors medially and laterally. At this point 2-0 Vicryl stay sutures are placed in each section of the fascia (Fig. 8.9). A subfascial plane, beginning beneath the popliteal fascia and extending into the deep investing fascia of the leg, is then dissected using blunt finger dissection and a spatula dissector, ensuring an adequate plane for the implant in the medial aspect of the calf (in line with preoperative markings/patient wishes) (Fig. 8.10). While performing this dissection, care is taken to avoid injury to the short saphenous vein which runs in the midline posteriorly and lies deep to the investing fascia of the leg along the surface of the gastrocnemius. Once a sufficient pocket

Table 8.1 Style 1 (Aesthetic and Reconstructive Technologies, Inc., Reno, NV)



Size	Catalog #	Width	Length	Projection	Volume (cc)
1	502–101	6.2	12.7	1.6	53
2	502–102	6.9	13.9	1.7	68
3	502–103	7.8	14.2	1.9	91
4	502–104	9.5	16.3	2.0	131
5	502–105	11.3	17.3	2.7	275
6	502–106	9.5	16.3	2.5	147
7	502–107	9.7	17.2	2.3	192

Table 8.2 Style 2 (Aesthetic and Reconstructive Technologies, Inc., Reno, NV)



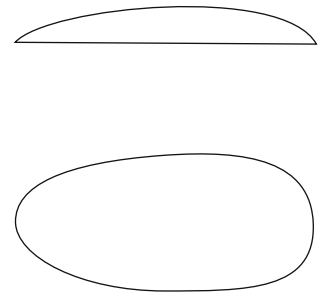
Size	Catalog #	Width	Length	Projection	Volume (cc)
1	502–201	6.1	17.4	2.1	94
2	502–202	6.5	20.7	2.3	126

is dissected, the pocket is irrigated with a solution containing normal saline, Betadine, Ancef, and gentamicin. Fifteen milliliters of 0.5 % Marcaine is injected into the pocket for postoperative analgesia. A lozenge-shaped implant is then placed into the pocket, making sure to attain symmetry (Fig. 8.11). Once the implant has been placed, symmetry is assessed. At this point closure is begun. The fascia is re-approximated with 2-0 Monocryl suture in interrupted fashion (Fig. 8.12). The deep dermis is re-approximated with 3-0 Monocryl suture in buried fashion. The skin is closed in subcuticular fashion with 4-0 Vicryl suture or with interrupted 4-0 silk sutures (based on surgeon preference). The same procedure is mirrored on the contralateral side. The legs are wrapped with Coban and the patient is then taken to the postanesthesia care unit (PACU).

Lateral Calf Augmentation

If the patient is in need of lateral calf augmentation, the same incision in the popliteal fossa may be used to augment the lateral calf. In this case, dissection is carried out below the popliteal/deep investing fascia of the leg over the lateral head of the gastrocnemius muscle. Incision is made in the same manner as described above and can be carried further lateral in the popliteal fossa to facilitate implant placement in the lateral calf. Subcutaneous dissection is carried out down to

Table 8.3 Style 3 (Aesthetic and Reconstructive Technologies, Inc., Reno, NV)



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0	502–300	5.2	12.5	1.5	49
1	502–301	6.5	14.0	1.7	72
2	502–302	6.7	14.3	1.8	80
3	502–303	8.0	14.6	2.0	133
4	502–304	9.5	16.5	2.2	163
5	502–305	6.2	13.5	1.6	68
6	502–306	6.5	14.5	1.8	81
7	502–307	7.9	14.7	2.0	110
8	502–308	9.1	17.1	2.0	144
9	502–309	5.7	12.4	1.5	47

the level of the deep fascia of the leg. An incision is made in the fascia and extended with Metzenbaum scissors. Stay sutures are placed in this fascia (Fig. 8.13). Dissection is performed in the subfascial plane with a combination of blunt finger dissection and a spatula-type dissector as described for medial calf augmentation (Fig. 8.14). The fibula is used as the medial extent of dissection, and as in the medial calf augmentation, dissection is carried caudally until resistance is met at the insertions of the deep investing fascia near the level of the ankle (Fig. 8.14). Just as with medial augmentation, the implant is positioned and closure is performed in layers (Fig. 8.15).

Postoperative Care Instructions

Postoperatively the patient may begin ambulating starting on the evening of the procedure. They may shower on the second postoperative day, making sure to keep dressings clean and dry the Robbins tape with a hair dryer on a low-heat setting. Patients are allowed to begin light activity at week 2 and full unrestricted activity at weeks 4–6. Patients are asked to wear compression stockings with a grading of 20–30 mmHg for 4 weeks postoperatively to prevent dead space, thereby helping to reduce the risk of seroma formation. The legs are to be elevated as much as possible to allow for better lymphatic/venous drainage. Patients are prescribed both narcotic analgesics and muscle relaxants (diazepam 5 mg every 8 h as needed for spasm) to assist with postoperative pain.

Complications

In performing calf augmentation, there is a host of complications that can arise (Table 8.4).

Infection

Infection, either superficial or deep, is a possibility in calf augmentation surgery. The literature

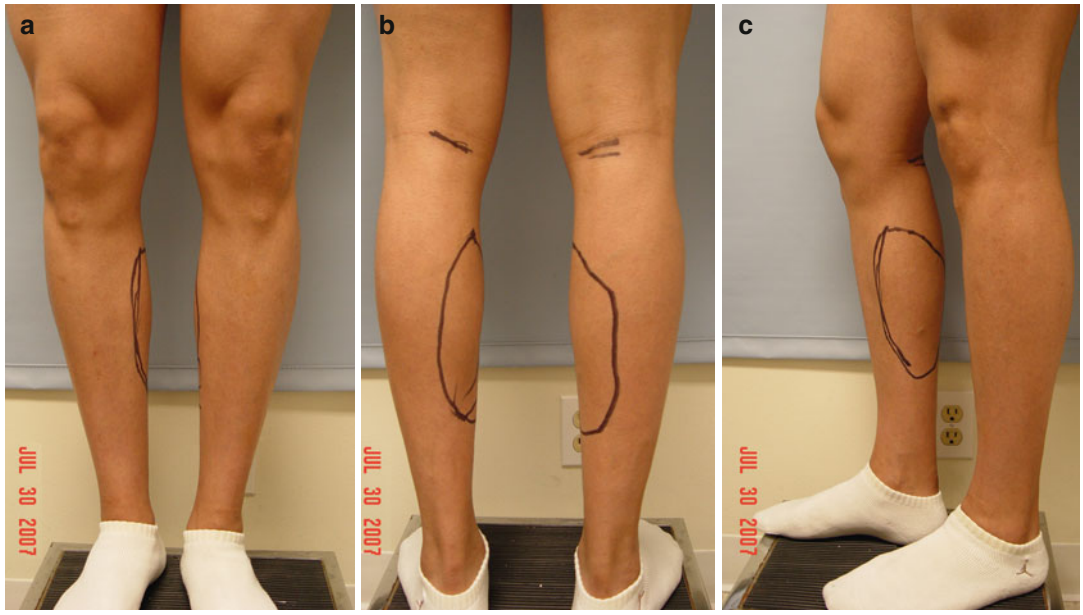

Fig. 8.6 (**a**–**c**) Preoperative markings for calf augmentation surgery. Note the site of the incision in the popliteal fossa and the outline of the site for calf augmentation. The markings for implant position are done in concert with the patient to maximize patient satisfaction postoperatively

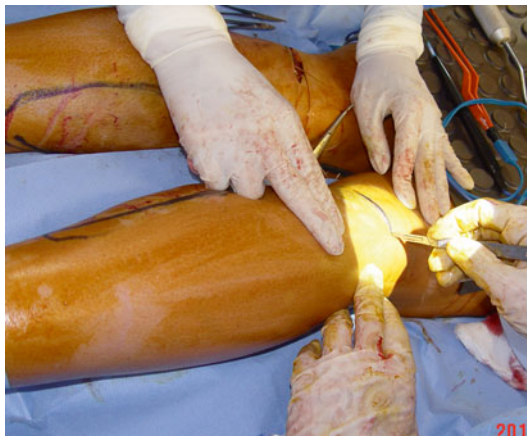

Fig. 8.7 Incision at the popliteal fossa

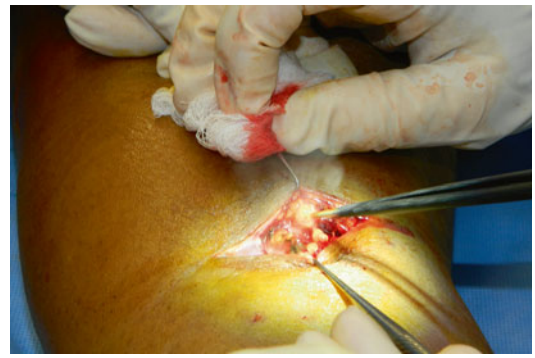

Fig. 8.8 Dissection through the subcutaneous tissues using electrocautery. Single-tooth hooks are used for retraction of the skin

reports infection rates between 0 [8] and 3.3 % [6]. Species identified in the authors' experiences were isolated to *Staphylococcus aureus* and *Staphylococcus epidermidis*, relatively common skin flora. Prior to making an incision, standard practice should be the administration of 2 g of intravenous (IV) Ancef (or 300 mg IV clindamycin in a penicillin- or cephalosporin-allergic patient). During the procedure, irrigation of the pocket with a standard antibiotic solution containing normal saline, Betadine, Ancef, and gentamicin should be performed. Postoperatively, a 7–10-day regimen of oral antibiotics covering normal skin flora should be administered. If a deep infection occurs, the standard practice is removal of the implant, closure, and possible reimplantation in 3–6 months. There are reports in other forms of implant surgery that conservative management and implant salvage are

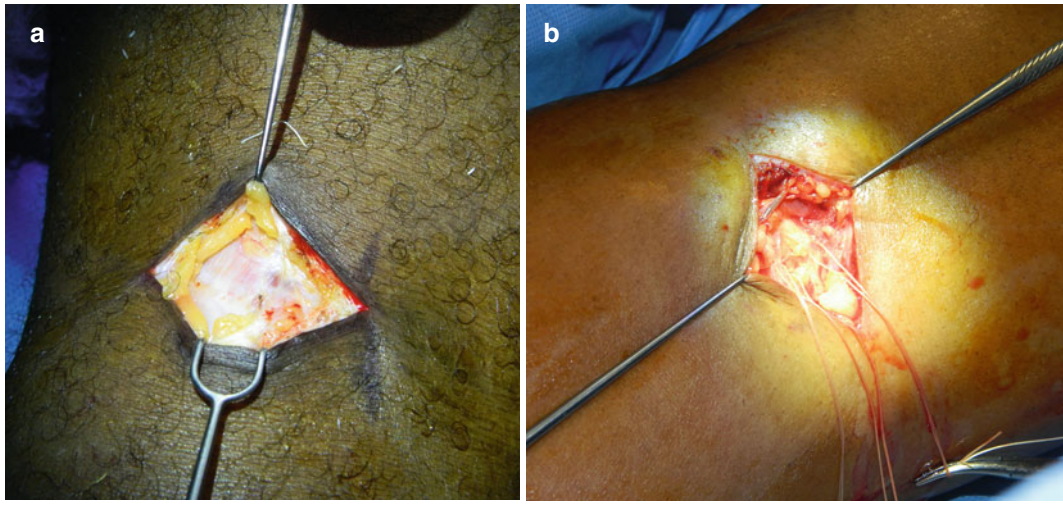

Fig. 8.9 (**a**) Deep investing fascia of the leg (glistening). (**b**) Incision has been made through the investing fascia with stay sutures being placed in the superior and inferior aspect of the cut fascia. The authors' standard is to put one up and two down as the inferior portion of the fascia tends to retract, and secure fascial sutures are key to helping re-approximation at the end of the case

possible. This should be left at the discretion of the surgeon and performed with careful counseling of the patient.

Seroma

Seromas are statistically the most common complication occurring in calf augmentation surgery, occurring in approximately 6 % of cases in most large volume studies [4, 12, 15, 16]. They typically present as new-onset pain, swelling, or asymmetry. The treatment of choice remains percutaneous aspiration. This complication is best prevented with patient compliance with compression stockings and proper implant placement at the time of surgery, thereby minimizing dead space.

Hematoma

Although this is a rare occurrence due to the relatively avascular plane of dissection for the calf augmentation procedure, a hematoma is always possible if damage is done to the vessels that perforate the investing fascia of the leg [12]. In the event of a hematoma, rapid evacuation, pocket irrigation, and reimplantation are the mainstays of therapy. This complication is best prevented by meticulous hemostasis at the time of surgery and good compression of the calf post-op to prevent potential space creation.

Old blood that has not been well absorbed by the body can be found at later dissection as a course granular material resembling fine gravel. A patient returned to the authors' practice 16 years after initial augmentation complaining of nodularity in the calves. He wished to have the calf implants out as they were too bulky for their present age. On return to the OR, the implants were removed and fine calcific material was found which explained the previously described nodularity (Fig. 8.16). Final pathology demonstrated significant calcifications and no evidence of malignancy.

Asymmetry

This can occur as a product of preexisting variability in the patient's legs or variability in dissection of the pocket bilaterally. This is best minimized by good preoperative photography

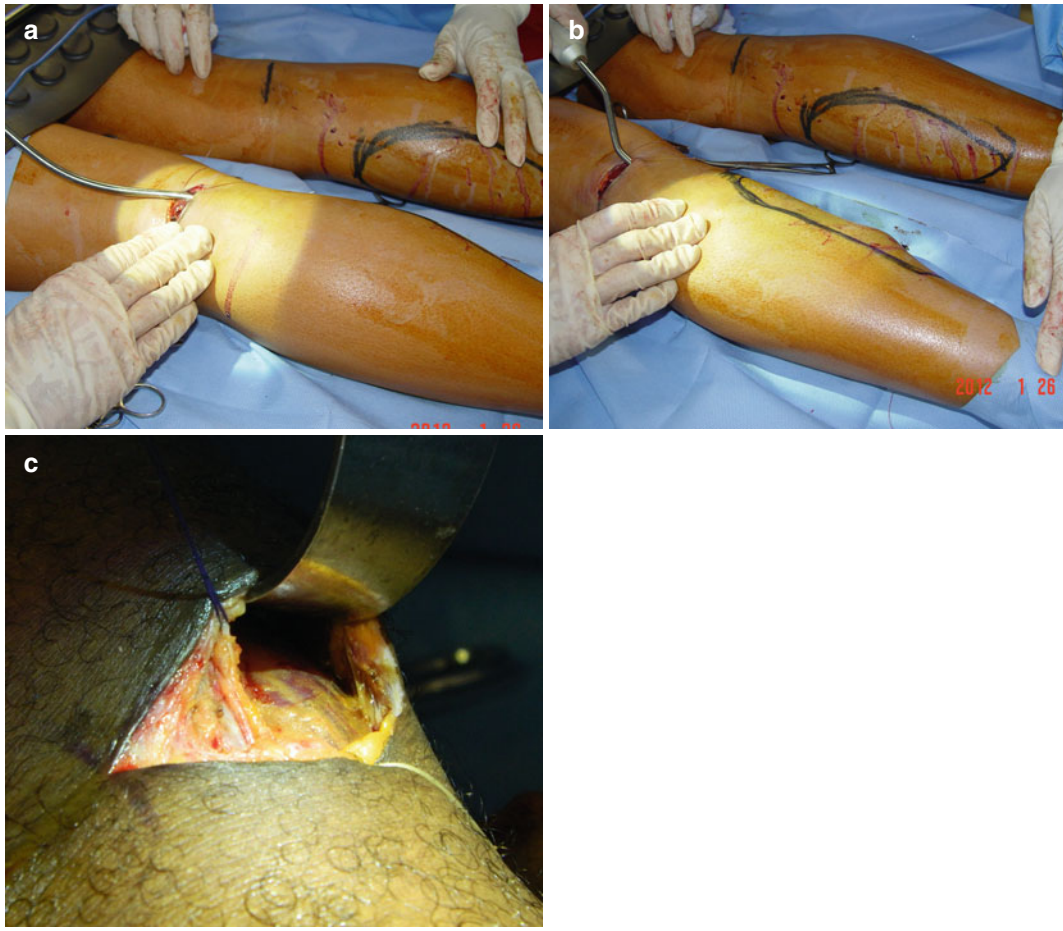

Fig. 8.10 Dissection of the subfascial pocket. (**a**) After initial dissection of the pocket using blunt finger dissection, a spatula dissector is used to further dissect the pocket. (**b**) The dissector tip is noted in the midportion of the calf tenting up the skin overlying the subfascial pocket. (**c**) At completion of dissection, there is an ample pocket that has been created with the gastrocnemius muscle seen below

and noting any asymmetries preoperatively. To avoid creation of asymmetry, it is important to maintain the same pattern of dissection and pocket creation bilaterally. Patients, like those suffering from clubfoot, must be made aware of the fact that despite multiple surgeries, they may never achieve absolute symmetry in their legs (Fig. 8.17).

Implant Visibility

Due to the subfascial placement of the implant, this is indeed a rare complication. However, those patients that have very thin and atrophic legs to begin with may suffer from implant palpability and visibility. Patients should be counseled on this fact preoperatively if there is a feeling that the patient could be at risk.

Scar Hyperpigmentation and Hypertrophy

In reviewing the primary author's (NVC) two-decade history with the procedure, the most frequent complication observed was hypertrophic or hyperpigmented scarring. This may be a function of the author's patient population which is primarily Hispanic and has a higher tendency to

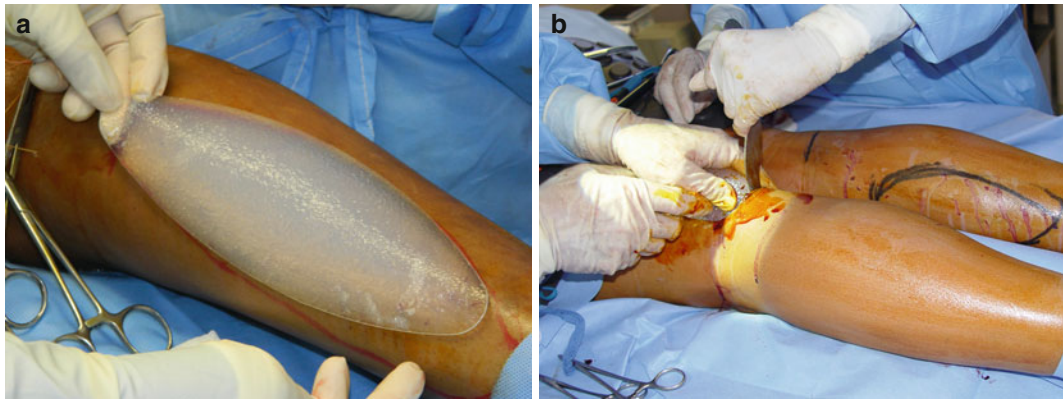

Fig. 8.11 (**a**) The implant (style 2, size 2) being demonstrated in its position in the right medial calf. (**b**) Insertion of the prosthesis into the subfascial pocket taking care to fold the implant along its long axis to facilitate positioning

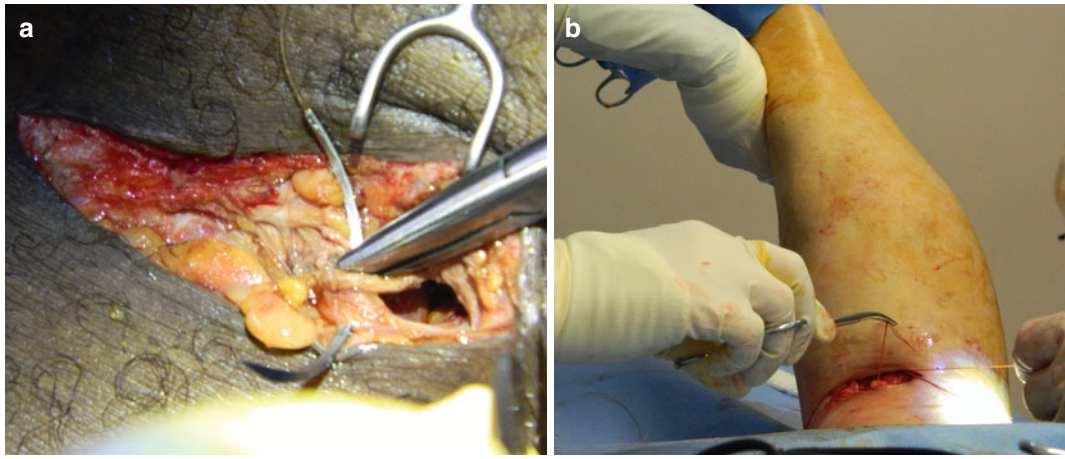

Fig. 8.12 (**a**) Closure of the deep investing fascia of the leg using 2-0 Vicryl suture. (**b**) To facilitate closure and take tension off of the ends of the fascia, the knee is flexed by the assistant

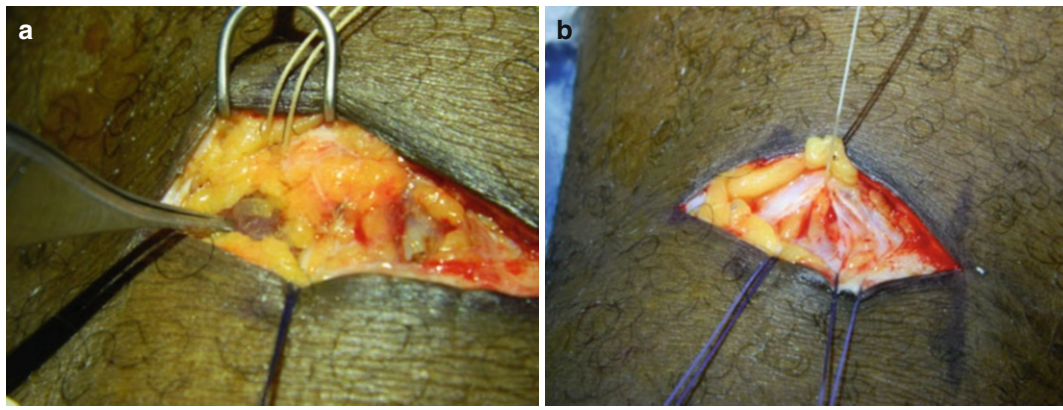

Fig. 8.13 (**a**) Incision has been made in the deep investing fascia showing the lateral head of the gastrocnemius muscle (9 o'clock). (**b**) Stay suture being placed in the fascia

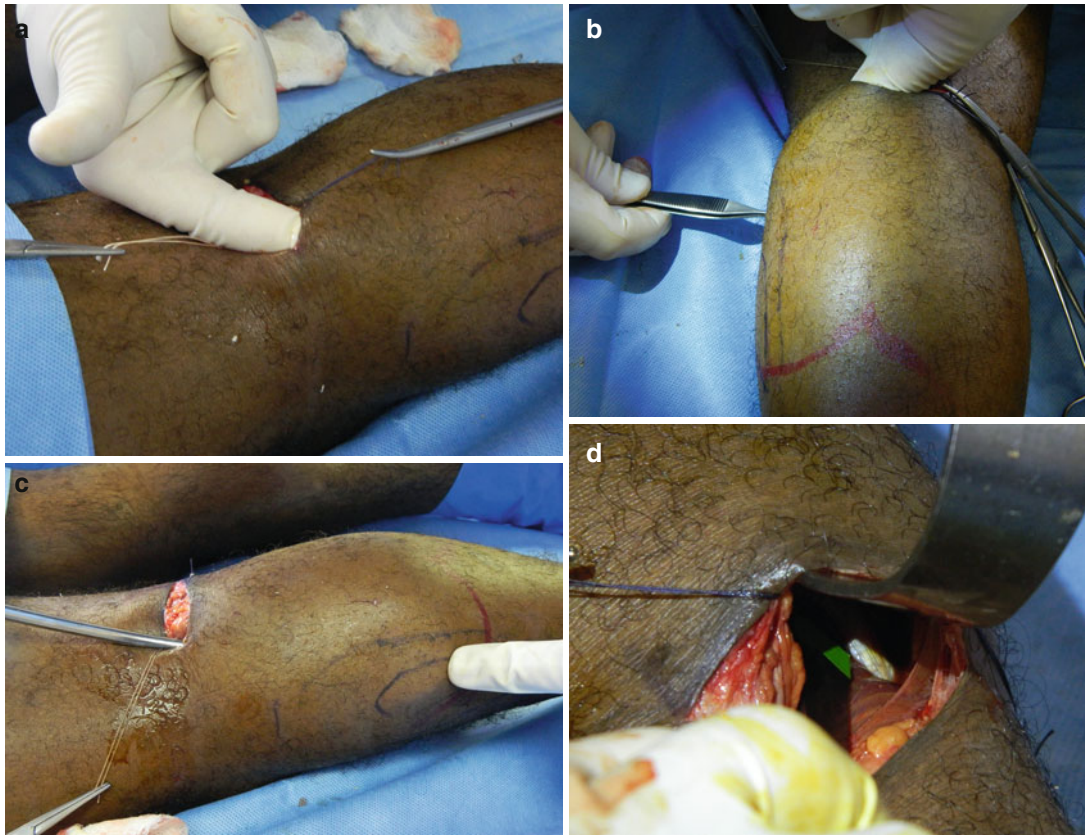

Fig. 8.14 Dissection of the subfascial pocket. (**a**) Dissection begins with blunt finger dissection. (**b**) Dissection is taken lateral to the shaft of the fibula (marked with tip of forceps). (**c**) Further dissection of the implant pocket is carried out with spatula dissector. (**d**) Demonstration of the completed subfascial pocket with the glistening lateral head of the gastrocnemius visualized

form hypertrophic and/or hyperpigmented scars. The key to reduction of these problems is careful layered closure.

Capsular Contracture

This is a possible late sequelae of any implant placement, most frequently described in the breast augmentation literature. The literature in calf augmentation has described a rate between 0 [3–5, 11] and 5 % [6]. In the event that a patient presents with signs/symptoms of capsular contracture (e.g., induration of the implant site, tightness in the leg, new-onset pain, new-onset swelling), ultrasound or CT evaluation of the affected extremity is warranted. If a capsule is identified, typically characterized by calcifications, then a partial or complete capsulectomy is warranted. An alternative might be to perform capsulotomies as the removal of the capsule may be quite difficult in the confined space of the calf.

Wound Dehiscence

Wound dehiscence is a product of poor wound closure under too much tension typically. In addition patients who do not comply with limited activity restrictions can be at increased risk of wound dehiscence. In order to prevent dehiscence, meticulous closure in three layers

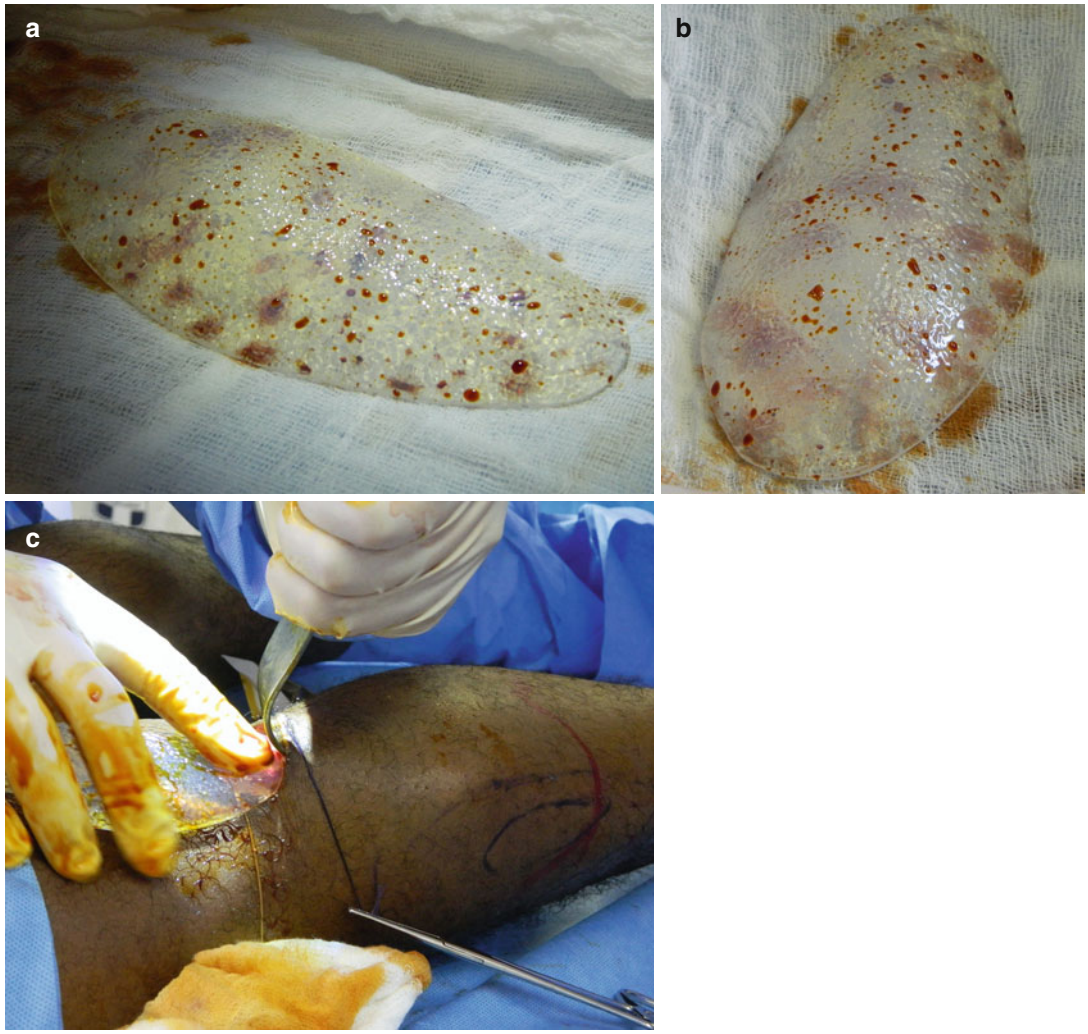

Fig. 8.15 The implant for lateral calf augmentation can be inverted if needed to give greater volume in the lower pole of the calf as in this patient who suffered from clubfoot deformity. (**a**) Natural position of the implant with bulk at the top tapering to a smaller point inferiorly. (**b**) Inverted position of the lateral calf implant (common for clubfoot patients who wish to achieve greater volume inferiorly in the leg region). (**c**) Insertion of the lateral calf implant

is paramount: fascia, deep dermis, and skin. While closing the fascia, the knee is flexed so as to bring about a good approximation of the fascia. Patient compliance with minimal activity in the first 2 weeks and light activity until the end of the first month is key. Even in the best-planned cases, dehiscence can occur and is typically found in the medial-most aspect of the incision due to the significant tension at this position (Fig. 8.18).

Nerve Injury

Due to the avascular and relatively structure-free dissection performed in the vast majority of cases, permanent nerve injury is rarely a problem. It is quite common for patients to complain of some numbness over the area of the popliteal fossa postoperatively; however, this returns within 1–3 months postoperatively. Major motor and sensory deficits can accompany

Table 8.4 Potential complications of calf augmentation

Potential complications of calf augmentation surgery
Infection
Seroma
Hematoma
Asymmetry
Implant visibility
Hypertrophic scarring
Hyperpigmentation of the scar
Capsular contracture
Wound dehiscence
Nerve injury (permanent or temporary, motor or sensory)
Compartment syndrome

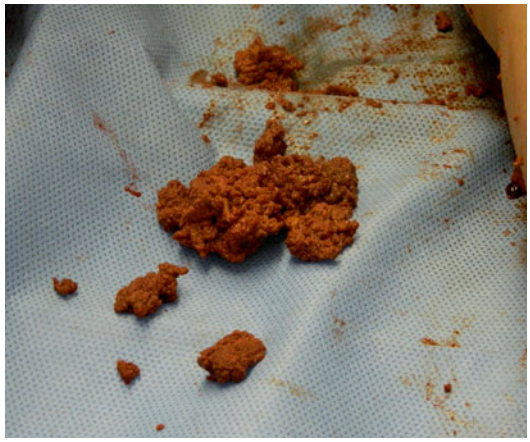

Fig. 8.16 Coarse granular material in a patient's calf region at time of implant removal 16 years after initial augmentation. The final pathology demonstrated significant calcifications but no malignancy

compartment syndrome, and this must be ruled out immediately if any significant deficits are appreciated.

Compartment Pressure Problems/ Compartment Syndrome

Compartment syndromes, typically seen in trauma, involve an acute increase in pressure inside a closed space, thereby impairing blood flow to the affected space and potentially putting the limb at risk for loss. Clinical signs of compartment syndrome include the 6 Ps: pain, poikilothermia, pallor, paresthesias, paralysis, and pulselessness. In conscious patients, pain out of proportion to examination is the prominent

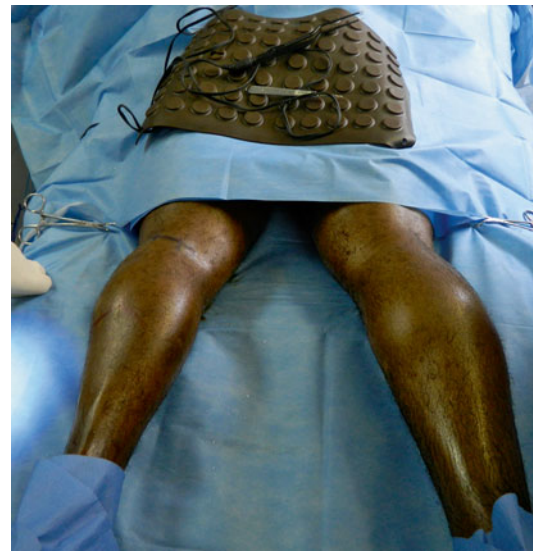

Fig. 8.17 This is a patient who suffers from left clubfoot deformity. He is athletic and wishes to have a more symmetric body. Despite a previous calf augmentation to the medial aspect of his left leg, he wishes to have further volume adjustment and is shown just prior to left lateral calf augmentation to achieve better symmetry. Even with the left lateral augmentation, there can never be a guarantee of achieving absolute symmetry

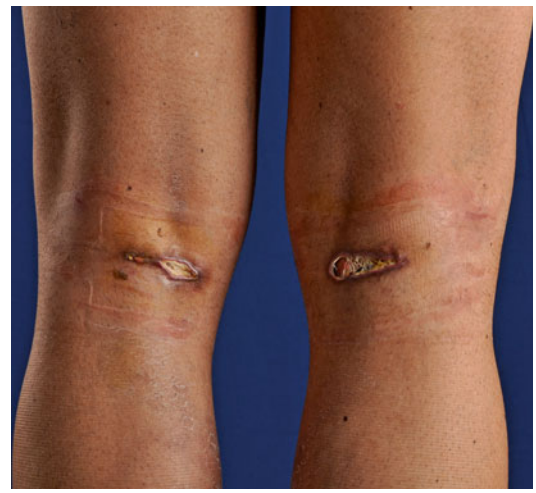

Fig. 8.18 Patient shown 2 weeks postoperatively with dehiscence of bilateral medial aspects of the popliteal incision and near complete dehiscence of the right calf incision. The patient later admitted to being more active in the first 2 weeks post-op than previously instructed, possibly resulting in his dehiscence

symptom. Pain with passive range of motion is particularly troubling. Paresthesias may also be described. In the lower extremity, numbness

between the first and second toes due to compression of the deep peroneal nerve in the anterior compartment is the hallmark of early compartment syndrome. Progression to paralysis can occur, and loss of pulses is a late sign. By the time pulselessness has occurred, it may be too late for limb salvage. In patients with a compatible history and a tense extremity, clinical diagnosis may be sufficient. If the diagnosis is in doubt, compartment pressures may be measured with a handheld Stryker device. An absolute pressure greater than 30 mmHg in any compartment, a pressure within 30 mmHg of the diastolic blood pressure in hypotensive patients, and a patient with a concerning history who demonstrates the constellation of signs and symptoms of compartment syndrome are all possible indications for surgical compartment release *via* fasciotomy [17].

In the case of calf augmentation, the cause of compartment syndrome is typically due to placing too large an implant in too small a space, thereby increasing the compartment pressure and causing arterial insufficiency or venous outflow compromise. However, due to the fact that the patient is post-op, there is an implant in place and postoperative edema is present. Therefore, diagnosis may be problematic. In an affected compartment, accurate pressure readings may be difficult to obtain and may be inaccurate due to the patient's postoperative state. Clinical assessment and clinical diagnosis is the mainstay in compartment syndrome in the postoperative calf patient. Patients who are suspected of having compartment syndrome should have serial neurovascular checks, and any worsening of the patient's examination warrants surgical intervention. A patient who is clinically stable, has evidence of decreased pain or clinical improvement, and is cooperative may be a candidate for further close observation and neurovascular monitoring rather than immediate surgical intervention [18].

Both of the following cases occurred in patients who had augmentation for leg asymmetry due to clubfoot deformity. These cases point to the fact that it is the job of the physician to take special care in these types of complex cases and be ever aware of the potential for compartment syndrome.

Case 1
Near-Compartment Syndrome with Dehiscence and Resolution

This 36-year-old male patient underwent an uneventful calf augmentation of the left leg for clubfoot deformity. A style 2, size 2 AART implant measuring 126 mL was placed in a subfascial plane without difficulty. Four days postoperatively, the patient presented with pain in his calf that had been quite severe for the past days until he noted minor serosanguineous drainage. On physical examination, he demonstrated a dusky appearance to the skin over the medial calf and dorsal aspect of the foot. He had an intact dorsalis pedis pulse, sensation was intact, and motor function was grossly intact. Serosanguineous drainage from his calf incision with compression of the leg and a slight dehiscence of the wound were noted. There was indeed pain on palpation over the entirety of the calf. He was promptly admitted to the hospital for admission and urgent ultrasound to evaluate for any collections or DVT. No collections or DVT were noted. The patient had regular neurovascular checks to follow progression of the suspected compartment syndrome. Likely due to the decrease in pressure resulting from wound dehiscence at the level of the fascia (as evidenced by the rush of serosanguineous fluid), the patient was able to avoid a full-blown compartment syndrome. Three days later the patient was discharged with resolution of his pain, a strongly palpable dorsalis pedis pulse, and good motor function in the lower extremity. He had no further sequelae and is now 2 years postoperative.

Case 2 (Fig. 8.19)
Near-Compartment Syndrome

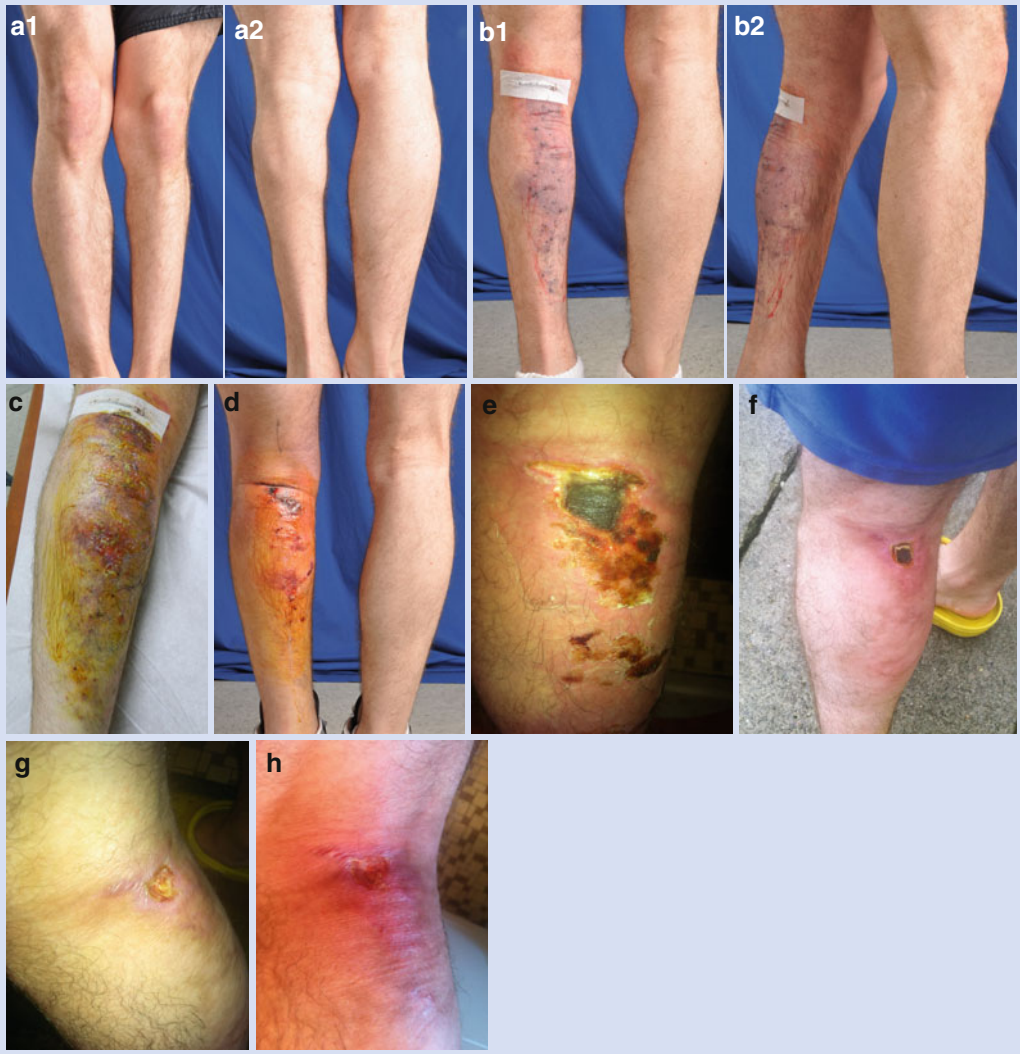

Fig. 8.19 (**a**) A preoperative 25-year-old male. (**b**) One day postoperatively, the patient is noted to have minimal bruising with a duskiness to the skin over the medial calf. The remainder of the leg is unaffected. (**c**) Two days postoperatively, the patient is shown to have more notable swelling with bruising and blistering over the medial aspect of his left leg. The leg has been painted with Betadine to help in the management of the blisters (drying them out). (**d**) Ten days postoperatively, the patient is shown with improved appearance to the leg with decreased swelling and blistering. (**e**) Two weeks after his surgery with necrosis over the site of the incision and scabbing over of the blisters. (**f**) 2.5 months after his initial surgery with significant contracture of his popliteal wound and healing of the skin in the areas that had previously blistered. (**g**) 3.5 months after his initial surgery with the scab in the popliteal fossa fallen off and continued contracture of the wound occurring. He still has no hair over the medial calf but coloration is continuing to improve. (**h**) The patient's medial calf 4 months after his initial surgery with granulation of the necrotic popliteal fossa and minor residual erythema of the leg in areas that have healed after blistering

This 25-year-old male presented with clubfoot deformity of his left leg which he had battled with since childhood. After consultation and implant selection, he had an uneventful left calf augmentation for clubfoot deformity. A style 2, size 2 AART implant, measuring 126 mL, was placed in a subfascial plane without complication. One day postoperatively, the patient presented with a foot that appeared dusky in color. His compression wrap was undone with return of color to the foot. His pain was not out of proportion to examination and the patient was ambulating on his operated leg. He had a strongly palpable pulse. His motor and sensory functions were intact except for a small area of numbness just below the site of the incision in the popliteal fossa. His foot was noted to be warm to touch. He was sent home with plans for follow-up on the next day, attributing his pale foot to a tight compression wrap postoperatively. He returned the following morning to the office with blisters over his leg and erythema of the calf region. Due to the fact that the patient desperately wanted to keep the implant if at all possible and did not have medical insurance, it was agreed in discussion with the patient and his mother that we would continue with close follow-up of the leg on a day-to-day basis. Any worsening of the condition would require prompt removal of the implant secondary to possible compartment syndrome. The patient was seen on a daily basis for wound assessment, pulse checks, evaluation of range of motion, and evaluation of sensation. The blistered areas were left intact and the calf was dressed with antibiotic ointment, as if treating any other pressure or burn wound. To minimize the risk of any additional pressure on the calf, the patient's compression garment was left off during the healing process. By postoperative day 10, the patient was much improved in the overall appearance of his leg and was ambulating and pain was minimal. He was cleared at this point to return home with plans for communication through email/phone. The patient did experience minor necrosis below the level of the popliteal fossa but had a full healing of the remainder of the skin overlying the calf. At no point in time did he ever have a complete loss of motor or distal sensory function. The foot was consistently warm and pulses were never lost. The patient was ambulating and even able to jog for short distances at 1 month post-op and continues to improve. The area of necrosis did granulate and heal by secondary intention without requirement of any further intervention by the fourth month postoperative. Once the scar has contracted, discussions will be had regarding scar revision to the affected area.

This case of near-compartment syndrome and its management may be criticized by some since there was not an immediate return to the operating room (OR) for implant removal. An open discussion was had with the patient and his mother regarding a return to the OR; however, since the patient had long wanted a corrective surgery for improvement of the aesthetics of his calf, he was willing to forego a trip to the operating room in the hope that his leg would slowly accommodate the increased volume. It was made clear that should any worsening of the patient's condition occur, we would be forced to immediately return to the OR for implant removal and limb salvage. This case clearly demonstrates the importance of a strong physician/patient relationship. To the patient's credit and to his mother's credit, they were consistently communicating with the physicians involved and took excellent care of the wounds in the postoperative period, allowing for good healing of the blisters and the popliteal fossa wound. While watchful waiting and close observation may be frustrating at times for both patient and surgeon, it is an option for those who wish to keep their implants in the face of a near-compartment syndrome. If there is deterioration of the patient or extremity at any point in time, a prompt return to the OR for implant removal is critical.

Special Cases

Reconstruction of the Hypoplastic Leg

In patients who have been afflicted with clubfoot, polio, or trauma, there is at times a noticeable discrepancy in the size of the lower extremities. For those patients wishing to achieve symmetry, a calf implant may be an ideal way to do so. However, that being said, a single augmentation may be insufficient to achieve symmetry.

Carlsen [15, 16], knowing this full well, designed a custom expander to slowly expand the calf region without having to subject the patient to multiple operations and risk possible issues of skin slough and excessively elevated compartment pressures. The expander designed had the following dimensions: 22 cm in length and 8 cm in width at the upper pole and 6 cm in the lower pole. This expander, which was filled with saline, was placed identically to the typical silicone calf implant and had a loop at the distal aspect which held a needle. Once the implant was well seated at the lower pole, near the malleolus, the needle was pushed through the skin and the implant was positioned as needed. The stitch was then cut at the skin level with the implant in position and an expander port was placed subcutaneously behind the knee. With this in place, Carlsen performed expansion every 7–10 days. At times, the expansion process could take 3–4 months, particularly in those patients with significant size discrepancies. Once the lower leg was overexpanded by 1 cm, Carlsen would remove the expander and place a solid silicone prosthesis.

While the idea of an expander makes sense, many patients are unwilling to go through a prolonged expansion period. In contrast, it has been the author's standard practice to place a smaller silicone prosthesis into position as per the technique described previously. Then 6 months later, after having stretched out the proposed implant pocket, a second procedure can be performed with either a larger standard implant or a custom-made implant. Regardless of the second operation performed, the patient is able to enjoy a fairly normal lifestyle free of return doctor visits for expansion and the possible discomfort associated with a port near the popliteal fossa. Although this method does require close attention in the postoperative period on the part of the patient and physician, it has been the author's experience that patients are much more content with the idea of this approach than the concept of slow expansion over time (Fig. 8.24). The following cases are examples of patients treated for hypoplastic legs. Staged operations are always discussed as a possibility but are not always required/desired.

Case 3 (Fig. 8.20)

A 17-year-old male was diagnosed with spina bifida occulta at birth. There was significant nerve damage due to lipomyelomeningocele which was removed at age 2 months. The patient and his mother wished to achieve greater symmetry between the left (hypoplastic) side and right side. He underwent augmentation of the left buttock (style 3, size 7) and left calf (style 2, size 1).

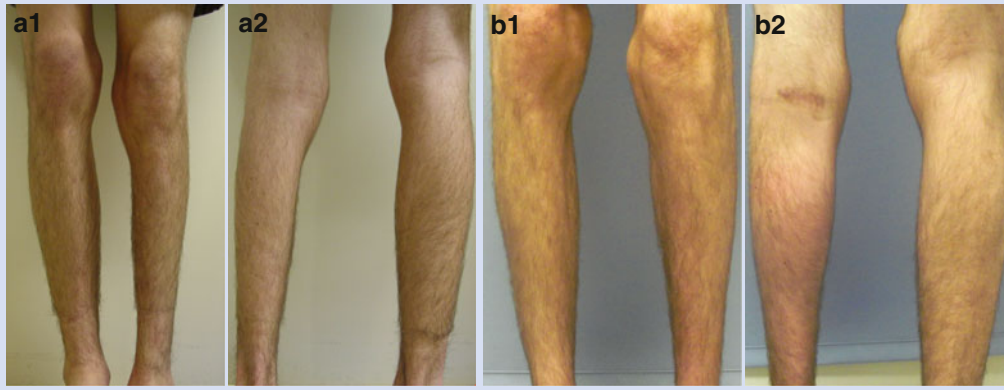

Fig. 8.20 (**a**) Preoperative. (**b**) Postoperative

Case 4 (Fig. 8.21)
A 56-year-old female had back surgery 12 years prior to presenting to the primary author. She had suffered a prolonged recovery with significant disability, leaving her right leg smaller than her left. She presented for augmentation of the affected limb with a style 2, size 1 implant to bring about greater symmetry.

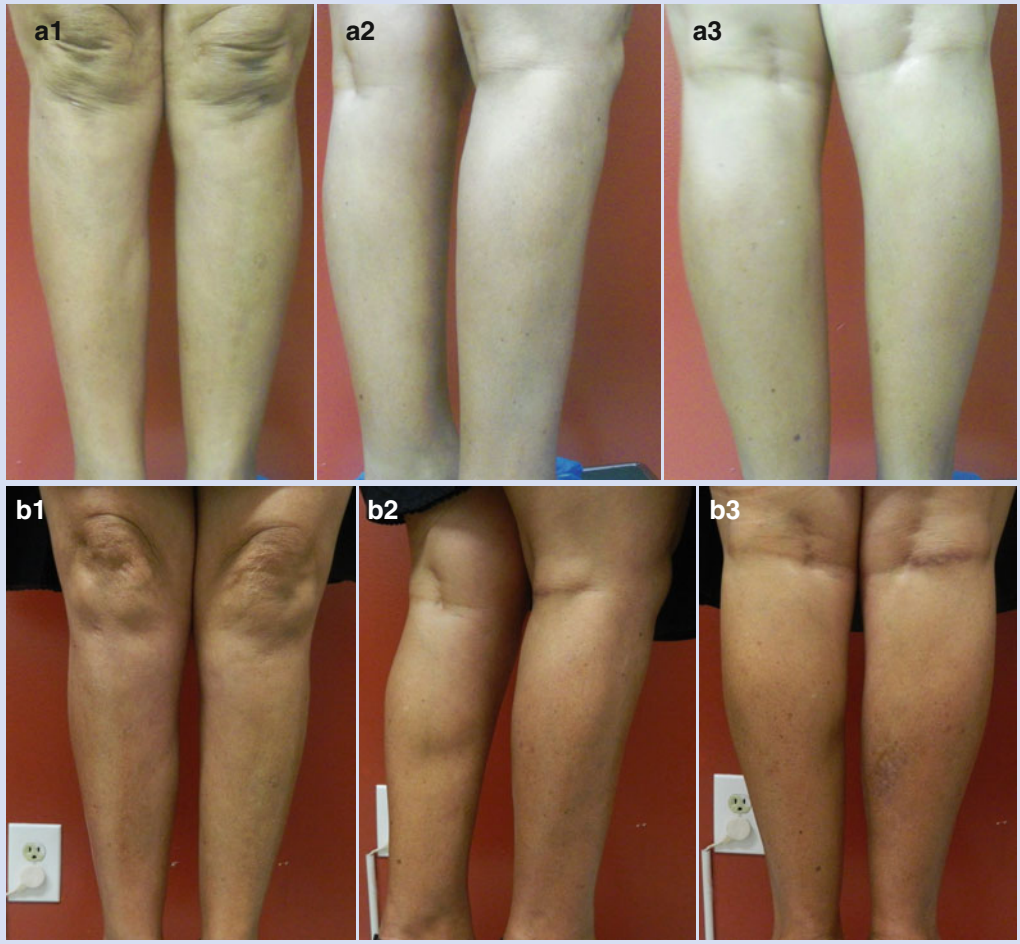

Fig. 8.21 (**a**) Preoperative. (**b**) Postoperative

Case 5 (Fig. 8.22)

A 38-year-old female suffered a trauma to her right leg as a child. She underwent many operations on the affected limb and developed a significant asymmetry. After presenting for consultation, she underwent medial calf augmentation with a style 2, size 1 implant to bring about greater symmetry. She is shown preoperative and 4 months postoperative.

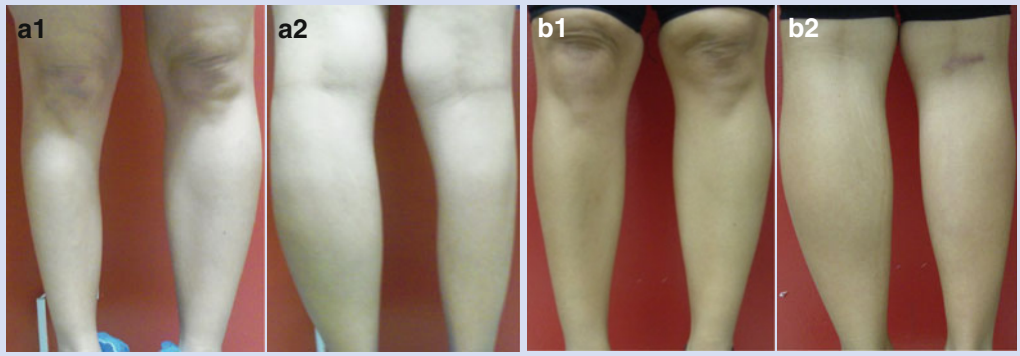

Fig. 8.22 (**a**) Preoperative. (**b**) Four months postoperative

Case 6 (Fig. 8.23)

A 32-year-old female suffered from polio as a child and was bothered by the asymmetry in her legs. She presented for augmentation of her leg and received a style 2, size 1 implant to the left medial calf with improvement in symmetry. She is shown preoperative and 6 months postoperative.

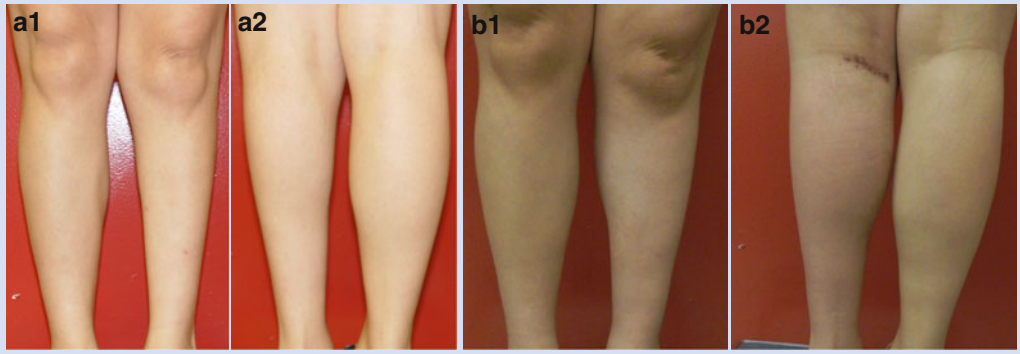

Fig. 8.23 (**a**) Preoperative. (**b**) Six months postoperative

Case 7 (Fig. 8.24)

A 30-year-old male was born with clubfoot deformity of the left leg. He presented for improved symmetry. He agreed to a staged procedure to bring about greater symmetry. First, he underwent augmentation of the medial calf with a style 2, size 2 implant. Eight months later, he underwent lateral calf augmentation with a style 3, size 1 implant. The next step will be either increasing the size of one of the implants or fat grafting to the lower leg, above the ankle.

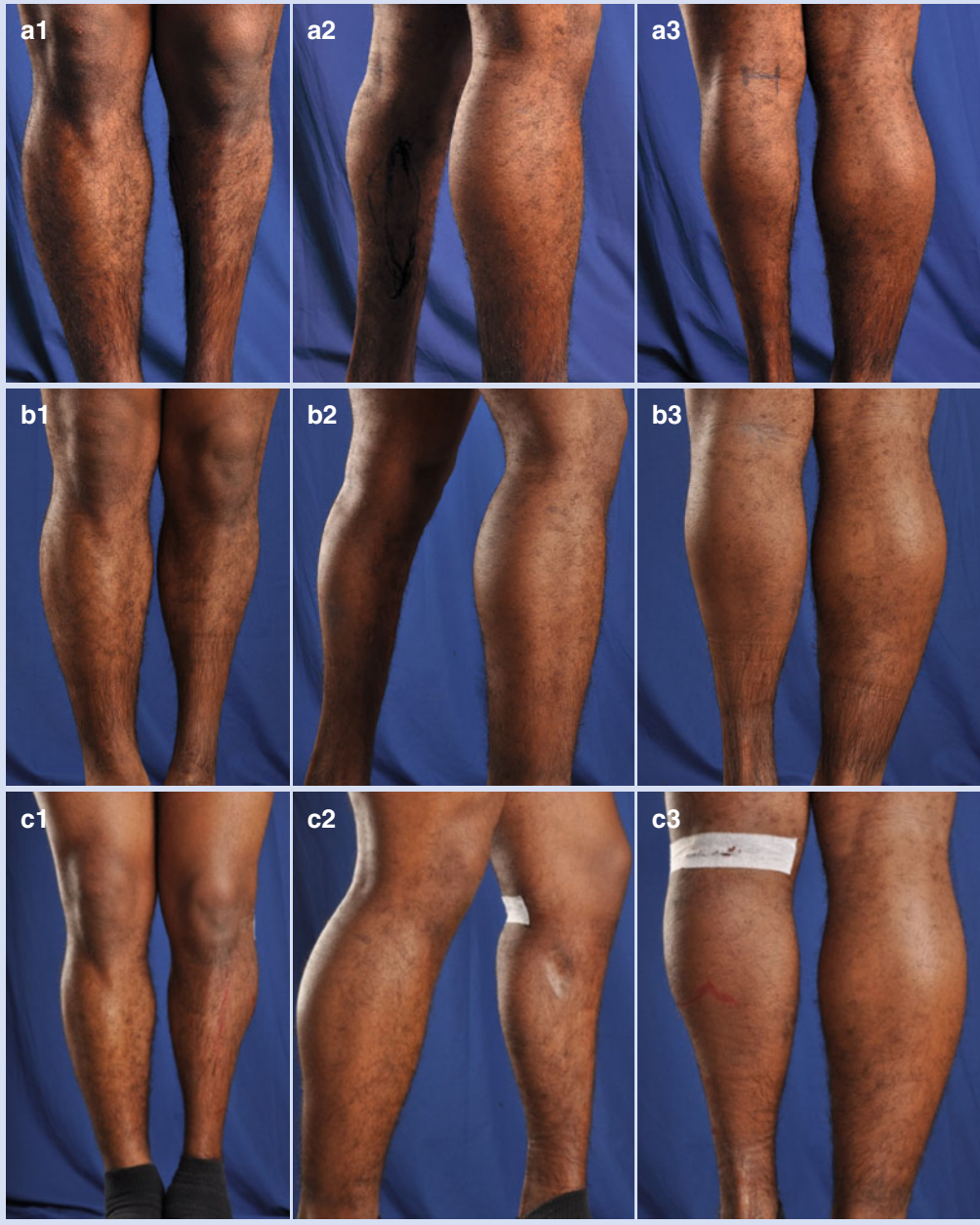

Fig. 8.24 (**a**) Preoperative. (**b**) Eight months postoperative. (**c**) One week after second surgery

Calf Augmentation with Fat Grafting

Over the course of the development of the calf augmentation procedure, some physicians have begun to explore the use of fat grafting to correct hypoplastic calves [1, 19, 20]. The use of fat injection for augmentation was explored to eliminate some of the common complications associated with implants: implant palpability, lack of correction of the ankle region, implant displacement, and the possibility of capsular contracture. Erol et al's [1] study of 2008 looked at 77 patients treated over a 10-year period with autologous fat and tissue cocktail injections, consisting of mini-micrografts of dermis, fascia, and fat. They noted a moderate improvement in 13 % of patients and a good improvement in 87 % of patients. Seventy-five to 200 mL of fat or tissue cocktail was injected into each leg to achieve the results noted in their study. These injections were repeated two to four times at 3-month intervals as was deemed necessary by the investigating physician.

While Eros et al. [1] have used fat grafting for calf augmentation with some success in their patients, the authors' results have been less than impressive. The largest complaint noted in the authors' patients that were augmented with fat is that the overall augmentation is not to their satisfaction or that the augmentation is asymmetric. These complaints are largely due to the variability in fat take and potential for fat cell death. In the hands of many cosmetic surgeons, the average patient can expect a fat take of 50–70 % without the use of stem cells [21–24]. However, this is largely dependent on placement of the fat in a place that has a rich blood supply that can foster the growth of the fat cells. When grafting to the calf, the calf muscles are already largely hypoplastic and so there is a lack of a robust blood supply to support fat cell take, in our opinion. While the authors' results are based solely on fat grafting without the use of tissue cocktail, we do not routinely recommend fat grafting to the calf as the results are inconsistent and there is the potential need for serial injections. On occasion fat grafting was performed to the distal aspect of the leg to produce further symmetry of the legs, particularly in clubfoot patients. But due to the minimal musculature and lack of robust blood supply, the grafting to this area is not reliable. However, the authors continue to look forward to further work in the realm of fat grafting to the calf and will continue to offer it to clubfoot patients in the hope of achieving greater leg symmetry.

Adjunct Procedures

Very commonly patients presenting for calf augmentation will have evidence of lipohypertrophy of the knees and thighs. A liposuction of these areas can often help in producing more shapely legs that are further enhanced by the calf augmentation procedure. These areas should be evaluated in each person presenting for calf augmentation.

Authors' Personal Results [11]

In evaluating the authors' most recent experiences with the technique from 2007 to 2011, it was found that there was an overall satisfaction rate of 92.1 % (186/202) (Table 8.5). Dissatisfaction was primarily due to hypertrophic scarring or an insufficient augmentation.

Table 8.5 Summary data for calf augmentations 2007–2011 [13]

Complication	Number	Percentage ($n=202$)
Infection	4	1.98 %
Seroma	13	6.43 %
Hematoma	1	0.49 %
Asymmetry	20	9.90 %
Hypertrophic/ hyperpigmented scar	30	14.9 %
Capsular contraction	0	0.00 %
Postoperative pain 8–10	19	9.40 %
Dehiscence	0	0.00 %
Satisfied	186	92.1 %
Unsatisfied	16	7.92 %
Compartment syndrome (near)	1	0.49 %
Permanent sensory or motor nerve damage	0	0.00 %

Patient Cases

Case 8 (Fig. 8.25)

A 49-year-old male presented for calf augmentation with style 2, size 2 implants. The patient is shown preoperative and 1 month postoperative.

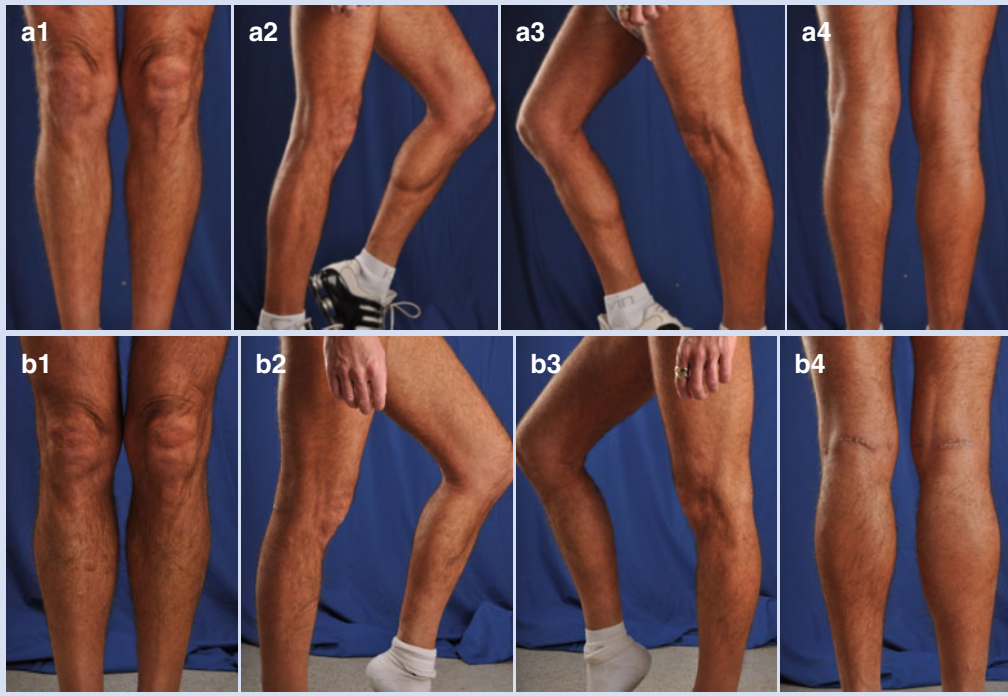

Fig. 8.25 (**a**) Preoperative. (**b**) One month postoperative

Case 9 (Fig. 8.26)
A 44-year-old female underwent augmentation with style 2, size 2 implants and minor liposuction of the right knee to achieve a more aesthetic and symmetric appearance to the legs. She is shown preoperative and 2 months postoperative.

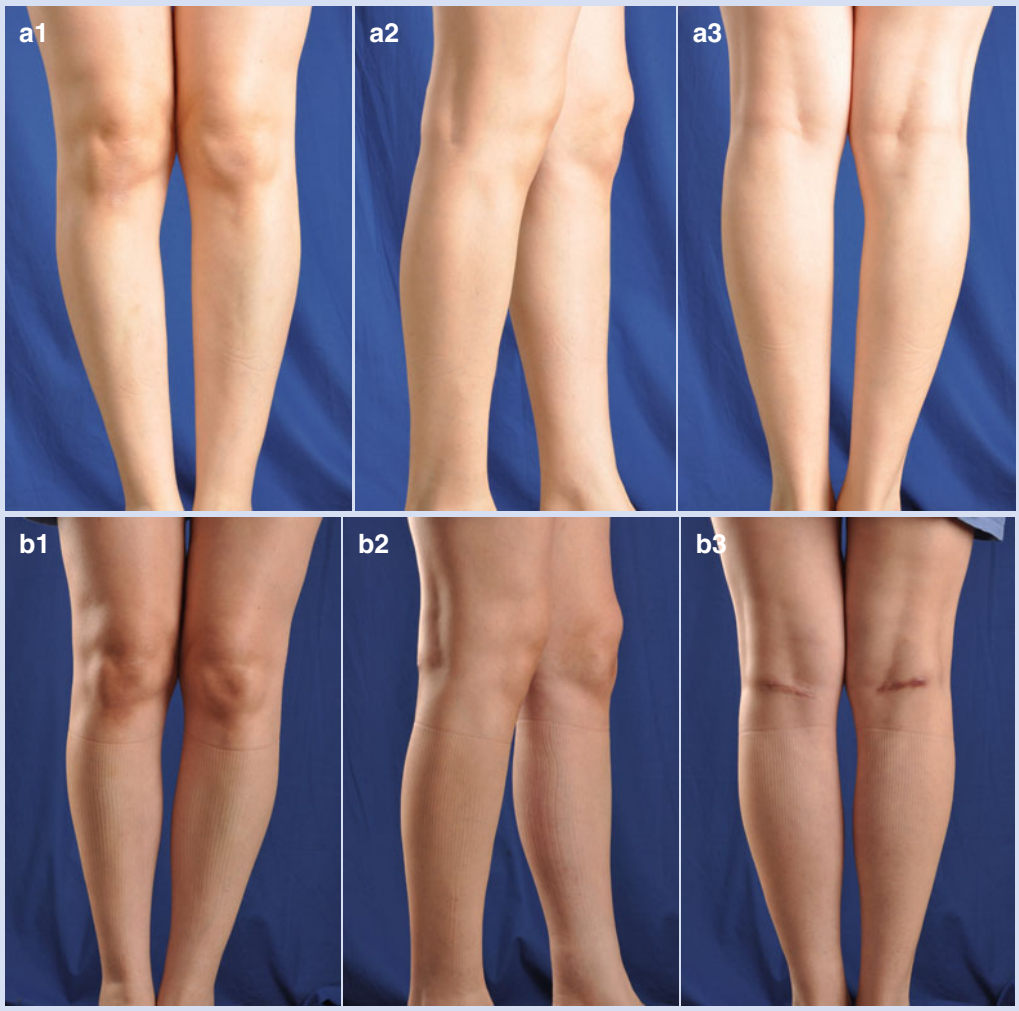

Fig. 8.26 (**a**) Preoperative. (**b**) Two months postoperative

Case 10 (Fig. 8.27)
A 40-year-old female underwent calf augmentation with style 2, size 2 implants. The patient is shown preoperative and 2 months postoperative.

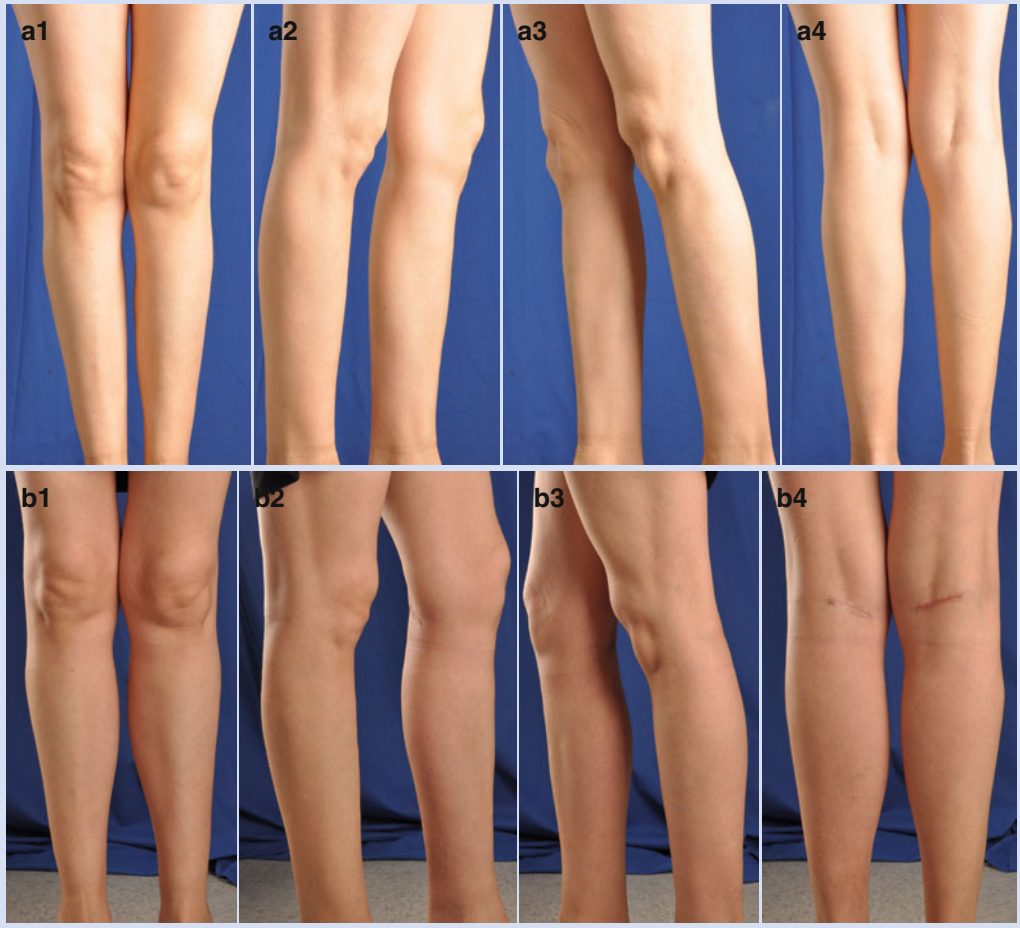

Fig. 8.27 (**a**) Preoperative. (**b**) Two months postoperative

Case 11 (Fig. 8.28)

A 52-year-old female underwent calf augmentation with style 2, size 2 implants. The patient is seen preoperative and 7 months postoperative. Note the hyperpigmented scars which are typical of Latin patients and other higher Fitzpatrick skin types.

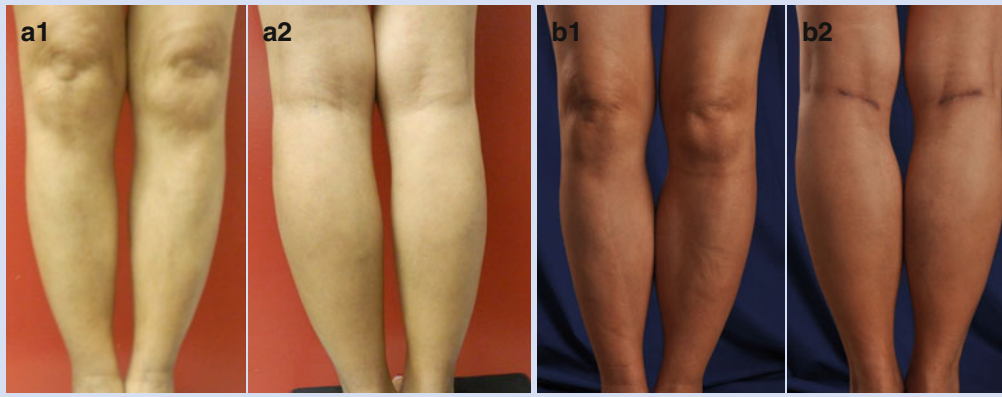

Fig. 8.28 (**a**) Preoperative. (**b**) Seven months postoperative

Case 12 (Fig. 8.29)
A 28-year-old female underwent calf augmentation with style 2, size 2 implants. The patient is shown preoperative and 1 week postoperative. Bruising as noted is very typical for early calf augmentation patients. Swelling extending to the ankles is very common in this early postoperative phase.

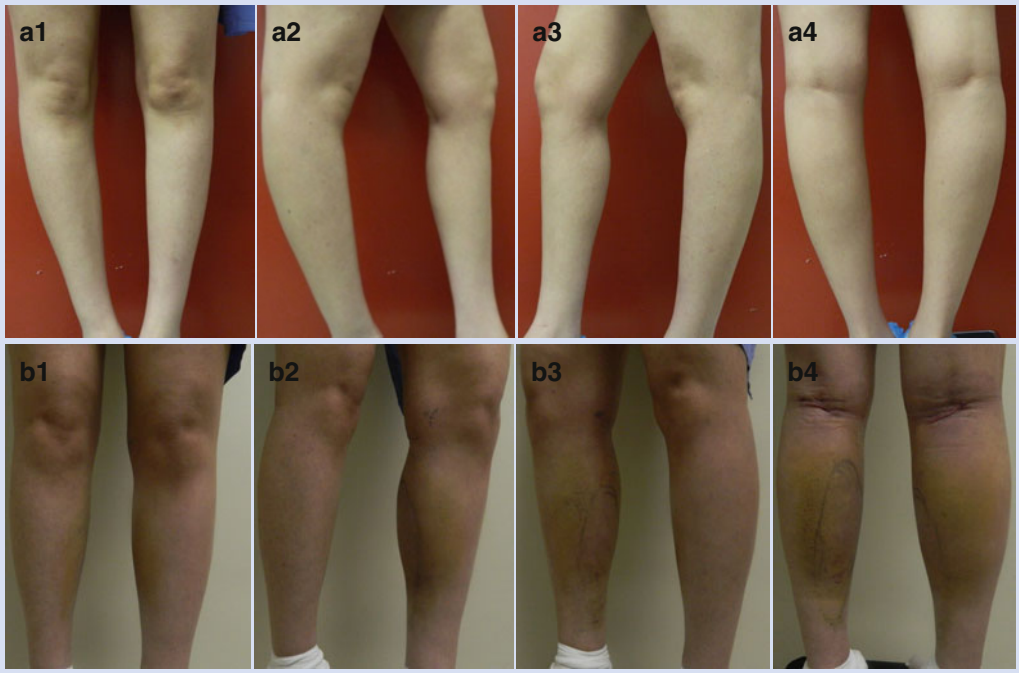

Fig. 8.29 (**a**) Preoperative. (**b**) One week postoperative

Case 13 (Fig. 8.30)
A 29-year-old female underwent calf augmentation with style 2, size 1 implants. The patient is shown preoperative and 6 months postoperative.

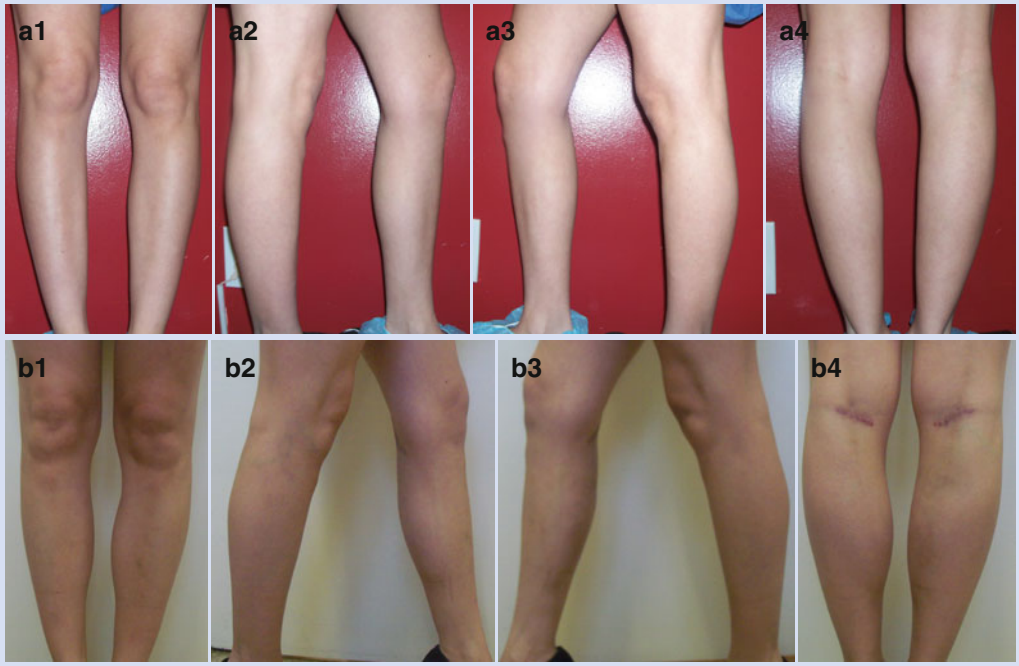

Fig. 8.30 (**a**) Preoperative. (**b**) Six months postoperative

Case 14 (Fig. 8.31)
A 31-year-old male underwent calf augmentation with style 2, size 2 implants. The patient is shown preoperative and 5 months postoperative.

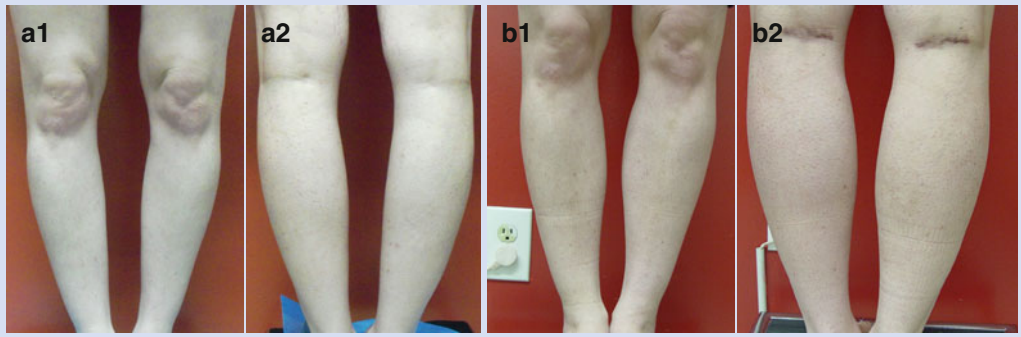

Fig. 8.31 (**a**) Preoperative. (**b**) Five months postoperative

Case 15 (Fig. 8.32)
A 33-year-old male desired to have a more pronounced bulky calf region and underwent augmentation with style 1, size 7 implants. These style 1 implants are well suited for men wanting a more "bulked out" appearance and patients who may be body builders and want an overall enlargement of the entire calf unit. He is shown preoperative and 1 month postoperative.

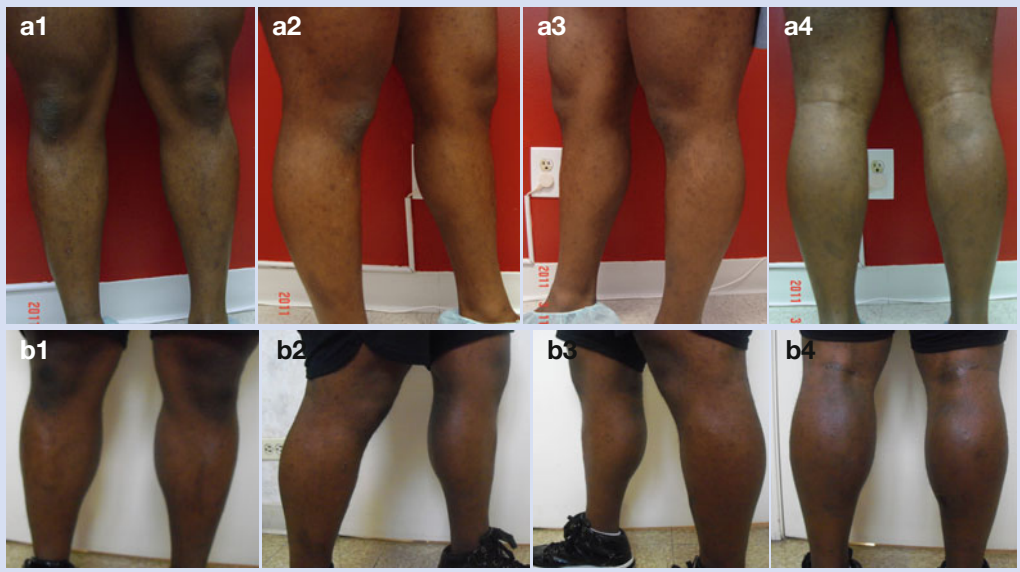

Fig. 8.32 (**a**) Preoperative. (**b**) One month postoperative

Case 16 (Fig. 8.33)
A 46-year-old male suffered from bow legs and felt very self-conscious. He underwent medial calf augmentation with style 2, size 2 implants. He is shown preoperative and 3 months postoperative.

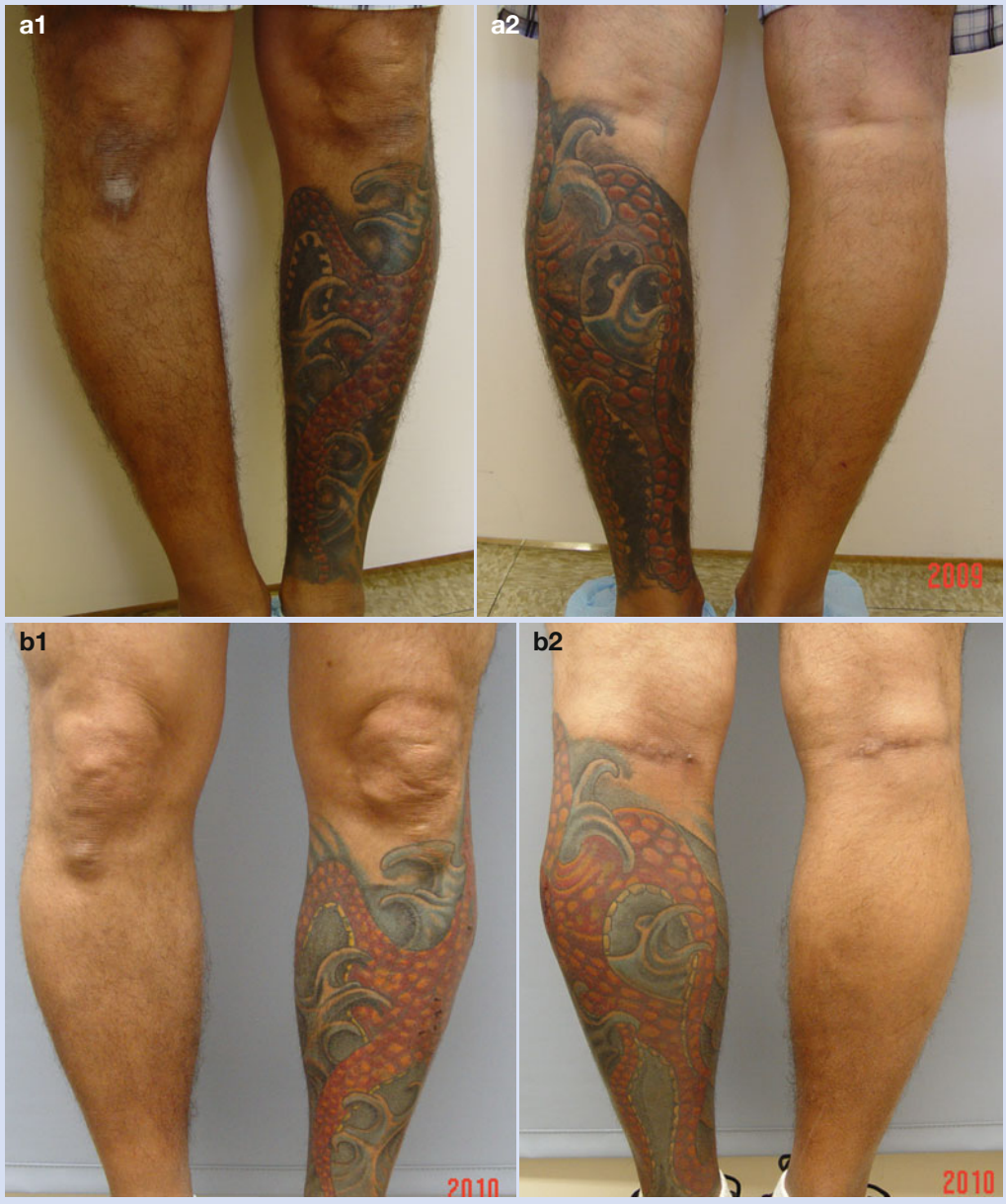

Fig. 8.33 (**a**) Preoperative. (**b**) Three months postoperative

Case 17 (Fig. 8.34)
A 32-year-old female underwent calf augmentation with style 2, size 2 implants. She is shown preoperative and 3 months postoperative.

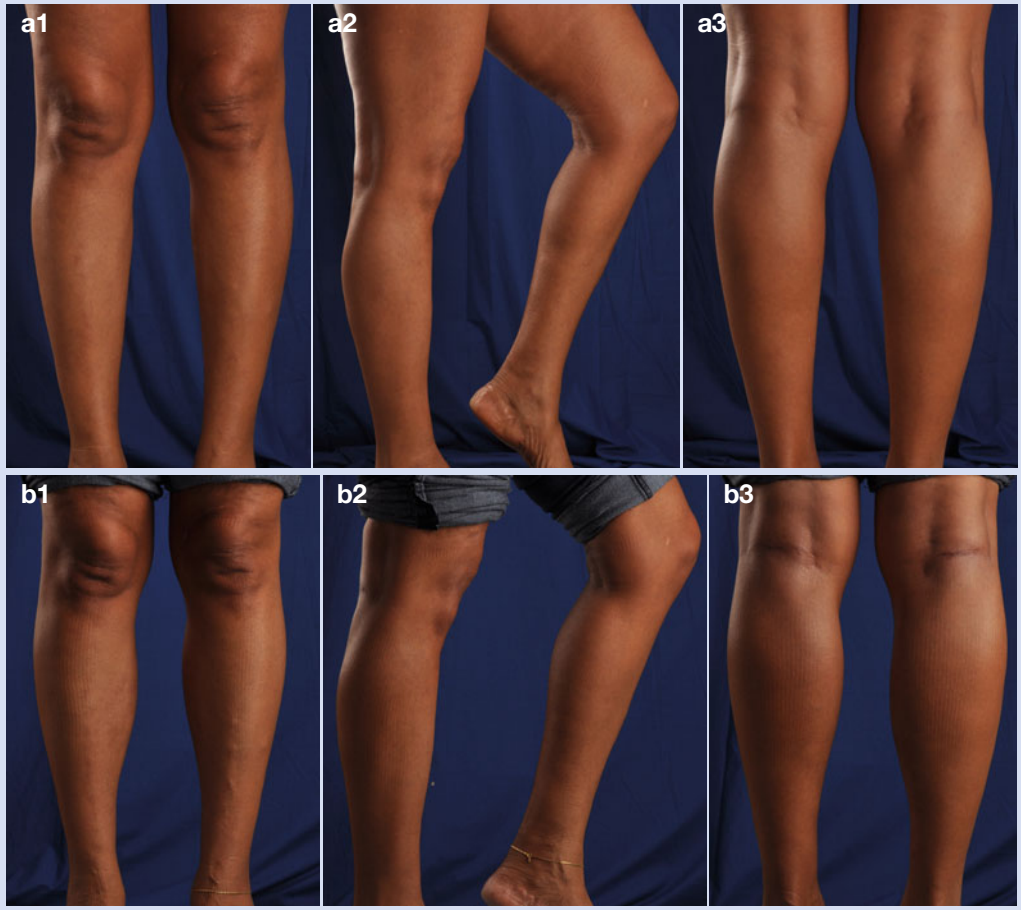

Fig. 8.34 (**a**) Preoperative. (**b**) Three months postoperative

Case 18 (Fig. 8.35)
A 34-year-old male underwent augmentation with style 2, size 2 implants. He is shown preoperative and 4 days postoperative. Bruising seen in the medial calf region is typical for this early phase in healing.

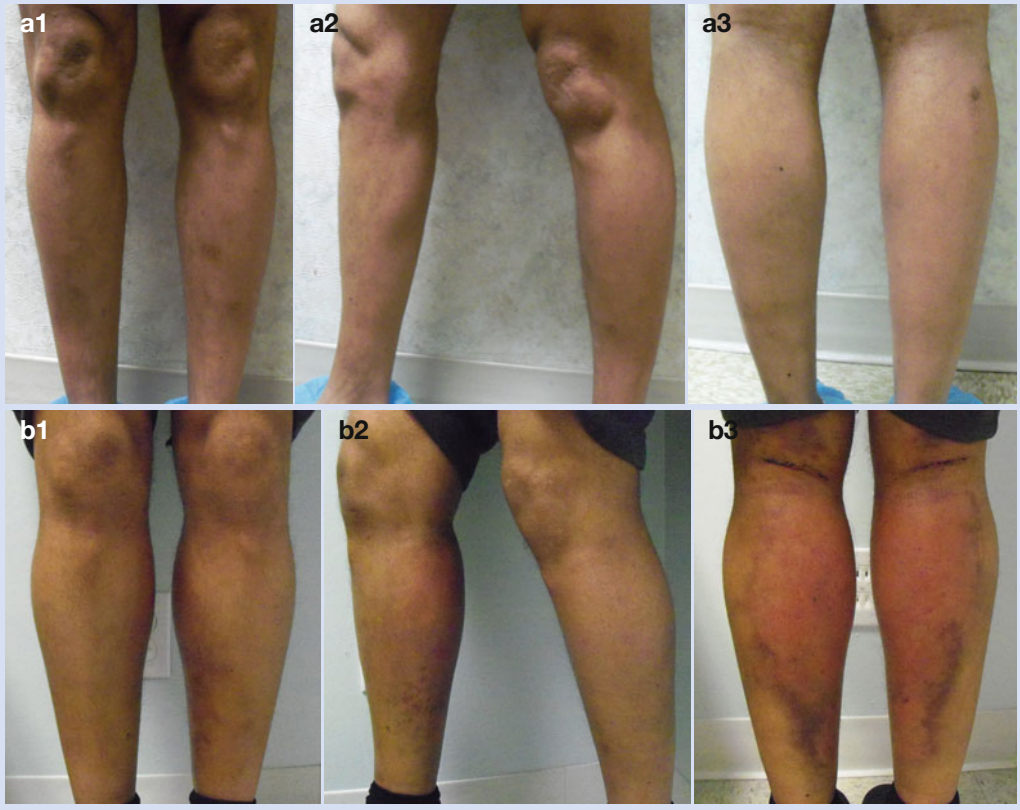

Fig. 8.35 (**a**) Preoperative. (**b**) Four days postoperative

Conclusions

Calf augmentation with silicone implants is a procedure that can nicely enhance the physique in a reliable fashion. The overall satisfaction rate is excellent as long as care is taken to ensure several things: choosing the right implant to meet the patient's expectations, meticulous attention to dissection of the pocket to minimize implant migration, and layered closure to minimize hypertrophic scarring.

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