
**Figure 4.11** An axial CT angiogram showing a perforator arising from the peroneal artery on the patient's left side (arrows). Note that this is the same patient as seen in Figure 4.12 and the anterior tibial arteries are not visualized.

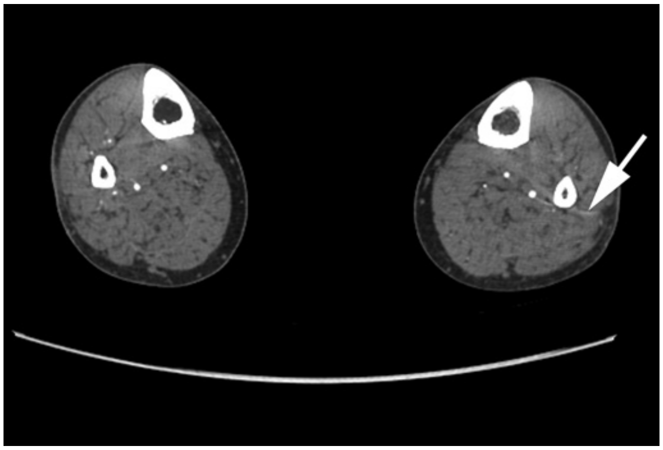

**Figure 4.12** A 3-dimensional CT angiogram reconstruction of a patient's lower extremities demonstrating bilateral occlusion of the anterior tibial arteries (arrow).

variety of free and pedicled flaps with a skin paddle component. Perforators were difficult to detect by ICG angiography when the flap thickness was >20 mm with perforators being identified only on 12 of 50 flaps (24% sensitivity). In contrast, CTA was not very useful in detecting perforators when the flap thickness was <8 mm, showing only 30% sensitivity in these patients. Perforators with a long course through subcutaneous fat are most easily visualized by CTA.

Based on their data, Ogata et al.[30] recommended utilizing ICG angiography in combination with handheld Doppler ultrasound when the flap thickness as ≤8 mm and, MDCTA in combination with handheld Doppler ultrasound to localize perforators when the flap thickness was ≥20 mm in order to minimize time and expense, while still maintaining reasonable accuracy. For flaps with intermediate thickness, they recommended using a combination of all three modalities. Combining these findings with our own experience,[28,29] it would seem that CTA is most useful in breast reconstruction with flaps of ample thickness, as well as in fibula flap harvest, where it can be utilized to confirm three-vessel patency to avoid donor site morbidity, and the relatively direct course of perforators within the intermuscular septum seems to result in accurate perforator location, despite the generally scant amount of subcutaneous fat in most patients' lower legs.

**Figure 4.13** A 3-dimensional stereophotogrammetry system (3dMD, Atlanta, GA) with two sets of multiple cameras attached to a central processing unit.

## THREE-DIMENSIONAL IMAGING SYSTEMS

Planning for soft tissue reconstructive surgery, such as breast reconstruction, largely relies on the surgeon's clinical assessment and review of 2-dimensional photographic images. Three-dimensional imaging technology has evolved in recent years and is now available in platforms specifically adapted to medical applications, primarily for face and trunk imaging. Most systems are based on either laser scanning or stereophotogrammetry. Stereophotogrammetry is probably more widely used in clinical practice and relies on depth perception achieved by taking photographs from slightly different views. Paired cameras rely on the triangulation of disparate images, which are matched by computer software to create a 3-dimensional image that can be examined from various angles on the computer monitor (Figs 4.13, 4.14). Laser systems also utilize the principle of triangulation, but rely on a laser light source to scan the desired body part(s), which are processed by computer software into a surface model. Software can be used to analyze the images and provide accurate quantitative data, such as surface area, distance measurements, and volume.[31,32] Currently available imaging systems in the USA include Vectra (Canfield Imaging Systems, Fairfield, NJ), and 3dMD (3dMD, Atlanta, GA), both available in various models

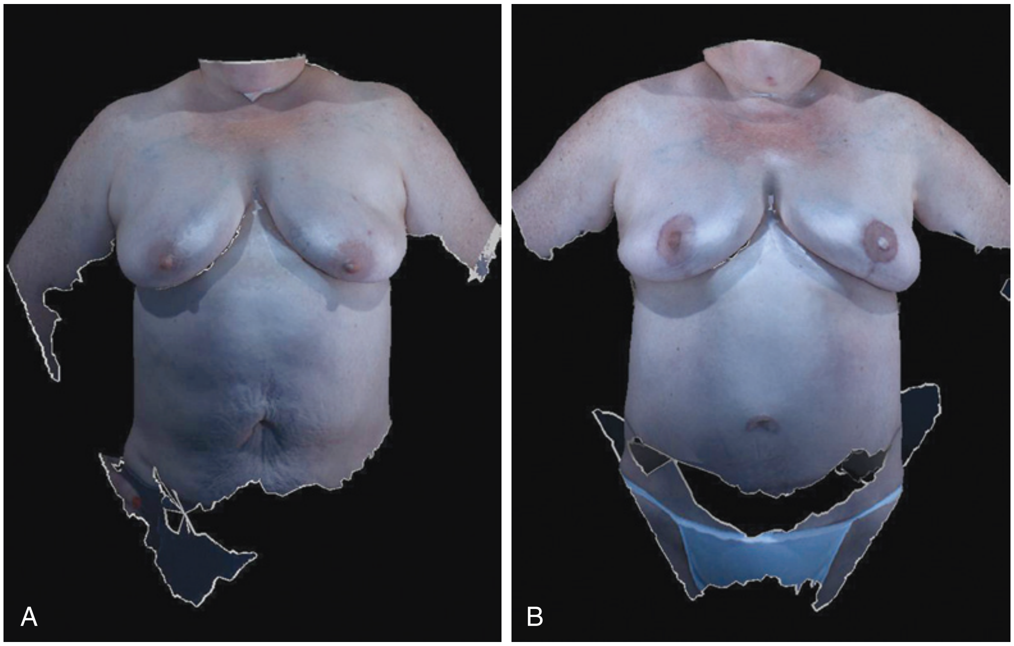


**Figure 4.14** (A) Representative preoperative and (B) postoperative 3-dimensional images in a patient who underwent left mastectomy and autologous tissue breast reconstruction.

depending on user needs. Costs remain high for these systems, in the range of US$20 000–US$60 000 at time of writing.[31,32]

Clinically, 3-dimensional imaging has mostly been used for subjective planning and as communication tool between surgeon and patient. Additionally, several studies have employed 3-dimensional imaging as a research tool to assess for shape and volumetric changes before and after surgical intervention, such as in orthognathic surgery or autologous fat grafting.[33,34] However, 3-dimensional imaging has potential useful applications in planning reconstructive surgery. In breast reconstruction, 3-dimensional surface imaging can be used to assist in selecting implant size prior to mastectomy; to determine whether sufficient abdominal tissue is present to reconstruct the breast or breasts when considering autologous abdominal flap(s); and to detect asymmetry in volume such as when reduction or reconstruction has occurred and a secondary symmetrizing procedure is planned.[35] Most recently, Ahcan et al.[36] utilized laser scanning to produce a plastic breast replica cast to assist in autologous breast reconstruction planning. The cast is a mirror-image model of the contralateral non-cancerous breast that they utilized in 12 patients to shape an abdominal free flap (TRAM or DIEP), cutting away excess tissue until the cast was precisely filled. Utilizing this reverse engineering method, none of the 12 patients required secondary procedures to correct symmetry and all patients were satisfied with their result. As the cost of imaging systems decreases, software platforms evolve, and other investigators demonstrate favorable clinical outcomes, reconstructive surgeons may more widely adopt 3-dimensional imaging for free flap planning.

## CONCLUSIONS

In recent years, surgeons have harnessed technology to further refine microvascular free flap reconstruction. While not a replacement for good judgment and technique, these technologies have been embraced by many surgeons as ways of increasing the reliability, accuracy, and efficiency of reconstruction. Undoubtedly, other technologies will be developed and applied to assist in the planning of reconstruction, as well as in the evaluation of flap vascularity.