Table 5.3 Clinical applications of prefabrication and prelamination: Facial skeleton

Defect	Technique	Flap location	Technique description	References
Maxilla				
(a) Partial – premaxilla (b) Extensive defect	Existing laminated flap Prelamination	Second toe proximal phalanx Scapular or fibula	Osteointegrated implants placed into proximal phalanx with composite flap based on dorsalis pedis artery and transferred to premaxilla Prelaminate scapular bone or fibula dermal graft + wrap with silicone sheeting ± osteointegrated implants	Pribaz and Guo[2] Holle et al.[19] Rohner et al.[20]
Mandible				
Segmental or total loss	Prelamination	Scapular	Cancellous bone in carrier tray placed in scapular flap territory + secondary transfer to mandible	Orringer et al.[21]

Table 5.4 Clinical applications of prefabrication and prelamination: Oropharynx and esophagus

Defect	Technique	Flap location	Technique description	References
Intraoral				
Mucosa-lined soft tissue loss	Prelamination	Forearm	Mucosal grafts placed over radial forearm and later transferred for intraoral reconstruction	Rath et al.[12] Carls et al.[22] Chiarini et al.[23]
Esophagus				
(a) Cervical esophagus (b) Entire esophagus	Prelamination Prelamination	Radial forearm Tensor fascia lata (TFL)	Skin surface of the radial forearm flap is rolled into a lumen during first stage to allow healing of suture line; during second stage 2 weeks later, microvascular transfer is completed Longer defect requires TFL flap with skin lumen prelaminated the same way	Chen et al.[24]

Table 5.5 Clinical applications of prefabrication and prelamination: Penis

Defect	Technique	Flap location	Technique description	References
Penis				
Absence secondary to tumor or trauma	Prelamination	Lateral arm radial forearm fibula	Prelamination with skin tube for neo-urethra reconstruction with subsequent transfer of osteocutaneous flap when using fibula	Young et al.[25] Capelouto et al.[26]

FLAP PREFABRICATION

CONCEPT

The first step in planning a reconstruction is to delineate the specific needs. It is desirable to use flaps that provide a good color match and restore surface and contour. Regarding head and neck reconstruction, in particular, the recipient site may require further specialized flaps, such as hair-bearing or mucus-producing flaps, for optimal reconstruction.[29] Although there may be local flap options with the desired characteristics, these may not have a reliable axial blood supply on which they can be transferred. The technique of flap prefabrication provides this by implanting an axial blood supply into the donor tissue, rendering that tissue transferable once neovascularization has occurred.

TECHNIQUE

A vascular pedicle includes at least an artery and its venae comitantes, surrounded by an adventitial cuff. It may be available locally or, if not, imported as a small free flap and implanted beneath the intended donor tissue. The distal end of the pedicle is ligated. To prevent scarring around the base of the pedicle and to facilitate secondary harvest of the prefabricated flap, a short segment of Gore-Tex (polytetrafluoroethylene) tubing or thin silicone sheeting can be placed around the pedicle up to the undersurface of the tissue that the new pedicle is expected to support (Fig. 5.1). A nonadhesive sheeting may be placed under the implanted pedicle, away from the proposed flap, not only to facilitate secondary elevation of the flap but also to shunt the direction of neovascularization from the pedicle toward the flap to be prefabricated. A tissue expander is frequently used in this capacity. In experimental animal models, a neural island flap can also be prefabricated. In this model, a peripheral nerve can be placed under subcutaneous tissue and the intrinsic vasculature of the nerve can supply the flap following a delay period.[30]

FLAP MATURATION

Neovascularization between the implanted pedicle and the donor tissue matures by 8 weeks in humans.[3] However, experimentally, *maturation* may possibly be hastened. Angiogenic factors, such as basic fibroblast growth factor (bFGF)[31] and vascular endothelial growth factor (VEGF),[32] have been shown in animal models not to improve flap survival by increasing its vascularity.[33] *Flap delay* has also been successfully employed, experimentally, to accelerate neovascularization.[34] By virtue of the need to prefabricate the donor tissue (which lacks a good axial blood supply), the delay is accomplished by progressively raising the flap tissue off its non-axial blood supply, thus rendering it dependent on the implanted pedicle. Although the contact area of the vascular pedicle did not seem to be significant in our initial experiments, others have found that there is a proportional relationship of pedicle size and the rate of neovascularization.[35]

Another helpful adjunct is the use of *tissue expansion*.[36] Tissue expansion and flap prefabrication both are two-stage procedures and thus complement each other nicely. The implanted pedicle is placed directly underneath the donor tissue and above the expander. Expansion can start as early as 1 week and may be monitored by Doppler ultrasonography. Expansion can be as aggressive, as allowed by the continued presence of the Doppler signal of a patent pedicle and clinical observation of flap color. Tissue expansion accomplishes four things: (1) it provides an abundance of tissue that facilitates donor site closure following final transfer; (2) it thins out the donor tissue flap, which is helpful in head and neck reconstruction; (3) it provides mechanical stretch that stimulates endothelial cells to proliferate, thereby enhancing the rate of neovascularization; and (4) it focuses the direction of the neovascularization from the implanted pedicle toward just the side of the prefabricated flap. Assessment of flap vascularity and viability by modalities designed to evaluate perfusion may be useful in preoperative planning and optimizing flap harvest.[37]

FLAP TRANSFER

During the second stage of flap prefabrication, the prefabricated flap is transferred to its final location, based on its newly acquired axial blood supply. This can be done locally as a pedicled flap if close to the defect or via microvascular anastomosis if prefabrication is at a remote site (Fig. 5.2). A commonly observed problem seen after flap transfer is transient venous congestion. This may be caused by unequal neovascularization of the lower-pressured venous system compared with the higher-pressured arterial system of the same pedicle. This problem can be ameliorated in several ways. All maneuvers that enhance neovascularization, including flap delay, lengthening maturation time, or increasing the contact area between the pedicle (usually in the form of a fascial flap) and the donor tissue, would help. Also, other strategies such as delayed insetting, temporary leeching (chemical or medicinal), avoiding flap folding or, if possible, performing an additional venous anastomosis using a native subcutaneous vein in the prefabricated flap can all help to minimize flap venous congestion. Finally, there was a recent report of a further surgical delay performed at 6–7 weeks after pedicle implantation and 2 weeks before flap transfer that was shown to minimize venous congestion in that series.[38]

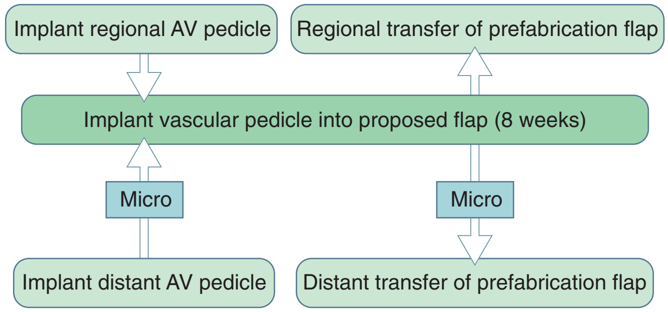

Figure 5.2 Various algorithms in flap prefabrication.

CLINICAL EXAMPLES

As illustrated in Figure 5.2, flap prefabrication can be designed in any of the four basic forms. With proper planning, it is possible to avoid performing microvascular anastomoses in two separate settings by choosing pedicles in nearby sites to fabricate a new flap with desirable characteristics. Choice of a design hinges on two questions: What is needed? What is available? With the patient presented in Figure 5.3, it is important to reconstruct the central defect in her face with similarly matched skin. Local reconstructive options were not available, as she previously underwent right external carotid artery embolization for an arteriovenous malformation and suffered full-thickness skin necrosis. In such cases, a flap may be prefabricated in the submental area by utilizing the descending branch of the lateral circumflex femoral vessels with microvascular transfer. The newly axialized submental flap may be transferred 8 weeks following the original procedure as a pedicled flap.

The patient illustrated in Figure 5.4 requires a significant contracture release and resurfacing of her neck after a disfiguring burn injury suffered many years before. There are no local options for reconstruction, as the surrounding skin has also undergone traumatic injury. For this type of defect, distantly prefabricated skin flaps have been used previously. In this patient, the deep inferior epigastric vessels were utilized to prefabricate a sizable and robust abdominal skin flap. Transfer of such distantly prefabricated flaps then takes place via microvascular anastomosis (Fig. 5.4).

Sometimes, one encounters the need to reconstruct a specialized surface, for instance, a hair-bearing area of the face. While local options for a good surface match may exist, it may not possess a reliable blood supply. Prefabrication can be used to bring in this blood supply. The patient illustrated in Figure 5.5 needs to have his cheek skin and lip mustache reconstructed after a disfiguring burn suffered several years prior to presentation. While he still has enough scalp hair to serve as a donor, the extent of his burn injury with subsequent scarring would prevent a reliable transfer, all the way to the midline, of any hair-bearing surface. The temporal parietal fascia (TPF) is not available in this patient due