CHAPTER 6

GRAFTS AND FLAPS

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When a deformity cannot be closed primarily, and secondary healing would be unlikely, too slow, or suboptimal, grafts and flaps are employed to restore normal function and/or anatomy.

I. GRAFTS

Grafts are harvested from a donor site and transferred to the recipient site without carrying its own blood supply. It relies on new blood vessels from the recipient site bed to be generated (angiogenesis). A graft MUST have a wound bed of healthy tissue (granulation tissue, muscle, fascia, bone with intact periosteum, tendon with intact paratenon) because the graft is totally dependent on blood supply from the wound.

II. SKIN GRAFTS

A. Thickness (Figure 1)
   1. Full thickness - Full thickness skin grafts (FTSGs) consist of the entire epidermis and dermis.
   2. Split thickness - Split thickness skin grafts (STSGs) consist of the epidermis and varying degrees of dermis. They can be described as thin, intermediate, or thick. A typical intermediate depth STSG is 12/1000 inch in depth.

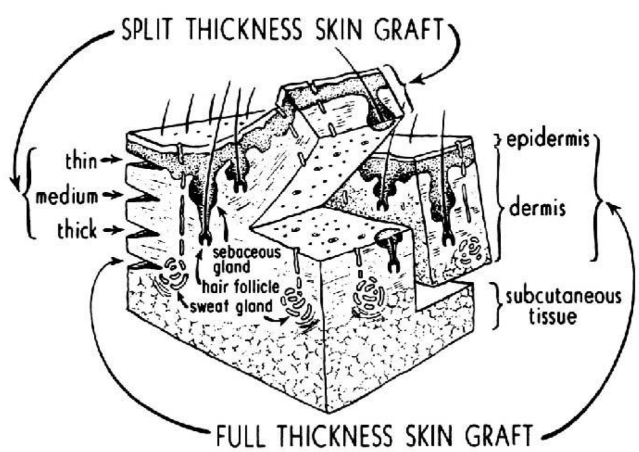

Figure 1. Components of a split thickness versus a full thickness skin graft

B. Donor site
   1. Full thickness - The full thickness skin graft leaves behind no epidermal elements in the donor site from which resurfacing can take place. Thus, the donor site of a FTSG is usually closed primarily. It must be taken from an area

that has skin redundancy. It is usually harvested with a scalpel between the dermis and the subcutaneous fat.
2. Split thickness - The split thickness skin graft leaves behind adnexal remnants such as hair follicles and sweat glands, foci from which epidermal cells can repopulate and resurface the donor site. This is typically harvested with a pneumatic or electric dermatome. The donor site is usually covered with an occlusive dressing and left to heal secondarily.

C. Recipient site
   1. Full thickness - Full thickness skin grafts are usually used to resurface smaller defects because they are more limited in size. They are commonly used to resurface defects of the face or hand. They provide better color consistency, texture, and undergo less secondary contraction.
   2. Split thickness - Split thickness grafts are usually used to resurface larger defects. STSGs undergo more secondary contraction as they heal compared to an FTSG. They typically darken in color compared to the area they were harvested from.

D. Survival
   1. Full thickness and split thickness skin grafts survive by the same mechanism.
      a. Plasmatic imbibition (First 24-48 hours) - Initially, the skin graft passively absorbs nutrients from the wound bed by diffusion.
      b. Inosculation - By day 3, the cut ends of the vessels on the underside of the dermis line up with and begin to form connections to those of the wound bed.
      c. Angiogenesis - By day 5, new blood vessels grow into the graft and the graft becomes vascularized.
   2. Skin grafts fail by four main mechanisms:
      a. Poor wound bed - Because skin grafts rely on the underlying vascularity of the bed, wounds that are poorly vascularized with bare tendon or bone, or because of radiation or ischemia, will not support a skin graft. Synthetic materials cannot be covered by grafts for this reason.
      b. Shear - Shear forces separate the graft from the bed and prevent the contact necessary for revascularization and subsequent "take", which refers to the process of attachment and revascularization of a skin graft in the donor site
      c. Hematoma/seroma - Hematomas and seromas prevent contact of the graft to the bed and inhibit revascularization. They must be drained by day 3 to ensure "take."
      d. Infection - Bacteria have proteolytic enzymes that lyse protein bonds needed for revascularization. Bacterial levels greater than 10^5 cells/gram of tissue in the wound will cause graft failure.

E. Skin substitutes - These are used for temporary wound coverage, or as a bridge to another form of reconstruction, typically a skin graft.
   1. Allograft/Acellular dermal matrices - Cadaveric skin or dermis
   2. Xenograft - Skin from a different species, e.g. pig skin – provides only temporary coverage

3. Synthetic - i.e. Integra™ (Integra LifeSciences Corporation) - collagen/silicone bilayer designed to provide an occlusive environment as granulation forms through the tissue matrix. This granulation will then support a skin graft after the silicone is removed.

III. OTHER GRAFTS

A. Nerve - Most common donor site is the sural nerve
B. Fat - Can be harvested as a structured graft or as lipoaspirate
C. Tendon - Common donor sites are the palmaris longus, plantaris, extensor digitorum longus
D. Cartilage - Common donor sites are the nasal septum, ear conchal bowl, rib
E. Bone - Common donor sites are the calvarium, iliac crest, tibial tuberosity, rib
F. Muscle - Typically small, can be harvested from any muscle
G. Composite - A graft that has more than one component, i.e. cartilage and skin graft, or a dermal-fat graft.

IV. FLAPS

Flaps are tissues transferred with an intact vascular supply to the recipient site. They survive through this blood supply and are not dependent on the wound bed. Flaps can be used when the wound bed is unable to support a skin graft (such as over exposed hardware), or when a more complex, larger, or more aesthetic reconstruction is needed. They are the most versatile type of reconstruction used by plastic surgeons. Flap harvest always leaves a donor site that will need to be closed either primarily, with a graft, or with another flap.

V. CLASSIFICATION

A. By composition - Flaps can be classified by the type of tissue transferred.
   1. Single component
      a. Skin flap - e.g. Parascapular flap
      b. Muscle flap - e.g. Rectus abdominis muscle flap or latissimus dorsi muscle flap
      c. Bone flap - e.g. Fibula flap
      d. Fascia flap - e.g. Temporoparietal fascia
   2. Multiple components - Named by types of tissue
      a. Fasciocutaneous - e.g. Radial forearm flap or anterolateral thigh flap
      b. Myocutaneous - e.g. Transverse rectus abdominis myocutaneous flap or latissimus myocutaneous flap
      c. Osteosecutaneous - e.g. Fibula flap with a skin paddle or medial femoral condyle flap with skin paddle
      d. Composite flap – flap components are directly attached to each other and harvested on single pedicle (e.g. latissimus myocutaneous flap)

e. Chimeric flap – flap components are harvested on their own vessel and freely mobile, with a single feeding vessel. (Figure 2)

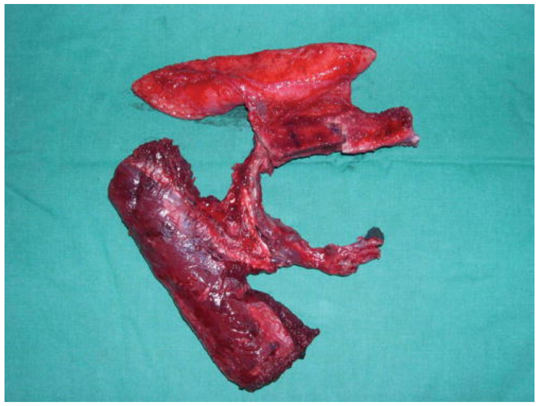

Figure 2. Multi-segment fibula flap with fibula bone osteotomies, harvest of soleus muscle cuff based on muscle perforators, and independent skin paddle based on cutaneous perforators. *From Saint-Cyr M, et al. Free Tissue Transfers and Replantation. Plast Reconstr Surg 2012;130(6):858e-878e.*

B. By location - Flaps can be described by the proximity to the primary defect that needs to be reconstructed.
   1. Local flaps
      a. Raised from the tissue adjacent to the primary defect.
      b. Movement into the defect can be described as advancement, rotation, or transposition.
      c. Ex. V-Y, rhomboid, and bilobed flaps.
   2. Regional
      a. Raised from tissue in the vicinity but not directly adjacent to the primary defect.
      b. Movement is described as transposition or interpolation.
      c. A good example would be a latissimus flap for breast reconstruction.
   3. Distant
      a. Raised from tissue at a distance from the primary defect.
      b. Usually requires re-anastomosis of the blood vessels to recipient blood vessels in the primary defect (see “free flaps” below).
      c. There are a few examples of distant pedicled flaps, such as using a groin flap for hand reconstruction.

C. By vascular pattern
   1. Random vs. Axial
      a. Random pattern flaps
         i. Do not have a specific or named blood vessel as their blood supply.
         ii. Instead, these flaps are designed based on the size of the flap base.
         iii. Because of the random nature of the vascular pattern, these flaps are limited in dimensions, specifically in a length:base width ratio of 3:1.
         iv. If designed longer than this ratio, a random blood supply often cannot support the flap (Figures 3, 4).

b. Axial pattern flaps
   i. Designed with a specific named vascular system that enters the base and runs along its axis. (Figure 5) This allows the flap to be designed as long and as wide as the territory the axial artery supplies (angiosome).
   ii. Blood supply requires artery and its accompanying vein
   iii. Greater length possible than with random flap
c. All free flaps are axial (see free flap, below)
d. Peninsular – skin and vessel intact in pedicle
e. Island – vessels intact, but no skin over pedicle

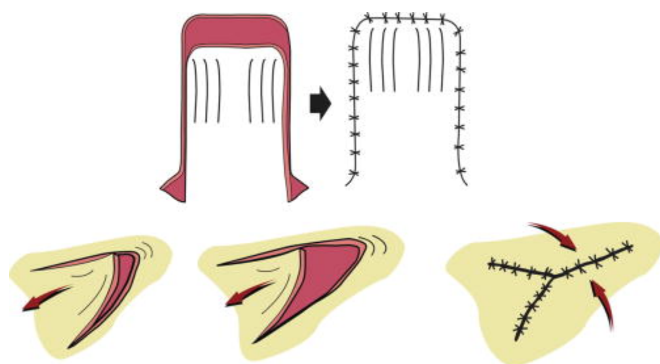

Figure 3. (Top) Advancement flap design. (Below) V-Y flap. Both are often designed as random flaps. *From Buchanan P, et al. Evidence-Based Medicine: Wound Closure. Plast Reconstr Surg 2016;138(3S):257S-270S.*

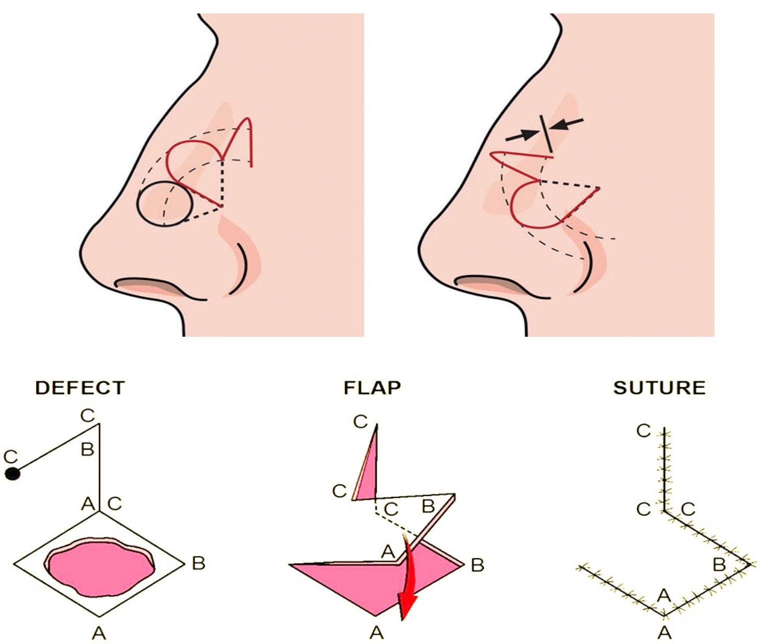

Figure 4. (Top) bilobe flap. (Below) Rhomboid flap. Both may be designed as random flaps. *From Buchanan P, et al. Evidence-Based Medicine: Wound Closure. Plast Reconstr Surg 2016;138(3S):257S-270S.*

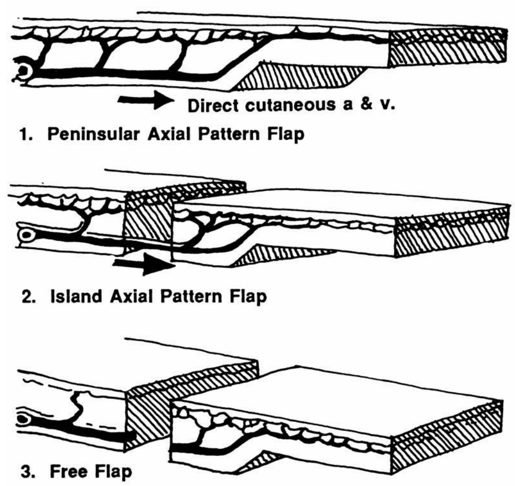

Figure 5. Axial/arterial pattern skin flaps

2. Pedicled vs. Free
    a. Pedicled flaps
        i. Flap blood supply remains attached to its source.
        ii. Transferred to the defect with its vascular pedicle acting as a leash.
    b. Free flaps
        i. Detached at the vascular pedicle and transferred from the donor site to a recipient site.
        ii. At the recipient site, the flap artery and vein are anastomosed to recipient vessels.
        iii. This allows more flexibility as tissues can be transferred nearly anywhere but requires microsurgical skill and increased operative time.
3. Perforator Flaps
    a. Supplied by smaller vessels that pass through or in between deep tissues.
    b. Typically harvested without the deep tissues in order to minimize donor site morbidity and to yield only the necessary amount of tissue for transfer.
    c. Can be transferred either as a pedicled or free flap.
    d. Perforators are described by their path from the main vessel to the skin (Figure 6).
    e. Common perforator flaps:
        i. Deep inferior epigastric perforator flap (DIEP)
            a) Skin and fat of the lower abdomen supplied by the deep inferior epigastric artery and vein perforators without the rectus abdominis muscle.
        ii. Anterolateral thigh perforator flap (ALT)
            a) Skin and fat of the anterolateral thigh supplied by the descending branch of the lateral circumflex femoral vessel perforator(s).
        iii. Thoracodorsal artery perforator flap (TAP/TDAP flap)
            a) Skin and fat of the lateral back supplied by the thoracodorsal artery and vein perforator without the latissimus dorsi muscle.

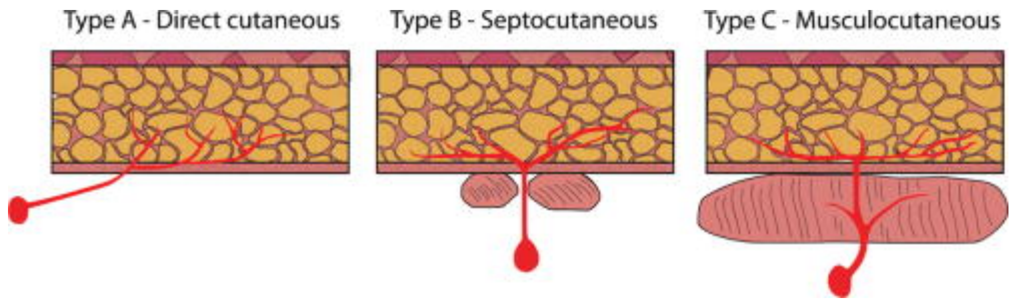

Figure 6. Mathes and Nahai classified fascial and fasciocutaneous flaps based on their vascular anatomy. Type A (left) are those flaps with a direct cutaneous pedicle to the fascia. Type B (center) are those flaps with a pedicle that has a septocutaneous perforator. Type C (right) are those with a musculocutaneous perforator. *From Buchanan PJ, Kung TA, Cederna PS. Evidence-Based Medicine: Wound Closure. Plast Reconstr Surg. 138(3S):257S-270S, September 2016.*

II. CHOOSING THE RIGHT FLAP

A. The primary defect - Recipient site considerations “replace like with like”
   1. Size
   2. Location
   3. Tissue type to be replaced: Muscle can eliminate more dead space, skin is better for resurfacing
   4. Functional and aesthetic considerations
B. The secondary defect - Donor site considerations
   1. Location
   2. Adhere to an angiosome, the territory that is supplied by a given vessel
   3. What type of tissues are needed
   4. Functional and aesthetic morbidity

III. FLAP SURVIVAL

A. Success depends not only on its survival but also its ability to achieve the goals of reconstruction.
B. Flap failure results ultimately from vascular compromise or the inability to achieve the goals of reconstruction.
   1. Tension
   2. Kinking of pedicle
   3. Compression
   4. Vascular thrombosis (typically more often a consideration in free flaps)
   5. Infection

REFERENCES

1. Mathes, S.J. Reconstructive Surgery: Principles, Anatomy and Techniques. New York, Elsevier Science, 1997.
2. McCarthy, J.G. (ed). Plastic Surgery, vol. 1. New York: Elsevier Science, 1990. Russell, R.C. and Zamboni,W.A. Manual of Free Flaps New York: Elsevier Science, 2001.
3. Serafin, D. Atlas of Microsurgical Composite Tissue Transplantation. New York: Elsevier Science, 1996.
4. Buchanan PJ, Kung TA, Cederna PS. Evidence based medicine: wound closure. *Plast Reconstr Surg*. 2014 Dec;134(6):1391-1404.
5. Saint-Cyr M, Wong C, Buchel EW, Colohan S, Pederson WC. Free tissue transfers and replantation. *Plast Reconstr Surg.* 2012 Dec;130(6):858e-878e.