

Flaps

Flaps

A flap is a block of tissue that contains an innate blood supply that may be transferred from a donor site to reconstruct a secondary defect; the pedicle is the 'base' of the flap that contains the blood supply. Unlike a graft, a flap can therefore be used to reconstruct a defect that does not have a vascularised wound bed, such as exposed tendon, cortical bone or a prosthesis. There are numerous methods of classifying flaps: according to their blood supply, their proximity to the defect, the method by which they are transferred and the tissue that they contain. The five Cs methodology is a useful flap classification system based on their circulation, composition, contiguity, contour and conditioning (Figure 47.12).

1 Circulation: random pattern flaps have no dominant blood supply whereas axial flaps have a dominant feeding vessel.

2 Composition: cutaneous, fasciocutaneous, fascial, musculocutaneous, muscle, osseocutaneous, osseous, omentum/bowel.

3 Contiguity: local (where the flap shares a side with the defect) (Figure 47.13), regional (where the flap is near but not immediately adjacent to the defect) (Figures 47.14 and 47.15) and distant (where the flap is far from the defect and can be either pedicled or free) (Figures 47.16 and 47.17).

Sydney Reese Coleman, contemporary, plastic surgeon, New York, NY, USA. George Carl Cormack, contemporary, plastic surgeon, Cambridge, UK. Byrom George Harker Lamberty, contemporary, plastic surgeon, Cambridge, UK. Bengt Pontén, 1923–2007, Associate Professor of Plastic Surgery, Uppsala University, Uppsala, Sweden. Stephen John Mathes, 1943–2007, Professor of Surgery, University of California, San Francisco, CA, USA. Foad Nahai, contemporary, Professor of Surgery, Emory University, Atlanta, GA, USA.

into the defect – advancement (Figures 47.18 and 47.19), transposition (Figure 47.20), rotation (Figure 47.21), interpolation, waltzing, crane principle and free.

5 Conditioning: whether the flap is delayed by partially elevating and resetting the flap prior to definitive elevation and transfer. Delay enables a larger flap to be harvested by – improving its blood supply.

– Fasciocutaneous flaps comprise a fascial component that augments the flap blood supply owing to a network of sub-fascial, fascial and suprafascial vessels. Fasciocutaneous flaps may be classified according to Cormack and Lamberty (1984) (Figure 47.22):

- Type A: multiple perforators that can be direct or indirect (e.g. Pontén flap).
- Type B: single perforator that is usually direct and runs along the axis of the flap (e.g. the scapular or parascapular flaps).
- Type C: segmental perforators that arise from the same source vessel (e.g. the radial forearm and lateral arm flaps) (Figure 47.23).
- Type D: similar to type C; however, the flap is raised as an osteomyofasciocutaneous flap (e.g. the free fibular flap).

In muscle and musculocutaneous flaps the motor nerve is always accompanied by a vascular pedicle, which is often the major source of the flap circulation. A dominant pedicle can sustain an entire muscle whereas a minor pedicle can normally only sustain a portion of the flap. The skin in a musculocutaneous flap is supplied by perforators. Muscle flaps are classified by Mathes and Nahai (1981) (Figure 47.24):

- Type I: single vascular pedicle (e.g. tensor fascia lata and gastrocnemius).
- Type II: one dominant pedicle with one or more minor pedicles (e.g. gracilis, biceps femoris, sternocleidomastoid, soleus and trapezius); the flap cannot survive on the minor pedicle(s) alone.

/uni25CF Type III: dual dominant pedicles (e.g. gluteus maximus, pectoralis minor, rectus abdominis, serratus anterior and temporalis). /uni25CF Type IV: segmental pedicles (e.g. flexor hallucis longus, sartorius and tibialis anterior). /uni25CF Type V: dominant pedicle with several smaller segmental pedicles (e.g. latissimus dorsi and pectoralis major) (Figures 47.25 and 47.26); the flap can survive on the minor pedicles alone. A chimeric flap consists of multiple otherwise spatially independent flaps, each of which has an independent vascular supply , with all pedicles linked to a common source vessel. For example, the descending branch of the lateral femoral

TRANSPOSITION FLAP Donor defect (grafted or sometimes closed Defect primarily) Pivot point (b) BILOBED FLAP Uses a /f_l ap to close a convex defect, and a second smaller /f_l ap to close the donor site Secondary ap Flap (c) RHOMBOID Tissue FLAP defect a' a' a A parallelogram- shaped transposition Flap /f_l ap a Figure 47.12 Local /f_l ap diagrams. (a) Transposition and Z-plasty /f_l aps. (b) Bilobed and bipediced /f_l aps. (c) Rhomboid and rotation /f_l aps. (continued overleaf) Z-PLASTY Two triangular transposition /f_l aps interposed 1 2 3 B A A B B A 4 5 6 B B B A A A BIPEDICLE FLAP A 'bucket-handle' /f_l ap supplied from both ends. Useful to rebuild the lower eyelid Flap ROTATION FLAP a a b b

ADVANCEMENT FLAP rectangular Simple r (with or without Burrow's triangle excision at base) Defect Two Burrow's triangles can be excised at base of /f_l ap to make it slide V to Y e.g. cut /f_l fingertip Flap (e) 2 1 Mark a long Burrow's scar zig-zag along with long the scar ellipse around it 5 4 The cut lines The /f_l finished wound will look will look something something like like this this each becomes Pad it well, and be a a' Advance the sure to splint open b' b tips of the when not exercising zig-zags into the spaces Y to V Usually multiple Area of to release band scar scars over joint s shaded This is one of the effective most ef means of releasing moderate isolated band burrow scars over /f_l excision cr eases 3 Add in the horizontal lines to the zig-zag; a' each becomes a b' a 'Y' b Figure 47.12 (continued) Local /f_l ap diagrams. (d) Advancement /f_l aps. (e) Multiple Y-to-V plasty for burn scar.

Figure 47.13 Bilobed /f_l ap reconstruction of a nasal defect following excision of a basal cell carcinoma. raised. (c) Transposition of bilobed /f_l ap. (d) Immediate postoperative appearance. (a) (b) Figure 47.14 Forehead /f_l ap reconstruction of nasal defect following excision of multiple basal cell carcinomas. demonstrating the forehead /f_l ap based on the right supratrochlear artery. The pedicle position is confirmed using a hand-held Doppler probe. /uni00A0(b) Flap inset to nose – note the bulky pedicle at the right medial eyebrow; donor site closed primarily except at the widest point, where it is allowed to heal by secondary intention. (c) The /f_l ap pedicle was divided at a second stage, allowing contouring of the /f_l ap. Appearance at 6 /uni00A0months. (a) Excision markings. (b) Bilobed /f_l ap (c) (a) Preoperative markings

(e) (f) (a) (b) (d) Figure 47.16 The medial sural artery perforator (MSAP) /f_l ap can be used as a pedicled /f_l ap for regional defects or as a free /f_l ap for distant defects. (a) Traumatic defect of the anterior knee with a partially transected patellar ligament and cortical loss of the tibial tuberosity following wound debridement. (b, c) The MSAP /f_l ap is harvested – the perforator (arrow) is identified arising from the substance of the gastrocnemius muscle belly. (d, e) The /f_l ap remains attached to a pedicle and is transferred through a subcutaneous tunnel to the anterior knee defect. (f) /uni00A0Appearance after inset of the /f_l ap. (g) Figure 47.15 Reconstruction of

calcaneal osteomyelitis using a pedicled medial plantar artery /f_l ap. (a) Chronic wound over calcaneal osteomyelitis. (b) The medial plantar artery (MPA), a continuation of the posterior tibial (PT) artery, marked out using a Doppler probe and the skin /f_l ap designed accordingly. (c, d) Calcaneal wound debrided and /f_l ap raised. (e) Flap transferred onto the heel. (f) Immediate postoperative appearance of the /f_l ap inset with a meshed split-thickness skin graft laid on the donor site. (g) One-month postoperative appearance. (c) (e) (f)

(d) (f) Figure 47.17 The medial sural artery perforator (MSAP) /f_l ap can be used as a pedicled /f_l ap for regional defects or as a free /f_l ap for distant defects. (a) A longstanding diabetic foot ulcer of the left hallux with underlying osteomyelitis. (b) Marking of the MSAP /f_l ap. (c) Amputation of the hallux – direct closure would have neces

sitated proximal excision of the /f_i rst metatarsal bone, thereby compromising weightbearing. /uni00A0 (d) The MSAP pedicle (arrow) dissected. (e) The detached MSAP /f_l ap with the pedicle (arrow). appearance of the (f, g) Immediate postoperative /f_l ap, with indwelling Doppler monitoring (arrows) for venous anastomosis patency. (b) (a) Figure 47.18 Excision of a basal cell carcinoma of the right alar groove and reconstruction with a V-to-Y nasolabial advancement /f_l ap. /uni00A0 (a) Tumour excision margins and /f_l ap design markings. (b) The defect following

excision of the basal cell carcinoma. /f_l ap. (d) Advancement and inset of the /f_l ap. (e) (g) (c) (d) (c) Raising the nasolabial

Figure 47.19 Hatchet /f_l ap reconstruction following excision of a skin cancer of the right eyebrow. the tumour with a back cut to enable /f_l ap advancement. (c) Insetting of the /f_l ap. (a) (b) x x y y

Figure 47.20 Reconstruction of a melanocytic lesion of the left pre-auricular region using a rhomboid (transposition) /f_l ap. (a) Preoperative markings. (b) Immediate postoperative appearance. (a) (b) Muscle Figure 47.22 Cormack and Lamberty classi /f_i cation of fasciocutaneous /f_l aps. small, segmental perforators. (d) Osteomyofascial perforators. (a) Preoperative planning. (b) Post excision of (d) Immediate postoperative appearance. (a) (b) Figure 47.21 Rotation /f_l ap reconstruction following excision of a pilonidal sinus. (a) Preoperative marking of the rotational /f_l ap with a back cut. (b) Immediate postoperative appearance. (c) (d) Bone Muscle /uni00A0 (a) Multiple large perforators. (b) Single large perforator. (c) Multiple,

(d) (e) (f) (g) Figure 47.23 Wound debridement and reconstruction with a pedicled /f_l ap based on a perforator arising from the posterior tibial artery. sinus overlying internal /f_i xation of a medial malleolar fracture. skin (X). (c) The perforator (arrow) and a pair of vena comitans were dissected and the fasciocutaneous /f_l ap islanded. 180° clockwise to reconstruct the defect. (g) The donor site was able to be closed primarily owing to local skin laxity. Type I Type II Gluteus maximus Gracilis Tensor fascia lata Figure 47.24 The Mathes and Nahai classi /f_i cation of muscle /f_l aps. /uni00A0 (a) Chronic (b) The perforator has been identi /f_i ed using a Doppler probe and marked on the (d-f) The /f_l ap is propellered Type IV Type V Type III Latissimus Sartorius dorsi

Figure 47.25 The latissimus dorsi /f_l ap can be used as a pedicled /f_l ap to reconstruct regional defects or as a free /f_l ap to reconstruct distant defects. (a) Dermato /f_i brosarcoma protuberans of the left breast. (a) (b) (c) (d) (e) Figure 47.26 (a, b) Limb-threatening, multiplanar degloving injury of the left foot and ankle from a road traf /f_i c accident. debridement, multiple skin defects with exposed extensor tendons and tibiotalar joint. /f_l aps as two separate free /f_l aps. (f, g) Immediate postoperative appearance with meshed split-thickness skin grafts laid over the muscle /f_l aps. (h, /uni00A0 i) /uni00A0 Postoperative appearance at 6 months with normal ambulation. (b) Reconstruction using a pedicled musculocutaneous latissimus dorsi /f_l ap. (f) (h) (i) (g) (c, d) Following wound (e) Harvest of left latissimus dorsi and serratus anterior

circumflex artery pedicle can support multiple skin and muscle flaps (Figure 47.27) or the subscapular vascular pedicle can support a scapular flap, a parascapular flap, a latissimus dorsi flap and a serratus anterior flap. This enables the reconstruction of complex composite defects involving di ff erent tissues. For example, following resection of a maxillary sinus tumour, a chimeric scapular flap can be used to reconstruct both the bony and skin defects. V enous flow-through flaps are based on a venous rather than arterial pedicle so that the vein delivers both inflow and outflow of blood. These flaps are thin and pliable but prone to venous congestion and partial necrosis as there is no arterial input and the flap survives on deo xygenated blood. There is minimal donor site morbidity . Examples include the saphenous flap and those based on the superficial veins of the forearm.

Figure 47.27 (a, b) Chimeric anterolateral thigh /f_l ap comprising spatially independent skin and muscle /f_l aps with all pedicles linked to a common source vessel (arrow), the descending branch

of the lateral femoral circum /f_ l ex artery.

Flaps

A flap is a block of tissue that contains an innate blood supply that may be transferred from a donor site to reconstruct a secondary defect; the pedicle is the 'base' of the flap that contains the blood supply. Unlike a graft, a flap can therefore be used to reconstruct a defect that does not have a vascularised wound bed, such as exposed tendon, cortical bone or a prosthesis. There are numerous methods of classifying flaps: according to their blood supply, their proximity to the defect, the method by which they are transferred and the tissue that they contain. The five Cs methodology is a useful flap classification system based on their circulation, composition, contiguity, contour and conditioning (Figure 47.12).

1 Circulation: random pattern flaps have no dominant blood supply whereas axial flaps have a dominant feeding vessel.

2 Composition: cutaneous, fasciocutaneous, fascial, musculocutaneous, muscle, osseocutaneous, osseous, omentum/bowel.

3 Contiguity: local (where the flap shares a side with the defect) (Figure 47.13), regional (where the flap is near but not immediately adjacent to the defect) (Figures 47.14 and 47.15) and distant (where the flap is far from the defect and can be either pedicled or free) (Figures 47.16 and 47.17).

Sydney Reese Coleman, contemporary, plastic surgeon, New York, NY, USA. George Carl Cormack, contemporary, plastic surgeon, Cambridge, UK. Byrom George Harker Lamberty, contemporary, plastic surgeon, Cambridge, UK. Bengt Pontén, 1923–2007, Associate Professor of Plastic Surgery, Uppsala University, Uppsala, Sweden. Stephen John Mathes, 1943–2007, Professor of Surgery, University of California, San Francisco, CA, USA. Foad Nahai, contemporary, Professor of Surgery, Emory University, Atlanta, GA, USA.

into the defect – advancement (Figures 47.18 and 47.19), transposition (Figure 47.20), rotation (Figure 47.21), interpolation, waltzing, crane principle and free.

5 Conditioning: whether the flap is delayed by partially elevating and resetting the flap prior to definitive elevation and transfer. Delay enables a larger flap to be harvested by – improving its blood supply.

– Fasciocutaneous flaps comprise a fascial component that augments the flap blood supply owing to a network of sub-fascial, fascial and suprafascial vessels. Fasciocutaneous flaps may be classified according to Cormack and Lamberty (1984) (Figure 47.22):

- Type A: multiple perforators that can be direct or indirect (e.g. Pontén flap).
- Type B: single perforator that is usually direct and runs along the axis of the flap (e.g. the scapular or parascapular flaps).
- Type C: segmental perforators that arise from the same source vessel (e.g. the radial forearm and lateral arm flaps) (Figure 47.23).
- Type D: similar to type C; however, the flap is raised as an osteomyofasciocutaneous flap (e.g. the free fibular flap).

In muscle and musculocutaneous flaps the motor nerve is always accompanied by a vascular pedicle, which is often the major source of the flap circulation. A dominant pedicle can sustain an entire muscle whereas a minor pedicle can normally only sustain a portion of the flap. The skin in a musculo-cutaneous flap is supplied by perforators. Muscle flaps are classified by Mathes and Nahai (1981) (Figure 47.24):

- Type I: single vascular pedicle (e.g. tensor fascia lata and gastrocnemius).
- Type II: one dominant pedicle with one or more minor pedicles (e.g. gracilis, biceps femoris, sternocleidomastoid, soleus and trapezius); the flap cannot survive on the minor pedicle(s) alone.
- Type III: dual dominant pedicles (e.g. gluteus maximus, pectoralis minor, rectus abdominis, serratus anterior and temporalis).
- Type IV: segmental pedicles (e.g. flexor hallucis longus, sartorius and tibialis anterior).
- Type V: dominant pedicle with several smaller segmental pedicles (e.g. latissimus dorsi and pectoralis major) (Figures 47.25 and 47.26).

); the flap can survive on the minor pedicles alone. A chimeric flap consists of multiple otherwise spatially independent flaps, each of which has an independent vascular supply, with all pedicles linked to a common source vessel. For example, the descending branch of the lateral femoral

TRANSPOSITION FLAP Donor defect (grafted or sometimes closed Defect primarily) Pivot point (b)
BILOBED FLAP Uses a /f_l ap to close a convex defect, and a second smaller /f_l ap to close the donor site Secondary ap Flap (c) **RHOMBOID Tissue FLAP** defect a' a' a A parallelogram- shaped transposition Flap /f_l ap a Figure 47.12 Local /f_l ap diagrams. (a) Transposition and Z-plasty /f_l aps. (b) Bilobed and bipediced /f_l aps. (c) Rhomboid and rotation /f_l aps. (continued overleaf) **Z-PLASTY** Tw o triangular transposition /f_l aps interposed 1 2 3 B A A B B A 4 5 6 B B B A A A **BIPEDICLE FLAP** A 'bucket-handle' /f_l ap supplied from both ends. Useful to rebuild the lower eyelid Flap **ROTATION FLAP** a a b b

ADVANCEMENT FLAP rectangular Simple r (with or without Bur ow 's triangle excision at base) Defect Tw o Bu ro w's triangles can be excised at base of /f_l ap to make it slide V to Y e.g. cut /f_i ngertip Flap (e) 2 1 Mark a long Bu rn scar zig-zag along with long the scar ellipse around it 5 4 The cut lines The /f_i nished wound will look will look something something like like this this each becomes Pad it well, and be a a' Advance the sure to splint open b' b tips of the when not exercising zig-zags into the spaces Y to V Usually multiple Area of to r eleas e band scar scars over joint s shaded This is one of the fective most ef means of r eleas ing moderate isolated band bur n scars over /f_l exion cr eases 3 Add in the horizontal lines to the zig-zag; a' each becomes a b' a 'Y' b Figure 47.12 (continued) Local /f_l ap diagrams. (d) Advancement /f_l aps. (e) Multiple Y-to-V plasty for burn scar.

Figure 47.13 Bilobed /f_l ap reconstruction of a nasal defect following excision of a basal cell carcinoma. raised. (c) Transposition of bilobed /f_l ap. (d) Immediate postoperative appearance. (a) (b) Figure 47.14 Forehead /f_l ap reconstruction of nasal defect following excision of multiple basal cell carcinomas. demonstrating the forehead /f_l ap based on the right supratrochlear artery. The pedicle position is con /f_i rmed using a hand-held Doppler probe. /uni00A0 (b) Flap inset to nose - note the bulky pedicle at the right medial eyebrow; donor site closed primarily except at the widest point, where it is allowed to heal by secondary intention. (c) The /f_l ap pedicle was divided at a second stage, allowing contouring of the /f_l ap. Appearance at 6 /uni00A0 months. (a) Excision markings. (b) Bilobed /f_l ap (c) (a) Preoperative markings

(e) (f) (a) (b) (d) Figure 47.16 The medial sural artery perforator (MSAP) /f_l ap can be used as a pedicled /f_l ap for regional defects or as a free /f_l ap for distant defects. (a) Traumatic defect of the anterior knee with a partially transected patellar ligament and cortical loss of the tibial tuberosity following wound debridement. (b, c) The MSAP /f_l ap is harvested - the perforator (arrow) is identi /f_i ed arising from the substance of the gastrocnemius muscle belly. (d, e) The /f_l ap remains attached to a pedicle and is transferred through a subcutaneous tunnel to the anterior knee defect. (f) /uni00A0 Appearance after inset of the /f_l ap. (g) Figure 47.15 Reconstruction of calcaneal osteomyelitis using a pedicled medial plantar artery /f_l ap. (a) Chronic wound over calcaneal osteomyelitis. (b) The medial plantar artery (MPA), a continuation of the posterior tibial (PT) artery, marked out using a Doppler probe and the skin /f_l ap designed accordingly. (c, d) Calcaneal wound debrided and /f_l ap raised. (e) Flap transferred onto the heel. (f) Immediate

postoperative appearance of the /f_l ap inset with a meshed split-thickness skin graft laid on the donor site. (g) One-month postoperative appearance. (c) (e) (f)

(d) (f) Figure 47.17 The medial sural artery perforator (MSAP) /f_l ap can be used as a pedicled /f_l ap for regional defects or as a free /f_l ap for distant defects. (a) A longstanding diabetic foot ulcer of the left hallux with underlying osteomyelitis. (b) Marking of the MSAP /f_l ap. (c) Amputation of the hallux – direct closure would have neces

sitated proximal excision of the /f_i rst metatarsal bone, thereby compromising weightbearing. /uni00A0 (d) The MSAP pedicle (arrow) dissected. (e) The detached MSAP /f_l ap with the pedicle (arrow). appearance of the (f, g) Immediate postoperative /f_l ap, with indwelling Doppler monitoring (arrows) for venous anastomosis patency. (b) (a) Figure 47.18 Excision of a basal cell carcinoma of the right alar groove and reconstruction with a V-to-Y nasolabial advancement /f_l ap. /uni00A0 (a) Tumour excision margins and /f_l ap design markings. (b) The defect following excision of the basal cell carcinoma. /f_l ap. (d) Advancement and inset of the /f_l ap. (e) (g) (c) (d) (c) Raising the nasolabial

Figure 47.19 Hatchet /f_l ap reconstruction following excision of a skin cancer of the right eyebrow. the tumour with a back cut to enable /f_l ap advancement. (c) Insetting of the /f_l ap. (a) (b) x x y y Figure 47.20 Reconstruction of a melanocytic lesion of the left pre-auricular region using a rhomboid (transposition) /f_l ap. (a) Preoperative markings. (b) Immediate postoperative appearance. (a) (b) Muscle Figure 47.22 Cormack and Lamberty classi /f_i cation of fasciocutaneous /f_l aps. small, segmental perforators. (d) Osteomyofascial perforators. (a) Preoperative planning. (b) Post excision of (d) Immediate postoperative appearance. (a) (b) Figure 47.21 Rotation /f_l ap reconstruction following excision of a pilonidal sinus. (a) Preoperative marking of the rotational /f_l ap with a back cut. (b) Immediate postoperative appearance. (c) (d) Bone Muscle /uni00A0 (a) Multiple large perforators. (b) Single large perforator. (c) Multiple,

(d) (e) (f) (g) Figure 47.23 Wound debridement and reconstruction with a pedicled /f_l ap based on a perforator arising from the posterior tibial artery. sinus overlying internal /f_i xation of a medial malleolar fracture. skin (X). (c) The perforator (arrow) and a pair of vena comitans were dissected and the fasciocutaneous /f_l ap islanded. 180° clockwise to reconstruct the defect. (g) The donor site was able to be closed primarily owing to local skin laxity. Type I Type II Gluteus maximus Gracilis Tensor fascia lata Figure 47.24 The Mathes and Nahai classi /f_i cation of muscle /f_l aps. /uni00A0 (a) Chronic (b) The perforator has been identi /f_i ed using a Doppler probe and marked on the (d-f) The /f_l ap is propellered Type IV Type V Type III Latissimus Sartorius dorsi

Figure 47.25 The latissimus dorsi /f_l ap can be used as a pedicled /f_l ap to reconstruct regional defects or as a free /f_l ap to reconstruct distant defects. (a) Dermato /f_i brosarcoma protuberans of the left breast. (a) (b) (c) (d) (e) Figure 47.26 (a, b) Limb-threatening, multiplanar degloving injury of the left foot and ankle from a road traf /f_i c accident. debridement, multiple skin defects with exposed extensor tendons and tibiotalar joint. /f_l aps as two separate free /f_l aps. (f, g) Immediate postoperative appearance with meshed split-thickness skin grafts laid over the muscle /f_l aps. (h, /uni00A0 i) /uni00A0 Postoperative appearance at 6 months with normal ambulation. (b) Reconstruction using a pedicled musculocutaneous latissimus dorsi /f_l ap. (f) (h) (i) (g) (c, d) Following wound (e) Harvest of left latissimus dorsi and serratus anterior

circumflex artery pedicle can support multiple skin and muscle flaps (Figure 47.27) or the subscapular vascular pedicle can support a scapular flap, a parascapular flap, a latissimus dorsi flap and a serratus anterior flap. This enables the reconstruction of complex composite defects involving di ff erent tissues. For example, following resection of a maxillary sinus tumour, a chimeric scapular flap can be used to reconstruct both the bony and skin defects. V enous flow-through flaps are based on a venous rather than arterial pedicle so that the vein delivers both inflow and outflow of blood. These flaps are thin and pliable but prone to venous congestion and partial necrosis as there is no arterial input and the flap survives on deo xygenated blood. There is minimal donor site morbidity . Examples include the saphenous flap and those based on the superficial veins of the forearm.

Figure 47.27 (a, b) Chimeric anterolateral thigh /f_l ap comprising spatially independent skin and muscle /f_l aps with all pedicles linked to a common source vessel (arrow), the descending branch of the lateral femoral circum /f_l ex artery.

Flaps

A flap is a block of tissue that contains an innate blood supply that may be transferred from a donor site to reconstruct a secondary defect; the pedicle is the 'base' of the flap that contains the blood supply. Unlike a graft, a flap can therefore be used to reconstruct a defect that does not have a vascularised wound bed, such as exposed tendon, cortical bone or a prosthesis. There are numerous methods of classifying flaps: according to their blood supply, their proximity to the defect, the method by which they are transferred and the tissue that they contain. The five Cs methodology is a useful flap classification system based on their circulation, composition, contiguity, contour and conditioning (Figure 47.12).

1 Circulation: random pattern flaps have no dominant blood supply whereas axial flaps have a dominant feeding vessel.

2 Composition: cutaneous, fasciocutaneous, fascial, musculocutaneous, muscle, osseocutaneous, osseous, omentum/bowel.

3 Contiguity: local (where the flap shares a side with the defect) (Figure 47.13), regional (where the flap is near but not immediately adjacent to the defect) (Figures 47.14 and 47.15) and distant (where the flap is far from the defect and can be either pedicled or free) (Figures 47.16 and 47.17).

Sydney Reese Coleman, contemporary, plastic surgeon, New York, NY, USA. George Carl Cormack, contemporary, plastic surgeon, Cambridge, UK. Byrom George Harker Lamberty, contemporary, plastic surgeon, Cambridge, UK. Bengt Pontén, 1923–2007, Associate Professor of Plastic Surgery, Uppsala University, Uppsala, Sweden. Stephen John Mathes, 1943–2007, Professor of Surgery, University of California, San Francisco, CA, USA. Foad Nahai, contemporary, Professor of Surgery, Emory University, Atlanta, GA, USA.

into the defect – advancement (Figures 47.18 and 47.19), **transposition** (Figure 47.20), **rotation** (Figure 47.21), **interpolation**, **waltzing**, **crane principle** and **free**.

5 Conditioning: whether the flap is delayed by partially elevating and resetting the flap prior to definitive elevation and transfer. Delay enables a larger flap to be harvested by – improving its blood supply.

– Fasciocutaneous flaps comprise a fascial component that augments the flap blood supply owing to a network of sub-fascial, fascial and suprafascial vessels. Fasciocutaneous flaps may be classified according to Cormack and Lamberty (1984) (Figure 47.22):

- /uni25CF Type A: multiple perforators that can be direct or indirect (e.g. Pontén flap).
- /uni25CF Type B: single perforator that is usually direct and runs along the axis of the flap (e.g. the scapular or parascapular flaps).
- /uni25CF Type C: segmental perforators that arise from the same source vessel (e.g. the radial forearm and lateral arm flaps) (Figure 47.23).
- /uni25CF Type D: similar to type C; however, the flap is raised as an osteomyofasciocutaneous flap (e.g. the free fibular flap).

In muscle and musculocutaneous flaps the motor nerve is always accompanied by a vascular pedicle, which is often the major source of the flap circulation. A dominant pedicle can sustain an entire muscle whereas a minor pedicle can normally only sustain a portion of the flap. The skin in a musculocutaneous flap is supplied by perforators. Muscle flaps are classified by Mathes and Nahai (1981) (Figure 47.24):

- /uni25CF Type I: single vascular pedicle (e.g. tensor fascia lata and gastrocnemius).
- /uni25CF Type II: one dominant pedicle with one or more minor pedicles (e.g. gracilis, biceps femoris, sternocleidomastoid, soleus and trapezius); the flap cannot survive on the minor pedicle(s) alone.
- /uni25CF Type III: dual dominant pedicles (e.g. gluteus maximus, pectoralis minor, rectus abdominis, serratus anterior and temporalis).
- /uni25CF Type IV: segmental pedicles (e.g. flexor hallucis longus, sartorius and tibialis anterior).
- /uni25CF Type V: dominant pedicle with several smaller segmental pedicles (e.g. latissimus dorsi and pectoralis major) (Figures 47.25 and 47.26); the flap can survive on the minor pedicles alone.

A chimeric flap consists of multiple otherwise spatially independent flaps, each of which has an independent vascular supply, with all pedicles linked to a common source vessel. For example, the descending branch of the lateral femoral

TRANSPOSITION FLAP Donor defect (grafted or sometimes closed Defect primarily) Pivot point (b) BILOBED FLAP Uses a /f_l ap to close a convex defect, and a second smaller /f_l ap to close the donor site Secondary ap Flap (c) RHOMBOID Tissue FLAP defect a' a' A parallelogram- shaped transposition Flap /f_l ap a Figure 47.12 Local /f_l ap diagrams. (a) Transposition and Z-plasty /f_l aps. (b) Bilobed and bipediced /f_l aps. (c) Rhomboid and rotation /f_l aps. (continued overleaf) Z-PLASTY Tw o triangular transposition /f_l aps interposed 1 2 3 B A A B B A 4 5 6 B B B A A A BIPEDICLE FLAP A 'bucket-handle' /f_l ap supplied from both ends. Useful to rebuild the lower eyelid Flap RO TA TION FLAP a a b b

A DVANCEMENT FLAP ectangular Simple r (with or without Bur ow 's triangle excision at base) Defect Tw o Bu ro w's triangles can be excised at base of /f_l ap to make it slide V to Y e.g. cut /f_i ngertip Flap (e) 2 1 Mark a long Bu rn scar zig-zag along with long the scar ellipse around it 5 4 The cut lines The /f_i nished wound will look will look something something like like this this each becomes Pad it well, and be a a' Advance the sure to splint open b' b tips of the when not exercising zig-zags into the spaces Y to V Usually multiple Area of to r elease band scar scars over joint s shaded This is one of the fective most ef means of r eleasing moderate isolated band bur n scars over /f_l exion cr eases 3 Add in the horizontal lines to the zig-zag; a' each becomes a b' a 'Y' b Figure 47.12 (continued) Local /f_l ap diagrams. (d) Advancement /f_l aps. (e) Multiple Y-to-V plasty for burn scar.

Figure 47.13 Bilobed /f_l ap reconstruction of a nasal defect following excision of a basal cell carcinoma. raised. (c) Transposition of bilobed /f_l ap. (d) Immediate postoperative appearance. (a) (b) Figure 47.14 Forehead /f_l ap reconstruction of nasal defect following excision of multiple basal cell carcinomas. demonstrating the forehead /f_l ap based on the right supratrochlear artery. The pedicle position is con /f_i rmed using a hand-held Doppler probe. /uni00A0(b) Flap inset to nose – note the bulky pedicle at the right medial eyebrow; donor site closed primarily except at the widest point, where it is allowed to heal by secondary intention. (c) The /f_l ap pedicle was divided at a second stage, allowing contouring of the /f_l ap. Appearance at 6 /uni00A0months. (a) Excision markings. (b) Bilobed /f_l ap (c) (a) Preoperative markings

(e) (f) (a) (b) (d) Figure 47.16 The medial sural artery perforator (MSAP) /f_l ap can be used as a pedicled /f_l ap for regional defects or as a free /f_l ap for distant defects. (a) Traumatic defect of the anterior knee with a partially transected patellar ligament and cortical loss of the tibial tuberosity following wound debridement. (b, c) The MSAP /f_l ap is harvested – the perforator (arrow) is identi /f_i ed arising from the substance of the gastrocnemius muscle belly. (d, e) The /f_l ap remains attached to a pedicle and is transferred through a subcutaneous tunnel to the anterior knee defect. (f) /uni00A0Appearance after inset of the /f_l ap. (g) Figure 47.15 Reconstruction of calcaneal osteomyelitis using a pedicled medial plantar artery /f_l ap. (a) Chronic wound over calcaneal osteomyelitis. (b) The medial plantar artery (MPA), a continuation of the posterior tibial (PT) artery, marked out using a Doppler probe and the skin /f_l ap designed accordingly. (c, d) Calcaneal wound debrided and /f_l ap raised. (e) Flap transferred onto the heel. (f) Immediate postoperative appearance of the /f_l ap inset with a meshed split-thickness skin graft laid on the donor site. (g) One-month postoperative appearance. (c) (e) (f)

(d) (f) Figure 47.17 The medial sural artery perforator (MSAP) flap can be used as a pedicled flap for regional defects or as a free flap for distant defects. (a) A longstanding diabetic foot ulcer of the left hallux with underlying osteomyelitis. (b) Marking of the MSAP flap. (c) Amputation of the hallux – direct closure would have necessitated proximal excision of the first metatarsal bone, thereby compromising weightbearing. (d) The MSAP pedicle (arrow) dissected. (e) The detached MSAP flap with the pedicle (arrow). (f, g) Immediate postoperative flap, with indwelling Doppler monitoring (arrows) for venous anastomosis patency. (b) (a) Figure 47.18 Excision of a basal cell carcinoma of the right alar groove and reconstruction with a V-to-Y nasolabial advancement flap. (a) Tumour excision margins and flap design markings. (b) The defect following excision of the basal cell carcinoma. (c) Advancement and inset of the flap. (d) Raising the nasolabial

Figure 47.19 Hatchet flap reconstruction following excision of a skin cancer of the right eyebrow. the tumour with a back cut to enable flap advancement. (c) Insetting of the flap. (a) (b) x x y y Figure 47.20 Reconstruction of a melanocytic lesion of the left pre-auricular region using a rhomboid (transposition) flap. (a) Preoperative markings. (b) Immediate postoperative appearance. (a) (b) Muscle Figure 47.22 Cormack and Lamberty classification of fasciocutaneous

Figure 47.19 Hatchet flap reconstruction following excision of a skin cancer of the right eyebrow. the tumour with a back cut to enable flap advancement. (c) Insetting of the flap. (a) (b) x x y y Figure 47.20 Reconstruction of a melanocytic lesion of the left pre-auricular region using a rhomboid (transposition) flap. (a) Preoperative markings. (b) Immediate postoperative appearance. (a) (b) Muscle Figure 47.22 Cormack and Lamberty classification of fasciocutaneous

/f_l aps. small, segmental perforators. (d) Osteomyofascial perforators. (a) Preoperative planning. (b) Post excision of (d) Immediate postoperative appearance. (a) (b) Figure 47.21 Rotation /f_l ap reconstruction following excision of a pilonidal sinus. (a) Preoperative marking of the rotational /f_l ap with a back cut. (b) Immediate postoperative appearance. (c) (d) Bone Muscle /uni00A0 (a) Multiple large perforators. (b) Single large perforator. (c) Multiple,

(d) (e) (f) (g) Figure 47.23 Wound debridement and reconstruction with a pedicled /f_l ap based on a perforator arising from the posterior tibial artery. sinus overlying internal /f_i xation of a medial malleolar fracture. skin (X). (c) The perforator (arrow) and a pair of vena comitans were dissected and the fasciocutaneous /f_l ap islanded. 180° clockwise to reconstruct the defect. (g) The donor site was able to be closed primarily owing to local skin laxity. Type I Type II Gluteus maximus Gracilis Tensor fascia lata Figure 47.24 The Mathes and Nahai classi /f_i cation of muscle /f_l aps. /uni00A0 (a) Chronic (b) The perforator has been identi /f_i ed using a Doppler probe and marked on the (d-f) The /f_l ap is propellered Type IV Type V Type III Latissimus Sartorius dorsi

Figure 47.25 The latissimus dorsi /f_l ap can be used as a pedicled /f_l ap to reconstruct regional defects or as a free /f_l ap to reconstruct distant defects. (a) Dermato /f_i brosarcoma protuberans of the left breast. (a) (b) (c) (d) (e) Figure 47.26 (a, b) Limb-threatening, multiplanar degloving injury of the left foot and ankle from a road traf /f_i c accident. debridement, multiple skin defects with exposed extensor tendons and tibiotalar joint. /f_l aps as two separate free /f_l aps. (f, g) Immediate postoperative appearance with meshed split-thickness skin grafts laid over the muscle /f_l aps. (h, /uni00A0 i) /uni00A0 Postoperative appearance at 6 months with normal ambulation. (b) Reconstruction using a pedicled musculocutaneous latissimus dorsi /f_l ap. (f) (h) (i) (g) (c, d) Following wound (e) Harvest of left latissimus dorsi and serratus anterior

circumflex artery pedicle can support multiple skin and muscle flaps (Figure 47.27) or the subscapular vascular pedicle can support a scapular flap, a parascapular flap, a latissimus dorsi flap and a serratus anterior flap. This enables the reconstruction of complex composite defects involving di ff erent tissues. For example, following resection of a maxillary sinus tumour, a chimeric scapular flap can be used to reconstruct both the bony and skin defects. V enous flow-through flaps are based on a venous rather than arterial pedicle so that the vein delivers both inflow and outflow of blood. These flaps are thin and pliable but prone to venous congestion and partial necrosis as there is no arterial input and the flap survives on deo xygenated blood. There is minimal donor site morbidity . Examples include the saphenous flap and those based on the superficial veins of the forearm.

Figure 47.27 (a, b) Chimeric anterolateral thigh /f_l ap comprising spatially independent skin and muscle /f_l aps with all pedicles linked to a common source vessel (arrow), the descending branch of the lateral femoral circum /f_l ex artery.