14

Free Grafts

PLATES

FREE SKIN GRAFTS

Free grafts are segments of skin completely detached from one area of the body and used to resurface another body area lacking an epithelial surface. Free grafts lack a vascular attachment upon transfer to the recipient graft bed. They must survive by absorbing tissue fluid from the recipient bed by capillary action during the initial 48 hours after transplantation. During this period, capillaries from the recipient bed unite with the exposed graft plexuses to reestablish vital circulation. New capillaries later grow into the graft and the vascular channels remodel. In addition, fibrous connective tissue forms to hold the graft securely in place. Grafts assume a pink color in 48 hours if circulation is adequate. Grafts with venous obstruction have a cyanotic hue until circulation improves.

Any accumulation of material such as pus, serum, blood, hematoma, or foreign matter between the graft and recipient bed will delay or prevent graft revascularization. This delay often results in graft necrosis. Motion between the graft and the recipient bed has a similar effect. Fibrinolysis secondary to bacterial infection destroys the early fibrin "glue" between the graft and the bed, resulting in motion and graft necrosis. Improper contact between the graft and the recipient bed prevents proper surface-to-surface interdigitation and poor graft revascularization. This occurs if the graft is stretched over the bed like a drum skin or if an excessively large graft is applied to form graft folds that lack proper recipient bed contact. Nonviable grafts are white or black in appearance when assessed after sufficient time has progressed for their revascularization.

Although free skin grafts require a vascularized recipient bed for survival, granulation tissue is not necessary before a graft is applied. Healthy muscle, periosteum, and peritenon can support a skin graft. Healthy pink granulation tissue, however, is an excellent recipient bed for skin grafts. Pale, collagen-laden chronic granulation tissue has a poor vascular supply and should be excised to promote formation of healthy granulation tissue. Contamination and infection should be controlled, and any "epithelial cover" can be excised with a scalpel blade before graft application. Skin grafting in dogs, cats, and birds can be highly successful once the surgical details on graft harvesting, application, and bandaging are mastered. Fortunately, the learning curve is not particularly steep.

Antibiotics and Skin Grafting

All granulation beds are contaminated with bacteria. Surgeons have their preference for whether to use topical and systemic antibiotics in skin-grafting procedures. Surgeons occasionally culture the granulation bed prior to skin grafting to assure appropriate treatment can be instituted prior to graft application. (The author does not culture wound beds before grafting in most routine clinical cases.) In humans, group A beta-hemolytic streptococci (*Streptococcus pyogenes*) is the biggest culprit for graft dissolution. Topical and systemic penicillin can be used to control this organism prior to grafting. Other organisms, including *Pseudomonas* sp. and *Klebsiella* occasionally are problematic for graft survival.

The following is the author's method: Once a healthy granulation bed is obtained, apply a heavy layer of silver sulfadiazine or triple antibiotic ointment over the recipient bed, followed by a nonadherent dressing and protective bandage. This should take place 24–48 hours prior to grafting. Place most patients on a broad-spectrum antibiotic, usually Cephazolin (Novaplus, Sandoz Inc., Broomfield, CO), 20 mg/kg TID, prior to surgery and postoperatively for 1 week.

At the time of surgery, cover the recipient bed with sterile gauze when fur is clipped. Thoroughly cleanse the skin and graft bed with a chlorhexidine-saline (or lactated Ringer's solution) in a 1:40 dilution.

Use gauze sponges to gently scrub the granulation bed. After transfer to the recipient bed, cover the graft with a layer of triple antibiotic ointment, followed by a nonadherent dressing and protective bandage wrap.

CLASSIFICATION OF FREE GRAFTS

Free grafts can be classified according to the source of the graft, the graft thickness, and the graft shape or design. Although autogenous grafts are used for permanent free graft coverage in small animals, allografts (homografts) and xenografts (heterografts) can be used as temporary biologic dressings until an autogenous graft can be successfully applied. Free grafts can be harvested as full- or split-thickness skin grafts. Split-thickness grafts are harvested with razor blades, graft knives, or a dermatome. Graft knives and razors are difficult to master and rarely harvest the quantities of split-thickness skin grafts required for larger skin wounds that occasionally justify their use. Uniform thickness and adequate harvesting of split-thickness grafts require the use of the more expensive gas- or electric-powered dermatomes.

Grafts usually are applied immediately after harvesting. Under unusual clinical circumstances, the harvested skin can be temporarily refrigerated until application can be completed.

GRAFT THICKNESS

Graft thickness varies according to the amount of dermis included with the overlying epidermis. The donor bed of a split-thickness graft bed can be excised and closed, or it may be left to heal by adnexal regeneration and epithelialization. Thin split-thickness grafts "take" more readily than full-thickness grafts, but they lack durability and proper hair growth, and they are more susceptible to secondary graft contraction. Full-thickness grafts are preferred by many veterinarians for these reasons. From the author's experience, properly prepared full-thickness grafts can achieve survival rates comparable to thinner grafts in the dog and cat. Free grafts can be applied as a sheet over the entire recipient bed, or they can be cut into various shapes or patterns.

The full-thickness hand or scalpel mesh graft is a highly effective technique for closing defects involving the lower extremities (see Plate 67).

PARTIAL-COVERAGE GRAFTS

Punch grafts, pinch grafts, strip grafts, stamp grafts, and mesh grafts are commonly used as partial-coverage grafts to increase the total recipient surface area that a small graft harvest can cover.

Although these grafts can vary in thickness, they are frequently full-thickness grafts. With these grafts, open spaces between the graft perimeters allow for drainage until the granulation tissue bed is covered by the advancing sheet of epithelial cells originating from the graft. For this reason, partial-coverage grafts are useful for recipient beds with low-grade infections. Small grafts also conform to irregular recipient beds and are simple to apply. Widely placed graft segments unfortunately can produce an epithelialized surface that lacks the functional and cosmetic results achieved with the more complete coverage of full-thickness grafts. The author prefers to use full-thickness mesh grafts to close wounds of the lower extremities and to use punch or strip grafts for smaller wounds that are not located over areas where durability is essential (Fig. 14-1 and 14-2). Thin split-thickness mesh grafts are used for extensive body defects, particularly those resulting from burns (Fig. 14-3).

Punch, pinch, and strip grafts are primarily used to facilitate epithelialization of problematic wounds. They lack the durability achieved with sheet grafts and [Q]mesh grafts which cover the majority of the wound with full-thickness skin.

Punch graft "Induction": There have been several cases, over the years, in which punch graft placement dramatically induced the processes of wound contraction and epithelialization in chronic open extremity wounds (see Fig. 14-1). Epithelialization from the perimeter of the wound quickly expands toward the center of the wound, oftentimes more so than the epithelial contributions of the punch grafts themselves. The cause of this dramatic healing process remains unclear. Grafts may enhance the release of cytokines to promote epithelialization or possibly they serve as anchors for more effective myofibroblastic contraction.

Of the various grafting techniques discussed, full-thickness skin grafts harvested manually are most useful in closing moderate skin defects involving the extremities. Full-thickness and split-thickness grafts, meshed with a scalpel blade, are practical and effective in providing a more durable skin coverage in small animals than are punch and strip grafts. Hair growth is fair, but does not achieve the density provided by a skin flap (Figs. 14-1–14-6).

DERMATOMES

There are several dermatomes available commercially for human use. The Brown Electric dermatome has been the most commonly used unit in veterinary practice. The author has used the Zimmer Electric Dermatome (Zimmer USA, Warsaw, IN) and has found this instrument to be superior in its ability to harvest split-thickness skin grafts in the dog and horse (Fig. 14-7). Although uncommonly used on a routine basis, large practices may find this instrument worthwhile to have on hand.

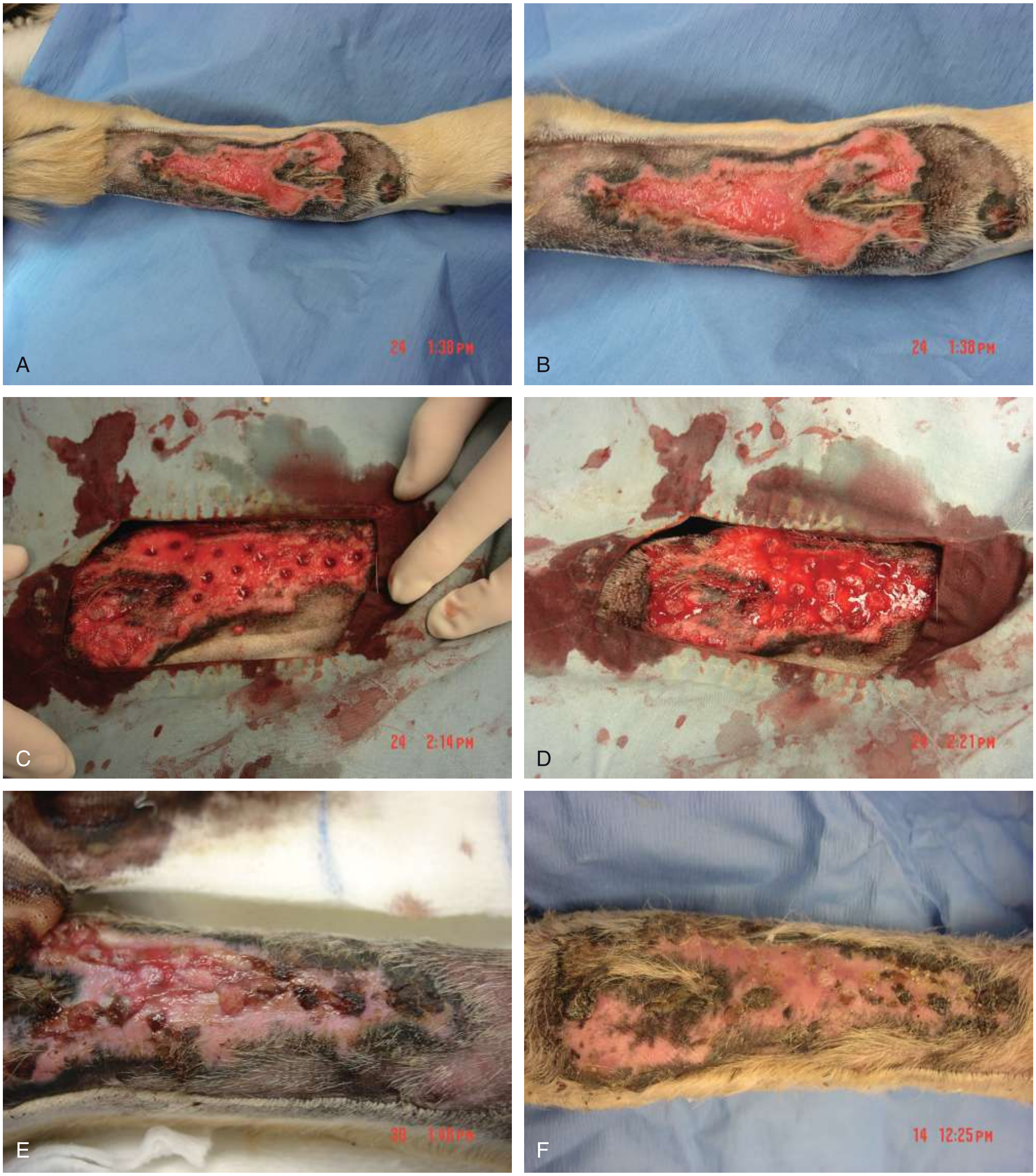

FIG. 14-1 *See legend on opposite page.*

FIG. 14-2 Pinch graft application. This technique is used for thinner granulation beds. A no. 15 blade is used to make a small pocket for insertion of a small pinch graft.

FIG. 14-1 (A) Chronic, fibrotic forelimb wound of several months duration. Multiple topical wound-healing stimulants and dressings were used in an attempt to promote second intention healing to no avail.
(B) Close-up view of the wound, note the perimeter of old epithelial coverage.
(C) A 4-mm disposable skin biopsy punch (Sklar Tru-Punch, Sklar Instruments, West Chester, PA) was used to create holes in the thick granulation bed, approximately 1 cm apart. Small iris scissors can be used to trim off the core of granulation tissue. Cotton swabs or topical compression with moistened sponges are used to control bleeding. A syringe and a 20-gauge needle can be used to flush clotted blood from the holes with sterile saline prior to graft insertion.
(D) A 6-mm biopsy punch was used to harvest skin plugs in the healthy skin more proximal to the wound. A single 3-0 nylon suture is used to close each donor hole. The punch grafts are kept between two moistened sponges prior to their insertion. The plugs are inserted, followed by the application of a nonadherent Adaptic pad (Adaptic, Johnson & Johnson) with a layer of triple antibiotic ointment applied over its surface. The Adaptic pad is stapled to the skin peripheral to the wound to prevent slippage beneath the outer protective bandage. The patient was discharged the same day.
(E) Recheck 5 days later. The wound has dramatically decreased in size as a result of wound contraction and epithelialization. The author has occasionally seen this phenomenon of rapid epithelialization and wound contraction after the use of punch grafts to promote epithelial coverage to lower extremity wounds and calls this phenomenon *punch graft induction.*
(F) Complete closure at a 2-week recheck. Prolonged use of an Elizabethan collar is advisable to prevent the patient from licking at the healed wound.

FIG. 14-3 *See legend on opposite page.*

PRESERVATION BY REFRIGERATION

In veterinary medicine, there is little need to refrigerate harvested skin: in most cases grafts are harvested and applied directly to the wound in one surgical procedure. If there is extra skin and the possible need for additional grafting, short-term refrigeration can be used to preserve the tissue (Fig. 14-8). In the event of a need to abort the grafting procedure, the skin can be refrigerated and reapplied at a later time in a more stable patient. In humans, excisional defects may be complicated by excessive bleeding or the graft may be necessarily delayed if the recipient bed is considered unsuitable for successful grafting. Careful planning can minimize these intraoperative errors.

Storage of grafts may reduce the phase of plasmatic imbibition by the production of anaerobic metabolites that stimulate early vascularization of the graft. This may be a benefit in those areas in which immobilization is problematic. In one limited study in horses, meshed skin grafts were refrigerated in a tissue culture medium composed of a balanced electrolyte solution with amino acids, vitamins, and dextrose (McCoy's 5A Medium, Flow Laboratories Inc, McLean, VA). Grafts were rolled in moistened gauze and placed in a sterile plastic container with 1.0–1.5 ml of McCoy's Medium per square centimeter of skin graft tissue; air was included in the container to support cellular metabolism. Grafts were refrigerated at 4 °C. Graft acceptance was good to excellent up to the 3-week limit of the study. For humans, successful graft storage has been reported up to 6–8 weeks. McCoy's 5A Medium contains phenol red as an indication of catabolite production. A color change of cherry red to orange-yellow is an indication of catabolite buildup, necessitating replacement of half the media volume; complete change of the medium may have an adverse effect on graft survival.

In small animal surgery, careful preparation of the patient and recipient bed can eliminate the need for graft storage and the costs incurred with graft preparation/refrigeration.

INTRAOPERATIVE CONSIDERATIONS

Strict aseptic technique is mandatory. The harvested graft must be kept moistened at all times with sterile saline or lactated Ringer's solution. Unless immediately applied, harvested skin is placed in moistened gauze pads and secured to the surgery table cover with forceps to assure the sponge is not accidentally used and discarded. To save time, an assistant can close large donor sites while the surgeon prepares and applies the harvested graft to the recipient site.

FIG. 14-3 (A) Miniature pinscher with a large circumferential skin defect of the left forelimb, secondary to vehicular trauma.
(B) A template of the wound is created, using the absorbent paper liner from a package of sterile surgical gloves. The paper is applied to the wound surface, leaving an outline of the moist wound surface. The paper is trimmed and placed over the lateral trunk area, with care taken to help assure that a reasonable hair growth pattern of the extremity is maintained.
(C) The harvested graft is placed on a 4-inch roll of autoclaved Vetrap (3M Animal Care Products), exposing the subcutaneous surface of the skin. 35W skin staples (sutures are also acceptable) are used to position the graft onto the Vetrap. This greatly simplifies the removal of the subcutaneous tissues down to the dermal surface.
(D, E) Saline is applied to the graft periodically to prevent desiccation. Upon completion of the "defatting" process, a no. 15 blade is used to create a series of 1-cm stab incisions in a staggered row configuration. Upon completion, the "hand mesh graft" is positioned over the viable granulation bed.

FIG. 14-4 *See legend on opposite page.*

BANDAGING TECHNIQUE FOR SKIN GRAFTS

Few bandages require more exact application than a bandage used to secure and immobilize a body region after application of a free graft. Most skin grafts are performed on the extremities. All three layers of a bandage are essential for a successful "take." Components of the bandage include the following (see Fig. 14-4):

1. *Ointment.* An antibiotic ointment (oil base) is applied to a nonadherent dressing uniformly. The ointment protects the graft from desiccation and helps to reduce bacterial proliferation. (The author normally prefers triple antibiotic ointment.)
2. *Nonadherent dressing.* The dressing overlaps the entire graft. It is applied evenly over the grafted surface, without wrinkles or folds. The nonadherent (or more properly called *low-adherent*) dressing helps prevent the bandage from sticking to the graft area during subsequent bandage changes. Skin staples or "tacking" sutures can be used to prevent shifting of the dressing. (The author prefers Adaptic, Johnson & Johnson.)
3. *Absorptive/padding layer.* Sterile 4 × 4 gauze sponges are unfolded to 4 × 8 lengths. Usually two sponges are spiraled around the circumference of the extremity to cover the dressing. Sterile self-adherent gauze is used to secure the pads around the extremity (or body part grafted). Layers of nonsterilized cast padding normally is used in conjunction with layers of roll gauze for the bulk of the bandage. This layering process is repeated until a thick, firm secondary layer of gauze and cotton is created to immobilize the graft against the recipient bed and discourage motion. The bandage is extended above the adjacent joint in the process of application.
4. *Elastic wrap.* An outer elastic wrap is applied to the bandage. Adhesive elastic is used to secure the bandage to the fur and skin to prevent slippage. (The author

FIG. 14-4 (A, B) Continuation of patient in Fig. 14-3. Graft application to the wound bed. Skin staples greatly facilitate graft application. Uniform tension is applied to the graft to assure it conforms to the wound bed without excessive tension; the stab incisions are allowed to gap slightly open to facilitate drainage from beneath the graft. The graft should directly contact the irregularities of the recipient wound bed. The graft slightly overlaps the adjacent skin bordering the wound bed; staples are used to secure the graft. Staples are also used to secure the graft to itself where the graft completes the circumference of the lower extremity defect.

(C) Triple antibiotic ointment is applied liberally to 3 × 8-inch Adaptic dressings (Johnson & Johnson). Each dressing is spiraled around the graft in a flat, uniform fashion. Staples are used to secure dressings to each other as well as to the skin bordering the grafted area.

(D) Sterile 4 × 8-inch surgical sponges are opened and spiraled over the Adaptic dressing (two layers).

(E) This can be followed by two or more layers of 4-inch wide cast padding (Specialist Cast Padding, BSN Medical, Brierfield, England) secured with roll gauze to form a firm bandage.

(F) Elasticon (Johnson & Johnson) forms the tertiary wrap. Note the tape overlaps the skin above the bandage for added security. Tongue depressors are added to the Elasticon with 1-inch surgical tape for added bandage rigidity.

FIG. 14-5 (A, B) Continuation of the patient in Figs. 14-3 and 14-4. The graft at 1 week (lateral and medial views), with complete survival or "take."

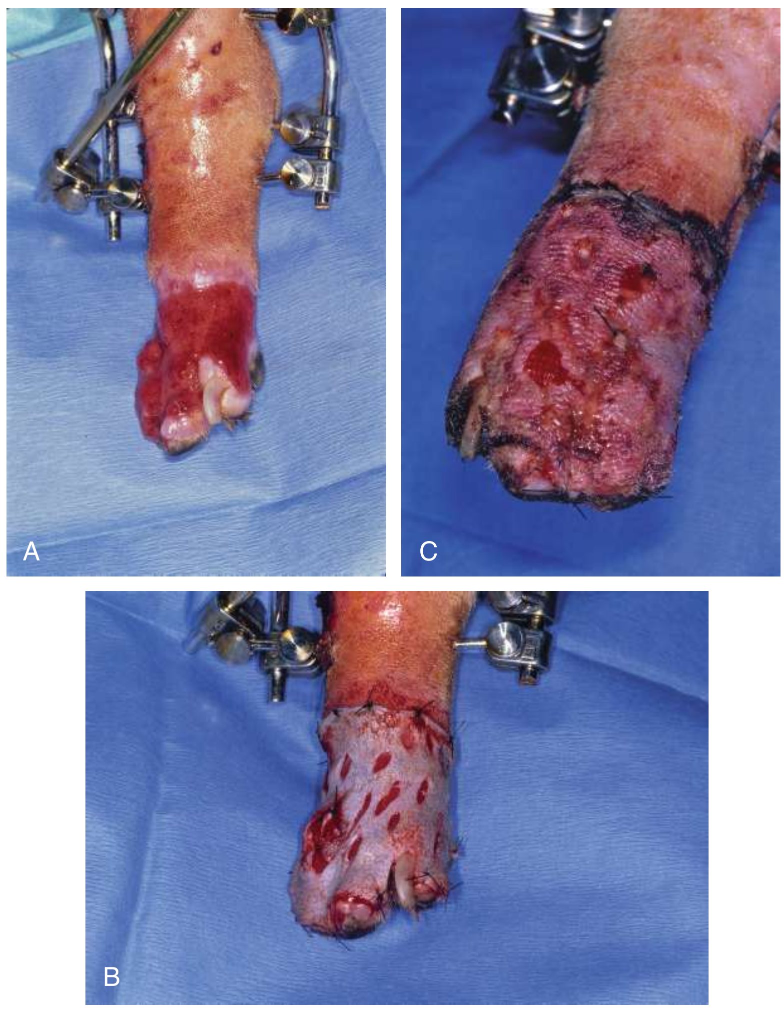

FIG. 14-6 (A, B) Hand mesh graft application to the lower extremity of a dog. External fixators used in fracture repair provide an additional "security anchor" for the graft bandage. (C) Approximately 5 days after graft application. Grafts that survive have a pink to lavender hue at the time of initial revascularization. Full-thickness mesh grafts are among the most useful techniques for closure of distal extremity defects.

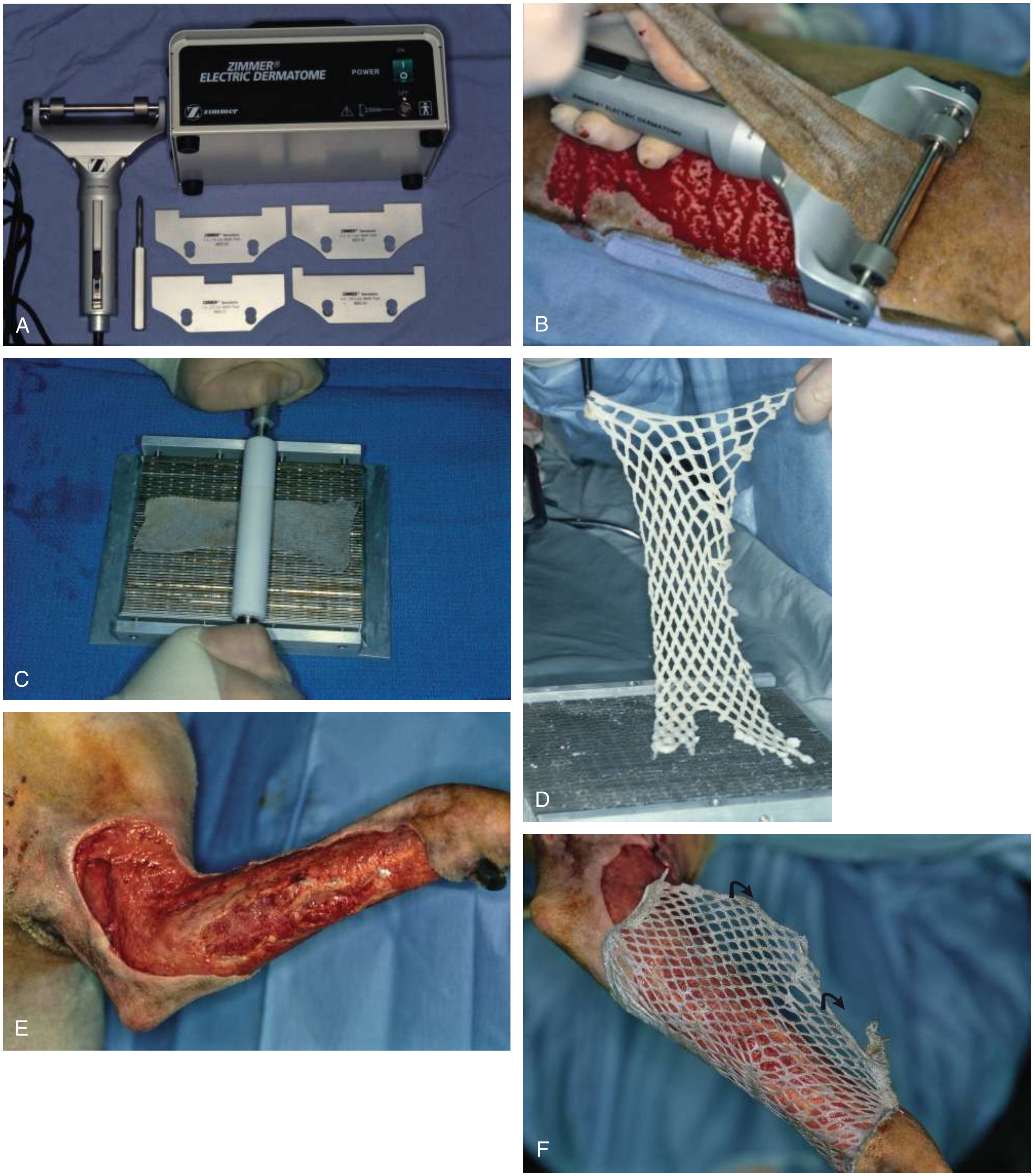

FIG. 14-7 (A) The Zimmer Dermatome is an excellent unit for harvesting split-thickness skin grafts.

(B) The width of the graft harvested is determined by which base plate is selected (A). Each plate has a slot that determines the amount of skin exposed to the dermatome blade.

(C) The Padgett Mesh Graft Expansion Unit (3:1 ratio). The Teflon roller compresses the graft into the staggered blades.

(D) The meshed skin graft elevated from the Padgett Expansion Unit.

(E, F) The graft can be expanded (stretched) up to three times the original surface area of the graft, depending upon the desired coverage.

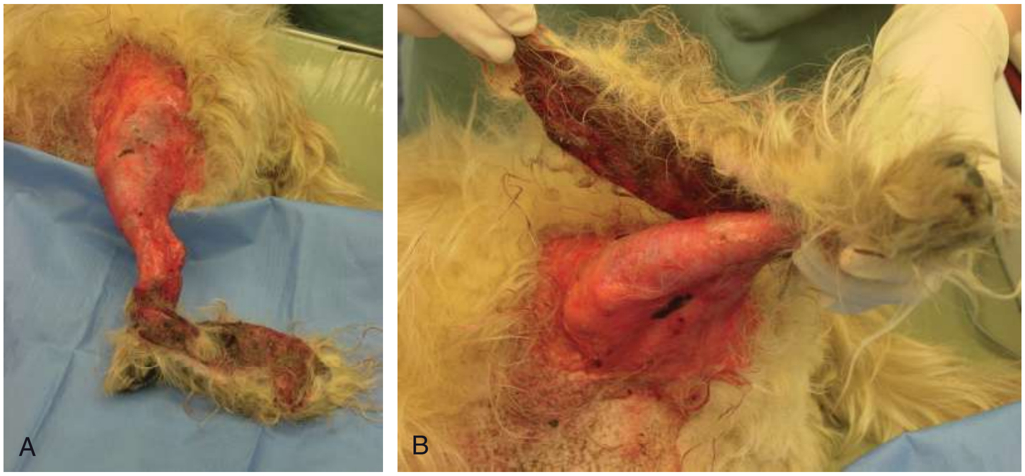

FIG. 14-8 (A, B) Fresh avulsion wound involving the rear leg of a small dog, as a result of a dog fight. This specific type of injury is occasionally referred to as a *degloving injury*, in which the skin is circumferentially avulsed or pulled distally in the fashion of removing a glove. Although this skin theoretically could be prepared (even preserved) and grafted back to the leg, it is best to discard this contaminated and traumatized tissue. The wound should be prepared for surgical closure using a freshly harvested skin graft. In this case, one or two caudal superficial epigastric axial pattern flap(s) also is an option (with or without the addition of a skin graft.)

prefers Elasticon, although a combination of Vetrap and Elasticon also can be used effectively.)

5. *Additional immobilization.* Slings, Mason metasplints, spicas, Schroeder-Thomas splints, tongue depressors, plywood coaptation splints, or reinforcement rods are used if additional rigidity or immobilization is necessary. Skin grafts applied over, or adjacent to, a joint surface usually require additional support or immobilization. A spica bandage/splint may be advisable for grafts applied to the proximal portions of the limb to avoid slippage and help restrict regional motion. Cats are quite adept at "flicking" bandages off their extremities, but cannot remove spica-style bandages (see Plate 5). Tie-over dressings can be effective in immobilizing grafts, especially in difficult areas (inner thighs, upper limbs, etc.).

6. *Postoperative care.* Bandages may be changed as early as 48 hours after graft application. However, it is safer to wait for a minimum of 3 days to assure the critical 48-hour period of the graft revascularization is not disturbed. Patients should be sedated and restrained during bandage changes to avoid accidental trauma to the graft site. General anesthesia is recommended for excitable/aggressive patients. Care must be taken not to pull or lift the graft from the underlying wound bed during dressing removal. In most cases, adherence of the topical dressing is the result of dried blood binding exposed areas of the granulation bed to the interstices of the dressing. These areas can be softened with warm saline and "unbuttoned" with gentle traction applied to the dressing. If the dressing is particularly tenacious, the dressing may be left on the graft followed by the addition of topical ointment *on top of this dressing*, before reapplication of the secondary and tertiary bandage layers. As noted in Chapter 4, VAC style devices (see Plate 1) also have been used to secure skin grafts.

The frequency of bandage changes varies with the patient and graft techniques used. Unless infection is a concern, bandage changes can be timed every 3–4 days after the initial change. Once healing is complete, bandaging can be discontinued (*usually by 2 weeks after mesh graft application*). However, the author has protected grafts up to 1 month, usually in conjunction with prolonged use of Elizabethan collars, in active patients with a propensity to lick or chew at themselves.

7. *Cage/run confinement.* Dogs and cats are confined to their cages. They are kept on a leash when taken outdoors to urinate and defecate. Minimal activity is essential to graft survival, especially in the first 48-hour period of graft revascularization. Minor soiling of the outer bandage does not necessitate a complete bandage change, as the heavy padding and the outer wrap usually limit the depth of contamination. However, bandages should not be allowed to get soaked with water or urine. A plastic bag can be applied temporarily to the bandaged foot when the dog is exposed to wet surfaces. It must be remembered that motion can result in bandage materials rubbing on the graft site. This has been recognized as a cause of graft failure in active patients.

With cooperative patients and compliant pet owners, the patient can be discharged from the hospital after the first bandage change. Again, the key factor is minimizing activity and local motion to assure graft survival.

Viable grafts assume a pink to lavender hue depending upon the state of vascularization. Dead skin assumes a white or black color. Early signs of superficial graft necrosis are discouraging, but not always catastrophic, because hair follicles and cutaneous adnexa in the deep portion of the graft may survive and may serve as a source for wound epithelialization.

Suggested Readings

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