CHAPTER NINE

Skin Grafting

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INDICATIONS

The use of free skin grafts is confined primarily to the reconstmction of large skin deficits involving the extremities of the limbs, which present the surgeon with some unique problems. Elsewhere in the body, the primary solution for dealing with skin deficits is simple coaption of the wound but this is usually precluded for limb sites due to the lack of adjacent mobile skin. Secondary healing can be allowed to proceed for some limb skin defects, although there is a risk of developing unsightly scars and those in the vicinity of joints may seriously impair limb function should excessive scar tissue form. Other options include local or random flaps which may be indicated for the reconstruction of some larger wounds but their use is again restricted in the case of limbs by the limited availability of adjacent skin. Heterotopic pedicle grafts, using microvascular anastomosis to relocate axial flaps based on a single arteriovenous supply, can provide an alternative solution but are used infrequently because of the complexity of the surgical procedure (see Chapter 11). Direct flaps offer an alternative solution in some cases by positioning the limb deficit under pedicles of skin created on the flank, although this may not be appropriate for the temperament of all patients.

In many cases therefore, free skin grafts provide the only viable alternative to the problem of reconstructing some of the larger skin deficits involving the distal limb. It should always be borne in mind, however, before undertaking a skin graft, that the technique can be very time-consuming, not only in terms of the surgery but also in the postoperative care. Since the successful outcome of the graft can never be guaranteed, it pays to consider carefully all other possible alternatives before selecting a skin graft.

TYPES OF SKIN GRAFT

Skin grafts are classified in two ways. First, according to the depth of skin harvested (Figure 9.1) as:

- Full thickness (containing the epidermis and the entire dermis) or
  Split thickness (containing the epidermis and only part of the dermis).

Full thickness grafts

Full thickness skin grafts are generally considered to be the more suitable depth of graft for small animal reconstructive use. They are robust and capable of withstanding considerable handling during collection and positioning over the recipient site. Because the grafts retain all the dermal structures they can provide far more cosmetic skin regrowth in the longer term. Their greater tissue content, however, means that the nutritional requirements during the 'take* period (see below) are considerably more fastidious than those of the thinner split thickness graft and hence they 'take' less readily.

Split thickness grafts

Split thickness skin grafts contain the epidermis and part of the dermis. They are sometimes referred to as Thiersch grafts and can be further subclassified as thin, medium or thick split thickness depending on the depth of dermis harvested in the graft. Despite their widespread use in human plastic reconstructions, split thickness grafts have a number of important disadvantages in small animal surgery and are used infrequently. They are rather fragile by comparison with full thickness grafts and require considerably more care during collection and placement. Due to the variable absence of the dermal structures the grafted sites tend to have poor durability, a greater tendency to contracture and to produce sparse hair regrowth. Equally important, the donor site heals by epithelialization and hence its final cosmetic appearance is poor. Although they are potentially useful for the reconstruction of very large wounds where the supply of donor skin is at a premium, it is unusual to be unable to harvest sufficient skin to permit full thickness grafting in the majority of cases. The complexity of accurate collection and the significant cost of the harvesting equipment tend to argue additionally against the use of split thickness grafts in small animals.

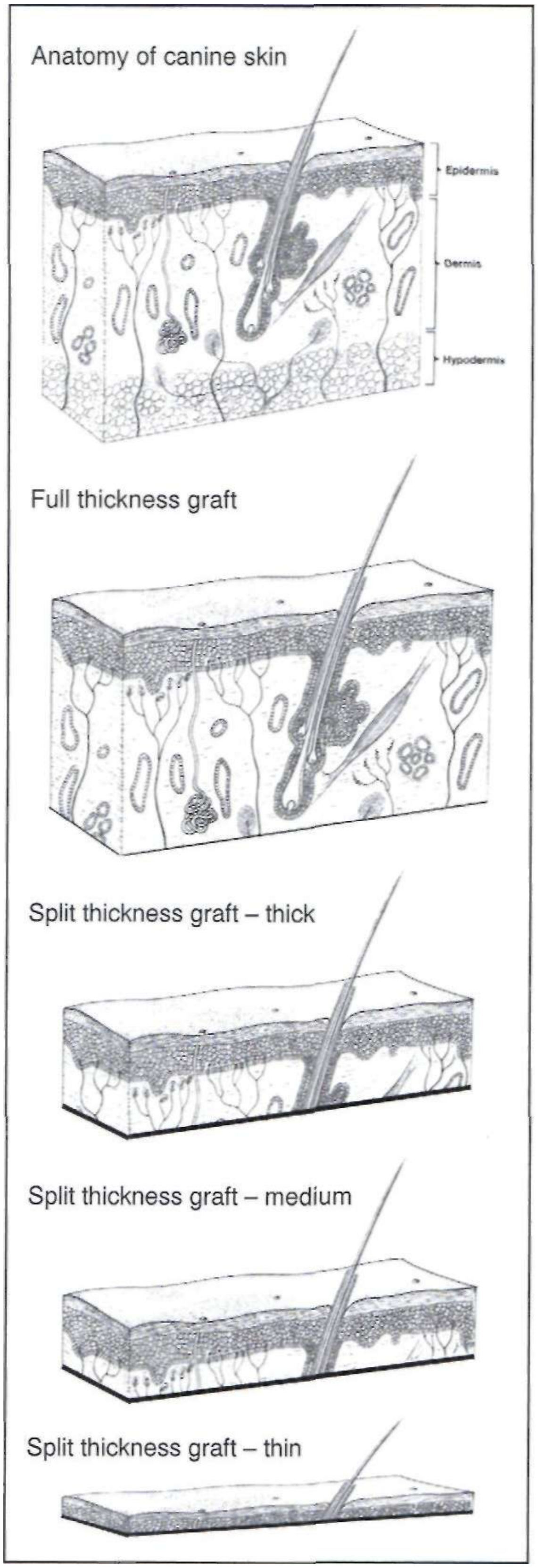

Figure 9.1: Types of skin graft. Classification according to skin depth.

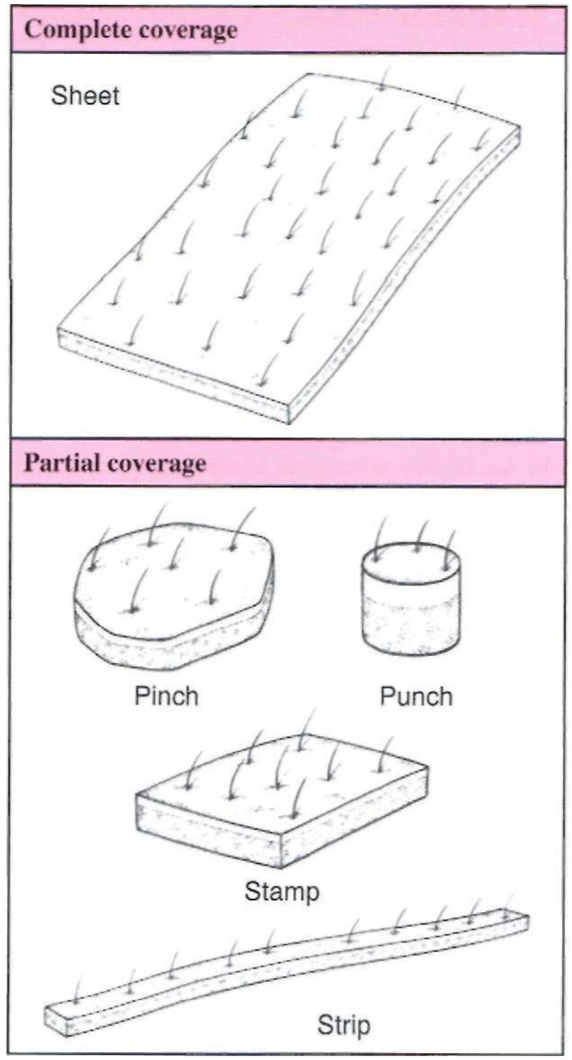

Figure 9.2: Types of skin graft. Classification according to wound coverage.

Secondly, skin grafts are classified according to the extent of wound coverage they offer (Figure 9.2) and the manner in which they are prepared as:

- Sheet grafts, providing full wound coverage, or
- Pinch, punch, stamp or strip grafts, for partial coverage of granulating wounds.

Sheet grafts

Sheet grafts are the most frequently used skin grafts in small animal reconstruction. They provide complete coverage of the wound and will ultimately provide the most functional and cosmetically acceptable result.

Pinch, punch, stamp and strip grafts

These provide partial coverage of granulating wounds. They are used simply as a means of promoting healing of granulation tissue by vastly increasing the surface of epithelializing tissue within the wound.

Their collection and placement is labour intensive and they provide a poor final cosmetic and functional result in a wound that heals largely by epithelialization and contraction.

HARVESTING THE GRAFT

Ideal donor sites for skin grafts in the small animal species should have:

- Durable skin of a suitable thickness (usually avoiding the thin skin over the ventral abdomen)
- An abundant supply of easily mobilized skin, to allow easy and cosmetic closure of the donor site
- Hair of a colour, length and density similar to that which it is intended to replace at the recipient site (less important for split thickness grafts).

The flank usually satisfies most of these criteria and offers the best opportunity to remove a sufficiently large area of skin to cover wounds involving the limb. In the case of full thickness grafts, however, hair length from this site can be noticeably greater than that which it replaces. The skin should be collected under strictly aseptic conditions and, once harvested, should be rolled in saline- or antibiotic-soaked sponges to prevent desiccation until required. Harvested skin prepared in this fashion can be preserved for several days by refrigeration at 4°C .

Full thickness grafts

Full thickness grafts are collected by elevating the skin, including its hvpodennal attachments, from the loose fatty tissue below, without disturbing the underlying panniculus muscles. This can be more easily accomplished with the use of skin hooks or fine monofilament nylon stay sutures strategically placed at the periphery of the graft as it is elevated. The need to pre-cut the graft in the shape of the recipient wound will depend on whether the graft is to be subsequently meshed or not. Meshing enables the sheet to be manipulated to the outline of the recipient bed and requires minimal pre-shaping whereas unmeshed sheet grafts are less flexible and require accurate pre-shaping. However, even unmeshed sheets have some degree of elasticity which will permit stretching to accommodate small irregularities. Where a graft is to be pre-shaped to a template it is best achieved with the help of a moist surgical swab cut to the outline of the recipient area and then laid over the donor skin. The general outline of the graft to be harvested is marked with a sterile marker, allowing some overlap (0.5-1.0 cm) to ensure collection of an adequate area. Donor sites require primary surgical repair with closure of the subcutaneous tissues.

Occasionally there may be an indication for the use of pinch, punch, stamp or strip grafts although, as already indicated, they provide a very poor cosmetic result and are limited to partial coverage of granulating wounds. These are normally harvested in full thickness. Pinch grafts are harvested by scalpel excision of small areas of skin raised by means of hypodermic needle. Punch grafts are most easily collected by means of the Keyes biopsy punch. Stamps are removed as small rectangular sheets, whilst strips are collected as 0.5 cm wide lengths.

Split thickness grafts

Split thickness grafts dictate accurate collection through the dermal layer itself by means of a blade pre-set to the required depth. A wide array of instruments are available for this, including the Humbly and Silva knives and also the Brown dermatome (Figure 9.3); the former are hand-held whilst dermatomes are either pneumatically or electrically driven. Most instruments have some device for presetting the depth of cut and, with the skin held in tension, the blade is either drawn to and fro across the surface or progresses by means of an oscillating blade. Split thickness grafts are quite fragile and should be carefully supported on a moist dressing until positioned over the recipient site.

PREPARING THE GRAFT

Once harvested, the underlying hypodermal and loose adipose tissue is carefully removed from the full thickness graft with fine scissors until the pigment of the dermal layer is apparent, in order to maximize subsequent vascular access to the graft from the recipient bed. Less ideally, this can be performed by careful scraping with a scalpel blade but overly vigorous scarification of the dermal structures should be avoided. The graft can be laid on the bevelled surface of a skin

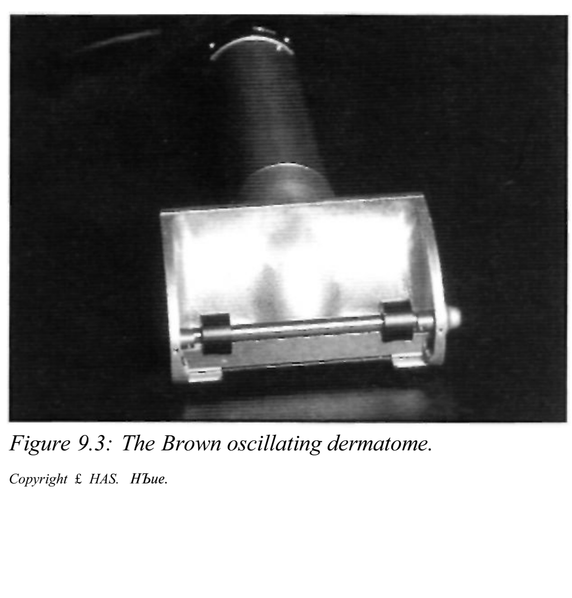

Figure 9.3: The Brown oscillating dermatome.

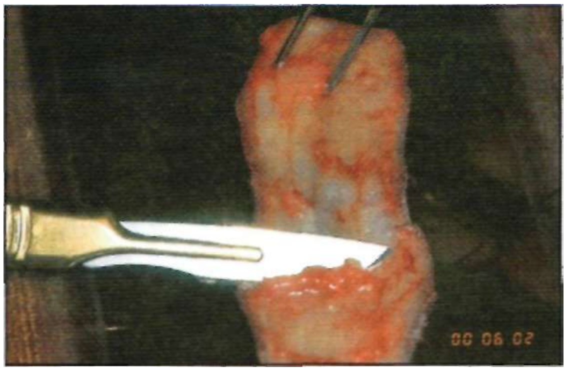

Figure 9.4: Removal of hypodermal tissue. A skin graft board with the unwanted tissue being removed by scalpel.

Figure 9.5: Removal of hypodermal tissue. The graft is draped over the surgeon's finger to permit removal of the unwanted tissue by careful trimming with scissors.

graft board (Figure 9.4) to achieve this, although many surgeons prefer to drape the graft over their fingers whilst the tissue is removed (Figure 9.5). Sheet grafts can now be further prepared as unmeshed. meshed or 'pie-crusted' (Figure 9.6).

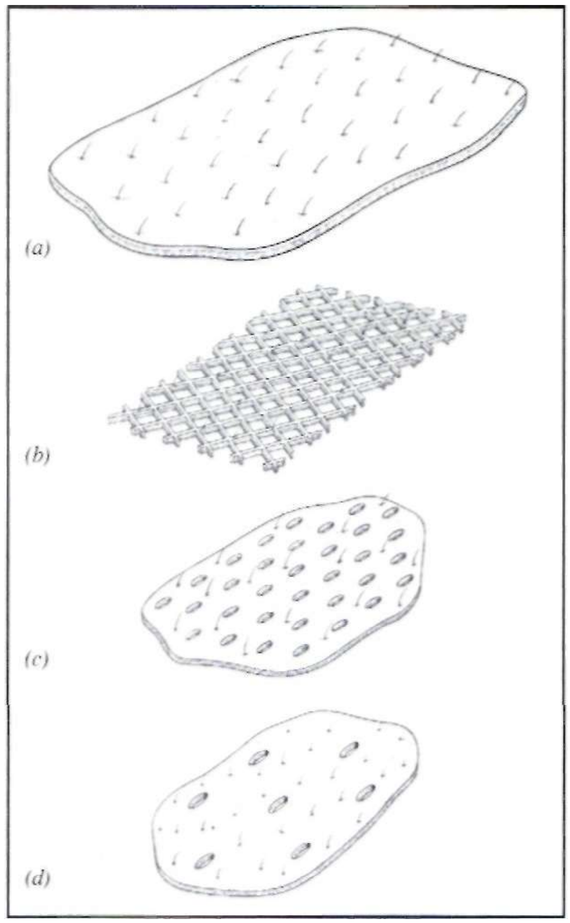

Figure 9.6: Skin meshing: (a) unmeshed; (b) fully meshed; (c) partially meshed; (d) 'pie-crusted'.

Unmeshed sheets

Unmeshed sheets are left intact after removal of the hypodermal tissues so that there is no disruption to contiguity of the dermal sheet. This type of graft provides potentially for the best cosmetic result and in the event that there is full "take' there will be little to distinguish the grafted area from normal skin elsewhere. Despite this apparent advantage, there are some significant drawbacks which make unmeshed grafts a rather impractical and infrequently used option. The most important of these is that the intact sheet provides no route for the drainage of the exudate which inevitably accumulates between it and the recipient site during the 'take* period. This fluid promotes lifting of the graft from the recipient bed and may lead to its eventual loss. This can be countered by aspirating exudate from under the graft using a hypodermic needle on a daily basis or by the use of a fine suction drain placed under the graft (see Chapter 6). but these options are likely to be less successful than a system of free drainage through the graft itself. Less importantly, unmeshed grafts must be pre-cut to the outline of the recipient site since they have only limited ability to stretch to wound shapes.

Meshed sheets

Meshed sheets arc prepared by the creation of perforations through the entire thickness of the skin. This can be performed by hand or mechanically by means of a meshing table (Figure 9.7) or roller mesher. Meshing can be complete, partial or 'pie-crusted* and confers a number of significant advantages on the graft:

- The graft has much greater flexibility and elasticity which enables it to be easily shaped to the outline of irregular wounds. In the wider regions of the wound the meshings of graft can be fully 'opened' to cover the required area whilst in the narrower regions the meshes are left 'unopened'. This obviates the need to pre-shape the graft and most wound shapes can be accommodated from a simple rectangle whose general dimensions approximate those of the recipient bed

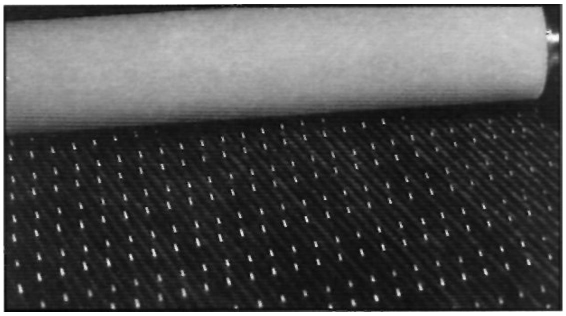

Figure 9.7: A table meshing instrument. The graft is laid over the table which consists of parallel rows of blades and then firmly rolled with the Teflon® rolling pin to produce a fully meshed graft.

- The greater flexibility of the graft also enables it to conform closely to uneven wound surfaces. Meshed grafts will readily conform to wounds with convex surfaces (e.g. over the elbow, hock) without the need for copious additional sutures through the graft surface to ensure immobilization
- The graft can be expanded simply by pulling the meshing open, allowing it to cover a greater area of wound. Meshing may therefore help to solve the problem of covering large wounds in situations where the amount of skin available for grafting is limited
- By far the greatest advantage of meshing lies in its inherent capacity to permit ongoing drainage of any exudate from the recipient surface during the 'take' phase. The greater the number of mesh openings and the wider they are opened, the greater is the potential for this fluid to drain without interfering with 'take'. However, the areas of the wound under the mesh openings do not have any dermal covering and hence these regions heal secondarily by granulation, contraction and epithelialization, the consequence of which is an area of alopecia. The goal is therefore to achieve a balance between providing adequate drainage and accomplishing a good cosmetic result.

'Pie-crusted sheets'

Tie-crusted' sheets represent a compromise between meshing (which provides drainage) and leaving the graft as an intact sheet (for optimal cosmetic results). Tie-crusting' describes the preparation of the graft by making a limited number of stab incisions through the graft, sufficient to permit adequate drainage whilst causing minimal damage to the cosmetic result.

Pinch, punch, stamp and strip grafts

Pinch, punch, stamp and strip grafts should also have the hypodermal tissue removed, as for sheet grafts, although this is often difficult and time consuming due to their small size and multiplicity. Drainage of exudate from the wound is not a consideration for these grafts since the wound surface itself remains largely open.

THE RECIPIENT SITE

A major determinant in the success of free skin grafting is the proper preparation of the recipient site. Sites should be well supplied with the active capillar}" vessels necessary to provide nutritional support and ultimately revascularization of the graft. All non-viable tissue debris or epithelialized tissue which may prevent capillary ingress into the graft should be removed. Any major bacterial contamination likely to lead to infection should be dealt with prior to grafting. Suitable recipient tissues for skin grafting may be: healthy granulation tissue; surgically clean wounds; or fresh surgical wounds.

Granulation tissue

Granulation tissue is an ideal graft recipient tissue, since it contains an abundant supply of vascular capillaries in a stable matrix of collagen ready to support the over-lying graft. Its appearance in the wound within 3-6 days of the original injury is an indication that all septic processes have been controlled and that grafting can proceed safely. Although grafting can be considered as soon as granulation tissue first appears in the wound it is often delayed for several days until the wound is completely covered and the prospects for successful "take' are considerably increased. Chronic granulation tissue that remains ungrafted, on the other hand, is less likely to support a graft because its capillary content is significantly reduced by the increasing proportion of connective tissue. This can, however, readily be con-verted to healthy tissue with a well vascularized surface by surgical debridement immediately prior to grafting or better still, 24 hours before grafting to minimize the risk of haematoma or seroma development. Where the granulation tissue is less chronically inactive, simple mechanical debridement for 1-2 days prior to grafting will be sufficient to promote surface revascularization (Figures 9.8 and 9.9). All vascular oozing should be controlled using diathermy to minimize the risk of fluid accumulating below the graft.

Figure 9.8: Preparation of granulation tissue for grafting. This degloving injury is covered with chronic granulation and will not support a skin graft.

Figure 9.9: Preparation of granulation tissue for grafting. The same wound as that in Figure 9.8 following wet-to-dry dressing over a 48-hour period. The granulation tissue now appears much more active and is suitable for grafting.

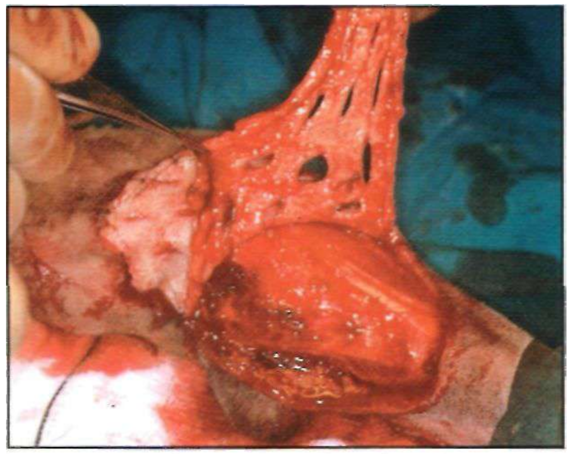

Figure 9.10: Fresh surgical wounds can be grafted immediately, although the problems of seroma development are likely to be more severe. A partially meshed graft is placed over a wound created by the resection of a benign tumour over a carpus following careful haemostasis.

Surgically 'clean' wounds

Recent wounds that have been debrided and retain a suitable vascular supply can undergo immediate grafting. Examples of this include degloving and avulsion wounds in which the skin has been removed but is still available to be replaced in its original location. Contamination of the wound and the subsequent collection of exudate are, however, considerably greater risks in this type of recipient bed.

Fresh surgical wounds

Fresh surgical wounds are frequently overlooked as potential sites for skin grafting. They are very suitable recipient sites providing that the wound is well vascularized (Figure 9.10). The development of haematomas or serous exudate below the graft is, however, a much more frequent problem and it is essential that some kind of provision is made for drainage. Delaying the graft by even as little as 24-48 hours after the original surgery to encourage early granulation substantially reduces this problem.

APPLICATION OF THE GRAFT

Unmeshed or 'pie-crusted' sheets

Unmeshed or "pie-crusted" sheets require pre-shaping to the recipient site (Figure 9.11) allowing a few millimetres overlap on all edges to provide for any contracture as the graft 'takes". Grafts are sutured in place with loosely applied and widely spaced simple interrupted 2 metric (3/0) monofilament nylon around their periphery. Anchoring the graft so that it is under a little tension ensures good contact with the recipient surface but care should be taken to avoid over-tensioning. In the case of large or convex wounds it is also wise to place loose mattress sutures through the graft itself into the underlying granulation tissue or wound to prevent graft movement. A fine suction drain should be implanted to prevent the fluid accumulation in the case of unmeshed sheets.

Figure 9.11: A 'pie-crusted' graft in situ over a distal limb deficit. Note that some sutures are placed through the graft itself to the recipient bed to ensure stability.

Meshed sheets

Meshed sheets do not require pre-shaping and the graft can be placed over the wound and expanded to fit the wound as necessary with the edges left overlapping the wound (Figure 9.12). The maximal expansion of the meshed graft is usually up to 2-4 times the original width of the graft but this is achieved at the expense of some reduction in graft length. Grafts are anchored as for other sheet grafts.

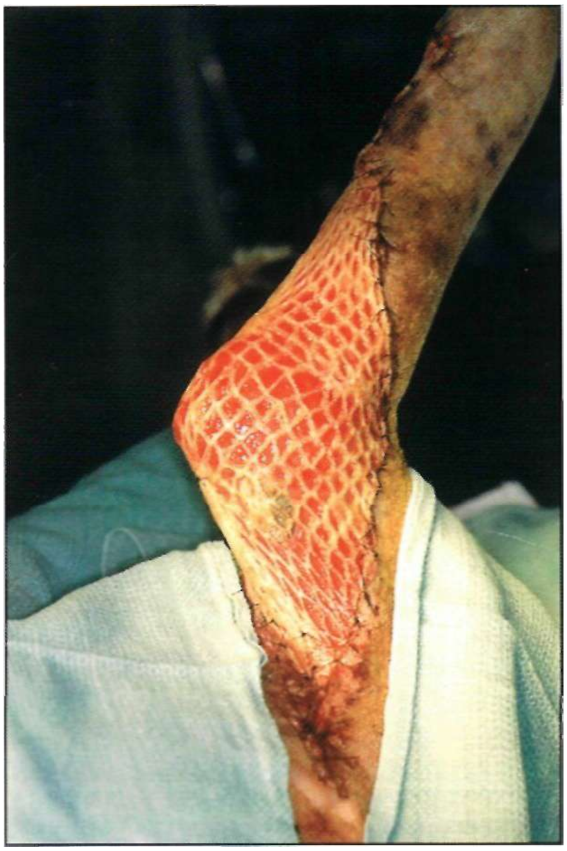

Figure 9.12: Afidly meshed graft positioned over a deficit over the elbow. The graft has been expanded to provide wound coverage. Note how in the fill ly meshed form the graft conforms to the convex wound surface.

Partial coverage grafts

Although stamps and strips can be sutured in place, pinch and punch grafts cannot be attached to wound surfaces in the manner described above and can only be positioned by firmly embedding them in granulation tissue. Punch grafts are placed in holes cut in the granulation tissue with a biopsy punch; pinch grafts are wedged into stab holes; stamps are positioned in square holes; whilst strips are placed in longitudinal grooves. All partial coverage grafts are inherently unstable and require careful pressure bandaging until they gain stability at the end of 24-48 hours.

GRAFT 'TAKE'

The processes whereby a graft survives from the time that it is placed over the recipient site until it becomes fully revascularized by the underlying capillaries are often collectively termed graft 'take'. They involve much more than simple ingrowth of new capillaries from the recipient bed. Two separate, but interrelated, processes are important for the take of a graft: adherence and nutrition.

Adherence

Adherence refers to the development of a 'scaffold' of fibrin between the graft and the underlying recipient surface. The fibrin is exuded from the recipient surface w ithin a few hours of the graft covering it and serves not only to anchor the graft but also provides a means of support for the subsequent ingrowth of new capillaries from the recipient tissue. The fibrin is progressively replaced by fibrous tissue, further adding to the stability of the grafted skin during the first week. The process of fibrin adherence is essential for the subsequent processes which contribute to graft nutrition.

Nutrition

Nutrition of the graft comprises three separate processes:

- Plasmatic imbibition
- Inosculation
- Revascularization.

Plasmatic imbibition

Plasmatic imbibition, sometimes called plasmatic circulation, occurs during the first 2-3 days. The graft behaves rather like physiological blotting paper at tins stage and absorbs the fibrinogen-free serum proteins and erythrocytes which are exuded from the recipient surface. As a result it takes on an oedematous appearance and is often darkly pigmented through absorption of haem degradation products. The swelling of the graft at this stage can be sufficient to cause the mesh openings in partially meshed and 'pie-crusted' grafts to close over, thereby impeding the drainage of any exudate. The rather unhealthy appearance of the graft at this stage is often mistaken for early rejection. Plasmatic imbibition, however, is thought to be important in providing early nutritional support until capillary ingrowth begins to develop.

Inosculation

Inosculation is the development of a rudimentary vascular circulation within the graft and begins around the second or third day. New capillary buds develop from the recipient tissue and cross the fibrin scaffold into the graft. Instead of simply distributing throughout the tissue they are able to locate the old vessels in the graft and anastomose with these. This process of connection between the new capillaries and old blood vessels is thought to provide sluggish and disorganized movement of blood. It is not clear how important this process is in contributing to the long-term survival of the graft but it may be responsible for the more viable appearance that successful grafts take on towards the middle of the first week. It is vitally important that the graft remains immobilized during this period to enable this delicate vascular 're-plumbing' to take place.