SKIN GRAFTING BY CROSS-LEG FLAPS

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Destruction of the skin and subcutaneous tissues of the lower limb is often associated with injury to underlying tendons or bone. Sometimes the skin lesions are allowed to heal by granulation, or they are closed more rapidly by the application of split-skin grafts, and the results of such treatment may be entirely satisfactory. But healing by granulation often leads to chronic ulceration, and healing by split-skin grafting may yield an inadequate and unstable surface, ischaemia developing in each case in consequence of the strangling effect of scar tissue. The importance of securing adequate skin cover before undertaking bone reconstruction operations was impressed repeatedly upon orthopaedic surgeons during the recent war. The most satisfactory skin cover is gained by means of a skin flap that includes subcutaneous tissue; and a whole-thickness skin flap which gains vascular supply from its margins and through its base may improve the nutrition of underlying tissues. In the case of the leg and foot a convenient donor area is provided by the opposite lower limb, and a flap applied direct from one lower limb to the other is known as a cross-leg flap.

Blood supply of flaps—The blood vessels of the skin form a complex pattern and they may be divided into three main units. The first lies in proximity to the papillary layer of the skin and is connected by vertical branches with arterioles of the subdermal and subcutaneous systems. There is also a mid-dermal plexus which is chiefly, but not entirely, venous in constitution. A third plexus, which is situated immediately beneath the dermis, hypertrophies greatly in tube pedicles and open flaps and appears to carry the major burden of vascular nutrition. These facts suggest that, in skin, there is a plexus of vessels with collateral circulation which can be maintained despite such ischaemia as may occur during the raising of a flap. Each of the three vascular systems is superficial to the subcutaneous fat and, unless inclusion of fat is specifically indicated, most of it may be discarded safely.

Design of flaps—In planning a cross-leg flap five important considerations must be borne in mind: 1) the basic relative positions of the limbs; 2) the size and shape of the lesion to be covered; 3) the ultimate purpose or function of the flap; 4) the site of the donor flap and disposition of its base; and 5) the age of the patient and vascular nutrition of the limbs.

Basic position of the two limbs—It is seldom necessary to use "acrobatic positions." The recipient area must of course be brought close to the donor area but the position should be easy to maintain and tolerable to the patient.

Size and shape of the lesion—The limbs are placed in one of the basic positions (Fig. 1) and the flap is designed on the donor limb in the situation that is most suitable. It is often wise to visualise the completed operation and then to reverse the steps of the procedure (Gillies 1932). The area of skin loss should be outlined carefully, and a replica be cut accurately from jacent or tinfoil, making allowance for the increase in size of the lesion that always occurs after excision of the scar tissue. The length of flap should equal the width of the deficiency plus the length of its "bridge" (Figs. 2 and 3). An outline is drawn on the donor limb by reversing the jacen pattern, due allowance being made for the "bridge."

Future purpose of the flap—The general purpose of a flap is to cover an area where skin is lost, or where the quality of skin cannot serve the purpose required of it. If the flap is to cover a weight-bearing area it must include sufficient fat, but not too much. For weight-bearing purposes the thickness of the fat layer should not be greater than 0.5 cm.

Site of the donor area and disposition of its base—In a flap that is well planned the donor area should never encroach upon the tendo Achillis or the anterior surface of the tibia.
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The five basic positions of the lower limbs as used for cross-leg flaps.

Fig. 1

Alternative methods of lining the "bridge" with skin in order to minimise the risk of infection. Fig. 2 shows the technique when the scarred area (XC) is wide; the posterior part (AC) is excised at the detachment stage and covered with skin from the bridge of the flap (AB); meanwhile the bridge as well as the doner area is covered with a free graft. Fig. 3 shows the technique when the scarred area (XC) is smaller; a flap of normal tissue (DE) is turned back from the recipient limb to line the bridge of the flap.

FREE GRAFT

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If this principle is not observed, and the transferred flap fails to "take," the surgeon may be faced with the necessity of planning further operations to repair the defect he has created as well as the original defect. Whenever possible the skin flap should be taken from the fleshy part of the calf, and for direct transfer the base should measure not less than two-thirds the length.

*Age of the patient and vascular nutrition of the limbs*—The age of the patient is less important than his general condition. This statement has limitations but, in general, a healthy man of fifty years will yield a more healthy flap than a young man who is recovering from the effects of a long-infected compound fracture. At the same time it must be recognised that, although the cross-leg position is often well tolerated by patients in middle age, convalescence may be prolonged by resulting stiffness of the knee joints and muscle wasting of the limbs.

**Fig. 4**  
Case 1. Cross-leg flap for ulceration of leg due to chronic osteomyelitis. The outline is marked out on the skin (Fig. 4). After raising the flap the donor area is covered by a split-skin graft (Fig. 5). The legs are brought together and the flap is sutured to the recipient area after excision of all scar tissue (Fig. 6).

**Delayed transference of flaps**—Delay in transference of the flap is sometimes imperative. The object of such delay is to encourage hypertrophy of the vessels of the sub-dermal plexus and thus improve the nutrition of the flap. Available methods include: 1) complete elevation of the flap and simple resuture in its original bed; 2) incomplete elevation of the flap, leaving a bridge of tissue at its extremity which is divided after an interval of ten to fourteen days. The first method has little to recommend it. If it is safe to raise a flap completely it is safe to transfer it at once. The second method is better and it should be adopted if the flap is based distally, if the patient is physically old or relatively unfit, if there is vascular insufficiency of the lower limbs, or if the length/base ratio of the flap exceeds 3:2. In elderly patients, and those with vascular insufficiency, it is wise to arrange postural vascular exercises for some time before cutting the flap.

**Indications and contra-indications for cross-leg flaps**—Skin grafting by cross-leg flaps is indicated for simple unstable scars of the leg and foot, unstable scars associated with chronic osteomyelitis or old compound fractures of the leg and foot, irradiation burns, unstable scars of the leg or foot due to burns or frost-bite, trophic ulceration, old varicose
ulcers which are adherent to the tibia, painful scarred areas in weight-bearing areas, and scarred or unstable skin in regions where reconstructive operations are needed such as bone grafts, tendon reconstructions or nerve grafts.

Cross-leg flaps are unsuitable in young women, children, and the aged. They are unsuitable for very small lesions. They should not be used when "acrobatic" positions of the limbs would be necessary, when there is arthritis of the knee or hip joints, or in patients of unstable mentality. Young women—In young women it is inadvisable from the aesthetic point of view to use the calf of the sound limb as a donor area because the resulting scar is always visible. It is better to use abdominal pedicles or "indirect flaps." The aged or physically old—These patients, especially when their mentality is unstable, do not tolerate the discomfort of an unusual position; nor do they easily withstand the several operations that are needed. Moreover their joints become stiff, muscles waste, and pressure sores occur. It is better, if possible, to close the defect by a free skin graft in spite of the deficiencies of such grafts.

Children—Young children are often distressed by the postural restrictions needed for a cross-leg flap. Skin deficiencies should be closed by free skin grafts—a method of repair that is more satisfactory in children than in older patients. Alternatively a flap may be transposed from an adjacent area in the same limb with free grafting of the secondary defect. Very small lesions—In small lesions transposition of a full-thickness flap from the same limb, with free grafting of the secondary defect, should be the method of choice.

Lesions of the knee and hip joints—When there is chronic arthritis of the knee joint replacement of skin by means of a cross-leg flap is contra-indicated because immobilisation, even for three weeks, may cause joint stiffness which is difficult to overcome.

Maintaining the cross-leg position—The required position can be maintained by simple crepe bandages, plaster-of-Paris bootees and crepe bandages, or plaster-of-Paris splints including the knee joint and thigh. Each of these methods has its merit and its indication, but immobilisation in plaster splints appears to be the method of choice. The purpose of fixation is to maintain proximity of the donor and recipient areas, and to minimise strain on the flap. Bandages alone may not suffice and if they are used special care must be taken to prevent pressure sores between the limbs.
When plaster fixation is to be employed the splints should be applied the day before operation with the limbs in one of the basic positions. The plaster should be applied separately to each limb in such a manner that a sufficient area is left free round the donor and recipient regions. After operation the two casts are joined together by wooden struts fixed by means of plaster bandage. If plaster is first applied after the operation is completed, when the muscles of the limbs are lacking in tone and the position must be maintained by assistants, great care and attention is needed if harmful tension on the flap is to be avoided, and it is sometimes difficult to secure the most comfortable position in which there is least danger of pressure sores. The fact that the thigh may be covered by a plaster, applied before operation, so that it is no longer available as a donor site for the free graft needed to cover the area from which the flap is taken, is not a serious objection.

The skin of the abdomen is still available and it has many advantages.

The attachment stage—A flap is raised from the donor area according to the outline that has been marked out. Deep fascia is not included with the flap. Unless the subcutaneous fat is very slight the flap is thinned. The donor area is then covered by a split-skin graft, and pressure is maintained by oversewing a flavine wool dressing. It is recommended that the "bridge" area of the flap should also be lined by means of a split-skin graft, or by a small direct flap from the recipient leg, so that the smallest possible area of the flap shall remain raw and exposed (Figs. 2 and 3). The recipient area is excised and all scar tissue is removed. The flap is then applied to the deficiency and it is sutured to its margins.

The area of attachment of the flap should be not less than 60 per cent. of its total area. In Fig. 2 the recipient area extends from X to C. The flap XAB covers only the extent XA, leaving scar tissue over the area DC to be excised later. The donor area YE, and the "bridge" area DE, are covered by free skin graft. In Fig. 3 the deficiency XC on the recipient limb is smaller than in Fig. 2, and a flap of normal tissue DE can be turned back from the recipient limb to line the bridge of the flap. Each method ensures that infection is minimal, and that the bridge remains supple and easy to manipulate during the detachment stage. If the bridge is not grafted it becomes infected, hard, oedematous, and covered by sprouting granulations.

Sutures—Vertical mattress and simple evert ing stitches of fine waxed silk are used. Suture material stronger than this is not required. If this technique is followed it is impossible to
suture a flap under tension. Small anchoring sutures are used to fit the flap snugly into concavities on the recipient site.

**Complications**—The three major complications are: haemorrhage under the flap; infection of the flap; and necrosis of the flap.

**Haemorrhage**—With adequate care this complication can usually be avoided. Bleeding is often venous and due to pressure from a bandage applied tightly round the limb proximal to the field of operation. If a haematoma forms under the flap, or under the graft covering the donor area, the haematoma should be evacuated in the operating theatre and the bleeding point secured.

**Infection**—If the recipient area is a chronic ulcer, slight infection may take place. Nevertheless the resistance of cross-leg flaps to infection is high. The presence of B. Pyocyanus, B. Proteus or B. Coli is not necessarily harmful. The potentially dangerous invaders such as haemolytic streptococcus and staphylococcus can be controlled by the use of systemic penicillin.

**Necrosis of the flap**—Necrosis is usually due to interference with the blood supply of the flap. Cyanosis is often the first indication, most flaps dying in congestion and not in pallor. The causes of necrosis are: a) haematoma forming under the flap; b) bad adjustment of the relative positions of the limbs, or inadequate fixation of the limbs, leading to kinking of the bridge; c) constriction of the base of the flap due to pressure by bandages or dressings, or to badly placed stitches; d) inadequate removal of scar tissue from the recipient area.

**Difficulties in the attachment stage**—During the attachment stage difficulties may arise owing to the nature of the surface to be covered. It is more difficult to cover a concave surface than a convex or flat surface. Concavity of the recipient area is usually due to loss of bone, for example a saucerised cavity in the subcutaneous surface of the tibia. In such a case the cavity may first be filled with bone chips in order to improve the seating of the flap. If this method is used certain precautions are necessary: 1) sclerosed bone lining the cavity must be removed thoroughly; 2) the flap should be larger than the bone cavity in
Case 5. Persistent ulceration over the heel and front of the ankle resulting from pressure sores in a prisoner-of-war (Figs. 15 and 16). Double flaps were marked out on the opposite calf (Fig. 17). Cross-leg flaps were applied simultaneously to the two areas of skin-loss (Fig. 18) with a satisfactory result (Figs. 19 and 20).
order that it may gain sufficient nutrition from around it; 3) the flap must cover the whole deficiency so that the operation is “closed”; 4) the chips must be of cancellous bone and include no cortical bone which might sequestrate.

**The detachment stage**—The flap must not be divided earlier than three weeks after its attachment. The confining bandages or plasters are then removed and the limbs are held in position until the base of the flap is severed. The line of section depends upon the condition under which the flap was attached (Figs. 2 and 3). If the conditions are as in Fig. 2 the flap is divided at B; the scar CD is excised and AB is seated into the deficiency caused after excision of its covering free skin graft. If the conditions are as in Fig. 3 the part AB is returned to the donor limb and such parts of DE as may be required are returned to the recipient limb. After the detachment stage light pressure is applied to the area by encircling crêpe bandages.

**Post-operative management**—The day after operation, exercises are practised once more. In older patients some stiffness of the knee joint is usual, but as a rule full movement is regained quickly. A crêpe bandage is applied to both lower limbs for four weeks, thus preventing oedema. Walking is resumed after ten to fourteen days, but direct transmission of weight through transferred flaps should be delayed for six to eight weeks, crutches being used meanwhile. Even after that, transferred flaps that carry weight should be protected by sorbo pads until sensation is restored.

Flaps on the feet sometimes show vascular abnormalities such as cyanosis or persistent coldness. Cross-leg flaps with such changes may be divided into: 1) flaps applied upon bases from which scar tissue has been excised inadequately; 2) flaps applied upon limbs with post-traumatic peripheral vascular abnormality; 3) flaps applied to limbs with vascular abnormality present before injury. If the foot and leg as a whole is warm, and only the flap is cold and blue, the cause is inadequate excision of scar tissue before the flap was applied, and the cyanosis and coldness will usually disappear when the scar softens. If impairment of circulation is the result of injury the condition often improves within about two years of injury. Lumbar sympathectomy is sometimes of value, particularly in patients who complain of burning pain in the region of the original injury. Active use of the limb is helpful in overcoming disuse atrophy. Pre-existing vascular disease should, of course, have been dealt with before plastic surgery was undertaken.

**SUMMARY**

1. After limb injuries with loss of skin and subcutaneous tissue, full-thickness skin flaps afford the most satisfactory cover. It is particularly important to replace unstable and scarred skin before attempting bone reconstruction and similar operations.
2. In the leg and foot, full-thickness skin cover is conveniently obtained by the cross-leg flap technique. The blood supply of such flaps is considered and the technique of operation is described. Free excision of avascular scar tissue is essential.
3. "Delayed transfer" of the flap is advisable unless conditions are favourable; two methods are considered.
4. Immobilisation in plaster is the most satisfactory method of fixation of the limbs after attachment of the flap. Muscle exercises are performed throughout the period of treatment in order to minimise joint stiffness and shorten convalescence.
5. The cross-leg flap technique should not usually be used in children, young women, or the aged and mentally infirm. Contra-indications include arthritis of the knee and hip joints because there is danger of joint stiffness.
6. Vascular complications of cross-leg skin grafting are discussed.

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**REFERENCE**