EPITHELIAL HEALING AND THE TRANSPLANTATION OF SKIN*

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STUDIES of epithelial healing and of the transplantation of skin have been made in close association with the clinical picture of the requirements and possibilities of repair in a large number of patients over a 17-year period. The reasons for wound healing or failure of healing, the spontaneous repair of donor sites of grafts, the behavior of homografts and many other points have been studied by microscopic sections of the tissues involved. Laboratory animals are not very similar to the human in skin and subcutaneous arrangement, and it is thought that human biopsies have been of the most direct value. The record has proven interesting and instructive and it is hoped that it may help furnish a histologic and physiologic basis for further investigation. To Dr. Nathan Womack, thanks are given because of his help, interest, and patience in the protracted observations.

SPONTANEOUS HEALING OF LARGE OPEN WOUNDS

Wounds heal spontaneously by contraction of the surrounding edges, by filling in with fibrous tissue, and by scar epithelium going across from side-to-side. Skin is a complex organ and the epithelium is the only part of it that regenerates. The pad of derma that is really important in giving bearing protection does not regenerate, to any noticeable degree, and when a claim is made that a chemical will produce healing without scarring, the healing process is apparently not understood.

The thin scar epithelium that creeps across a wound by itself, and without any pad of derma to attach it to the subcutaneous tissue, may not be very serviceable as a bearing surface. It is thin, has no papillae, no hair follicles, no glands, and may form an excessive layer of keratin with nuclei remnants present far out in it. The latter finding may be evidence of a short life cycle of the cells associated with the continual wound stimuli of tension and repeated trauma. This scar epithelium may never become very firmly attached to the underlying fibrous tissue, so that large areas of it can be detached and lost by trivial injuries or infections (Fig. 1).

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Failure of healing may occur and is seen most often in circular burns of the extremities and wide open areas on the scalp. In such extremities there may be little or no upward growth of epithelium from the lower skin edge, so that the presence of even a narrow longitudinal strip of skin may be a big

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help in spontaneous healing. In the scalp, it has been conjectured that the follicles are so far differentiated into hair-forming structures that they do not revert to the production of surface epithelium so easily as elsewhere in the body. This is not true in the face, however, where rapid healing occurs, even

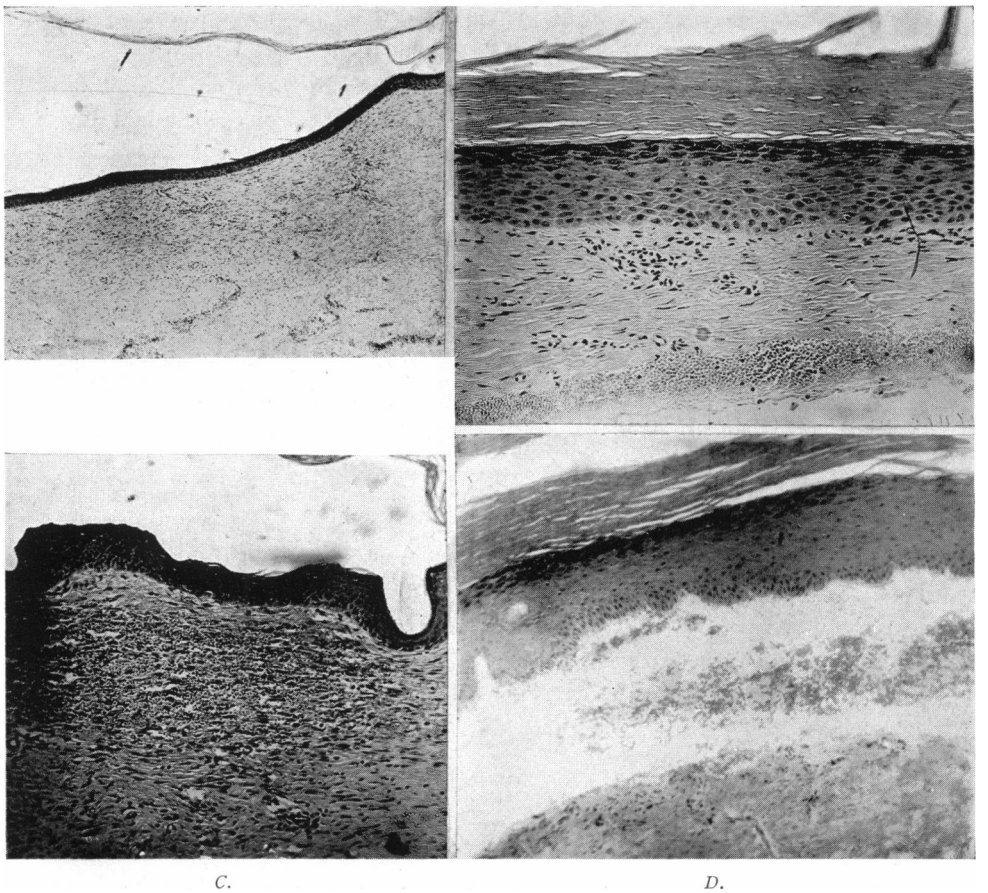


FIG. 1.—(*A*) Typical scar epithelial healing, with no dermal pad to attach it to the fibrous tissue under it. (*B*) Same thing existing in a scar after 20 years. This does become "tougher" but retains the same microscopic appearance. (*C*) Fresh scar, with red blood cells collected interstitially, just ready to detach the surface scar epithelium. (*D*) Microscopic appearance of the frequent gross finding of detachment of scar epithelium by hemorrhage. Even slight trauma may cause a large surface loss from hemorrhage under this poorly attached epithelium.

in full-thickness losses, presumably from deep hair follicles that extend clear down into the subcutaneous tissues (in men) (Fig. 2).

Individual variations in the growth of epithelium, aside from general nutritional factors, are marked. An occasional patient will heal a wide full-thickness loss and even get permanent bearing function. Others may heal rapidly but with so much dense, deep, fibrous scar that marked deformities are produced. These patients give about the most trouble of repair of any,

as this deep scar may have to be removed to allow normal function. Other patients seem not to grow any epithelium and may linger on over long periods, developing more pain and losing more body fluids all the time, and may die.

Studies of open wound (ulcer) edges have followed from the above considerations, and one of three pictures is usually found in them: (1) There may be no activity apparent at the edge at all, the epithelium simply thinning out and the stratum granulosum appearing to curve around to meet the basal layer, as though a permanent condition of open edge were to be established. This might be taken to illustrate an absence of response to the wound stimulus of the open area and usually occurs where there is little fibrous tissue laid down.

FIG. 2.—(*A*) Failure of healing in complete, circular full-thickness loss. (*B*) Edges quiescent, no growth from lower edge. (*C*) Complete healing following one thick split graft operation.

(2) There may be excessive keratosis with epithelial débris piled up along the edges, indicating a response to the wound stimulus by the short life of the cells, but failure of them to go on across the defect and effect a closure. (3) There may be a breaking up of the cells with apparent invasion of the deeper fibrous tissue, and it is presumably in this type of reaction that carcinoma develops. Carcinoma develops infrequently in comparison with the numbers of burns that occur. It occurs most often in areas that are prevented from collapsing, such as the scalp, or in large, dense fibrous ulcers that are repeatedly broken open.

Deep fibrous healing is presumably the only mechanism by which defects below the skin level may finally become closed, the area filling with granulation tissue that gradually changes to fibrous tissue. This dense tissue tends

at times to defeat its own purpose by becoming so thick and avascular that it cannot support its own surface or any epithelium struggling across it. In some old leg ulcers, calcium may even be laid down in the scar and resemble sequestra roentgenographically. (This, of course, may come from adjacent periosteum.) It is the failure to remove this deep scar that accounts for many of the failures of grafts for leg ulcers and other wounds that have been open for a long time. Because of the thick, deforming dense fibrous tissue that may go along with rapid epithelial growth and produce early distortion, it is sometimes easier to repair the patient who makes little if any epithelial effort of his own, but who at least does not go into every possible kind of deformity.

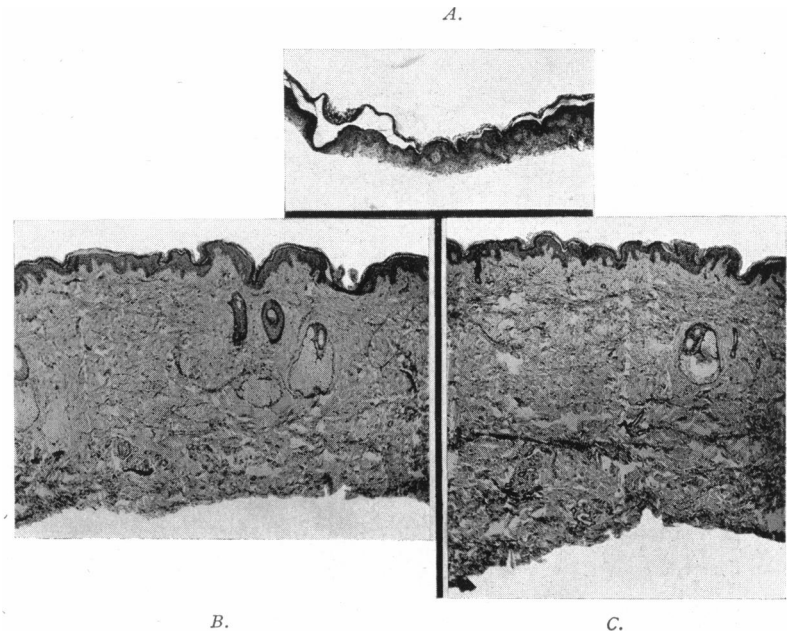


FIG. 3.— Three Types of Skin Grafts: (*A*) Ollier-Thiersch graft, with practically no derma. (*B*) Thick split-graft of about 80 per cent of the full-thickness. (Used in 1932.) (*C*) Full-thickness graft.

Generalized skin shortening is a term applied to areas that have healed, possibly with satisfactory surface, and which show no gross deformity but which do not permit normal function of complete flexion and extension. This is due to deep scarring and insufficient skin and is comparable to clothes that are too tight—the patient simply cannot bend around in his skin-envelope. The situation becomes especially bad if he puts on weight, as the dense blanket of scar will not distend for the new fat, and at times this thick, unyielding surface actually seems to form bursae over the deep fat. Notable examples of this have been published—one patient could not raise his arm without raising his leg, and another had not sat down normally for 26 years. The repair consists of opening suitable areas, either stretching back the edges or removing scar that is too dense, and filling the defect with free skin grafts.[2, 9]

THE TRANSPLANTATION OF SKIN

Early Skin Grafting of Burns and Other Open Wounds.—The main interest, generally, perhaps, is the problem of massive defects due to burns that have to be grafted to save life and prevent deformity, and in the later repair of contractures and deformities. Burns can usually be made clean enough for

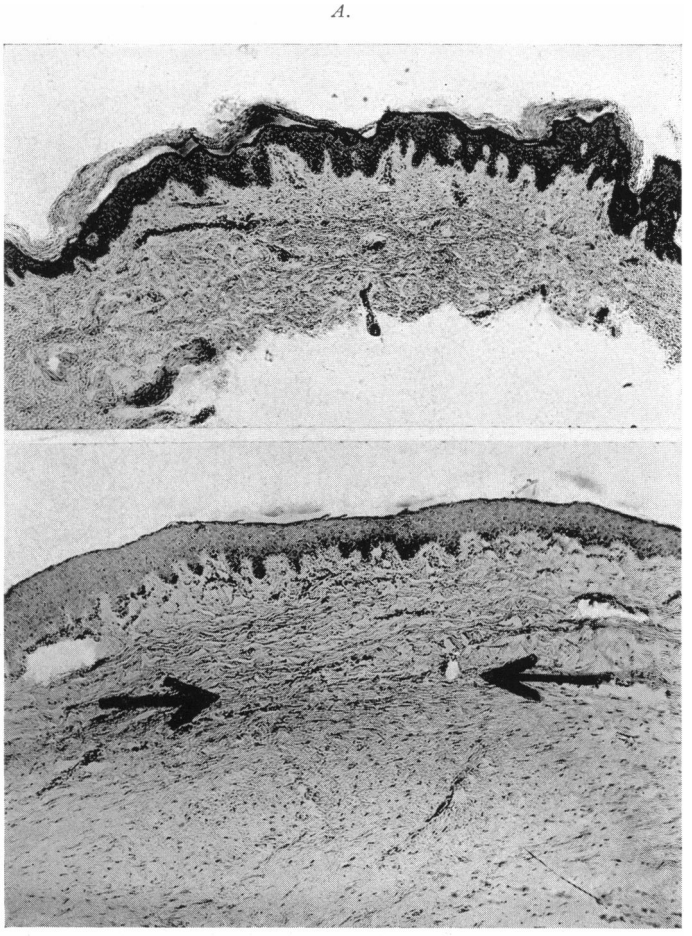


FIG. 4.—(*A*) Thick split-skin graft used successfully in repair of a burn. (*B*) Biopsy of same graft one year later. Arrows point to attachment of normal dermal pad to deep tissue. May be compared with Figure 1.

grafting in 20 to 30 days and, as this plan has been followed for a long period, it can be extended now in war wounds, if suitable preparation can be carried out and tanned membranes gotten off early enough.

The immediate excision of burns and grafting, as suggested by Murat Willis many years ago, may have isolated applications, but cannot be a routine procedure for all burns. It would result sometimes in much good

tissue being sacrificed or in not getting rid of enough burned tissue and, because of this, a loss of the graft.

Thick Split-Skin Grafts and the Relative Thicknesses of Other Types of Grafts.—Figure 3 shows these grafts all taken from the same area in the same patient and magnified to the same degree. The split-graft is about 80 per cent of the full-thickness in this instance. When large areas have to be resurfaced, it is necessary to utilize only partial-thickness of the donor skin, leaving behind some derma containing portions of hair follicles so that healing can occur. When the full thickness of the skin is not taken, then it has been split in two and the most appropriate name for this type of graft seems to be "thick split-graft." The original Ollier-Thiersch graft was too thin to be of much value, but almost any operator would, automatically, cut thicker grafts as he progressed in the work, so that the usual graft now used is one-half to three-fourths of the full thickness of the skin. Various other names have been employed to describe this graft.

The actual thickness of whole skin varies greatly in age, sex, race, various degrees of nutrition, and in different areas of the body. The skin is also of different character in various areas. On the back, for instance, the epithelium is relatively thin but the derma is so thick that full-thickness grafts from this area can hardly be counted on to survive. Burns in this location are seldom completely through the derma and tend to heal readily. Split-grafts from this area do not need to be as thick, relatively, as from other areas, and because of this, as many as five "crops" of skin have been taken from the same donor site at intervals as short as 19 days. The palm is just the opposite, with a specialized type of epithelium that produces a thick keratin layer for protection and has a thin derma without hair follicles. It heals very poorly following burns and even rather superficial ones may produce marked deformity, especially in children. The same is true of the sole.

Importance of the Dermal Pad of a Skin Graft.—To show the importance of a pad of normal derma between the underlying base and the surface epithelium, the split-graft in Figure 4 A was followed clinically for one year, at which time the result was satisfactory, and a biopsy was taken. Figure 4 B shows the graft after one year, appearing as normal skin with normal papillae, no excessive keratin—indicating a normal life cycle of the cells and absence of wound stimulus. The epithelium is attached to what is left of the fibrous base by the pad of derma included in the graft and a normal bearing-surface is produced that can withstand the usual trauma of getting around. This may be compared with Figure 1 A and B, in which the scar epithelium on a scar base is seen, and the comparison is the essential difference between spontaneous scar epithelial healing and healing by grafts.

Cutting Thick Split-Skin Grafts.—These grafts may be cut in several ways, the main essentials being a long sharp knife and some method of producing a diaphragm on which to cut. The diaphragm may be produced by pressing down, as with two large spatulae, or lifted up, as with tenacula, a vacuum suction retractor, or with glue, as on the dermatone. Each method has its

advantage, according to the availability of the skin in relation to size and nutrition of the patient. For large defects, the grafts should be cut as large as necessary for ease of repair—on a large person, ones 18x5 inches are possible, and grafts 36x4 inches have been cut free-handed with a long knife (Fig. 5 A, B). The dermatome may be useful in obtaining smaller grafts from more difficult areas, such as over the thorax, or from small children, where its size (8x4 inches) may be sufficient. One has to be careful not to

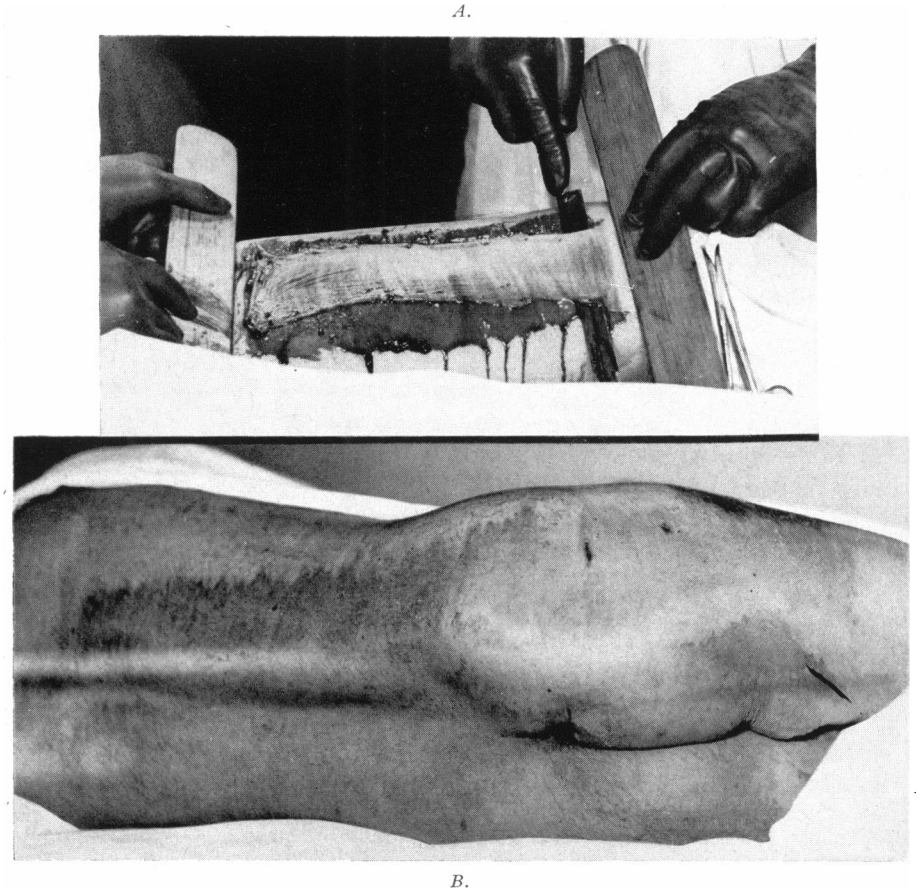


FIG. 5.—(*A*) Free-hand method of cutting thick split-graft, about 75 per cent of the full-thickness (11 × 4 inches). (*B*) Larger grafts are available in large patients. Healed sites shown of one graft 36 × 4 inches, and one 30 × 4 inches.

set it so deep that the full thickness of the skin is taken, or so thin that the graft cannot be detached from the drum. The free-hand method, when possible, is usually the fastest and safest method, and with some practice the thickness of the graft can be graduated and certain designs roughly obtained (Fig. 5 A).

Preparation of Base for Split-Grafts and Where They Will Grow.—Grafts may be put directly on the surface of open wounds if the granulations are bright red, flat, firm, and not edematous. However, if feasible, the granula-

tions are *sliced* cleanly off with a graft knife. They are not scraped, as this seems definitely to interfere with the take. In healed areas, especially if they have recurrently broken down, the scar epithelium and deeper fibrous tissue are removed down to a thin scar base so the area can relax. It may be necessary to open entirely through the scar to gain correct position of the parts, but this should always be done very carefully if there is any possibility of exposing tendons by sudden force. In Figure 4 B, the deep scar that has been left is seen under the graft.

Grafts will not grow on tendon or bare cortical bone (without periosteum), but may carry a lateral blood supply of their own across small areas of these tissues when exposed. This is important in work about hands because, if one goes very carefully, one can stop any tendon exposure before it is over 1 cm., and this is about the limit that the graft can be expected to carry over.

When put on fat or muscle, or uneven scar bases, the grafts will grow, but will later show every irregularity and there will be new scar tissue laid down that may contract the surface markedly. This has been said to be due to contraction of the graft, but it is probably from contraction of the bed under it.

Sulfanilamide may be dusted sparingly over the bed for the graft without measurably stopping the growth, but any excess certainly would be contraindicated and it cannot be expected to replace any precaution of cleanliness nor to prevent loss of a graft if a severe contamination has occurred.

The preliminary preparation is as important as any step in the repair of a large open wound and consists mainly of open drainage, soap and water, local sulfonamides, and daily débridement. Rest, elevation, and pressure dressings are fundamentals that cannot be omitted, but are only mentioned here for the sake of completeness. Ointments on areas to be grafted are used on fine-mesh gauze during the preparation but none should be on the wound at the time of operation, and if suspected, ether should be used as a solvent. Grease left under a graft almost precludes its growth. Somewhat of a reason for this has been noted (by others) in tissue cultures, in the finding that on the addition of a drop or two of mineral oil to a tissue culture, taxis of the cells ceases.

Pressure dressings on skin grafts are almost an absolute necessity (an occasional graft laid on and not protected might survive, but one could not run a service that way.) The medium of pressure distribution that seems most suitable is white cotton mechanic's waste. It has to be held on the same as any medium does and it is, therefore, the final bandage that produces the pressure (Fig. 6). Firm pressure is an excellent antiseptic, apparently by preventing the accumulation of surface fluid and keeping down edema, and its use has been noted in the hieroglyphics of the Edwin Smith Surgical Papyrus. Pressure dressings are also used on fresh burns when possible.

EPITHELIAL HEALING

The Epithelial Healing of Donor Sites of Thick Split-Grafts.—This provides an especially good opportunity for gaining information of epithelial

healing in general. Large areas are denuded under sterile conditions and the influence of any agent on the rapidity of epithelial healing can be readily noted. The resemblance to a superficial burn or to a deep abrasion is evident. The ability of these to heal promptly makes possible the transfer of 100 to 250 square inches of skin at one time, and it is most important to make sure that

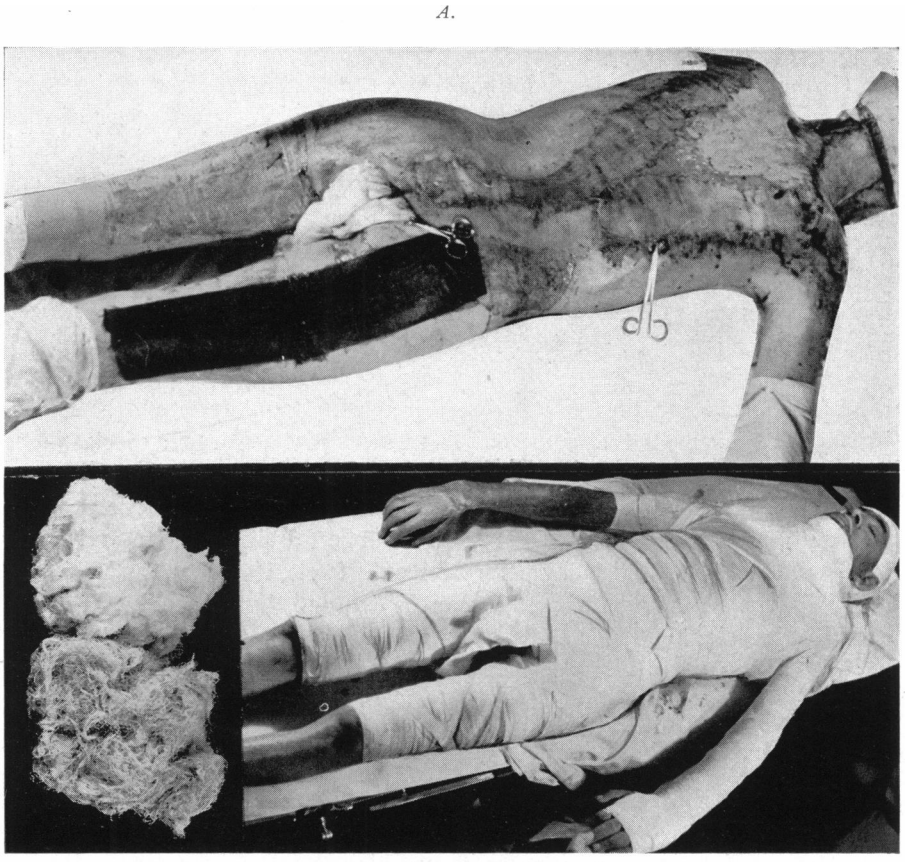


FIG. 6.—*Fine-mesh gauze* next to donor sites and over grafts. *Massive-pressure dressing,* using *cotton-mechanic's waste* to protect both donor sites and grafts. *Massive,* thick split-grafts, 210 inches in one operation. One graft, 16 × 4 inches, from shoulder to buttock. Others over back, arm and neck.

this healing does occur by using extreme care in dressings and protection (Fig. 6).

Dedifferentiation of the Hair Follicles in the Healing of Donor Sites.—In the healing of donor sites, the deep glandular epithelium in the derma spreads out over the surface and entirely recovers it in six days, and in six more days, dressings can be left off. In fact, only one dressing is done on the tenth to the twelfth day. This process is a sort of "dedifferentiation" of the cells of the hair follicles, as far as we have been able to determine, and a gross observation

in substantiation of this is the fact that on the palms and soles, where there are no hairs, healing is slow.

Microscopic Appearance of Epithelial Dedifferentiation.—The whole process can be studied microscopically in biopsies taken at intervals (Fig. 7). Healing is complete by the sixth day, and by the ninth day, conversion to squamous epithelium is so complete that papillae are formed and some keratin

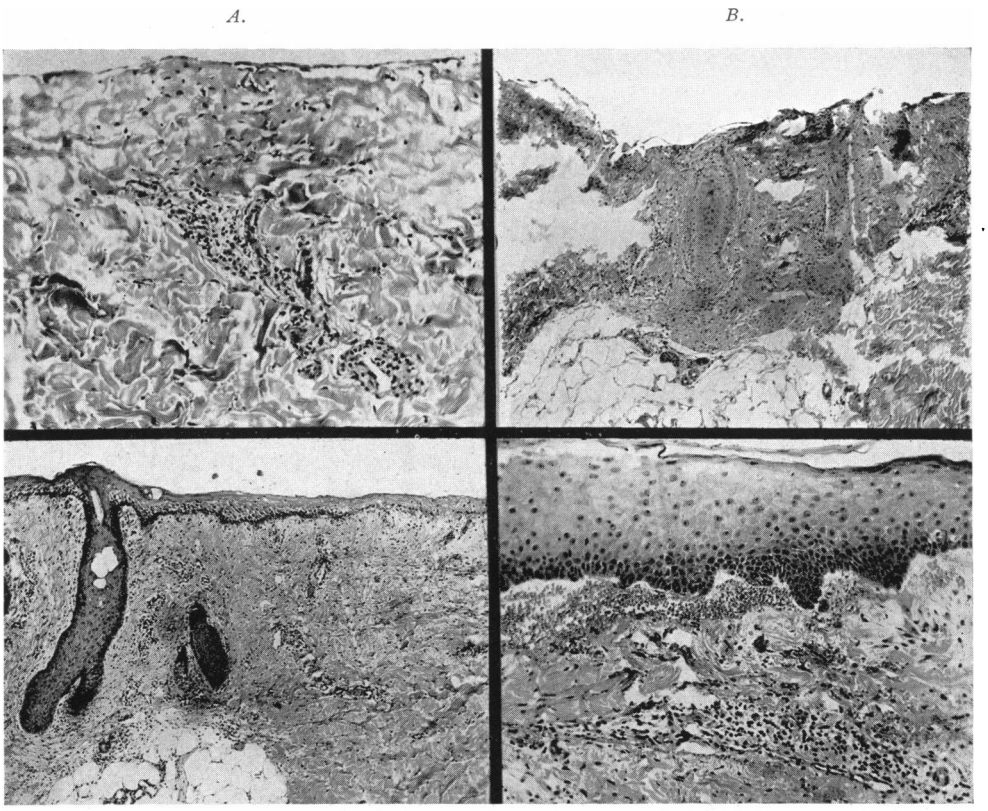


FIG. 7.—Healing of Donor Sites of Thick Split-Grafts: (*A*) Biopsy, two-day-old donor site—no surface epithelium. (*B*) Two-day-old biopsy showing deep follicle but no surface coverage. (*C*) Four days later, or sixth postoperative day, showing complete coverage with squamous epithelium. (*D*) Ninth day, with normal appearing epithelial surface.

is being thrown off. This process is apparently the reverse of the original formation of hair follicles. It is also something like a reversal of carcinoma formation, and it was thought that a somewhat similar picture might be found if enough healing donor site biopsies were done. This has not been entirely clearly shown because the cells go out so rapidly and orderly, but suggestions of it have been found.

Careful Protection of Donor Sites to Obtain Healing.—It is apparent that this process is a very delicate one and that irritation of any nature, chemical, bacterial, or mechanical, will prevent healing. When this does occur, the healing period is changed from ten days to eight or ten weeks, and whole

areas of the derma seem to melt away. It is evident that extreme care should be taken not to damage these cells and, therefore, no strong chemicals are put on the area. It is dressed immediately to protect it from trauma and contamination with fine-mesh grease gauze (No. 44 gauze), held firmly in place with overlying pads, adhesive and bandage that cannot slip. If any openings have been cut through the derma, they are carefully closed before the dressing is applied (Fig. 6).

When large areas are denuded, the additional bleeding and fluid loss may be considerable and whole-blood transfusions are often advisable.

The application of fine-mesh gauze to these and all raw surfaces is a fundamental of extreme importance to allow healing to progress smoothly and, on granulating surfaces, to avoid growth of them through the meshes of coarse gauze.

Rapidity of Healing and Multiple "Crops" from Same Area.—Split-graft donor sites usually have to be guarded a week or so longer after the 10 to 12 days, but a second "crop" of grafts has been taken as soon as 10 days after the previous "crop," and five "crops" have been taken from the same area. There is a marked variation in patients in their rate of healing. One patient, for example, who healed his donor sites rapidly and had four "crops" from the same area, did not make any new lateral spread of epithelium over his burns. Negroes are ideal patients for grafting; grafts seem to grow on them almost regardless of technic, but they are a little slower in healing their donor sites. This may be because they tend to have less hair.

The Skin of the Back.—This early and repeated healing where multiple "crops" are taken has usually been from the back, where the derma is thick, but care is taken not to cut too deeply; the skin does finally wear out and the last "crops" are not as nice to use as the first one.

The possibility of enough skin for repair in each burned patient is usually present if the above precautions are taken. The graduation of the thickness that is possible in free-hand cutting is probably the safest way of avoiding trouble, and of insuring the possibility of multiple "crops" from the same area.

Saving a good donor site on badly burned patients is important for obtaining smooth full-thickness grafts when final operations are to be performed about the face and neck. A thigh or the lower abdomen may be left for this work, but it is frequently found that someone has removed pinch-grafts right out of the center of these areas.

HOMOGRAFTS

Homografts are usually thought of at this point, when the possibilities of the patient having enough of his own skin are considered. These grafts will take almost universally even without regard to blood grouping. In grouping one series of 26 down into the M. and N. groups (with Dr. Francis E. Holfort) no relation was found either to the take or to the length of persistence. However, they will not persist in place over 10 to 11 weeks, and usually begin to disappear at the third week by a sort of solution of the graft, usually without pus formation.

Biopsies taken early in this process of solution show interstitial edema, with slight cellular infiltration, as might be seen in an urticarial wheal. Later, the interstitial edema is less striking, and the cellular infiltration becomes heavy, consisting chiefly of round cells with many eosinophils and some polymorphonuclear cells. This heavy cellular infiltration coincides with the disappearance of the various dermal elements and epithelium in scattered areas. Grossly, the graft has numerous tiny areas of loss and appears "moth-eaten"

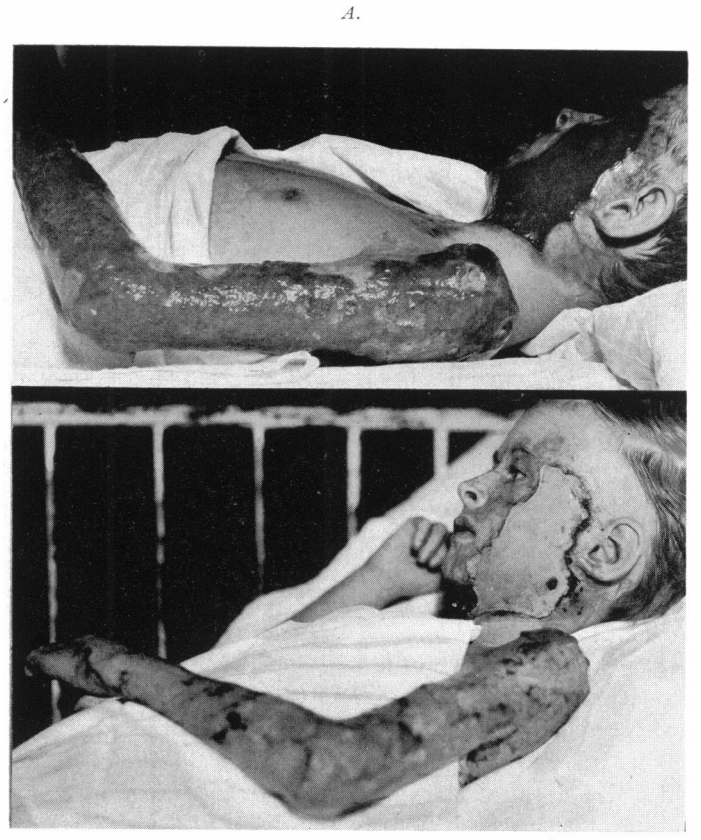


FIG. 8.—Emergency Dressing of Wounds in Homografts: (*A*) Extensive burns of arms, legs and face. (*B*) Whole arm healed with homografts from father. At same time, permanent autographs put on hand and face.

at this time. These areas increase in number and coalesce until final complete solution of the graft occurs. It would appear that the proteins in the homograft are antigenic and that the host requires about three weeks to build up a maximal allergic response to them. If a second crop of hemografts from the same donor were applied to the patient at this time, one would expect almost complete failure to take. By the same reasoning, any previous attempts to "desensitize" the patient to the donor's skin proteins would probably decrease the chances of take. Conversely, attempts to "denature" the antigenicity of

the proteins in a homograft, or to change them by previous immersion in the patient's serum, have not proven clinically successful in skin grafts.

The emergency "dressing" of wounds in homografts is employed occasionally as a life-saving measure and in intractable children. Large sheets are taken from the donor and applied quickly, about as a dressing of the wound. The effect is stopping of pain; and the necessity of care, improvement generally, cleaning up locally, so much that there may be a marked stimulus in the patient's own epithelization, have been misinterpreted by some observers as a permament survival of the homograft (Fig. 8).

According to Dr. Leo Loeb, no two individuals are exactly alike, and with our present knowledge, there is no use to expect a homograft to survive. Much work has been done along these lines, and if the problem could be solved, one of the greatest possible advances would have been accomplished. Skin is an organ and not just the epithelial element, so that it probably cannot be grown in a foreign body any more than any other organ and persist.

Homografts in identical twins, however, have been shown to survive, and if a twin were burned, the other one could probably be used satisfactorily.[4]

Delayed or refrigerated grafts are possible and have been used clinically occasionally, and experimentally in animals, and from humans to animals, but there is not much clinical use in the procedure at present, since the patient is always on hand to supply his own skin, and the obtaining of the graft is the minimal part of the procedure. In one case a successful full-thickness graft on the neck had been stored in an ice-box for forty-eight hours; as far as is known, this is the first clinical instance of the use of this procedure. One can conjecture all sorts of storage plans and tissue culture plans for grafts, to be used in war time, but final success has not been attained.

(Illustration of this part and eight other figures omitted.)

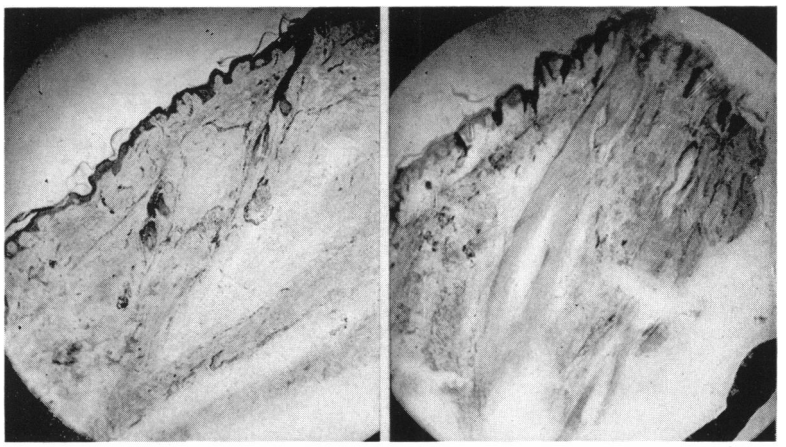
LATE COURSE OF THICK SPLIT-GRAFTS

Sebaceous collections may occur to an annoying degree, possibly because the cut glands secrete backwards. At least it appears this way since multiple large collections may develop. Their importance is that final healing may be delayed, and if the large collections become infected, excoriation or even loss of part of the graft may occur. There is usually a deep layer of epithelium under these collections, so that if they are opened and expressed, and any overhanging edges trimmed away before infection causes damage, serious loss is avoided. This occurrence is one of the marked variations, some patients not showing it at all and others showing it badly, regardless of how thick the graft is cut; however, full-thickness grafts never show it. This also may be due to small areas of the original skin being left behind and the grafts having been put over them.

Persistence of function of skin grafts over long periods of growth has been studied and it seems that grafts do grow or stretch out, so that if a graft has been successful at the beginning, it is apt to remain so. If any lack of skin for ease of function (skin-envelope) is noted, suitable openings can be made and more skin let in.[9]

Satisfactory function of grafts is meant to include: "(1) Enough skin for free movement; (2) moderate looseness; (3) ability to withstand the usual trauma of getting around; and (4) the development of normal sensation. Full normal sensation usually develops in free skin grafts and is influenced by the amount of deep scar that is left and, of course, is dependent on the presence of sensory nerves in the area."[9]

Metaplasia of grafts (and flaps also) does not take place and, therefore, a really normal sole or palm, for instance, cannot be restored. The skin of



A. *B.*

FIG. 9.—Failure of Metaplasia of Skin-Grafts: (*A*) Biopsy after one year—from graft in orbit. Graft is still skin, grossly and microscopically. (*B*) Biopsy after five years—from inside larynx. Graft is still skin, with hair growing from it.

each of these areas is specialized to the point of being an organ; the microscopic structure is different from birth and the peculiar bearing qualities are not developmental. "A graft or a flap on a sole may make calluses (or even annoying warts) but it will not metaplase into true skin or subcutaneous tissue of the area. They always have to be protected and the wart formation guarded against. If hair is transplanted, it will continue to grow, except that it may be worn off.

"Skin grafts transplanted to normal mucous membrane surfaces, such as the mouth, larynx, and eye socket, show no evidence of a change to a mucous membrane. The skin simply persists as such and even raises hair in these areas, if there are any functioning follicles in the graft" (Fig. 9).[9]

LINES OF INVESTIGATION.—At this time, when burns and grafts demand a good deal of attention, it is desirable to have the whole subject, including objects, reasons, possibilities and limitations, put on a plane approaching other surgical subjects. Important lines of investigation are: (1) Information to be gained and correlated from tissue cultures; (2) chemotherapy in relation to preparation of wounds and at time of operation; (3) refrigeration of grafts before being applied and of the areas after operation; (4) development of occlusive dressings that are transparent and removable; (5) prevention of

burns; (6) earliest possible replacement of skin following burns; (7) improvement in dressings and pressure media, and of air pressure on wounds plus burns; (8) simplification and ease of obtaining split grafts; (9) possibility of getting homografts to survive; and (10) utilization of delayed grafts.

Much has been accomplished, but it is apparent that there is room for vast improvement.

PREVIOUS PUBLICATIONS

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[2] The Repair of Surface Defects, from Burns and Other Causes, with Thick Split-skin Grafts. South. Med. Jour., **28**, 408, 1935.

[3] A Study of Ulcerations of the Lower Extremity and Their Repair with Thick Split-skin Grafts. Surg., Gynec., and Obstet., **63**, 331, 1936.

[4] Homografting of Skin: With Report of Success in Identical Twins. Surgery, **1**, 559, 1937.

[5] Restoration of the Entire Skin of the Penis. Surg., Gynec., and Obstet., **65**, 362, 1937.

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[7] The Treatment of Burns. Brennemann's Practice of Pediatrics, Vol. 4, Chap. 52, p. 1, January, 1937.

[8] The Covering of Raw Surfaces. Internat. Abst. Surg., **67**, 105–116, August, 1938.

[9] Persistence of Function of Skin Grafts through Long Periods of Growth. Surg., Gynec., and Obstet., **72**, 848–853, 1941.

[10] Thick-split Skin Grafts in the Repair of Burns. Surg., Gynec., and Obstet., **73**, 265–267, 1941.

[11] Skin Grafting of Burn Deformities. (Army Manual, to be published.)

[12] Massive Repair of Burns with Thick-split Grafts. ANNALS OF SURGERY, **115**, No. 4, 658–674, April, 1942.

DISCUSSION.—DR. SUMNER L. KOCH (Chicago): There were so many things Doctor Brown could not include in this rather brief discussion, that I want only to emphasize just a few of the principles that he has suggested and repeat them, because we think they need to be repeated from time to time.

First of all, if there has been a whole-thickness loss of skin, no dressing will bring about healing. The only way that raw surface can heal is by ingrowth, the slow ingrowth of epithelium, or by replacement.

Second, the more quickly replacement is brought about, the less will be the contracture that develops. All of us, I am sure, see, too often, patients left for long periods of time in the hope that spontaneous healing will occur. While it does go on very slowly, difficult and serious contracture is developing and increasing and, of course, the longer it goes the more difficult it is to overcome.

Third, Doctor Brown has not had time to talk about the importance of securing a clean field. He has suggested it, and he has referred to it in his paper, but to secure a successful result one must have a clean field. Many advances have been made recently, particularly in methods of securing grafts, and all of us have seen very beautiful grafts taken by various methods. Too often the unthinking surgeon forgets that the field has to be clean or the graft cannot live. Nothing that I know of helps so much to secure cleanliness of that field as simple surgical cleanliness and avoiding adding infection to the raw surface that is to be covered.

Again, surgeons so often forget the importance of not adding infection to the open wound as they are trying to transform it into a clean wound. They forget that the more serious potential sources of infection are the surgeon's hands and his instruments and, most of all, the uncovered mouth and the unmasked nose. I never have had the opportunity of going to another hospital to see a patient with an extensive injury and been offered a mask to cover my face before examining the large wound that was distressing the surgeon. I

think it is something that we have to repeat over and over again to our students and our house officers, that just as in the operating room, where everyone admits the importance of preventing infection, so in the ward and in the patient's room those same precautions must be taken, and that if we are going to secure clean wounds we must prevent adding infection to them throughout the course of treatment.

DR. NATHAN WOMACK (St. Louis): There is one thing about Doctor Brown's paper that I would just like to stress, and that is his demonstration of the extraordinary rapidity with which apparently perfectly normal epidermis can be formed in five or six days from squamous epithelium. If it is sectioned longitudinally and separated with a clothespin, one sees a very marked resemblance to skin, but functionally it does not resemble skin. It does not resemble it in pigmentation. It does not resemble it in its metabolism.

It will be very interesting to observe what happens to some of these donor sites that Doctor Brown has under observation many years from now, whether or not the function of the stratified squamous epithelium of the skin is picked up as well as its morphologic structure.

One other thing: I think the preservation of potency we see explains the marked variation that one sees in the other direction; that is, the formation of tumors.

The fact that cells are able to perform other functions than those they are normally supposed to do, such as squamous epithelium in the bronchus, and squamous epithelium in the gallbladder, explains some of the multitudinous morphologic experiences and some of the skin cancers that Doctor Brown has been talking about.

DR. VILRAY P. BLAIR (St. Louis, Mo.): May I emphasize a point that Doctor Brown brought out? I did not catch that he said it directly, though he demonstrated it. That is the futility of homografts in preserving the vitality of the patient and bringing about an early condition where one can put on the autograft. Especially in young children, that is very useful. A child is badly burned. You take the graft from the mother and put it on, knowing it is not going to last, but by the time it has disappeared it has fooled many people into reporting in the literature that they have had permanent results, which I do not believe they ever did get.