Skin grafting for surgeons and general practitioners / by Leonard Freeman ; with 24 illustrations.

SKIN GRAFTING

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FOR SURGEONS AND GENERAL PRACTITIONERS

BY

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WITH 24 ILLUSTRATIONS

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SKIN GRAFTING

CHAPTER I

TERMINOLOGY—EARLY HISTORY

Definitions.

Skin grafting should not be confused with plastic surgery (anaplasty), as is frequently done. The former refers to operations in which portions of skin or of epithelium are entirely severed from their original connections and used to fill in defects elsewhere; while the latter should be limited to procedures where flaps of skin are employed which are merely loosened from the underlying tissues and slid from one point to another, or are provided with pedicels through which nutriment is furnished until union takes place.

The simplest form of plastic work consists in "mobilizing" the integument adjoining a wound in order to relieve tension and facilitate the application of sutures. The most complicated is perhaps that introduced by Schrady,[1] in which a skin-flap is made to adhere to the denuded side of a finger, so that when the original connections are severed the flap may be conveyed, attached to the finger, to any portion of the body—the digit serving as a sort of movable pedicel.

[1] Medical Record, Jan. 24, 1891, p. 117.

Transplantation is another term for skin grafting. *Implantation* means practically the same as transplantation (Gould), although its use is often limited to operations in which dead organic or inorganic substances are employed. *Dermanoplasty* (Esmarch) and *dermepenthesis* are somewhat obsolete synonyms for skin grafting. The word *flap* should be confined to plastic surgery, and the word *graft,* to transplantation.

Transplantation is sometimes designated as the *first* or *older Indian method,* in contradistinction to the *second Indian method,* often called simply *"Indian method,"* in which a pedunculated flap, with more or less twisted pedicel, is taken from the adjacent tissues. In the *Italian method,* the flap is obtained from one of the extremities which can be brought in contact with the field of operation—for instance, the arm in rhinoplasty.

When grafts are composed of epithelium alone, whether in the form of large or of small pieces, or of so-called "epidermal dust," they are known as *epidermal grafts;* when comprising both epidermis and a portion of the true derm, as *dermo-epidermal grafts;* and when made up of the entire thickness of the skin, whether including the subcutaneous connective tissue or not, as *total cutaneous* or *"whole-thickness" grafts.*

Vegetable grafting, termed *instition,* by Küster, has little in common with skin grafting, in spite of a superficial similarity. Vegetable grafts grow upon their hosts from first to last as separate individuals, something in the nature of parasites. Skin grafts, on the contrary, become a portion of the tissue into which they are transplanted. Such experiments, however, as the one made by John

Hunter, a hundred years or more ago, of transplanting the spur of a cock to the comb of the same fowl, has a strong resemblance to vegetable grafting.

When grafts are obtained from the patient himself, they are preferably called *autodermic;* when from another individual, *hetero-, homo-,* or *isodermic;* and when from animals, *zoödermic*—the methods being known as autoplastic, heteroplastic, and zoöplastic.

Early History.

Surgery is usually regarded as a modern science, and yet the ancient Hindus, perhaps two thousand years ago, performed many difficult operations as successfully as we perform them now. Particularly is this true of some forms of plastic surgery and of skin grafting.

It was the custom in India to punish certain offenses by cutting off the nose. As an almost necessary consequence, there appeared at an early date men skilled in plastic surgery, who belonged, strangely enough, to a low and despised class, the tile-maker's caste. Their work is said to have been excellent, even superior in some respects to that done at the present time. One of the most remarkable achievements of these pioneers in surgery was the replacement of the nose by a graft from the thick skin of the gluteal region, a feat which even now cannot be repeated with certainty. When we consider that the subcutaneous fat was included and that no support could have been had from underlying tissues, the success obtained seems little short of marvelous. The temptation is great to ascribe some virtue to the secret "cement" employed,

but we know so little of the actual technic that speculation in this line is not of much value.

It was once thought that pieces of skin transplanted from one individual to another grew vigorously or withered as the original possessor's health became good or bad. Hence, it may be imagined that the man bearing such a graft must often have been very solicitous as to the physical welfare of the donor.

It is probable that skin grafting, like some other arts, was largely lost sight of during the middle ages, although here and there a more or less authentic account of an isolated case has been preserved. For instance, it is related by Sancassani (1731 to 1738), that a female street-vender, in order to prove the efficacy of a certain salve, was accustomed to cut a piece of skin from her leg, pass it around the audience upon a plate, and then replace it in its original position, covering it with salve. Such perfect union took place that the site of the operation was scarcely discernible.

About the end of the eighteenth century some account of the Indian methods of grafting was brought to Europe by travelers. The statements, however, were credited by few, and those who did believe were generally disappointed when they tried the experiment themselves. Nevertheless Van Helmont [2] states that Tagliacozza, a Bologna surgeon famous for his achievements in rhinoplasty, constructed a nose for a patient in Brussels from the skin of the arm of a workman; but Tagliacozza has been credited with so many wonderful things that it is difficult to sift the true from the false.

[2] Opera Omnia, 1682.

The skin from the back of a student's hand is said to have been used by Dzondi in the formation of a woman's nose, and Bünger [3] succeeded in getting a portion of a graft from the thigh to adhere in a similar operation.

And yet, while disbelief was almost universal, it must have been generally known among medical men that certain parts—such as noses and fingers, when accidentally severed from their connections—were capable of becoming reunited under favorable circumstances. In fact, records of such cases are not uncommon in the writings of various ages, and one would imagine that the conception of skin grafting, based upon such a foundation, would have been almost unavoidable. John Bell,[4] however, scornfully mentions two instances, regarding them as fabrications; and yet they may well have happened. The first was described by Garengeot as follows:

> A soldier, reeling out of a tavern drunk, along with some of his companions, got into a quarrel, in which one of them bit his nose off, threw it into the gutter and trode it under foot. He picked up his nose, flung it into Mr. Gallin's, an apothecary's shop, ran after the fellow who had done it, and when he returned, Mr. Gallin washed the nose at the well, stuck it with plaster in its place, and in two days after it was firmly united.

The second instance was related by Sir Leonard Fioravanti:

> In that time when I was in Africa there happened something strange and this was it. A certain gentleman, a Spaniard, that was called Seignior Andrew Guitiero, of the age of twenty-nine years, upon a time walked in a field with a soldier, and had words with him and began to draw. The soldier seeing that, struck him with the left hand and cut off his nose, and then it fell down in the sand, and then I happened to stand by and took it up, and washed away the

[3] Gräfe and Walther's Jour., 1823.
[4] Principles of Surgery, London, 1826.

sand, and stitched it on again very close and dressed it with our balsamum artificiato, and bound it up and so let it remain eight days, thinking that it would have come to matter, nevertheless, when I did unbind it, I found it fast conglutinated, and then I only dressed it once more, and he was perfectly whole.

A unique feature of this interesting narration is the fact that the sand was removed from the severed part by urinating upon it—certainly an easy method of procuring a supply of sterile salt solution!

So firm was John Bell in his belief that no portion of the body could grow on again after it had once been completely removed, that when confronted by a man who had chopped off the end of a finger and successfully replaced it, Bell tried to explain the circumstance by supposing that "so small a piece of the finger may have rotted after it was bandaged, the remaining flesh upon the point of the finger growing up to supply its place." What would this eminent surgeon have thought had he come in contact with a case similar to one reported by Finney[5] in which a finger became reunited after being completely severed from the body some seven hours, or the case observed by Kelley[6] where the soft parts of a nose grew in place after having been separated an hour? As early as 1836, Hoffacker,[7] surgeon to a students' duelling corps in Heidelberg, succeeded in reuniting numerous severed portions of noses and a piece of a lip.

[5] Johns Hopkins Hosp. Bull., Oct.–Nov., 1892.
[6] Times and Register, Phila., Aug. 16, 1890.
[7] Med. Annalen, 1836.

CHAPTER II

COMPARATIVE VITALITY OF GRAFTS FROM THE OLD AND FROM THE YOUNG—HETEROGENEOUS GRAFTING—DANGERS OF TRANSFERRING DISEASE—INFLUENCE OF THE PATIENT'S GENERAL CONDITION UPON SKIN GRAFTING—SURGICAL CLEANLINESS

Grafts From the Old and From the Young.

It has often been stated that grafts taken from the old, especially when including the entire thickness of the skin, do not grow so well as those removed from younger individuals, even when the transplantation is made from the patient's own body. Most of these assertions, however, are based upon an article by Dobson,[1] whose experiments were limited to but one graft in one case. More recently others have made similar claims, with somewhat more ground for their assertions, and Sullivan[2] says that experience has taught him that skin from babies, particularly those at the breast, is possessed of superior vitality. Ivanova has utilized this idea in grafting from the bodies of dead infants.

Many successful graftings are, nevertheless, done upon individuals well advanced in years; and not only that, but they are done under unfavorable conditions, as in ulcers of the leg. Even admitting that grafts from the young

[1] Medical Times and Gaz., Oct. 29, 1870.
[2] Med. Rec., Jan. 9, 1897, p. 48.

may show a somewhat greater vitality than those from the old, there is not sufficient difference in this regard to warrant either a refusal to operate upon old people or an attempt to invariably employ in such cases skin taken from the young.

Heterogeneous Grafting.

There is no doubt that grafts thrive best when obtained from the patient's own body, but nevertheless grafting from others may be successful, although many of the marvelous cases described in the daily press are either exaggerated or have been reported too soon to be scientifically reliable. Although the grafts may apparently flourish at first, many of them, even when derived from blood relations, are apt ultimately to disappear in two or three weeks, with or without suppuration.[3] This was exemplified in one of the writer's cases, in which a large burn was covered by grafts partly obtained from the patient's thighs and partly from those of his mother. Every one of the autodermic grafts survived while all of the isodermic transplantations ultimately perished.

Davis[4] has recently reported forty cases of isodermic Thiersch grafting with nineteen complete successes, sixteen partial successes, and but five failures. In his opinion, "isodermic grafts are quite as successful as those from the same individual under similar favorable conditions," but the experiences of many others do not warrant so optimistic a conclusion; and it is undoubtedly safer, from all points of view, to transplant from the patient's own body. Heterogeneous grafting should always be done when possible

[3] Lexer, Zent. f. Chir., 1911, No. 29, p. 23.
[4] Ann. Surg., 1909, Vol. 50, p. 542.

under local anesthesia, in order to avoid danger to the donor of the skin. Schaefer [5] thinks that heterogeneous transplantations do best when donor and recipient are of about the same age, but the accuracy of this view may well be questioned.

Transmission of Disease.

There is no doubt that diseases of various kinds can be transmitted in skin grafting from one individual to another; and in fact, this has been done in numerous instances. SYPHILIS is most to be feared. Deuvel [6] reports the case of an old gentleman with a large ulcer following erysipelas, which was grafted from a number of different persons, including his son. The patient soon developed syphilis, originating in the grafted area. Upon investigation, the son was found to be afflicted with the disease in its secondary stage. Such unfortunate accidents may be guarded against, however, by obtaining a preliminary Wassermann reaction.

Czerny [7] mentions two cases, which are, however, not convincing, in which TUBERCULOSIS was thought to be transmitted by grafts obtained from legs which had been amputated for white-swelling of the knee. The patients developed phthisis, although no signs of the disease had existed before, and the family histories were clear.

SMALLPOX is said to have been inoculated through skin grafting in at least one instance; and as far as the other acute infectious diseases are concerned, the list is probably limited by lack of opportunity only.

[5] Tr. Internat. Med. Cong., 1887.
[6] Union Med., Dec. 11, 1881.
[7] Verhand. d. Deut, Gesell. f. Chir., 1886; Cent. f. Chir., 1886, No. 24.

Hahn [8] has shown, by an experiment for which he has been severely censured, that CANCER may be transplanted from one portion of the body to another. He grafted an area of skin from an inoperable carcinoma to the surface of a wound made elsewhere, thus producing a malignant growth at the point of implantation. Similar experiments have since been repeated many times by others, and auto-inoculations have often been observed following operations for cancer.

The Patient's General Condition.

This is not of so much importance as a contraindication to grafting as might be supposed. On the contrary, the correction of a local septic process by transplantation can materially assist in the regaining of health and strength. Wounds may heal and grafts grow in a satisfactory manner upon those whose physical status is much below par, unless some specific poison be present.

ERYSIPELAS can cause grafts to dissolve even after adhesions have taken place; hence transplantations should not be made for perhaps six or eight weeks after the disease has disappeared, as streptococci are capable of existing for a long time within the tissues. Any acute fever, especially one of the exanthemata, may act in a more or less unfavorable manner.

It can scarcely be doubted that DIABETES and NEPHRITIS exercise a somewhat unfavorable influence; and yet successful grafting has been done in the presence of these conditions, and they need not deter us from operating in the absence of other contraindications, although, for obvious

[8] Ber. Klin. Woch. No. 21, 1888, p. 413.

reasons, local rather than general anesthesia should be chosen.

Of all constitutional disorders, SYPHILIS is probably the most disturbing, so much so that it has been claimed that grafting should never be attempted when this disease is present, and Hartley [9] cites several cases which he thinks show that grafts will not adhere until syphilis has disappeared from the system. Much depends, of course, upon the stage of the trouble, and upon whether the surface which is to receive the grafts is directly syphilitic. Wounds often heal readily in syphilitics, and there would seem to be no reason why grafts should not grow; in fact, they frequently do so, as has been demonstrated by the writer and by others. Nevertheless, it is wise to subject the patient to a preliminary course of antisyphilitic treatment lasting at least three or four weeks, particularly if the disease is active. Grafting on genuinely specific ulcers is not to be thought of, as it will almost certainly be followed by failure.

Death From Skin Grafting.

A case in which death followed the transplantation of skin to the surface of a large burn is reported by Dunn.[10] He suggests that a fatal toxemia was produced by disturbance of the granulations; but suppuration had been in existence for a year, and it is possible that amyloid disease may have been responsible for the accident. The urine was not examined.

It is well established that skin grafting is an extremely safe procedure. The small mortality which accompanies

[9] N. Y. Med. Jour., Aug. 27, 1892, p. 247.
[10] Northwestern Lancet, Apr. 15, 1893.

it being due to extraneous causes and not to the operation itself.

Surgical Cleanliness.

This is of much importance, because the more nearly the surface to be grafted approaches an aseptic condition the greater is the likelihood of success; and if the skin from which the cuticle is obtained is not cleansed, infection may result with more or less disastrous effects.

Just as in other surgical operations, the cutaneous surface should be shaved, scrubbed, and rubbed with alcohol. Strong antiseptics, such as bichlorid of mercury, are unnecessary; but if they are used, they must be washed away with care, as the presence of even a small quantity may interfere with the vitality of the grafts. For this reason, the iodin method is not often employed in skin grafting.

The edges of cutting instruments, such as razors and knives, are injured by boiling; hence they are best sterilized by placing them in pure carbolic acid, afterward rinsing them in alcohol, which in turn is removed with salt solution.

Although asepsis is undoubtedly desirable, it must not be supposed that it is always necessary to success. Transplantations will often adhere in the presence of the most profuse suppuration, providing the granulations are in reasonably good condition. In fact, in the grafting of ulcers and granulating wounds, it is seldom possible to procure even an approximately aseptic surface, although more or less successful attempts are often made in this direction, as described in detail under the various methods of grafting.

CHAPTER III

THE METHOD OF REVERDIN

Skin grafting is really one of the oldest procedures in surgery; and yet, so far as modern times are concerned, we knew little or nothing about it until Dec. 8, 1869, when J. L. Reverdin,[1] an interne of La Charité, in Paris, made his famous report on the subject to the Societie de Chirurgie, in which he claimed that bits of skin, completely severed from their original connections, would adhere and grow upon granulating surfaces. Others had reported similar experiments prior to this, however, to which scant attention had been paid.

The principle was so audaciously new that many medical men of prominence in England and upon the Continent sneered at the discovery and greatly underrated its value, claiming that it was a painful operation which made new wounds and distracted attention from legitimate treatment of the old ones. Even David Page,[2] president of the Royal Medical Society of Edinburgh, with the usual fatuity of a medical prophet, said that skin grafting was "not likely to occupy a permanent position in minor surgery."

Pollock[3] was among the first to adopt Reverdin's discovery in England, being rapidly followed by Bryant and others. Hodgen[4] and Munoz were two of the earliest

[1] Bull de la Soc. de Chir., Dec. 10, 1869.
[2] Brit. Med. Jour., Dec. 10, 1870—Archiv. Gen. de Med., 1872.
[3] Trans. of the Clin. Soc., London, 1871.
[4] St. Louis Med. and Surg. Jour., July, 1871.

writers on the subject in America. In France, Reverdin's claims were soon abundantly established, and skin grafting became very popular.

From sneering indifference, the surgical world then passed to overcredulity, in which exaggerated notions were held regarding the possibilities of the discovery. It was frequently stated that the new skin was identical with normal cuticle, and that one need have no hesitation in making the most extraordinary promises in this regard, even in operations about the face and other exposed portions of the body. We now know, however, that the limitations of the method are great, and that its use should be restricted to certain cases only where the cosmetic results are of minor importance.

It is often asserted that Hamilton, of New York, conceived the idea of skin grafting in 1847, and put it into execution on January 21, 1854, many years before Reverdin published his experiments, and Parmenter[5] even goes so far as to designate the process the "Hamilton-Reverdin Method." But if Hamilton's reference to his own operation is referred to,[6] it is at once evident that what he performed was not a Reverdin operation, or even skin grafting at all, in the proper sense of the term, but merely a neat piece of plastic work in which he partially covered a crural ulcer with a pedunculated flap from the other leg. Hamilton, however, stated the important principle that it is unnecessary to cover a granulating surface completely in order to procure cicatrization, the new skin having a tendency to increase in area and fill in the deficiencies. He designated his procedure *elkoplasty*.

[5] Surgery by American Authors, Roswell Park, 1896.
[6] N. Y. Med. Jour., Sept. 1871, p. 225; N. Y. Med. Gaz., Aug. 20, 1870.

Preparation.

Some attention must be paid to the surface to be grafted, in Reverdin's method, in order to insure reliable results, although this is of less importance than in other procedures. With fresh wounds and "healthy" granulating surfaces little preparation is requisite, but under more unfavorable conditions it is quite necessary.

Bryant [7] recognized that it was possible for epithelium to grow upon an unhealthy granulating surface. In fact, the majority of Reverdin grafts are applied in the presence of more or less pus, and they have been known to thrive even upon the ulcerating surfaces of cancers (Kraske). It is nevertheless true that the healthier the granulations the greater the chance of success. One would hesitate before grafting upon tuberculous ulcers or those directly due to syphilis, and certain other conditions should be regarded in a similar manner. Ulcers in which the granulations are large and pale ("indolent," "exuberant," "succulent,") are unfavorable, as are likewise those presenting patches of necrotic tissue.

The granulations should be of medium size, vascular, and of a fresh red color; not large and "flabby" or small, hard, and "irritable," as is sometimes found in ulcers possessing little tendency toward healing. One of the best indications of fitness for the reception of grafts is the formation of a pellicle of new skin around the borders of an ulcer. It has been claimed by some that grafting should never be attempted unless such a pellicle exists, but this is undoubtedly going too far. Nevertheless, excavated ulcers

[7] Guy's Hosp. Reports, 1872, p. 237.

and those with undermined edges do not usually present surfaces fitted for transplantation. It has been asserted that no pus should be present. Desirable as such an aseptic condition undoubtedly is, in the majority of instances it is unnecessary or practically impossible of realization.

It is generally sufficient, then, that SUPPURATION is not too profuse, and that the pus is "laudable" in character; but if actual or at least relative asepsis is desired, it may be secured by mopping with pure carbolic acid, scraping away the granulations down to the firm tissues beneath, and then dressing with a layer of gauze, over which is smeared sterile boric acid ointment. In twenty-four to forty-eight hours a healthy granulating surface suitable for grafting is obtained.[8] Painting with tincture of iodin is also effective. (See chapter on Thiersch Grafting.)

The CICATRICIAL TISSUE, which often surrounds the margins of old ulcers and lines their bases, encapsulating them, as it were, interferes decidedly with the vascular supply and may render skin grafting difficult if not impossible. Sometimes this tissue is so dense that suitable granulations refuse to form, and the surface of the ulcer remains comparatively smooth and bloodless, as though scooped out of cartilaginous material. Inflammation of the surrounding skin or of the ulcer itself is also prejudicial to success.

If the circulation be impaired by cicatricial tissue or by varicosities, or if marked inflammatory changes be present, complications which are more likely to occur when the ulcer is on one of the lower extremities, the patient should remain in bed until the part regains as far as pos-

[8] J. S. Davis, Internat. Jour. Surg., June, 1910.

sible its normal tone. This may require from a few days to several weeks.

Gauze compresses wrung out of warm salt solution or weak bichlorid of mercury are of use in allaying INFLAMMATORY PROCESSES. Carbolic acid should not be employed, for this purpose, as its prolonged contact with tissues having at the best a deficient vitality may do more harm than good, as has been sufficiently demonstrated in connection with gangrene of injured fingers produced by weak solutions (2 per cent). Moderate pressure, applied evenly with a roller bandage, is generally of value.

When all necrotic tissue has disappeared, and acute inflammation has been allayed, the granulations should be prepared for reception of the grafts, providing the conditions are not already satisfactory. This is best done in most cases by CAUTERIZATION AND COMPRESSION, employing stick nitrate of silver or tincture of iodin for the former and a roller bandage for the latter. Between the cauterizations, which should take place every two or three days, compresses wet with bichlorid, liquor sodæ chlorinata, or 0.5 per cent chloral, may be placed upon the ulcer, or else boric acid, aristol, or acetanilid salve, or perhaps these substances in the powdered state. Iodoform gauze saturated with balsam of Peru sometimes does good service. Where there is a tendency to acute eczema, dry dressings with talcum powder are often preferable. A daily washing of the part in warm soapsuds may be desirable when there is considerable discharge.

When induration and fibrous thickening of the borders of the sore exist, absorption may be induced by compression applied with imbricated strips of adhesive plaster or

by means of a coin bound rather firmly against the part. Sometimes a few RADIATING INCISIONS through the ring of callus down to the softer tissues beneath are of service in relieving tension and favoring vascular supply (Fig. 1). These incisions may at times be continued through the thickened floor of the ulcer itself, and are usually not very painful owing to the obtunded sensibility of the tissues. A number of small parallel incisions are valuable

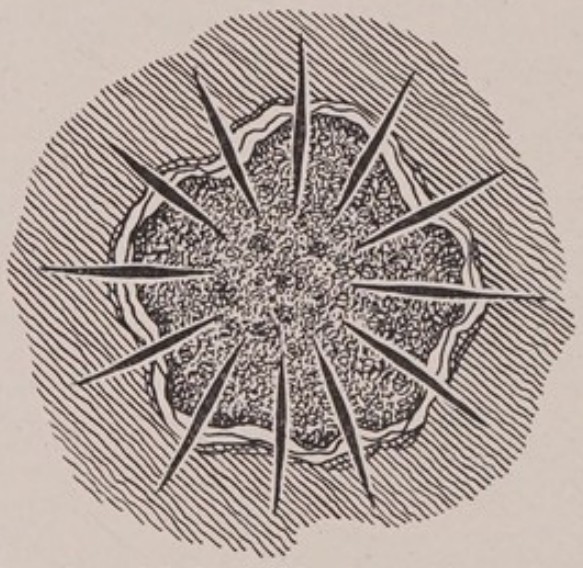

Fig. 1.— Incisions through indurated border and floor of "callous ulcer."

for the purpose of loosening up the indurated floors of certain old ulcers.

For the purpose of cleaning up old ulcers and stimulating their granulations, Richard Harte often employs an aseptic flaxseed poultice, held firmly in place by the elastic pressure of a thin rubber bandage.

Any strong ANTISEPTICS which may have been used for cleansing must be washed away before transplantation is begun, for fear of injuring the vitality of the grafts.

Where to Obtain Grafts.

When possible, the grafts should be obtained from the patient's own body rather than from another, not only be-

cause they are apt to grow better, but because there is less risk of conveying disease. Whether there is any advantage in employing skin from a region corresponding to the one operated upon is doubtful, although this point has been insisted upon by Lewis,[9] Agnew,[10] Hueter,[11] and others. Donnelly, for some unexplained reason, prefers grafts from a portion of the skin subject to slight motion, such as the insertion of the deltoid muscle.

There is an object, however, in grafting from the inside of the arm or thigh, or the side of the chest or bend of the elbow; for in these situations the skin is thin and soft and comparatively free from hairs or glands. But practically skin from any convenient part of the body may be employed with almost equally good chances of success—even the delicate new skin from the borders of ulcers which have begun to heal (see p. 23). The anterior surface of the thigh is often selected.

Lucas [12] considers that "the prepuce of a child possesses a germinal vitality which renders it peculiarly serviceable for grafting," in addition to suppleness, thinness, and vascularity. He claims that preputial grafts will adhere when those from other parts fail, even on unhealthy granulating surfaces. However this may be, the suggestion is of value in cases where sensitive patients, children for instance, strongly object to grafting from their own persons; but great caution must be exercised in order to avoid the carrying of disease. The material can be obtained in abundance in children's hospitals, just where it is most needed.

[9] Phila. Med. Times, March 21, 1874, p. 389.
[10] Med. and Surg. Reporter, Nov. 28, 1874, p. 424.
[11] Allgem. Chir., 1889.
[12] Lancet, Oct. 4, 1884, p. 586.

Pusey [13] claims many advantages for the loose redundant skin of the scrotum; but in the Reverdin method, at least, it is difficult to understand how anything can be gained by procuring grafts from this situation or from the prepuce, although it might be otherwise in the method of Wolfe.

Before cutting the grafts, whatever be the situation selected, the skin should be carefully cleansed, and the instruments sterilized; for, although the wounds are small, they are nevertheless wounds, and should be guarded against infection.

It is probably neither necessary nor desirable to irritate the skin by brushing or beating, with the idea of increasing its supply of blood and serum, as was practiced by the Hindus. Fowler, Hirschberg, Granbury, and others have nevertheless recommended this, while Berger applies a mustard plaster or a poultice for the same purpose.

Size of Grafts.

The grafts should be small, about the size of a grain of wheat, as originally recommended by Reverdin. Not that larger ones will not grow, as was early demonstrated by Ollier and others, but one of the principal claims of the Reverdin method is that pain and scars are reduced to a minimum, which would not be true if the grafts were unnecessarily large. In addition, small grafts generally answer the purpose as well as larger ones, and the latter are apt to produce unsightly lumps. If the portions of skin are originally too large, they may be spread upon the thumb-nail and divided.

[13] Lancet, Oct. 18, 1884, p. 676.

Method of Cutting Grafts.

Grafts are most easily cut by elevating a small fold of skin with a pair of mouse-tooth forceps and dividing it with scissors curved on the flat or with a knife or razor (Figs. 2 and 3). Iridectomy scissors are convenient for the purpose. The entire epithelium and a portion of the corium, perhaps one quarter to one half of a line in thickness, is thus obtained. None of the subcutaneous cellular

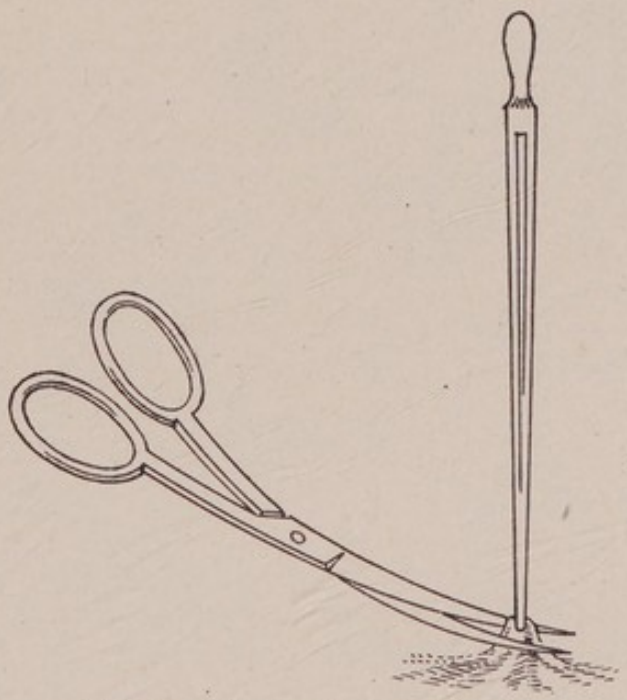

Fig. 2.— Cutting a Reverdin graft.

tissue and fat should be included, as it does not possess sufficient independent vitality. The epidermis alone is all that is really necessary, although better results are perhaps obtained if a portion of the corium be included. Reverdin employed the term *"greffe dermique,"* which Poncet changed to *"greffe dermoepidermique,"* thus more correctly expressing what is really meant.

An insignificant oozing of blood results. The trifling amount of pain can be obviated, if necessary, by partially

freezing the skin with chlorid of ethyl or by anesthetizing the cutaneous surface by the injection of novocain. (See chapter on Local Anesthesia in Skin Grafting.) When partial freezing is resorted to, the necessary number of grafts may all be cut at once and placed until needed in warm physiological salt solution, or raw-side down upon a warm piece of glass, which prevents the edges from curling under.

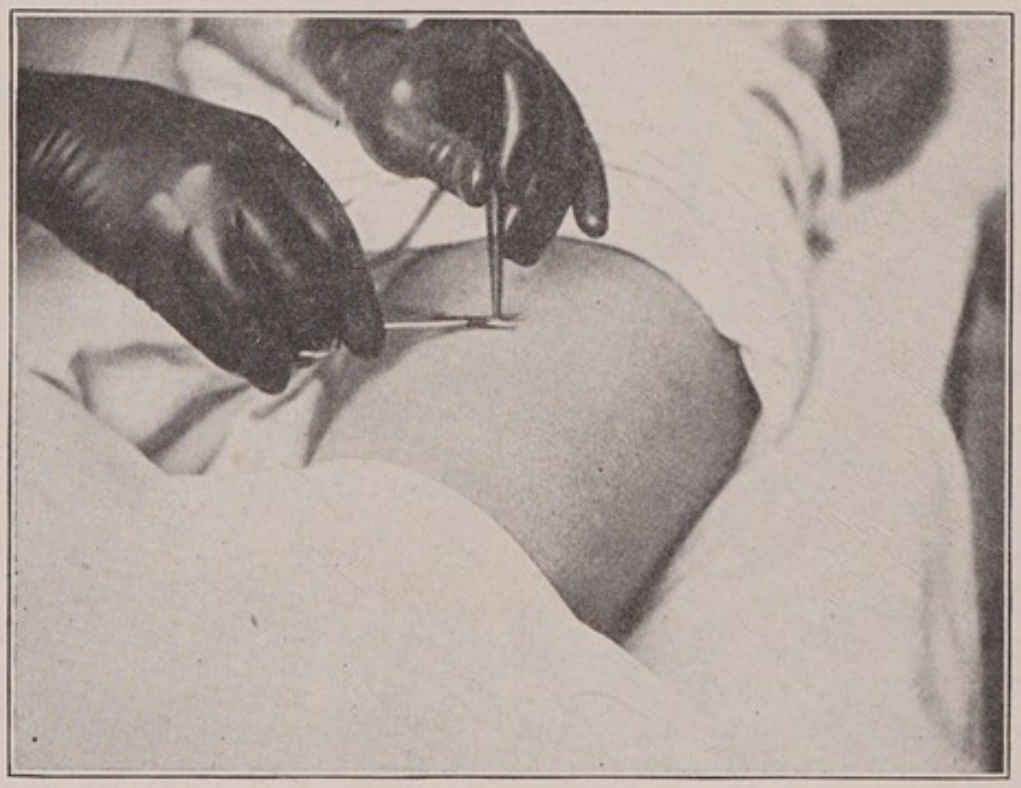

Fig. 3.— Cutting a Reverdin graft.

The little wounds are, from the method of cutting, more or less elliptical, which favors rapid healing, with the formation of a small, almost punctate, white scar. Sutures are unnecessary. An ordinary aseptic or antiseptic dressing should be applied, dry or moist, according to preference. A good one consists of boric acid ointment covered with rubber protective. The neglect of this precaution may permit the development of erysipelas or other infectious troubles.

Satisfactory grafts may often be cut by pressing a pair of curved scissors firmly against the skin and snipping off the portion which protrudes between the blades.[14] Some prefer to elevate a fold of skin by transfixion with a fine needle, but this offers no advantage over forceps. Special skin grafting scissors were introduced by Bryant and by Smith, but they are entirely unnecessary.

Souchon[15] has recently emphasized an old and useful

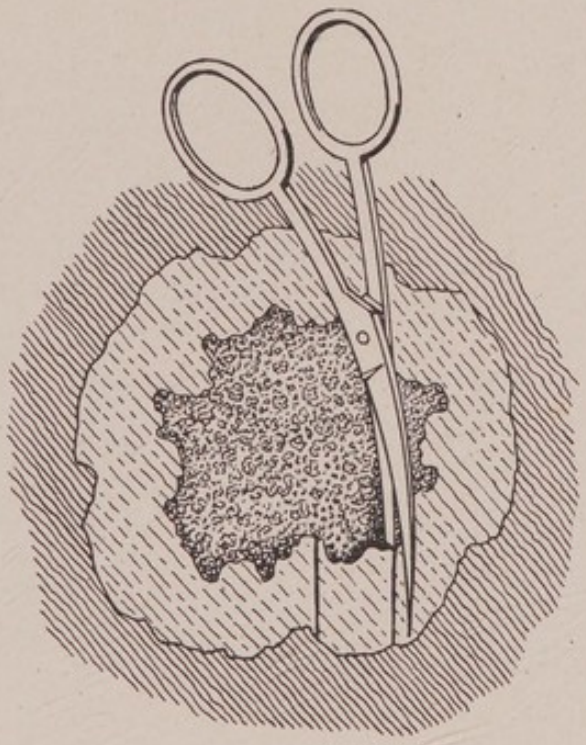

Fig. 4.— Cutting grafts from pellicle of new skin at border of healing ulcer.

method of obtaining small grafts by cutting them with scissors from the thin, new epithelium as it "floats" out from the skin-edges of a healthy granulating surface which is beginning to heal (Fig. 4).

The surface to be grafted is nearly always granulating and covered with more or less pus. The method of Reverdin, however, is also applicable to fresh wounds, although

[14] W. H. Marcy, Med. Rec., Aug. 18, 1894, p. 206.
[15] J. A. M. A., July 17, 1909, p. 207.

other procedures, such as those of Thiersch and Wolfe, give better results.

Placing the Grafts.

There is no object in scraping away the granulations, as is often done in the process of Thiersch. In fact, the only excuse for using the Reverdin method is its comparative painlessness and insignificance as an operation; and this advantage would disappear if so harsh a procedure as curetting were resorted to, and little if anything would be gained.

All that is necessary, then, is to wash away the pus as

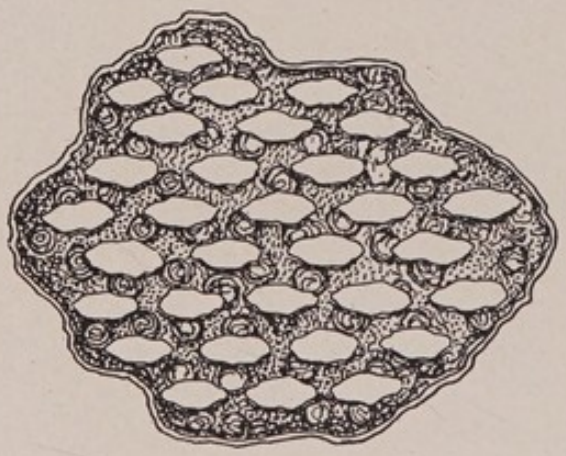

Fig. 5.— Reverdin grafts in place.

thoroughly as possible with salt solution or sterilized water, using cotton sponges if desired, but avoiding hemorrhage. Mild antiseptics which do not coagulate albumin may be employed without injury, providing they are subsequently removed with some neutral solution, but it is questionable if any benefit is derived. A suppurating, granulating surface cannot be sterilized by the brief use of ordinary antiseptics, and it is likely that positive harm is done by lowering the vitality of the superficial cells.

Certainly no benefit can result from irrigating with antiseptics after transplantation, as has been suggested.

As soon as the grafts are cut, they are placed at once, by means of forceps or needle, upon the surface to be grafted, with their raw sides down (Figs. 5 and 6). Edges which have a tendency to curl under are carefully unfurled by pressing upon the bit of skin with a probe and shoving it

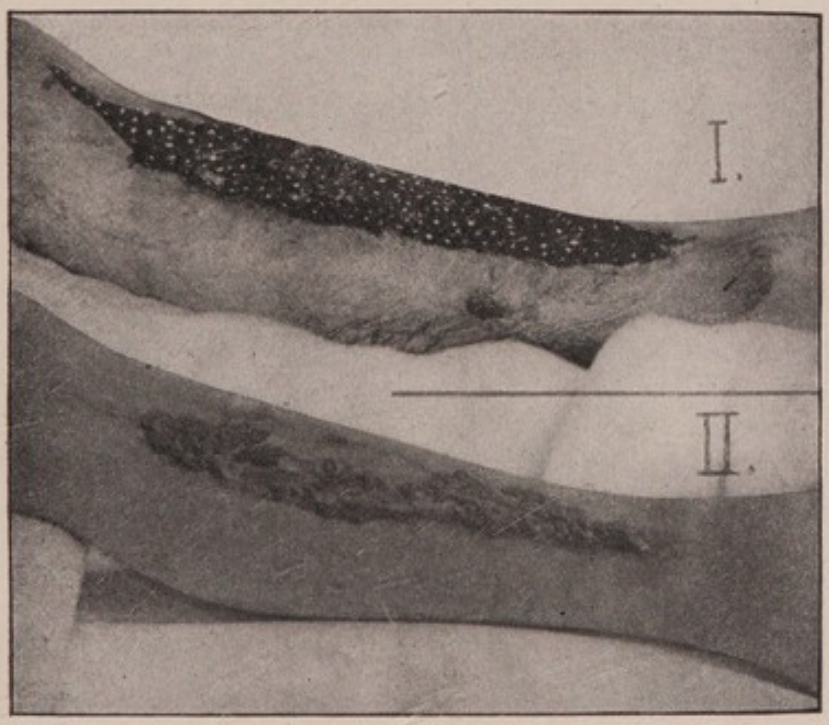

Fig. 6.— (I) Reverdin graft in place at the end of planting; (II) Sixteen days later (Ehrenfreid and Cotton). (From Boston Med. and Surg. Journal, Vol. CLXI, No. 26, 1909.)

carefully from side to side. Adhesion to the granulations immediately takes place, especially if no blood or other fluid be present, slight pressure with a *moist* pledget of gauze assisting the process. Roberts and others claim that exposure of the ulcer to the atmosphere for a time before and after operating causes the surface to become sticky and facilitates adherence, but this can seldom be required. It is unnecessary to fasten the grafts in place with fine sutures (Hueter), or to bury them beneath a trap-door in the gran-

ulations, as was advocated by North,[16] Dunn,[17] and others.

Each graft is capable of enlarging to but a limited extent, perhaps the size of a silver dime, and it cannot stimulate the borders of the ulcer effectually at a greater distance than half an inch. If a single graft is placed in the center of a sufficiently large ulcer, it will produce an island of skin only, and in addition it does not seem to grow so well.

Hence the transplanted pieces should not be farther apart than half an inch, and better closer than this. They should also not be at a greater distance from the edges of the ulcer.

If the grafts are sufficiently close together, there is no object in placing them in regular rows or geometrical figures. Should the number be limited, it is wiser to thoroughly cover a comparatively small area than to scatter the material over too extensive a surface. The use of scarlet-red ointment may hasten epithelial formation over the remainder of the ulcer,[18] but it should not come in contact with the grafts.

Legal Questions.

Legal complications have arisen from skin grafting in one or two instances at least. One of these occurred in Atlanta. A boy, thirteen years old, brought his little cousin to a physician's office, with an affection requiring the transplantation of skin. The boy willingly consented to have the grafts removed from his own arm, which was accordingly done. The father immediately brought suit

[16] Med. Rec., Jan. 9, 1886, p. 36.
[17] St. Louis Med. and Surg. Journal, July, 1895.
[18] Von Schmieden, Zentralbl. f. Chir., 1908, p. 153.

upon the grounds that the action was unjustifiable and brutal, and that he had not been consulted. The case was promptly decided for the defendant, as was also another in Cincinnati, in which a man who was paid to furnish grafts claimed that too much skin had been taken and sued the surgeon for damages.

Dressings.

Some sort of dressing should be employed for the sake of protection from dirt and accident, not, however, because a dressing is essential to the vitality of the grafts, which will thrive just as well when enclosed in some box-like

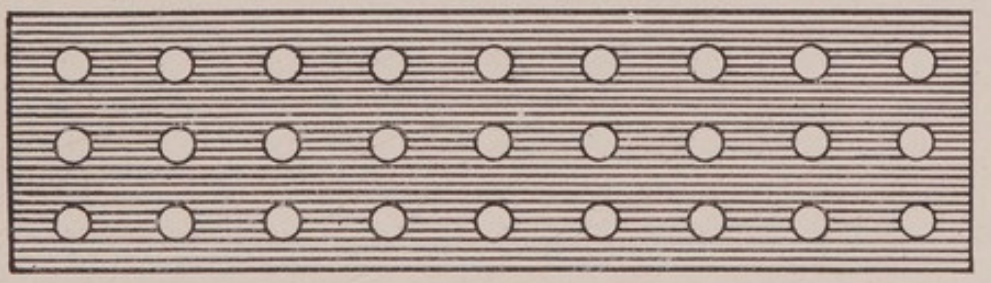

Fig. 7.— Strip of rubber tissue with punched-out drainage holes.

covering, or when not covered at all [19] (see chapter on Thiersch Grafting).

It is usually recommended to place rubber protective next the grafts to prevent their adherence and displacement when the dressings are changed. This should be cut into strips, perhaps half an inch in width, which are placed side by side, or criss-crossed, like basket-work, or punched full of holes, in order to furnish exit for the secretions (Fig. 7). Strips of transparent sheet gutta-percha may be used, and their ends allowed to project on the sound skin, where they will adhere if moistened with a

[19] Yemans—Leonard's Med. Jour., 1888.

little chloroform. If more convenient, there is no objection to the employment of goldbeater's skin, oiled silk, isinglass plaster, tin or silver foil, etc. Marcy [20] prefers to use ordinary adhesive plaster, which may often succeed on the principle that epithelium will grow in spite of almost anything.

All of these methods possess the disadvantage of causing more or less maceration which may jeopardize the vitality of the new skin. A preferable and much simpler device consists in spreading a single layer of gauze over the grafted surface and pinning it around the limb, or

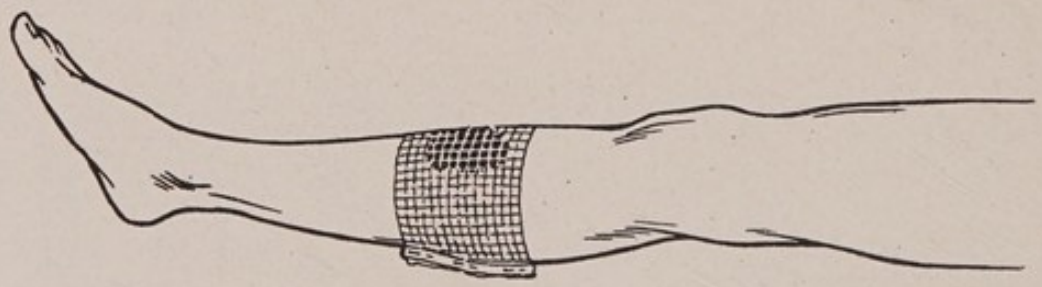

Fig. 8.— Strip of gauze pinned about leg for holding grafts in place.

fastening it to the skin in a number of places with collodion (Fig. 8). This was suggested by McCarthy,[21] and later independently by the writer.[22] Bidwell [23] uses gauze of spun glass, which would seem to be an ideal material for the purpose. The meshes of the specially prepared netting employed by Davis are so wide that it is more suitable for "splinting" large Thiersch grafts than for holding in place the small pieces of epithelium under consideration (see p. 51). While the superjacent dressings are changed, the gauze remains permanently in place until healing is complete. Absorption of the discharge is thus permitted, and

[20] Med. Rec., Aug. 18, 1894.
[21] Med. Press and Circ., Apr. 13, 1881, p. 311.
[22] Cincinnati Lancet-Clinic, 1885.
[23] Lancet, July 21, 1894, p. 130.

the condition of the grafts is easily ascertained at any time without disturbing them.

Bryant insisted upon the use of a separate piece of lint over each graft, but this is perhaps more troublesome than advantageous.

Wet and Dry Dressings.

Whether the main dressing is dry or moist is usually of little importance, but no powerful antiseptic should be employed. It is customary to dust various non-irritating powders over the grafted surface, such as iodoform, boric acid, acetanilid, aristol, etc., but their value is questionable, simple sterile gauze often being equally serviceable. If a powder is used, care must be taken that it does not form a crust, beneath which pus may accumulate and destroy the grafts.

If the operator prefer, an ointment containing any of the powders mentioned above will give good results if the discharge is not excessive. Scarlet-red ointment (see p. 56) may be useful in hastening the epithelialization of uncovered portions of a granulating surface, but it should not come into contact with the grafts themselves, at least until they have become firmly adherent, for fear of causing their destruction.

Bovinine has often been employed—so-called "grafting in blood"—with the idea that additional nutrition is thus furnished to the grafts during the process of adhesion, but the utility of the method is somewhat questionable. The material may be spread upon the grafted surface like butter upon bread.

A pad of gauze covered with cotton completes the dress-

ing, which is held in place under moderate pressure with a bandage.

In case a wet dressing is chosen, the powder or salve is omitted, a pad of gauze wrung out of warm normal salt solution or boric acid being used instead. An outside covering of oiled silk will prevent too rapid evaporation and render moistening of the dressings unnecessary oftener than perhaps once in twenty-four hours.

Changing Dressings.

If the field of operation were always aseptic, it would be unnecessary to change the dressings at all during the process of healing; but unfortunately this can seldom be the case, as a certain amount of suppuration is nearly always present. It is, therefore, desirable to remove all but the lowermost layer of gauze, or protective, as the case may be, every twenty-four to forty-eight hours, prolonged soaking in warm salt solution being necessary when the dressings have a tendency to stick. Gentle irrigation is then in place, although the surface must not be rubbed for fear of displacing the transplanted cuticle.

When there is considerable discharge, and protective has been used, it should frequently be changed as well as the remainder of the dressing; but when the discharge is not great, it can often be left in place for from five to ten days.

It is difficult to avoid a certain amount of musty or even more offensive odor, and at times the dressings become green in color from the presence of *Bacillus pyocyaneus;* but success is not often seriously jeopardized by these occurrences.

Instead of employing dressings of various kinds, the

"open method" may be used, as is often done in Thiersch grafting, the grafts being directly and freely exposed to the air beneath a protecting wire-gauze cage (see p. 49). The presence of much discharge, however, is apt to render the procedure unsatisfactory, owing to the formation of thick crusts.

When grafting is done near a joint, particularly in children, some form of splint should be applied to prevent motion of the part. The lower extremity, especially where varicose veins exist, should be elevated in order to favor circulation.

Process of Healing.

In the course of twenty-four hours the grafts seem to swell, appearing whiter, thicker, and softer; and in two or three days those which have "taken" become pinkish in color with a reddish areola. Then a thin, pearl-gray epithelial pellicle begins to grow out from their borders and from the adjacent edges of the ulcer, like ice from the shores of a pond. The bits of skin which turn brown are probably dead, while those which are yellowish white will lose their superficial layers of epidermis at least. This exfoliation of epidermis is common and usually occurs in three to five days. It does not mean that the grafting has failed, as the deeper layers remain, and that which has been lost is soon reproduced.

The new epithelial pellicle is not attached to the granulations at first, but rests like fine tissue-paper upon their flattened surfaces, from which it may easily be lifted, and perhaps utilized for further grafting (see p. 23). Soon long fine processes or "roots" grow down into the granula-

tions, anchoring the epithelium, and "bridges" are often thrown out, connecting the grafts with each other or with the borders of the ulcer.

After-treatment.

When cicatrization is complete, the part must be preserved from injury for several weeks, until a certain amount of resisting power has been attained; for ulcers cured by the Reverdin method, especially those of the lower extremities, are prone to break down on slight provocation. If there is a tendency to dryness and exfoliation, an ointment should be used containing some unirritating substance, such as boric acid.

The new skin is not by any means equal to ordinary skin, although it is much better than mere cicatricial tissue. It contains no hair bulbs, sweat glands, or sebaceous follicles. The grafts regain a certain amount of sensation in the course of time, although it is often imperfect and long in making its appearance, slowly progressing inward from the periphery.

CHAPTER IV

THE METHOD OF THIERSCH—ITS USE IN SPECIAL CASES

There is no process of skin grafting so simple, so reliable, and so generally applicable as the method of Thiersch,[1] and yet it has never received the thorough recognition to which it is entitled. Granulating surfaces or fresh wounds of almost any extent may be covered with epithelium in from ten days to three weeks; embarrassing cicatricial contractions are avoided; and the prevention of suppuration and other septic processes may be instrumental in saving life or limb, to say nothing of shortening the period of convalescence. In many cases the cosmetic value can scarcely be overestimated.[2]

General Technic.

If a suppurating area is to be grafted, the adjacent skin should be scrubbed, all crusts and hairs removed, and the surface on which the grafts are to lie irrigated with normal salt solution. The patient is anesthetized, and the granulations are then scraped away with a spoon down to the comparatively firm tissue beneath, which is sometimes suprisingly deep. Oozing is checked by pressure and by

[1] XV. Kong. deut. Gesell. f. Chir., Berlin, 1886.

[2] As regards priority, Ollier (Bull. de l'acad. de Med., 1872) was in the habit of cutting grafts 10 to 15 mm. wide and 2 to 4 cm. long, resembling in every way Thiersch grafts; but unlike Thiersch, he did not scrape away the granulations before making the transplantation. Fischer (Zeit. f. Chir. Bd. 13, 1880, p. 193) also shaved from the surface of a limb, thin strips of skin identical with those used by Thiersch.

elevation, where practicable. After removing the blood and débris with warm salt solution, the surface is ready for the grafts.

These are best obtained from the anterior surface of the thigh and are conveniently cut with a sharp razor. An assistant makes the surface as tense as possible by means of a hand on either side of the limb, or by grasping the thigh from below, while the operator, standing with his

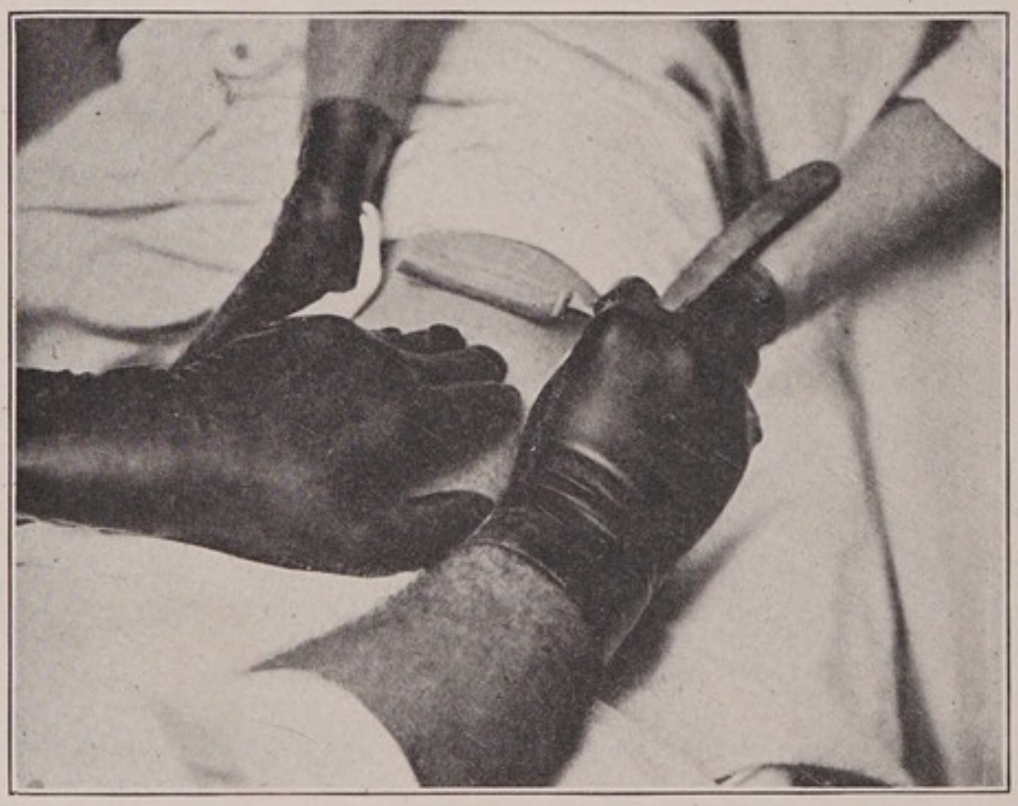

Fig. 9.— Cutting Thiersch grafts from thigh.

back to the patient's feet, cuts toward himself, with his left hand stretching the skin in front of the razor in the direction of the knee (Fig. 9). Pieces of gauze beneath the hands will prevent them from slipping. With a side-to-side sawing motion it is not hard to remove thin shavings of epidermis, from half an inch to an inch or more in width and several inches in length, the manipulation being easier with firm skins than with flabby ones, and

rather difficult with the thin cuticle of young children and old people. Both skin and razor should be kept wet with salt solution.

It is neither necessary nor desirable to remove the entire thickness of the skin, but simply a paper-like layer, leaving a number of bleeding points from division of capillary vessels in the ends of the papillæ. Although the procedure

Fig. 10.— Thiersch graft partially cut — note position of assistant's hands on each side of thigh, with gauze pads to prevent slipping.

is simple enough, it should be practiced upon the cadaver before being tried upon the living.

The delicate strips of skin fold up on the razor as they are cut (Fig. 10), and as soon as a sufficient length has been obtained, a slight inclination of the instrument away from the thigh will readily sever the graft from its connections.

The grafts are then spread smoothly upon the area to be covered, so that they overlap each other shingle-wise, and

also overlap the edges of the wound, completely concealing the raw surface (Figs. 11 and 12). When the sections are

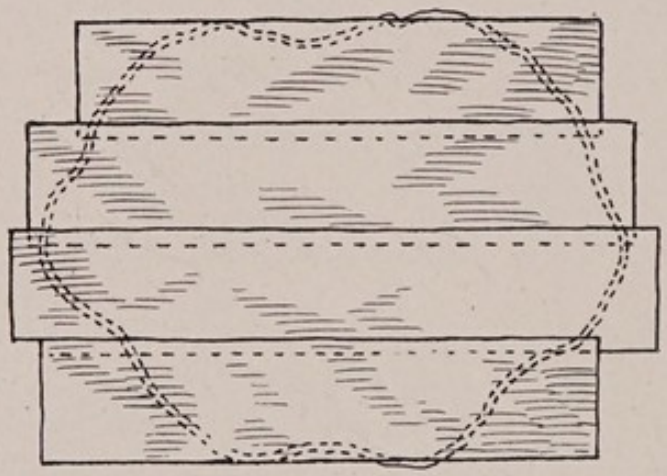

Fig. 11.— Showing how Thiersch grafts should overlap each other and the borders of the ulcer.

large, they may advantageously be "buttonholed" with a pair of scissors or extensively perforated with a punch

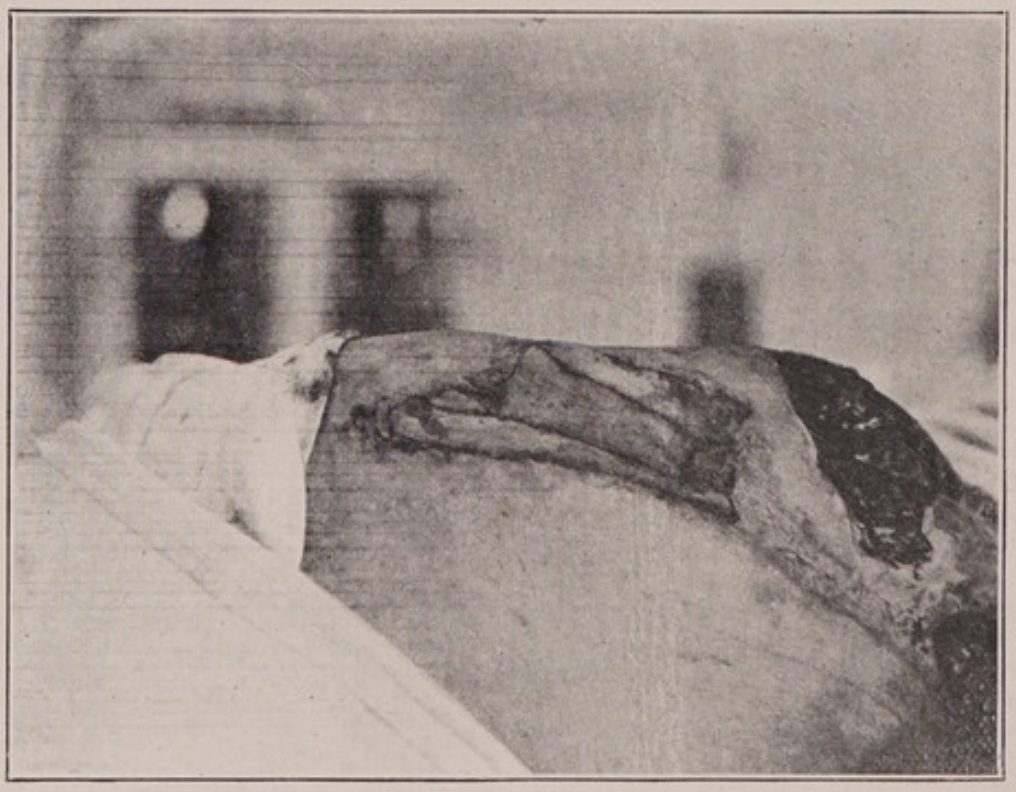

Fig. 12.— Thiersch grafts in place — granulating wound of buttock.

in order to facilitate drainage (Davis). If too much skin has been obtained, the redundant portions may be replaced

upon the raw surface from which they were removed, where they will readily adhere.

Hemorrhage.

In order to control hemorrhage which may follow the curetting, Thiersch at first employed an Esmarch strap, leaving it in place until the grafts and dressings had been applied, but he afterward discarded the procedure as being unnecessary and possibly harmful. Others, however, have taken up the idea, thinking, perhaps, that it was new, and have used it extensively. In general, there is little objection to the employment of the strap, and it is at times of advantage, although following its removal undesirable oozing may take place beneath the transplanted skin.

There seems to be no reason for agreeing with Fischer, who says that skin will grow better when removed from a bloodless part and applied to one equally bloodless, a view curiously at variance with the ideas of those who advocate irritation and congestion of the skin before grafting.

Pressure with moist pledgets of gauze, perhaps saturated with peroxid of hydrogen or a solution of adrenalin, nearly always controls bleeding in a few moments, especially if the part be elevated and the pressure applied over a piece of rubber protective, in order to prevent tearing the clots from the mouths of the small vessels when the compressing material is removed. An effective method is to apply a thin rubber bandage around the limb or body and directly over the raw and oozing surface. Rushmore [3] advocated the use of a high-frequency electric current for the purpose of coagulating the blood and causing the grafts to adhere.

[3] Ann. Surg., 1904, Vol. 40, p. 404.

but this is of doubtful advantage and has never been extensively adopted. It is much better to twist a vessel than to tie it, as ligatures are prejudicial to success. The surface should be rendered as "dry" as possible, in order to favor adhesion and growth of the new cuticle.

Curetting.

With Thiersch, the removal of granulations was one of the principal features of his original method. He claimed that the more or less large and soft, superficial granulations, during their slow transformation into connective tissue, were the cause of cicatricial contraction, and that this contraction could be avoided by scraping away the granulations until firmer tissue was reached. He also thought that grafts grew better when this was done. This advice was universally followed until it was demonstrated by Schnitzler and Ewald [4] that it is unnecessary to remove healthy granulations and that grafting can be done directly upon their unaltered surfaces with the production of a movable skin, and without appreciable subsequent contraction. It should be mentioned, however, that numerous operators have been unable to obtain reliable results without curetting, and it will certainly always be in place where it is desirable to remove unhealthy granulations or diseased tissues. In any case, the results are probably more universally satisfactory, when the granulations are removed.

It has been claimed that where scraping is not resorted to an anesthetic, either local or general, is unnecessary, because of the comparatively slight burning pain produced by the cutting of the grafts, which is said to be made still less by

[4] Cent. f. Chir., No. 7, 1894, p. 148.

the use of the Esmarch strap. These statements, however, by no means always hold good, the pain being often quite severe.

Instead of scraping with a curette, Sick [5] simply rubs away the granulations with a bunch of gauze, or a stiff nail-brush may be used. Halsted, McBurney, and others prefer to shave the surface with a scalpel or an amputating knife, claiming that a smoother surface is obtained devoid of partially separated and bruised portions of tissue, which tend to become necrotic and interfere with the vitality of the transplanted skin.

Warm salt solution, upon which Thiersch has laid so much stress, is to be recommended for irrigation, but it is not necessary, as ordinary sterilized water answers almost the same purpose, both during the operation and subsequently. A four per cent solution of boric acid can also be used if desired. Thiersch and many others speak decidedly against the employment of antiseptics after the curetting has been done, claiming that the superficial necrosis thus produced interferes materially with the adherence of grafts; but there is no doubt that strong antiseptics may be freely employed both before and after curetting,[6] providing they are subsequently washed away with some neutral solution. Their utility, however, is questionable, as asepsis cannot thus be obtained.

Preparation of Granulations.

Granulating surfaces should be prepared with even greater care in Thiersch grafting than in the method of Reverdin. (See chapter on The Method of Reverdin.)

[5] Arch. f. Klin. Chir., Bd. 43, p. 387.
[6] C. Hübscher, Beitr. z. Klin. Chir. Bd. 4, 1888, p. 395.

When considered advisable, the procedure of Wilcox may be used:[7] The evening before the operation, the part is thoroughly cleansed with green soap and hydrogen peroxid and put up in a compress wet with 1 per cent formaldehyde (the ordinary 40 per cent solution being taken as the unit), which is left on over night. The granulations, rendered dark, red, and dry, are then scraped away down to the firm vascular tissues beneath, an Esmarch bandage being wound directly over the raw surface, when possible, in order to control oozing by means of pressure, the rubber having no tendency to stick when removed.

Davis[8] recommends cleansing and drying the ulcerated surface on the previous day, painting it with tincture of iodin, and then dressing it with balsam of Peru (2 to 6), which is allowed to remain until the operation, when it is washed away with normal salt solution.

These methods are said to have the advantage of rendering the part aseptic, and they probably do so, in the majority of instances at least; but they are seldom necessary.

Methods of Cutting Grafts.

The grafts may be removed from any convenient portion of the body, the anterior surface of the thigh being usually chosen, although Franke prefers the outer side, as it can be made tense by adducting the limb. Davis claims that grafts should always be obtained from the right thigh when possible, because phlebitis is more apt to follow when the left limb is employed, but this somewhat theoretical assumption is generally disregarded in practice.

McBurney stretched the skin between two "hooks" sup-

[7] Ann. Surg., May, 1904.
[8] Ann. Surg., Dec. 1910, p. 721.

plied with teeth, which catch the skin transversely to the long axis of the limb. (Fig. 13.) Mixter [9] employed an instrument consisting of an oblong fenestrated steel plate with several short, sharp pins projecting from its slightly concave surface to prevent slipping. When this is pressed firmly against the thigh, the skin projects through the fenestrum and may be flattened with a roller and shaved off with a specially constructed knife.

Fig. 13.— McBurney's hooks for stretching skin.

Some operators prefer razors which are flat on one side, and others use an amputating knife, a small scalpel, or the blade of a microtome; but there is really nothing more convenient than an ordinary sharp razor. The complicated apparatus of Mixter is not necessary, although it produces strips of skin with smooth edges; but this can be accomplished, if desirable, by outlining the graft with a scalpel before shaving it off. A safety razor can sometimes be employed to advantage.[10] Whatever instrument is used, its

[9] Boston Med. & Surg. Jour., Dec. 31, 1891. p. 700.
[10] Doolittle, J. A. M. A., Mar. 26, 1898, p. 716.

blade should be kept moist with salt solution, or with a mixture of glycerin 25 parts, alcohol 25 parts, and water 50 parts.[11]

Halsted, of Johns Hopkins,[12] employs very large grafts, especially following operations for cancer of the breast.

Fig. 14.— Halsted method of cutting large Thiersch grafts. (From Johns Hopkins Hospital Reports, Vol. XV, p. 316.)

In cutting them, he places a sand-bag beneath the thigh, so as to give a broader surface, and stretches the skin between two small boards, like shingles, held crosswise to the limb, with their edges pressed firmly against the sur-

[11] E. Barker, Practitioner, Oct., 1888.
[12] Ann. Surg., 1909, Vol. 50, p. 542.

face. One of these boards is pulled upward by an assistant, while the other is pulled downward by one hand of the operator (Fig. 14). An amputating knife is used to sever the grafts, which are spread raw side upward on rubber protective or silver-foil, upon the surface of a board, before transferring them, together with the protective, to the wound. The procedure requires some technical skill.

There is no danger of the subsequent development of hairs in the transplanted cuticle, as has been affirmed by Thompson, because in Thiersch grafting the bulbs are left behind. It is desirable, however, to shave the part to prevent the severed hairs from getting beneath the grafts and interfering with their union. The skin should be surgically clean, as in any other operation.

Placing the Grafts, Etc.

The strips of epidermis are so thin that they fold up on the razor and may be carried directly to the surface to be grafted without first floating them out in water and transferring them upon a spatula or piece of glass, as is often done. The edge of the razor with its folded graft is placed near the border of the ulcer, and the end of the graft slid from the blade and held by a probe against the skin (Figs. 15 and 16). The razor is then slowly moved across the ulcer, spreading out the strip much as a nurse spreads a sheet beneath a patient. The edges, which are often more or less turned under, must be carefully unfurled by sliding the grafts back and forth with a probe. The new skin should be gently pressed in place with a pledget of *moist* gauze in order to promote adhesion and disperse air-bubbles and blood.

Jungengel has shown that if a layer of clot be present beneath the grafts which is a little too thick the outer layers of epithelium are apt to exfoliate, and if very much coagulated blood exists, the entire graft may perish. It has been said that a certain amount of clot is of value in that it promotes nutrition and prevents suppuration, but this statement has not been confirmed.

Some surgeons prefer to cut at once all the grafts they

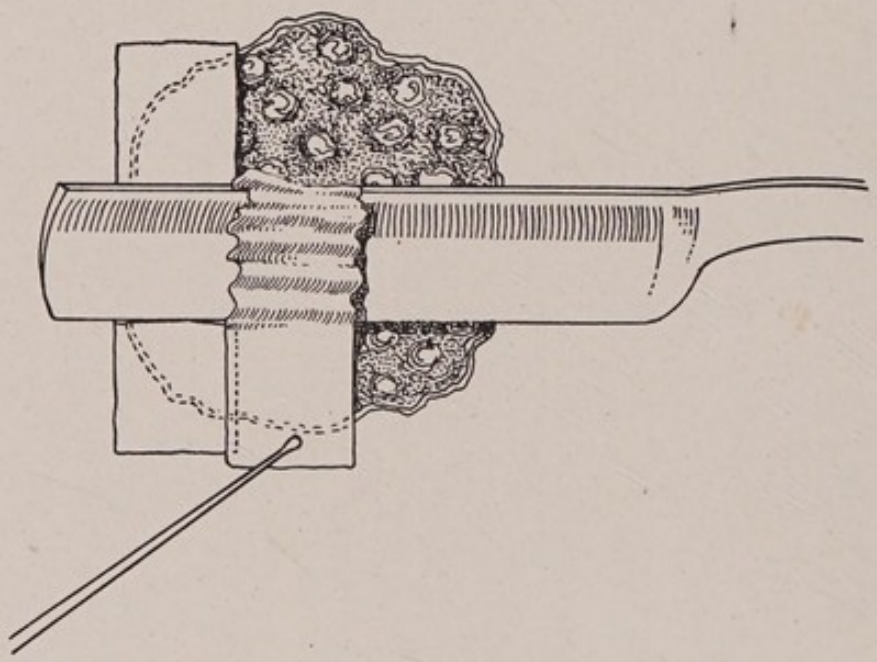

Fig. 15.— Sliding Thiersch graft from razor on to surface of ulcer.

expect to use, placing them in warm salt solution. An assistant then spreads them raw side up on strips of sterile protective or on moist toilet-paper, by means of which they are transferred to the field of operation, the protective remaining in place as the first layer of the dressing. This has its advantages where, owing to the locality to be grafted, the simpler method already mentioned cannot be employed. McNaught rolls the strips of skin upon a probe, by means of which they may easily be transported and accurately adjusted; or they can be spread upon a

sponge and applied as a goldbeater applies gold leaf (Bruce Clarke).

If the grafts are large, they should be perforated at frequent intervals in order to provide means of exit for fluids, which might otherwise accumulate beneath them and cause their disintegration by separating them from the underlying surface. This can be accomplished after the

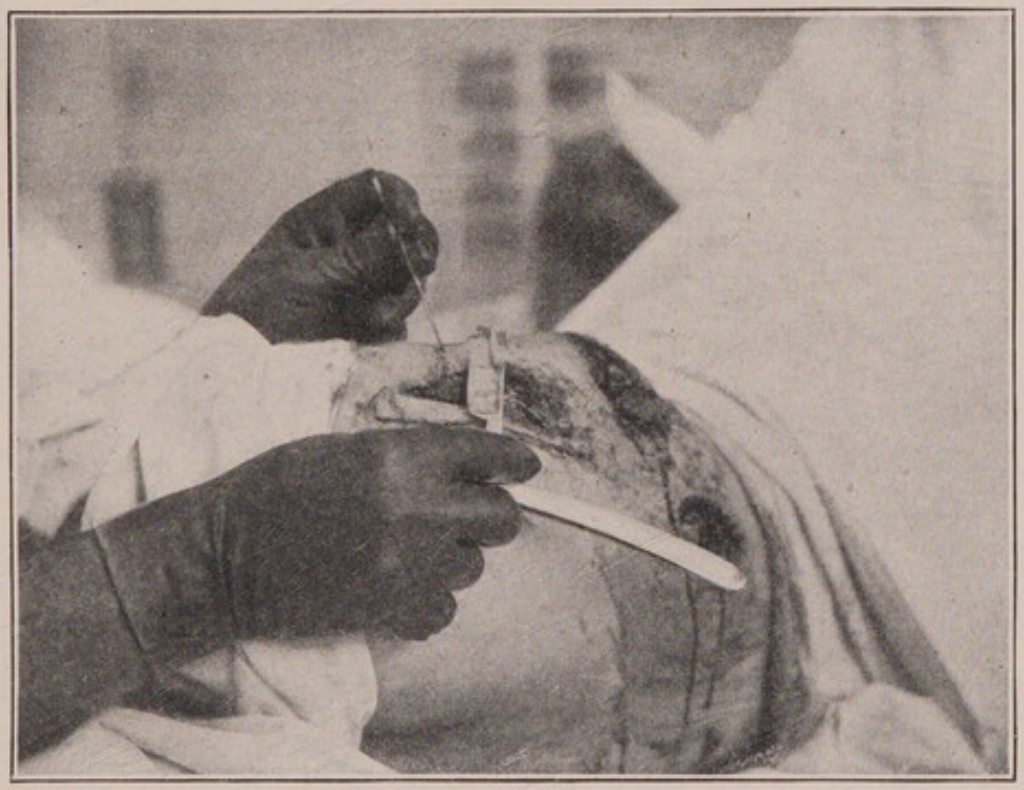

Fig. 16.— Placing Thiersch grafts from razor — granulating wound of buttock.

grafts are in place by snipping out small pieces with a pair of curved scissors, or the grafts may first be spread on strips of rubber protective and perforated with a punch or with scissors.[13] This seems like an excellent method, but Vogel claims that when it is used it is desirable to employ a moist dressing for several days to prevent closure of the openings by dried secretions.

[13] Davis, Internat. J. Surg., May, 1910.

Grafting in Two Stages.

Wentscher [14] and Porter advocate the performance of Thiersch grafting in two stages, at least in certain cases, especially where bleeding cannot be promptly checked. At the first sitting, they scrape the ulcer and cut the necessary grafts, putting them in salt solution at room-temperature, where they may be kept without injury for many hours. At a second sitting, the new skin is placed in position, no anesthetic being required. In this connection, it is interesting to note that Lynngren has successfully grafted pieces of epithelium kept for three months in sterile ascitic fluid, and that dried epidermis has "taken" after as long as 418 days.

Thin vs. Thick Grafts.

There is some difference of opinion as to whether it is desirable to use thin grafts or thick ones, some going so far as to recommend the employment of the entire thickness of the skin (Fowler, Moullin, Cheyne, etc.). When this is done, however, it is better to dissect out the grafts and suture the resulting wound according to the method of Wolfe. Fowler [15] contends that more than the papillæ should be removed with the razor, but that no fat should be included, the idea being to obtain the stroma containing the horizontal network of vessels. Kellock [16] suggests a sort of combination of Wolfe grafts with Thiersch grafts, cutting them so that the whole thickness of the skin remains in the center surrounded by a thinner

[14] Berl. Klin. Woch., No. 43, 1894.
[15] Ann. Surg., 1889, p. 179.
[16] Lancet, Nov. 25, 1899.

area, the latter being shaved off first. The technic, however, is complicated and has not been generally adopted, although Porter strongly recommends it in grafting areas from which x-ray burns have been excised from the hands (see Grafting in X-ray Burns).

It is perhaps well to avoid grafts of exceeding thinness; but nevertheless, when moderately thin ones are placed by the side of those which are quite thick, the former seem to be as satisfactory for most purposes as the latter. In general, a good graft may be said to be but little thicker than the paper upon which this is printed.

Little or no scar results from the removal of these thin slices of epithelium, at most a thin, white, almost imperceptible cicatrix, although the seat of the operation remains brownish in color for weeks. Different sets of grafts may be removed from the same area, providing sufficient time elapses between the operations to allow a new growth of epithelium to occur.

Anesthetics.

It has been claimed that a general anesthetic, especially ether, was detrimental to the vitality of grafts, and patients have been needlessly tortured on this account. Experience has demonstrated that a general anesthetic has no appreciable effect upon the transplanted skin, and the operation is often sufficiently painful to justify its employment, in spite of the statements of Fowler, Plessing, and others to the contrary. (See chapter on Local Anesthesia in Skin Grafting.)

Dressings.

It has been abundantly demonstrated that it is unnecessary to keep the grafts moist as emphasized by Thiersch; in fact, they seem to do better in many cases when the dressing is a dry one—simply a sprinkling of iodoform or boric acid and a covering of gauze and cotton, as in the treatment of ordinary wounds, and there is really no great need for a powder at all. There are those, however, who speak against a dry dressing, claiming that the desiccated secretions interfere with the escape of fluids between the grafts, which accordingly accumulate and elevate the new skin at various points, thus leading to its destruction. Moderate pressure is beneficial, but too tight bandaging may cause sloughing.

If a moist dressing is preferred, it is unnecessary to change it, if a heavy one and protected by oiled silk, oftener than every day or two, as has been shown by McBurney, Halsted, and others; although Thiersch contended that a fresh dressing must be applied every two hours, or the old one moistened at least.

A sterilized non-irritating ointment of some kind (boric acid, iodoform, etc.) makes a satisfactory dressing and is used by some, while others prefer bovinine, from the somewhat questionable idea that it furnishes nutriment to the grafts prior to their firm adhesion. Instead of salt solution, the layers of gauze may be moistened with sterilized olive oil, which will not require such frequent renewal, or with a 4 per cent solution of boric acid. Dunham [17] thinks it advisable to remove a moist dressing at

[17] Ref. Handb. Med. Sci., Supplement.

the end of six days and allow the grafts to become dry, claiming that they are thus rendered tougher.

Strips of rubber protective, silver foil, tin foil, gold-beater's skin, etc., are ordinarily used next the grafts, or simply a layer of gauze, as described on page 28. Other

Fig. 17.— Wire cage in place in open method of grafting — side view. (From International Journal Surgery, May, 1910.)

successful methods of dressing have been suggested, in one of which everything is lifted clear of the new skin by means of small strips of board elevated on cushions of cotton; or "cages" made of wire gauze may be employed, their rough edges being bound with adhesive plaster—the "strainers" used in kitchens are convenient (Figs. 17, 18, and 19).

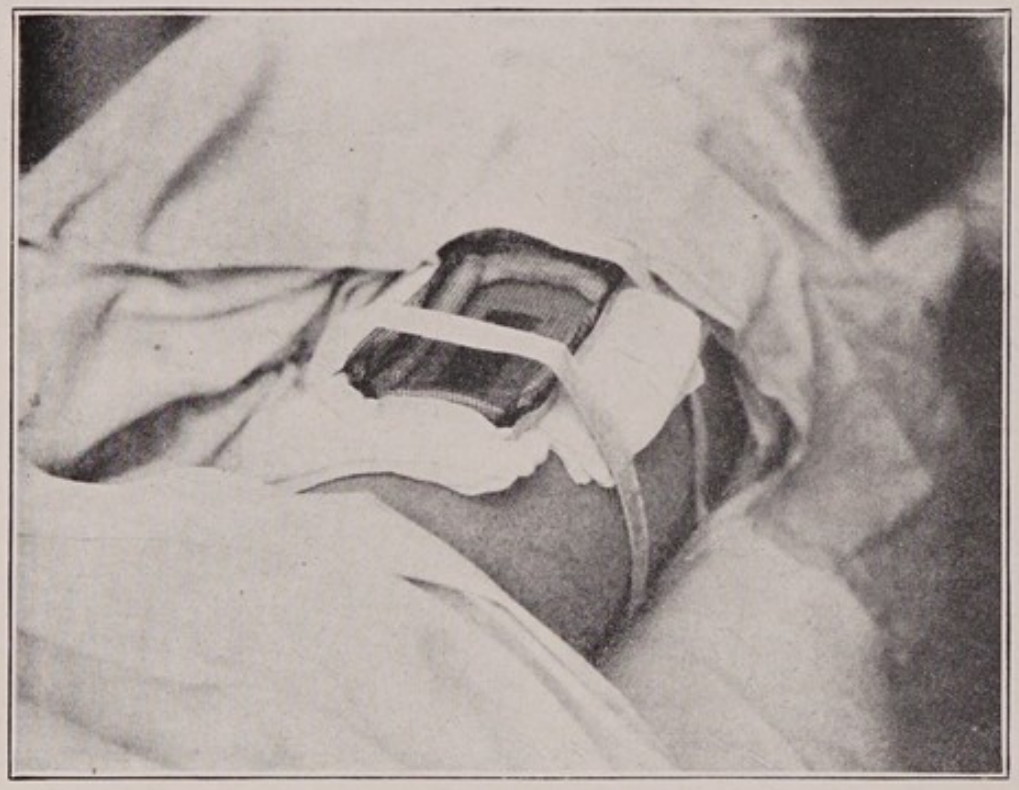

Fig. 18.— Wire cage in place in '' open method '' of grafting — front view.

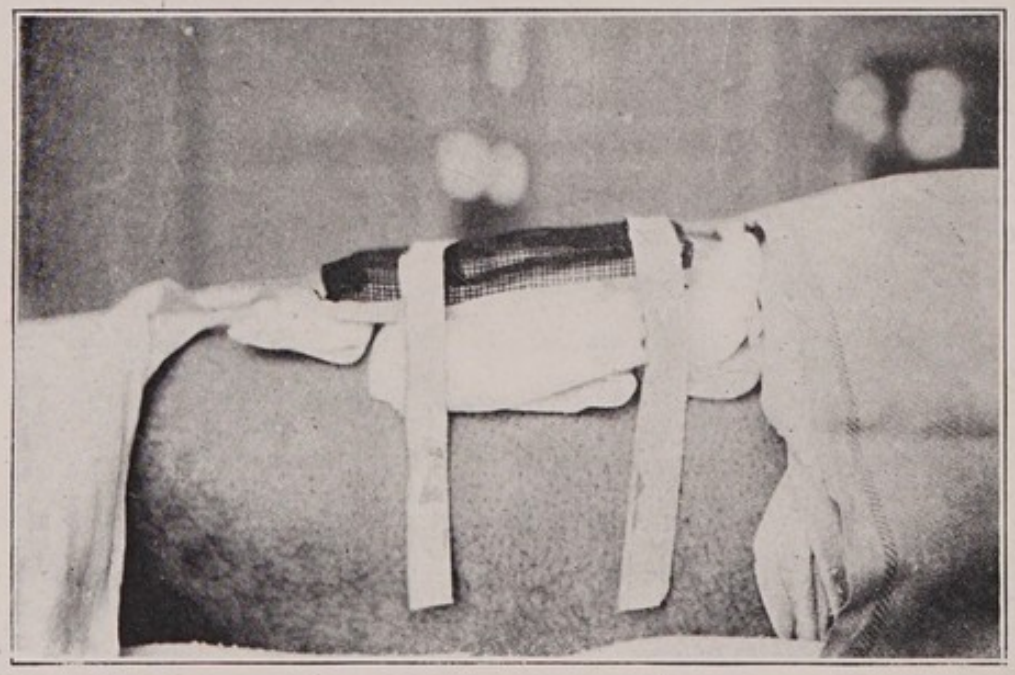

Fig. 19.— Wire cage for open method of grafting — edge bound with adhesive plaster.

Much has been claimed for this "open method," and it certainly gives excellent results, sometimes succeeding where other procedures fail. Goldmann [18] emphasizes the point that the *primary* fixation of the grafts, which takes place by filbroblasts and capillaries in from 12 to 24 hours, is the most important thing, This, he says, is best accomplished by the open method, and after it has once occurred, the further character of the dressing, whether dry or moist or by means of ointments, is of little significance.

A "dry cage" can be converted into a "moist chamber" by covering it with wet gauze, or salt solution can be dropped directly upon the grafts from an irrigator; but there would seem to be nothing gained by this.

"Splinting" Grafts.

Davis [18a] holds down or "splints" the grafts with curtain netting, having a mesh of about $\frac{2}{5}$ of an inch (Fig. 20). In order to give the material stability, he soaks it in 30 parts of gutta-percha dissolved in 150 parts of chloroform. It can be sterilized by placing it between layers of gauze, and treating it for 36 hours in 1:1000 bichlorid, changing the fluid every 12 hours. It can then be kept permanently in this solution, which must, however, be thoroughly rinsed away before the material is used. Book-muslin impregnated with varnish may also be used, or silk netting treated with paraffin.[19] In employing these "splints," they must overlap the sound skin, and may remain in place from 4 to 10 days, the overlying dressings being meanwhile changed as often as may seem necessary.

[18] Zentralb. f. Chir., p. 793, 1906.
[18a] Am. Surg., 1909, p. 416.
[19] Parry, Am. J. Surg., July, 1909, p. 243.

Bernhard [20] advocates exposure of the newly grafted area for a short time to the direct rays of the sun; while Schepelmann [21] douches the new skin for several weeks with hot air, by means of a special electric instrument,

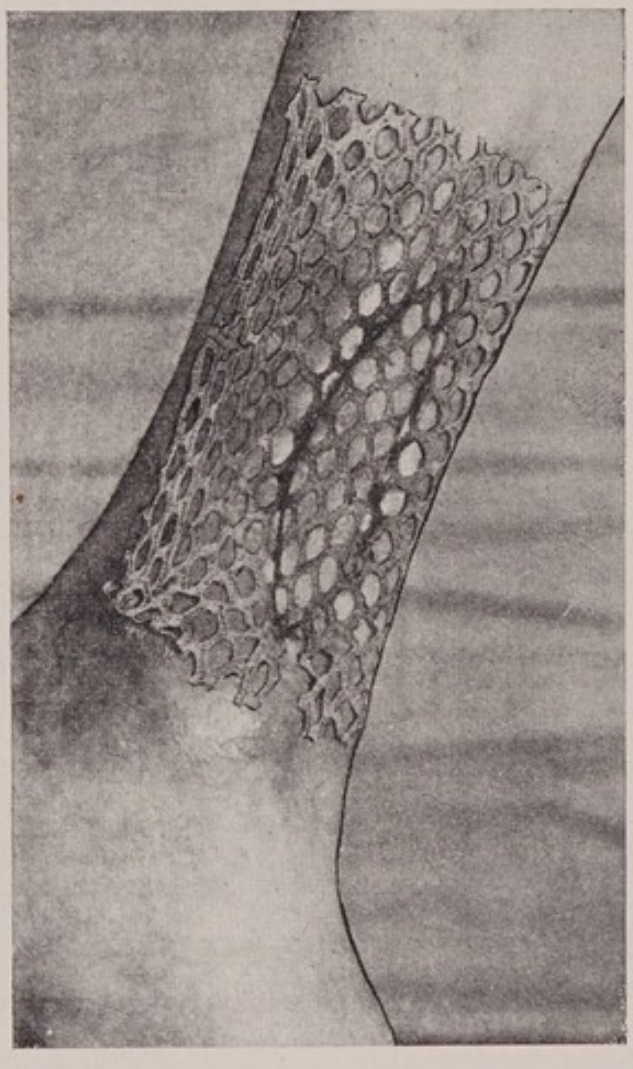

Fig. 20.— Method of "splinting" grafts with rubber-impregnated curtain-netting (Davis). (From Johns Hopkins Hospital Bulletin, XXI, p. 41.)

claiming that better and more permanent results are thus obtained.

Thies [22] covers the grafts with a thick layer of fine sand, which has been sterilized by boiling in a 1 per cent solution of sodium carbonate and then dried. He considers that

[20] Deut. Zeitschr. f. Chir., 1905, B. 78, p. 574.
[21] Med. Klinik, 1911, p. 1048.
[22] Zent. f. Chir., 1911, p. 458.

this method has a number of advantages, among which are the removal of fluids by capillary suction, the splinting of the grafts, and the prevention of coagulation of the discharges by the alkalinity of the material. The sand should be changed frequently.

If the grafted surface is near a joint, it is best to prevent movement by means of an ordinary splint. It is well to examine the transplanted skin, especially if about the face, in 24 hours, in order to make sure that nothing has slipped because of vomiting, etc. If everything is in place at that time, it will remain so. If a graft has become displaced, it is best to remove it and apply another at once, which can usually be done under local anesthesia with but little inconvenience to the patient.

Treatment of Wounds After Removal of Grafts.

The raw and slightly bleeding surface of the thigh, from which the grafts have been taken, can be dressed as one would dress an ordinary wound. McBurney, however, prefers a covering of gauze moistened with normal salt solution, believing that healing will thus take place more readily and with less pain; but others have been unable to notice a difference in this respect. An excellent method is to use sterile boric acid ointment and rubber protective, thus avoiding drying and sticking of the dressing, which causes considerable discomfort. Frequent changing of such a dressing is unnecessary.

Much more pain is usually felt in the thigh than in the part to which the grafts have been applied; in fact, even when considerable pain is present in an ulcer, it is apt to cease when transplantation has been done.

"Accordion Grafts."

Lanz [23] has suggested a method by which the wound from which the grafts were obtained can immediately be recovered. This is accomplished by shaving off a large Thiersch graft and stamping slits in it with an appropriate

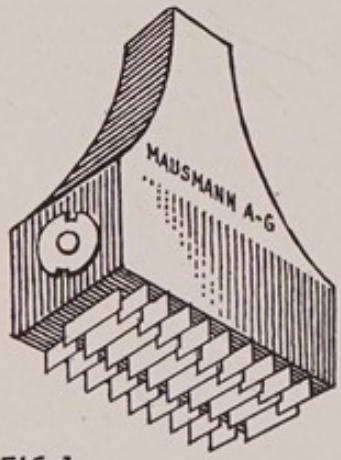

FIG. 1

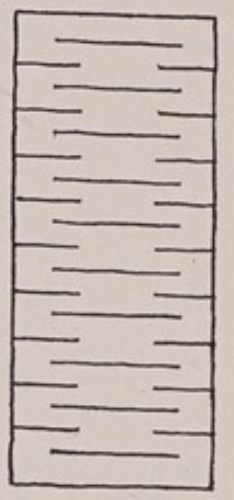

FIG. 2

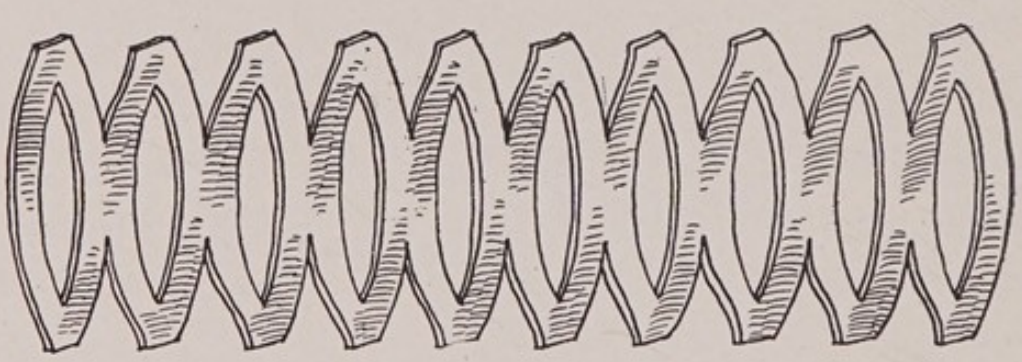

FIG. 3

Fig. 21.— " Accordion grafts " (Lanz). (From Zentrabl. f. Chir., 1908, p. 3.)

die, so that it may be drawn out, like an accordion, to twice its original length (Fig. 21). It is then divided, one half being used to cover the wound from which the graft was cut, while the other half is placed on the surface to be grafted. This ingenious procedure should be of much service—by shortening the tedious healing of a large raw surface, by promoting drainage, and by furnish-

[23] Zentralbl. f. Chir., 1908, p. 3.

ing a means of obtaining more material in cases where the surface to be grafted is large and the available skin small in amount. Under local anesthesia the extent of the operation will also be lessened—a point of some importance to the patient. Such grafts should be "splinted" firmly in place by gauze or by netting (see p. 51). Instead of using a specially made die, the grafts may be spread upon a sterile board and nicked with a sharp knife.

Proper Time for Grafting.

There is no reason for deferring skin grafting until granulation has set in, as is habitually done by some, as the grafts take just as well or better when applied to fresh wounds, thus saving the patient the considerable annoyance, not to say danger, of a second anesthetization. If, for instance, an operation is to be done in which the wound will be too large to permit approximation of the edges, as in cancer of the breast, a thigh is sterilized and wrapped in a surgically clean towel. As soon as the major operation is completed, the grafts may be cut, immediately put in place, and an ordinary dry dressing applied, the entire procedure occupying but a few minutes.

When granulation has once begun, it is well to wait until the process has become thoroughly established and all sloughing tissue has disappeared, which, according to Thiersch, and others, requires five or six weeks; but this is unnecessarily long, two or three weeks usually being sufficient.

It is important that the granulations should be in good condition, especially if the operation is to be done without scraping. It is sometimes possible, however, to graft un-

healthy ulcers, and Kraske has succeeded in covering the ulcerating surfaces of malignant tumors, although the new skin is apt soon to disappear. Better results are, of course, obtained when the conditions are more nearly normal, a favorable sign being the appearance of a pellicle of new skin at the borders of the ulcer.

After-treatment.

From seven to ten days are required for grafts to become firmly fixed; and unless suppuration or some other accident occurs, the lowermost layer of gauze or protective may be left in place for two weeks. To avoid danger of loosening the delicate adhesions of the new skin, the coverings should be soaked off with warm salt solution; although occasionally, when healing has been perfect and dry dressings have been employed, they slide off as though no defect in the skin had been present.

Some mild ointment should subsequently be used to prevent dryness and cracking of the tender epithelium, which must be guarded from injury or sudden changes of temperature for several weeks. Particularly is this true of crural ulcers and those which have a tendency to reappear after grafting.

It often happens, especially under moist dressings, that the outer layers of epidermis die and become macerated, so that when the dressing is removed the grafts apparently come away with it, leaving a grayish, sodden surface behind. This does not necessarily mean failure, for in a few days the epithelium will generally be replaced from the remaining rete Malpighii.

Schmieden [24] claims that scarlet-red ointment stimulates the growth of epithelium to a remarkable degree, and this opinion has been confirmed by many others. The method may be used to advantage in Thiersch grafting where for some reason the entire area has not been covered by skin, but care should be taken that the ointment should not come in unnecessary contact with the grafts, especially before they have become firmly adherent, as it might cause their destruction.

Application of Thiersch Grafting.

It is astonishing to what useful purposes Thiersch grafting may be applied in the treatment of various lesions —such as old ulcers, including the intractable crural ulcer, fresh wounds with loss of skin, defects remaining after plastic operations, or after the removal of tumors, nevi, cicatrices, etc., and extensive burns, especially where subsequent contractions are feared. Debilitating suppurative and septic processes may be checked by this means, and sometimes life saved. Amputation may occasionally be avoided. The offensive ulcerating surfaces of inoperable, malignant tumors may be skinned over, as demonstrated by Kraske. Tuberculous affections of the skin may be cut and scraped away, and the defects filled in with Thiersch grafts. Flat nevi may at times be shaved off and replaced by new skin, causing comparatively slight disfigurement. Even obstinate cases of lupus erythematosus have been successfully treated in this manner. The grafts will adhere to periosteum, to bone from which the external surface has been removed, to tendons, fascia, dura mater, muscle, etc., and mucous surfaces may also be grafted—for

[24] Centralbl. f. Chir., 1908, p. 153.

instance, the vagina, either with sections of mucosa or with skin.

Urban asserted that transplantation could not be made on surfaces having a tendency to perish when the covering of soft parts is removed, for instance, bone, tendons, aponeuroses, and cartilage; and this is to a large extent true, although not strictly so, as has been abundantly proved. It must not be forgotten, however, that skin grafts can never be covered up within the tissues, for instance, as a substitute for a tendon sheath or a lost portion of peritoneum or dura mater, because of the impossibility of obtaining reliable asepsis.

A few of the writer's cases, briefly reported, will serve to illustrate the applicability of the Thiersch method:

The hand of a boy had been badly crushed. The entire dorsum was occupied by a granulating surface which presented little tendency to heal. If healing had occurred, there would have been much deformity from contraction. The dressings were all removed on the ninth day after the transplantation, and the grafts found adherent. The superficial epithelium came off over a small area, but was soon reformed. The patient was seen as late as two years after the operation, the new skin being in excellent condition, perfectly pliable and free from contraction.

In another instance several crural ulcers were grafted that had existed eight or ten years, the patient spending considerable time in the hospital during that period. At the end of ten months the ulcers still remained healed, with no puckering of their surfaces. The patient was a heavy drinker and did the work of a hostler.

An interesting case was one in which the right foot had been badly crushed in a railroad accident. The member was finally saved, but with the loss of a large amount of skin over the inner side of the foot and ankle and posterior portion of the sole including the heel—an area somewhat larger than the entire hand. A Wladimiroff-Mickulicz operation was discussed, but it was determined to try skin grafting first. The grafts adhered without difficulty, and the wound was soon well; although a small ulcer in the vicinity which was not grafted failed to heal for several weeks thereafter. This might be considered an instance in which Thiersch grafting saved a foot from amputation.

An extensive burn of both feet and the anterior surfaces of both legs in a little girl had caused such extreme contractures that the feet were drawn up almost against the tibiæ. The physician in charge, after dissecting out the cicatricial masses and straightening the limbs, attempted to fill in the large remaining wound surfaces with pedunculated flaps from the adjacent uninjured regions of the legs. The flaps, however, sloughed, leaving the child's condition worse than before. The raw surfaces were then scraped and covered with Thiersch grafts, which all grew vigorously. The child was heard from six months or more after the operation; there had been no contraction, no ulcers had formed, and the result was satisfactory.

A large epithelioma was removed from the frontal region, leaving the dura exposed over an area the size of a saucer. This was grafted at once, using the dry method. The result was perfect, notwithstanding that the wound was thoroughly septic. After several weeks the patient was again seen, and the grafts found in good condition. Every surgeon knows what a tedious process the healing of such a wound is under ordinary circumstances.

In the case of a young lady, a fairly large nevus (port-wine stain) disfigured the lower eyelid and the upper portion of the cheek. This was excised down to the subcutaneous tissues, and the edges of the wound brought together as far as possible with sutures, leaving an opening as large as a silver half-dollar, which could not be closed without danger of drawing down the margin of the lid. The gap was filled with a single moderately thick graft and covered with a wet dressing. The transplantation succeeded, and in the course of time the skin became pliable. At the end of eight or nine months not the slightest puckering of the lid had resulted. Although the graft could still be easily detected, it continued to approach month by month more nearly to the appearance of the surrounding skin.

Failure resulted in the case of a young and healthy man with a large ulcer of the leg occupying the site of a scar due to a crush. The ulcer had existed for years with no tendency toward healing. In operating, the tissues were found so dense and fibrous that a properly soft and bleeding surface could not be obtained, even by criss-crossing the floor of the ulcer with incisions. The grafts apparently dissolved under the wet dressing. It would undoubtedly have been better to have dissected out the entire cicatrix before grafting.

In a case of epithelioma of the nose, the tissues were peeled from the bony framework, leaving only the periosteum. Grafts placed upon this surface "took" without difficulty, the process of healing being greatly shortened and the disfigurement lessened.

In excising an epithelioma from the bridge of the nose, a circular piece of skin the size of a silver quarter was removed. In two or three weeks the graft, which was at first considerably sunken, became

elevated to the level of the surrounding surface. There was no contraction and but a slight rounded cicatrix at the border of the transplanted skin.

In another case, quite an extensive area of tuberculous skin was removed from the inferior maxillary region of a small boy. A Thiersch graft filled in the defect quite satisfactorily, although some contraction took place about the edges. In such a case the surgeon operates with a freer hand and a better chance of eradicating the disease when he is conscious that the loss of tissue can readily be replaced.

Thiersch Grafting in Special Cases.

Accidental wounds are frequently permitted to granulate before transplantation is done, as it is often impossible to render them surgically clean and, in addition, the patient may be bleeding excessively or in a condition of shock. If everything is reasonably favorable, however, grafting should be done at once, as it may prevent subsequent infection.

Burns.—As a matter of course, granulation is always a first requisite in burns. If the part can be kept aseptic, the new skin may be applied in about six weeks, and the time should even be longer if extensive sloughs must separate (Urban). Judicious grafting in large burns of the third degree cannot be too strongly urged, in order to prevent long-continued and exhausting suppuration, unsightly scars, and embarrassing contractures.

Dunham [25] succeeded with a thick Thiersch graft in bridging over a finger-joint exposed by a burn, but this was a piece of good fortune which cannot frequently be imitated, the covering over of hollow spaces being a matter of plastic surgery rather than of transplantation.

The Nose.—The results of Thiersch grafting about the

[25] Ref. Handbook Med. Sci., Supplement.

nose are reasonably good, even when the entire covering of the organ has to be removed, providing the mucosa remains uninjured. When, however, so flimsy a framework as the mucous membrane alone exists, it is better to plug the nostrils with cotton so as to obtain a firmer basis. The grafted alæ are at first quite thin, but in the course of time they become thick enough to be presentable.

It is sometimes desirable to use pedunculated flaps of skin in repairing defects about the nose or lips involving the entire thickness of the part. When this is done, their raw surfaces may be covered with Thiersch grafts, either at once or after granulation has taken place, in order to prevent contraction. In replacing a portion of the cheek, for instance, a flap may be dissected from the neck, supported on a piece of gauze for ten days or two weeks, and grafted before insertion in its new position. The wounds from which these flaps are taken may also be grafted when necessary.

In the worst form of ACNE ROSACEA the cutaneous surface of the end of the nose becomes irregularly hypertrophied, so that the grotesquely enlarged organ has a swollen, red, and nodular appearance. Such unsightly noses can sometimes be pared down to a proper size, and the surface at once grafted, the results being often cosmetically good.

NEW GROWTHS.—The Thiersch procedure has a wide field of usefulness in filling the defects left by the removal of malignant tumors, particularly carcinoma of the breast. With an effective method of grafting at his disposal, the operator does not fear to excise an amount of skin which he would otherwise hesitate to do, and it is in the skin that

the majority of relapses occur. Kraske [26] found it possible to graft the ulcerated surfaces of inoperable carcinomata, thus preventing septic infection and offensive discharge; but it is questionable if such a course is worth while, as the grafts soon break down and disappear.

In excising HAIRY MOLES it is necessary to be sure that the hair bulbs are completely removed; otherwise hairs force themselves through the new epidermal covering, as happened in a case reported by Gnarch.[27]

HANDS AND FINGERS.—In injuries and burns of the hands, grafting is of immense service in the prevention of unsightly scars and annoying contractures. The Thiersch method may even be used with considerable success upon the palmar surface, although better and more durable results are obtained, especially when the knuckles and wrist are involved, by means of pedunculated flaps from various portions of the body, or by the Wolfe-Krause method. Skin grafts may be employed with satisfaction in operations for syndactylism.

SCARS AND CONTRACTURES.—One of the most useful applications of Thiersch grafting is in the prevention and removal of deformities, due to extensive scars and contractures. Where possible, it is usually preferable, for the sake of nutrition as well as for cosmetic reasons, to dissect out the cicatricial tissue entirely. In contractures about the neck, for instance, where the chin is drawn down toward the sternum, the entire scar should be removed prior to the application of grafts. It should be noted, however, that pedunculated flaps or Wolfe-Krause grafts are often

[26] Münch Med. Woch., Jan. 1, 1889.
[27] Verhand. Internat. Med. Cong. Berlin, 1890, p. 224.

more serviceable and sightly than are Thiersch transplantations.

Grafting on Bone.—Following sequestrotomy and other bone operations much time is often consumed in healing. A few judiciously applied skin grafts will, however, frequently hasten convalescence, although they are less likely to "take" than under most other circumstances. Even the entire orbit may be lined with epithelium after the removal of a malignant growth, as was successfully done by von Noorden.[28]

In some cases, where a smooth, clean surface can be obtained, transplantation may be done at once, although it is often preferable to wait until granulations have appeared, perhaps four to six weeks. When a gutter has been chiseled in the bone, it may be necessary to shove the grafts through quite a small opening, and much difficulty may be experienced in adjusting them smoothly. They may sometimes be held in place by packing the cavity with small pledgets of gauze. Even when success is but partial, the remainder of the surface is often stimulated to rapid healing. After the removal of exostoses, the bone may at once be covered with new skin with considerable assurance of a good result.

Chronic Empyema.—In this troublesome affection it is sometimes necessary to remove portions of the chest wall in such a manner as to leave a large granulating cavity which is very slow in healing. Tillmanns, in 1890, demonstrated that such surfaces can be successfully grafted, and since then, the operation has been repeatedly done by others.

[28] Berl. Klin. Woch., 1892, No. 41.

Bedsores, after the breaking-down process has ceased, can sometimes be provided with an epithelial covering, either with or without preliminary curettement, thus saving time, disfigurement, and annoyance.

Chronic leg ulcers present such a severe test of any form of grafting that methods will often fail which uniformly succeed elsewhere. Urban, however, is so confident that Thiersch grafting, when properly carried out, will be effective in these cases, that he says amputation should never be resorted to even in the most extensive lesions; but his elaborate method requires so much time, care, and patience that it can scarcely be considered advisable except in aggravated cases. Three to four months are necessary, six to eight weeks of which must be spent in preparation alone, and during the entire time the patient must remain in bed!

It is advisable in many instances to completely excise ulcers of the leg, almost as if they were malignant growths, before transplantation is attempted, especially if much induration is present; and failures would undoubtedly be much less frequent if this were more often resorted to. Excision is of course inevitable if lupus or epithelioma exists.

The cause of the ulcer must be carefully considered, for upon this may depend the character of the operative procedure. In various ulcers, for instance, the enlarged veins should always receive attention, either by obliterating them, by means of one of the various procedures employed for that purpose, or by applying a suitable support to the leg, in the shape of a bandage, an elastic stocking, or a Murphy

corset. Prolonged rest in bed will of course improve the nutrition of the limb, but the old condition returns as soon as the patient resumes his feet. Syphilis is always a contraindication to operation until appropriate treatment has been used for a sufficient length of time to insure local freedom from the disease.

Following a transplantation for leg ulcer, the patient should remain in bed for some time, as a sudden afflux of blood to the part often injures the tender grafts, and an elastic flannel bandage should be worn for several months, reaching from the toes to the thigh. Some mild ointment should occasionally be applied to the grafted area in order to prevent excessive dryness, and great care must be exercised in the avoidance of injury to the limb.

Urban lays much stress upon massage in the after-treatment. This should be begun in the vicinity of the ulcer upon the tenth day, and the longer it is continued the better. The new skin may be rendered pliable without actually touching it by carefully pulling and massaging the skin in its vicinity.

Mucous Surfaces.—Thiersch grafting has been successfully done in the mouth, the vagina, the urethra, the eye, and the ear, although the chances of success are not so good in these situations as elsewhere. The statement made by Thiersch is not strictly true, that it is impossible to graft upon surfaces connected with mucous cavities, Schnitzler and Ewald having succeeded even upon a granulating surface, following the removal of an epithelioma from the inside of the cheek. The new skin soon conforms more or less to the characteristics of the surrounding mucous mem-

brane, although not becoming identical with it. Hairs or glandular elements never develop, partly because of the thinness of the grafts.

It is occasionally possible to form a new urethra, in operations for hypospadias, or to replace lost portions of the urethral canal by means of Thiersch grafting, the grafts being wound around a catheter, which is left *in situ* until adherence has taken place.

Heterogeneous Thiersch Grafting.

As in other forms of transplantation, skin taken from the patient himself grows better than that obtained from others, even from a blood-relation. When, however, it is necessary to employ the heteroplastic method, local anesthesia (see Chap. X) should always be used, if possible, in order to avoid danger to the donor. In extensive burns occurring in children, for instance, it may be advisable to obtain grafts from another, usually the mother or the father. When this is the case, the two individuals may be placed side by side, the grafts removed under local anesthesia from the parent being transferred directly to the unscraped granulating surface on the child without causing pain to either of them.

Statistics.

In order to give some idea of the proportion of successes obtained in Thiersch grafting, the following statistics are quoted:

Nancrede [29] estimates that seven out of ten operations succeed; but if the cases are at all well selected, the pro-

[29] Ann. Gyn., Feb., 1892.

portion should be greater than this. Thorndike has collected 123 cases with 102 successes (82.9 per cent). Jungengel's statistics show 119 transplantations with 100 successes. Von Eiselsberg [30] reports 37 operations on fresh wounds with 33 good results, and 13 operations on granulating wounds with 11 good results. Plessing [31] tabulates 78 graftings with 58 successes (75 per cent) and 12 partial successes. Out of 544 cases of grafting by various methods, collected by Davis from the reports of the Johns Hopkins Hospital, 341 were completely successful, and but 17 were absolute failures.

[30] Wien. Klin. Woch., 1889, Nos. 34 and 35.
[31] Arch. f. Klin. Chir., Bd. 37, p. 53.

CHAPTER V

THE WOLFE-KRAUSE METHOD

The credit for introducing the use of grafts filling the entire cutaneous defect and comprising the whole thickness of the skin, without including fat or cellular tissue, is due to J. R. Wolfe, an oculist of Glasgow. His first experiments were made in connection with the conjunctiva, portions of which he shifted, without pedicels, from one part of the eye to another. He soon began to employ the conjunctivæ of rabbits in repairing defects in the human eye, announcing his method before the Glasgow Med. and Chir. Soc., in 1872. In 1875, he published his experiments in skin grafting for ectropion,[1] being closely followed by Wadsworth, who introduced the procedure in America. Von Esmarch was among the first to apply the operation to any extent in general surgery.[2]

Grafts composed of the entire thickness of the skin had been used frequently enough, however, prior to their employment by Wolfe, not only by the ancient Hindus, but in modern times as well, although the subcutaneous tissues were nearly always included. Jacenko [3] was probably the first to successfully employ grafts devoid of fat, and in 1872, Le Fort reported a successful operation in a case of ectropion.

Wolfe was probably correct in believing that the avoid-

[1] Brit. Med. Jour., Sept. 18, 1875.
[2] Wien. Med. Woch., 1885, Nos. 29 and 30.
[3] Ber. Klin. Woch., No. 8, 1871.

ance of fatty tissue was an important feature of his method, as it is apt to undergo necrosis and to interfere with nutrition. This has been denied, however, by many, including Hirschberg[4] and Taylor,[5] and there is no doubt that success can often be obtained without this precaution; in fact, free masses of fat alone are not infrequently transplanted from one locality to another, in order to fill up unsightly depressions, a substitution for the mammary gland having even been provided in this manner. Wolfe's original method has been modified, and the technic so much improved by Fedor Krause, that it is often referred to as the Wolfe-Krause Method.

Preparation.

If an ulcer is to be operated on, its preparation must be undertaken with even greater care than in the Thiersch process (see Chap. IV). After curetting away the granulations, there should be no hesitation in excising the callous borders and base, so as to obtain as free a circulation as possible; and in some cases—for instance, in old crural ulcers—it may even be advisable to chisel away a layer of thickened and diseased bone from the face of the tibia. Rather than employ ligatures on the wound surface, it may occasionally be preferable to delay operating for a day or so and apply compression, afterward soaking off the compress so as not to renew the bleeding; or direct pressure with an Esmarch bandage may be used (see p. 37).

Contrary to former belief, it has been demonstrated (Davis[6]) that good results can be obtained by placing

[4] Verhand. d. Deut. Gesell. f. Chir., 1893.
[5] Practitioner, Dec., 1882. p. 428.
[6] Internat. Clinics, 1905, Vol. 1, p. 81.

whole thickness grafts directly on a healthy granulating surface, without preliminary curettement. The granulations should be cleaned the day before the operation, however, and a mild antiseptic dressing applied. Such grafts are at first higher than the surrounding skin, but they soon come down to the common level. Although it is questionable if success is as certain as when the granulations are removed, it is nevertheless well to know that under certain circumstances the operation may be simplified in this manner.

Technic.

The grafts are best cut in the shape of a spindle, so that the defect produced by their removal can be closed by sutures, although in fleshy individuals it may be necessary to dissect the fat from the bottom of the wound before it can easily be united.

The arm or the thigh is usually chosen, but owing to the fact that the skin retains almost indefinitely its original character of fineness or coarseness, it is well to use on the face grafts from the inside of the arm. Aside from this consideration, it is of little moment, contrary to Hirschberg, where the grafts are obtained, or whether the blood plexus is highly developed or not, and it is unnecessary to produce an artificial hyperemia by preliminary irritation of the cuticle. Davis suggests using skin from the abdomen obtained in the course of a laparotomy. Hueter and Krause claim that hairs may be transplanted by this method, although they are apt to be deformed and rather few in number. An eyebrow, for instance, might thus be replaced from the pubes.

The graft should be carefully outlined by an incision. Then one end is seized with forceps, and the whole flap is freed with the knife, the edge of which is turned toward the surface so as to remove the fat, although the retention of a small amount will do no serious harm. At least one third should be allowed for shrinkage, which is always great, owing to the elasticity of the skin. In order to avoid touching the raw tissues more than is necessary, which is detrimental to their vitality, it is best to fold the end of the spindle under as soon as enough is loosened, so as to bring the two raw surfaces together and permit handling of the graft by its epithelial covering only. Rough handling should be avoided with the greatest care, such as tight pinching with forceps, rubbing with gauze, or unnecessary traction before the graft is completely divided.

Young[7] excises the subcutaneous fat along with the grafts, afterward trimming it off with curved scissors while the flap is spread on the palm of the hand or is curled over a finger. He claims that less time and trouble are thus required and that the resulting wound is more readily closed. Adipose tissue soon reforms beneath the transplantation, in sufficient amount to fill up inequalities and render the skin pliable.

An essential feature, according to Krause, is absolute dryness, surgically speaking, which he thinks is conducive to rapid healing. There must be no douching and no moisture about the hands or instruments or about the surface upon which the grafting is to be done. He is probably correct in this, although there are others who do not agree with him.

[7] Glasgow Med. Jour., Oct., 1907.

Adjustment of Grafts and Dressings.

The grafts, cut into smaller pieces if desirable, are pressed firmly in place in order to remove blood and bubbles of air, and if too much moisture is not present, they will adhere as if glued fast. Subsequent bleeding beneath the surface is fatal. Sutures are detrimental and are never necessary, except occasionally about the eyelids and lips, although they were at first invariably employed by Wolfe.

The entire wound must be *completely* covered with as large sections of skin as possible, because wherever there is an open space more or less of a cicatrix results. If this is not practicable, the operation may be completed with Thiersch grafts.

It was at first customary to keep the new skin warm by applying artificial heat; but this was found to be detrimental rather than beneficial, as decomposition was thus favored. Either a dry or a moist dressing, as described under the Thiersch method, may be used, but the former is usually preferable, nothing but ordinary sterilized gauze and cotton really being necessary. The grafts should be inspected in three or four days in order to open blisters, etc., the gauze being soaked off with warm boric acid solution if strips of rubber protective have not been employed. After this, sterilized borated vaselin can be used.

After-treatment.

Inequalities of the surface soon fill out as they do under Thiersch grafts. If the outside layers of the new skin exfoliate much, a moist covering can be used to hasten the

process, and the lost epithelium replaced by Thiersch grafts, if necessary. Even when the surface rises in blisters and assumes a bluish color, failure should not hastily be assumed, as the necrosis is often superficial and of comparatively slight importance.

Healing should be complete in from three to six weeks, success being aided by massage and other measures as in the Thiersch process. Without actually massaging the grafts themselves, they may be loosened quite early by manipulating the skin in their vicinity.

With proper care whole thickness grafts may be employed wherever the Thiersch method is applicable, even upon tendons, bones, and aponeuroses; but its greatest usefulness begins where that of the Thiersch graft ends—that is, where an especially thick and durable covering is required—although the technic is much more exacting and the chance of failure greater. Davis,[8] however, has reported 19 cases of grafting with the whole thickness of the skin with but one partial failure, which is certainly encouraging.

[8] Ann. Surg., 1909, Vol. 50, p. 542.

CHAPTER VI

THE METHOD OF HIRSCHBERG—SKIN-PERIOSTEUM-BONE GRAFTS

In the original "Indian method," as used by the ancient Hindus in rhinoplastic operations, grafts were employed comprising the subcutaneous fat; and nearly all the transplantations which were done up to the time of Wolfe, with the exception of that introduced by Reverdin, were patterned after this method, as is most plastic work at the present time.

Hirschberg [1] has attempted to revive the Indian method, but has met with little response from other surgeons. He claims that better results will be obtained by transplanting the subcutaneous adipose tissue along with the cutis, and supports his assertion by calling attention to cases in which pieces of fat alone have been used to fill up various defects in the tissues, even to the replacement of the entire mammary gland (Czerny). It is interesting to note, however, in this connection, that Pitschke has called attention to the necrosis of adipose tissue which often follows surgical operations, causing troublesome fistulæ, thus showing that the vitality of fat is not great.

Hirschberg [2] lays great stress on the amount of blood and other fluids which the graft contains at the time it is transplanted, with the idea that it subsists until new vessels

[1] Verhand. d. deut. Gesell. f. Chir., XII Kong., 1893.
[2] Verhand. d. deut. Gesel. f. Chir., XXIV Kong., 1895.

are formed almost entirely upon the nutritive material already within its substance; and in this connection Dieffenbach, Thiersch, and Hanff have shown that for some time after the removal of a thick portion of cuticle there is more or less perceptible motion of its fluids.

Hirschberg also believes that not a little depends upon the locality from which the skin is derived, some portions of the body being richer in vessels than others, which accounts, he thinks, for the comparatively ready reunion of severed portions of noses and fingers. The success of the Hindus, he attributes partially to the fact that they usually grafted from the gluteal region, where the skin is very vascular.

Hence, he advises artificial irritation of the skin by means of rubbing it, or beating it with a piece of rubber tubing, until the surface becomes red and swollen; and in order to further increase the congestion of a limb, an Esmarch strap may be lightly fastened about it. The general opinion is, however, that but little if any benefit is derived from the production of artificial hyperemia in skin grafting.

Sutures are often desirable in the method of Hirschberg, as the grafts will not adhere readily without them. As a matter of convenience, he often places them in position before entirely detaching the flap.

Morrow [3] has utilized the Hirschberg method by removing small defects from the face and other regions with an instrument known as "Keyes' cutaneous punch," and filling the hole thus left with a button comprising the entire thickness of the skin together with the subcutaneous fat, which

[3] Trans. Am. Derm. Assoc., 1891.

is removed in the same manner from some other region. He claims that hair may easily be transplanted in this way.

Skin-Periosteum-Bone Grafts.

It should be mentioned that grafts are occasionally employed which include not only the skin and subcutaneous tissues, but also the periosteum and even a portion of the bone itself. The technic, however, is very exacting, and asepsis must of course be absolute. The indications for this method of transplantation are not numerous and are confined mostly to certain rhinoplastic operations and to the filling in of defects in connection with the skull and scalp.

In outlining the graft, which is usually obtained from the anterior surface of the tibia, the incision is made directly down to the bone, a more or less thin layer of which is then removed with a sharp chisel without disturbing its connection with the superjacent periosteum and skin. The tibial wound is then closed by undermining and suturing the surrounding integument. Better results are usually obtained when a section of bone is included than when the periosteum alone is employed.

CHAPTER VII

THE TRANSPLANTATION OF MUCOUS MEMBRANE—ANOMALIES IN SKIN GRAFTING—SPONGE GRAFTING

Mucous Membrane.

The first systematic transplantation of mucous membrane, other than the conjunctiva, was done by Wölfler, who grafted urethras, after the excision of strictures, with strips of mucosa from a prolapsed rectum, from the cervix of a prolapsed uterus, or a uterus which had been removed from the body. Subsequently he similarly obtained good results with the stomach of the frog, the esophagus of the rabbit, etc. In one of his cases the condition of the new urethra was perfect at an autopsy made six months after the operation. Beigel [1] also did some excellent work in this line, and Fenwick [2] repaired a defect in a human urethra with a portion of the urethra of a sheep.

It should be mentioned in this connection that the urethra has recently been satisfactorily replaced with portions of the internal saphenous vein as well as with the ureter and the vermiform appendix, removed from other individuals during the course of necessary operations.

Wölfler claims that mucous membrane adheres as well as skin, but this has not been the experience of others. It

[1] "Die Krankheiten des Weibl. Geschlechtes," 1875.
[2] Lancet, Feb. 8, 1896, p. 353.

can be shaved off as in Thiersch grafting, or may be stripped off in its entirety.

Hirschberg, in 1874, made the first transplantation of buccal mucous membrane to the conjunctiva. Since that time the experiment has been frequently repeated. To Wolfe, in 1872, is due the credit of grafting from the conjunctivæ of animals to that of man, and of bringing the procedure into general use.

Czerny showed that mucous membrane from the mouth, with flat epithelium, and from the nose, with cylindrical or ciliated epithelium, soon comes to resemble epidermis when grafted upon a raw skin surface. Sick [3] has observed that the same phenomenon occurs in connection with vaginal mucosa.

Most writers, following the teaching of Virchow, maintain that skin transplanted to a mucous surface becomes transformed into mucous membrane. It is certainly true that in most cases it very largely conforms itself to its surroundings, losing its hairs and other distinctive features. Thiersch,[4] however, denies that this change takes place, citing as proof a case in which he used a skin-flap in manufacturing a soft palate. So much hair grew upon the part that the patient was compelled to continually shave the inside of his mouth!

In operations for hypospadias Thiersch grafts have been successfully employed to line the new urethra, by wrapping them around a catheter, which is left in position until adhesion has taken place.[5] They have also been used within the larynx after the excision of a stricture.[6]

[3] Archiv. f. Klin. Chir., Bd. 43, p. 387.
[4] Beiträge z. Cent. F. Chir., 1888, No. 24.
[5] Nove-Josserand, Rev. de Chir., 1903, Vol. 1, p. 403.
[6] Alapy, Zentralbl. f. Chir., 1900, p. 1313.

Anomalies in Skin Grafting.

Kibler,[7] Parmenter,[8] and Granbury [9] insist that shavings from CALLOSITIES of the palms of the hands or soles of the feet furnish particularly good material for grafting, having the advantage of being easily obtained without pain or other inconvenience to the patient. From three to six or more grafts, as thin as tissue-paper, may be cut from the same surface at intervals of three or four days. In the experience of Kibler and others over 80 per cent of the transplanted pieces of epithelium have lived, the results being excellent.

Granbury recommends preliminary friction of the callus, imagining that the vitality of the grafts is increased and union hastened. Experience has proved, however, that in other situations irritation of the skin prior to transplantation is of little or no value, and it is difficult to see why it should be otherwise where callus is concerned.

Hodgen [10] was successful in grafting with shavings from CORNS, preferring this material to that otherwise obtained. Leale [11] had good results with WARTS, his method being to separate the growth into its component vascular "epithelial rods," which were scattered over the ulcerated surface. He attributed his success to the superabundant tendency to growth which verrucosities are supposed to possess. Hodgen has also transplanted from MOLES, but it is difficult to imagine why this should ever be done, particularly as there is some danger of transferring malignancy in this way.

The fact that pieces of old, dried, and often LOOSE

[7] Jour. Am. Med. Assoc., Aug. 8, 1891, p. 224.
[8] Park's Surgery, 1896.
[9] Texas Sanitarian, Sept. 1894.
[10] St. Louis Med. and Surg. Jour., July, 1871.
[11] Med. Rec., Vol. 14, p. 188, 1878.

EPIDERMIS could be used in grafting was also demonstrated by Hodgen, his experiments being confirmed by Lusk.[12] When desirable, almost unlimited quantities of epithelium can be obtained by the application of a CANTHARIDES BLISTER, as was first suggested by the writer,[13] and afterward by Morris [14] and by Lusk. It is unnecessary to dry the epidermis, as is recommended by Lusk, but it can be used at once, as it is cut from the blister, small pieces furnishing better results than large ones (Morris). It is true that "blister grafts" are not as durable as those obtained by other methods, and that they are best adapted for use on certain small wounds and granulating surfaces, although Lusk, by using very small pieces, claims to have obtained good, durable, elastic skin.

Schweninger observed that when HAIRS were placed upon an ulcer a growth of epithelium resulted; but von Nussbaum showed that this occurred only when the root sheaths were present, and that the hairs themselves were of no importance. The process, then, amounts simply to a transplantation of epithelium, and is of little practical value.

Howard [15] claims to have grafted ulcers with bits of MUSCLE, which grew well and stimulated the remainder of the surface to rapid cicatrization. This does not mean, of course, that epithelium can develop from muscle as has been asserted.

It has long been known that scrapings from the surface of the skin, so-called "EPITHELIAL DUST," will adhere to granulations or to fresh wounds and grow as do larger grafts. Reverdin tried the experiment and reported

[12] Med. Rec., Dec. 7, 1895, p. 800.
[13] Denver Med. Times, May, 1895, p. 428.
[14] Lectures on Appendicitis and Notes on other Subjects, N. Y., 1895.
[15] N. Y. Med. Jour., Sept., 1871.

against it, as did also Czerny, Reclus, and others, although Fidder and Hodgen claimed to have had good results, especially the latter, who employed scrapings from the sole of the foot. It would seem probable that the less the suppuration the greater the chance of success, as the tiny grafts would not be so likely to become macerated or washed away.

In this connection the method of Mangoldt [16] possesses some merit. He carefully disinfects the skin and scrapes it with a scalpel until a sort of paste is procured, formed of epithelial scales and a little blood. This is smeared upon the surface of the ulcer, to which it readily adheres, owing to the coagulation of the blood, forming a brick-red layer. In five to seven days the blood vanishes, leaving new pinkish skin, which becomes firm in about three weeks. A fine mosaic is seen with a lens, but to the naked eye it is smooth epidermis. Mann, of Dresden, has utilized the method in open wounds following operations upon the mastoid.

GRAFTING FROM DEAD BODIES OR FROM AMPUTATED LIMBS is easily done and has frequently been resorted to; but the danger of carrying disease is positive and cannot be disregarded, while failures are much more frequent than in autodermic methods. Czerny reports cases of tuberculosis, communicated by grafts obtained from a leg removed for white swelling of the knee, and there is always danger from syphilis.

Girdner [17] claims that the method is original with him, but the credit probably belongs to Steele, of Bristol, who made successful transplantations from amputated limbs in

[16] Deut. Med. Woch., Nov. 28, 1895, p. 798.
[17] Med. Rec., July 30, 1881.

several cases. Ivanova [18] has transplanted with much success from the bodies of infants, one and one-half and two hours after death. In grafting from amputated limbs, Symonds [19] sometimes employed the Thiersch method and at other times that of Wolfe. Tillmanns, in his work on surgery, advances the questionable idea that in transplanting from the cadaver the operation must be performed before rigor mortis sets in.

Each of the above-mentioned means of obtaining grafts is of scientific interest, and may be of practical use in certain cases; but none of them is of so much general value as the method usually employed. Grafting with hairs, moles, or warts would scarcely be considered under ordinary circumstances.

Sponge Grafting.

Sponge grafting, introduced by Hamilton, in 1881, is essentially different in principle from skin grafting, nevertheless a brief consideration of the subject will not be out of place. It was formerly in quite general use. Sponge does not grow fast to the surface as does skin, but acts merely as a stimulating support for the granulations, finally undergoing complete absorption. The procedure is much inferior in its results to the transplantation of cuticle, and is now seldom employed.

A fine Turkey sponge is selected, soaked in dilute nitrohydrochloric acid until all calcareous particles have been dissolved, and then placed for a time if desired in a

[18] Ann. Surg., Vol. 12, 1890, p. 354.
[19] Brit. Med. Jour., Dec. 14, 1889, p. 1331.

solution of potassium hydroxid. Very thin slices, which are the most serviceable, can be cut with a sharp knife, or, more conveniently, with a microtome, and sterilized by boiling, or in a 5 per cent solution of carbolic acid, which is afterward removed by washing.

The sponge is then spread upon the granulations, which have been rendered as nearly aseptic as possible (see the method of Reverdin), and dressed much as if it were a transplantation of skin. The granulations soon acquire new energy and push their way into the interstices of the sponge, which often almost disappears beneath them, so luxuriant is the growth. Cicatrization proceeds more rapidly than under ordinary circumstances, providing that sepsis and decomposition do not become too prominent, which is not infrequently the case.

Robinson combines sponge grafting with the transplantation of skin, small bits of which he places beneath the layer of sponge. He claims that the filling up of ulcers and the formation of epithelium go on side by side with unusual rapidity.

The transplantation of fascia,[20] muscle, nerves, brain-tissue, blood-vessels, omentum, bones, joints, and even of entire organs, has recently assumed much prominence in surgical literature, but the consideration of these interesting subjects is scarcely in place in connection with a monograph on skin grafting.

[20] Davis, Ann. Surg., Dec. 1911.—Zeit. f. Chir., 1911, pp. 23 to 36.

CHAPTER VIII

GRAFTING FROM ANIMALS

The idea of obtaining grafts from animals, thus avoiding pain and inconvenience to the patient, is certainly attractive. If it could be demonstrated that such transplantations were sufficiently often successful, and that the new skin was as satisfactory as that obtained by other processes, zoögrafting would be the method of choice. Unfortunately the procedure is at best uncertain, so much so that Reclus has classed it among "laboratory experiments," rather than among useful operations. Colrat laid down the general rule that such grafts usually become absorbed, granulations sooner or later growing through them, although they may seem to thrive at first. This is undoubtedly going too far, as numerous instances have been recorded where the method has been of great service.

Cousin makes some interesting comparisons between the value of grafts obtained from man and from animals. He made 165 transplantations from frogs, chickens, guinea-pigs, and rabbits, out of which he had but 15 successes. In 122 human grafts, however, good results were obtained in 115.

Success has varied much in the hands of different operators; so much so that by some the method has been absolutely condemned, and by others praised beyond all reason. A partial explanation of this lies in the fact that many

results have been reported too soon, before time and exposure had tested the resisting powers of the new skin.

Zoögrafting possesses an advantage over transplantation from another person in avoiding the danger of transmitting disease; and where it would otherwise be necessary to call upon the patient's friends for epidermal donations, it is perhaps most in place. Even in these cases it is questionable whether it would not often be better to run the small amount of risk and obtain human skin from the bodies of recently dead infants, amputated limbs, circumcisions, etc., or from living individuals.

One of the first recorded instances of grafting from an animal to man, and certainly one of the most remarkable in medical literature, is said to have occurred in the seventeenth century. A surgeon replaced a defect in the scalp and skull with a skin-periosteum-bone graft from a dog; but under threat of excommunication, the Church compelled the unfortunate operator to remove the transplanted tissues, which had already grown in place.

Zoögrafts have been obtained by various operators from frogs, chickens, lizards, pigs, dogs, cats, rabbits, guinea-pigs, the lining membranes of eggs, etc. Frogs furnish, perhaps, the most reliable and most easily obtainable material, although Miles [1] considers it to be the least desirable of all.

Grafting from frogs was performed by Allen, in 1884,[2] and by Baratoux and Dubousquet-Laborderie [3] a few years later. The skin of the abdomen is usually employed, but that from the back or any other portion of the

[1] Edinburgh Med. J., Sept., 1895.
[2] Lancet, Nov. 15, 1884.
[3] Le Prog. Med., Nov. 15, 1887.

body answers the purpose equally well. Smith [4] affirms that the dorsal skin is thicker and grows more satisfactorily than that from other parts. Small pieces can be removed, or long strips, which may afterward be divided if desirable. Nesterovsky [5] pinches up a fold of skin with forceps and snips off a piece the size of a finger-nail, which is a rapid and satisfactory method. Fowler [6] skins the entire frog, legs and all, in strips ¼ to ½ inch wide.

In order to render everything as aseptic as possible, the frog, after a preliminary scrubbing, may be immersed as far as the neck for five minutes in a solution of corrosive sublimate (Nesterovsky), or allowed to swim about indefinitely in a solution of boric acid (Polaillon).

The cuticle of frogs, as well as that of other animals and of man, may be preserved apart from the body for a number of hours; hence grafts wrapped in some waterproof tissue with moist gauze, to prevent drying, may safely be carried to patients at a distance (Allen).

The new skin soon becomes pinkish and so nearly translucent that one must observe rather closely at times to detect its presence; in fact, it occasionally seems almost to disappear, and then to reappear as a delicate film through which the red surface beneath can easily be seen. Should the grafts even vanish entirely, cicatrization is said to be promoted. The pigmentation, so universally present with frogs, disappears in a few days,—five, according to Smith; ten, according to Fowler,—but, nevertheless, for some reason the new skin remains somewhat darker than the surrounding cuticle.

[4] Boston Med. and Surg. Jour., Jan. 24, 1895.
[5] Brit. Med. Jour., June 1, 1889, p. 1246.
[6] Ann. Surg., Vol. 9, 1889, p. 179.

A soft, pliable covering is produced, which, were it only durable, would be all that could be desired; but unfortunately it has a tendency to ulcerate and disappear, which renders frog's skin inferior to that obtained from the human body. Even under the most favorable circumstances, great care must be given the soft and immature cuticle for at least three months.

Redard [7] was the first to use the skin of CHICKENS for grafting, and for a time this material became quite popular, although, like other forms of zoögrafting, it is now seldom resorted to. The soft, nude cuticle on the under surfaces of the wings was selected, and the fat carefully removed. When the grafts survived, they ultimately came to resemble to a great extent the normal surface of the body.

Altamirano [8] successfully grafted an ulcer with 20 pieces of COCK'S WATTLE. The circulation in these structures is so vigorous that one would expect comparatively good results.

Miles, of Edinburgh,[9] and a few months later, M. E. Van Meter, of Colorado,[10] employed with considerable success the skin of PUPPIES, Miles using the greyhound, and Van Meter the Mexican hairless puppy, which possesses a particularly soft and white integument. The cuticle of a young PIG has been utilized with satisfaction by Raven [11] and Hübscher.

Miles [12] has also transplanted from RABBITS and KITTENS. His method is to shave the abdomen, and if neces-

[7] Arch. Roum. de Med. et de Chir., Jan., 1888.
[8] Satellite of the Ann. Univ. Med. Sci., Oct., 1889.
[9] Lancet, Mar. 15, 1890, p. 594.
[10] Annals Surg., Aug., 1890, p. 136.
[11] Brit. Med. Jour., Nov. 3, 1877, p. 623.
[12] Edinburgh Med. Jour., Sept., 1895.

sary the flanks, and remove the cuticle in strips from one to six inches in length and from one-half to one inch in width, avoiding the subcutaneous cellular tissues. It is perhaps unnecessary to curette the granulating surface, but it should be healthy. The grafts are pressed down firmly, with their edges together, and the dressing should not be disturbed for from forty-eight to seventy-two hours, and then with the greatest caution. Superficial sloughs and pustules may form. The latter should be opened at once. Granulations which show a tendency to grow through the new skin and destroy it should be removed with a sharp spoon. The color of the grafted skin soon becomes satisfactory, and sensation develops; hair does not grow, and there is no contraction. Miles reports four successes in 10 cases and only two absolute failures.

As a matter of interest only, it should be mentioned that skin has been successfully grafted from man to the lower animals.

E. Aievoli [13] made use of thin sections of the TESTES OF RABBITS for purposes of grafting in four cases, assuming that the testicle possesses a greater cellular activity than other portions of the body. The results were undoubtedly good, but it does not follow that they were better than could otherwise have been obtained.

The LINING MEMBRANE OF AN EGG furnishes a material for grafting which is easy to obtain and is sometimes efficacious, although the results are not so durable as they might be, in spite of the views of Watson and others to the contrary. Amat [14] achieved some success in this way in cases

[13] Cent. f. Chir., No. 14, 1891, p. 289—Med. Rec., Aug. 6, 1892, p. 164.
[14] Arch. d. Med. et de Pharm. Milit., Mar., 1895—Medicine, Oct., 1895.

of extensive burns. Small pieces were placed 12 to 15 millimeters apart and covered with sections of tin foil 1 cubic centimeter square. An ingenious application of the method has been used by Berthold, in closing perforations of the tympanum (see grafting in connection with the ear). The procedure has been of value in filling defects in the conjunctiva, such, for example, as are produced by the removal of a pterygium.

CHAPTER IX

GRAFTING IN LUPUS, IN X-RAY BURNS, ON THE CRANIUM, AND IN CONNECTION WITH THE EYE AND EAR

Lupus.

This is a stubborn tuberculous affection of the skin, almost as difficult to eradicate as epithelioma itself. It has been cauterized, curetted, and salved from century to century until the patience of all concerned has been tried to the utmost. Where other measures failed, the problem of scientific and satisfactory operative cure, with a minimum of disfigurement, was at last solved by von Esmarch in 1885, who excised the diseased tissue and filled in the defect by skin grafts. It remained for Urban, however,[1] in 1892, to develop this form of treatment and bring it into general use.

It is true that lupus had occasionally been removed previous to this, and the defects filled in with new skin; but scraping instead of excision was nearly always resorted to, and plastic surgery relied upon to fill the gap.[2] Sometimes, however, a Reverdin grafting was done[3] with fair results, although contractions took place and unsightly scars remained. Recurrence was frequent by either method.

In many instances Thiersch grafting is satisfactory,

[1] Deut. Zeitschr. f. Chir., Bd. 34, 1892, p. 187.
[2] Blasius, Oppenheim's Zeitsch., Bd. XIX—Friedberg, Chir. Klin., Jena, 1855.
[3] Roux, Revue Med., Apr. 15, 1885.

while in others it may be better to resort to the Wolfe-Krause method, in which the entire thickness of the skin is employed. The former is more easily and quickly accomplished, and perhaps more certain of success; while the latter is at times preferable on account of the superior durability of the new skin and its greater resemblance to the surrounding surface. Where it is desirable to transplant hairs, in the replacement of an eyebrow, for instance, the procedure of Krause is indicated, although not always successful. Of course, where the raw surface can easily be covered by flaps, or by undermining the skin and suturing, this should be done, but it is not often practicable, owing to the situation or the extent of the disease.

It should be mentioned that all authorities do not agree upon the operative treatment of lupus. Some cling to the older methods, and maintain that various combinations of scraping and cauterization are to be preferred. For instance, Schütz [4] and Brooke [5] speak unfavorably of excision and subsequent grafting, maintaining that it is "too dependent for its success on either unknown or unpreventable factors; and in private practice it is not easy to get patients or their friends to submit to the loss of a second slice from another part of the body. Further, the cosmetic effects are doubtful, and the removal of the disease by excision is uncertain."

In reality, however, if the operation is properly done, recurrences are much less frequent than by other methods, as has been abundantly demonstrated; and in addition, one who is affected with lupus and who appreciates the stub-

[4] Arch. Derm. u. Syph., Bd., XVII, Heft 1, 1894.
[5] Med. Chron., Apr., 1894.

bornness of the disease should be as willing to have it excised and the surface grafted as if it were carcinoma, especially as the chances of speedy recovery with comparatively slight disfigurement are greater than are offered by other procedures.

As in malignant growths, everything depends upon thorough excision; and if this is not accomplished the operation is a failure. The encircling incision should lie at least 2, and better 3, millimeters within the sound skin; and the entire cutis, including most of the subcutaneous cellular tissue, must be removed. The reason for this extensive dissection lies in the fact that small foci, invisible to the naked eye, frequently exist far from the apparent borders of the diseased area, and may be left behind unless considerable apparently sound tissue is sacrificed. Bruce Clarke [6] considers that the outlines of the disease may be more exactly defined by a preliminary injection of tuberculin.

A different knife from the one used in removing the lupus should be employed in cutting the grafts, in order to avoid the somewhat remote possibility of transferring the disease. It is also well to be careful in regard to fingers and sponges.

If the lupus is very extensive, there may be reason for operating in two or more stages. In such cases a part only is cut out, and the wound grafted. Eight or ten days must elapse before the operation is repeated; and it is then well to remove a portion of the grafts which have already been applied, which may have been invaded on their edges by tubercles.

As the entire thickness of the skin is excised in the oper-

[6] Lancet, Mar. 18, 1893.

ation, the thin Thiersch grafts sink quite decidedly below the surface. This hollow fills up, however, in two or three weeks; and in ten or twelve weeks the new skin approaches the color of that which surrounds it, although it may remain somewhat paler. The only situation in which much shrinkage occurs is about the eyelid, when nearly all of it has been removed. Almost the entire skin of the nose, especially that over the bony framework, can be cut away and replaced by either Thiersch or Wolfe grafts with quite good results.

Care must be taken that the grafts are not shifted during the vomiting which often follows anesthesia. About the neck a plaster casing may be required to secure the necessary quietude, and it may even be desirable in certain situations to apply no dressing at all, or merely strips of protective, or a single layer of gauze, or a wire-mesh "cage" (see p. 49).

X-ray Burns.

With the introduction of the Roentgen-ray came the so-called x-ray burn—a peculiarly stubborn form of chronic dermatitis, in which there is atrophy of the various constituents of the true derm, often with areas of epithelial proliferation, resembling papillomata, and a strong tendency to bacterial invasion, ulceration, and malignant degeneration (Fig. 22). There is but little inclination toward spontaneous healing, so that it is sometimes necessary to excise the diseased area, especially if there is a possibility of malignancy. When this is done, transplantation of skin may be required, by either the Thiersch or the Wolfe-Krause method (Fig. 23).

It has been the experience of the writer that when the thinner grafts are used, they may in time undergo degen-

Fig. 22.— X-ray dermatitis of hip treated daily for one year by unskilled operator for tuberculosis of hip. Areas of malignant degeneration (Dr. H. G. Stover).

erative changes similar to those for which they were originally applied, hence, when practicable, it is better to

1 2

Fig. 23.— (1) X-ray burn of hand. (2) Same after skin grafting. (From Journal Medical Research, Vol. XXI, No. 3, 1909.)

employ transplantations from the whole thickness of the skin. Because of their greater durability, Wolfe-Krause

grafts should always be preferred about the knuckles, the wrists, and the tips of the fingers. In operating it is necessary to remove all the burned area, if possible, as the disease will otherwise tend to reappear around the edges of the grafts.

According to Porter,[7] especial care must be used in these transplantations. For instance, hemostasis must be absolute, the dressings should be applied with moderately firm pressure, and the hand, for this is the part usually affected, should be kept somewhat elevated for at least two weeks. It is best to bevel the borders of the wound and cut the grafts to fit exactly, in one piece, with their edges thinner than their centers to correspond with the bevel.

When rubber protective is used as a covering, it should be removed in from 24 to 36 hours; and if there are any collections of serum or blood, the grafts must be incised, and the fluid pressed out. The edges of the transplantations are then smeared with lanolin.

From the experience of others, it seems unlikely that this elaborate technic has many advantages over other measures, because, if the diseased area is completely excised, as it should be, the surface to be grafted does not differ from that of an ordinary wound. The writer has certainly had good success with the methods in common use. About the hands it is often difficult to check oozing. When this is the case, instead of prolonging the anesthetic, the grafts may be preserved on rubber protective in an aseptic jar containing moist gauze and applied without anesthesia on the following day (see p. 46). When the oozing is not excessive, however, it may almost always be

[7] J. A. M. A., Jan. 23, 1909, p. 323.

stopped by placing the grafts in position and applying temporary pressure (see p. 37).

Grafting on the Cranium.

Occasionally a woman's long hair is caught in a revolving belt in some factory, and the scalp more or less completely stripped from the skull, everything down to the pericranium being torn away, sometimes from the back of the neck to the eyelids and from one ear to the other. If these extensive wound surfaces are left to themselves, healing will go on for a certain distance around the edges, accompanied by much contraction; but if the central portion ever heals, which is doubtful, the delicate cicatrix will require many months for its formation and will readily break down again. Hence the problem of successful skin grafting upon a denuded cranium becomes one of considerable importance.

The Reverdin method has been most often employed,[8] but Thiersch grafting gives much better and quicker results and should be the operation of choice, although whole thickness grafts are occasionally applicable, especially when they can be obtained from the lost scalp, large portions of which may thus be utilized at times.

Schaefer[9] has written an excellent article on the use of Reverdin grafts in these cases. He concludes that the grafts should be thick, even to comprising some of the subcutaneous connective tissue, should be placed close together, and should be taken as far as may be from the patient's own body. The aim should be to obtain a cutane-

[8] Originally, perhaps, by S. C. Bartlett, Am. Jour. Med. Sci., Oct. 1872, p. 573.

[9] Trans. 9th Internat. Med. Cong., Vol. III, p. 166.

ous covering for the bone containing at least a good share of glandular elements and as movable as possible. He states that: "The most reliable skin is formed by grafting about the circumference of the wound, say one or two rows, producing a narrow strip 1 centimeter wide, and waiting until the blood-vessels are well developed in it; then plant another series close to the last one. By this plan, contraction in the marginal tissue takes place in advance of the subsequent graftings, diminishing the liability for an ulcerative process to occur by means of such contraction." The grafts are also more likely to grow well, as much of their nourishment is derived, according to Schaefer, from the borders of the wound.

Because of the poor blood supply afforded by bare bone, it is often better not to operate at once, but to wait until granulation has become well established, when transplantation may be done directly upon the uncuretted surface. In order to prevent drying out and exfoliation of the bone during the interval of waiting, it should be covered with moist dressings or with rubber protective (Davis [10]).

Scalping by Indians is luckily rare at present, but in the early times many an inhabitant of the border towns carried on the crown of his head a section of white and denuded bone which refused to become covered, even with granulations. Sneve [11] calls attention to an almost forgotten method which was once employed in the cure of these troublesome cases. An unknown French surgeon was the inventor of the process, which was first described by Robertson.[12]

[10] Ann. Surg., Dec., 1910, p. 721.
[11] Med. News, Mar. 4, 1893, p. 239.
[12] Nashville Journal of Medicine and Surgery, Apr., 1855.

With a drill, a number of holes are bored close together through the outer table of the skull, through which granulations push their way in the course of four or five weeks and coalesce upon the outside. In order to prevent the drill penetrating too far, a piece of cork may be fastened ⅛ inch from the end. Use may occasionally be found for this old method at the present time in certain cases.

A positive danger, however, is sepsis, which is peculiarly apt to be grave in connection with the diploic structures (in a case reported by Pond [13] the patient's temperature went up to 105°), but with proper precautions the danger can be reduced to a minimum.

The Eye.

Much attention has always been given to grafting in connection with the eye, and most of the early skin transplantations were made upon the lids for the purpose of correcting ectropion. Von Gräfe is said to have succeeded as early as 1818. These operations were given a definite footing, however, by Wolfe, of Glasgow, in the years between 1872 and 1875. His first experiments were made by shifting small pedunculated flaps from one portion of the conjunctiva to another; but although he was successful in this, the range of applicability was so small and the available material so limited that he soon began to obtain grafts from the conjunctivæ of rabbits.[14]

Von Wecker, it is true, has transplanted from one human conjunctiva to another, but opportunities for this exist practically only when another eye is to be enucleated un-

[13] Med. Rec., Dec. 16, 1893, p. 772.
[14] Glasgow Med. Jour., 1873, p. 220.

less one desires to experiment with the cadaver. Mucous membrane from the prolapsed rectum of a child has also been used.

Wolfe's cases of SYMBLEPHARON were probably the first ever remedied by transplantation from animals, and his operations were almost uniformly successful. He was closely followed by Raymond, Brettauer,[15] Becker,[16] von Wecker, and many others, both in this country and abroad. His method, given in his own words, is as follows[17]:

I first separate the adhesion by means of blunt-pointed scissors, so that the eyeball can move in any direction. The conjunctival sac and cornea are cleared of nodules, so as to obtain an even surface. Two rabbits are then put under chloroform, one being kept in reserve in case of accident.

I take from the rabbit that portion of the conjunctiva which lines the inner angle, covering the "membrana nictitans" and extending as far as the cornea, on account of its vascularity and looseness. If the palpebral opening is too narrow, I enlarge it at the external angle, and introduce a ligature through the whole thickness of the free border of the lower lid, and by means of the ligature the lid is drawn open and kept steady, and the conjunctival cul-de-sac exposed. Into the middle of the flap to be removed a black silk ligature is introduced, a knot is tied, and the ligature cut short. This knot is intended to mark the epithelial surface of the membrane, for without it the flap is apt to curl up, and leave us at a loss how to adjust it.

Next I mark the boundary of the conjunctiva of the rabbit which I wish to transplant, by inserting four black silk sutures which I secure with a knot. The ligatures having been put on the stretch, I separate the conjunctiva to be removed with scissors, and by means of a fine spatula I spread it upon the back of my left hand. The four ligatures are then cut off, and the conjunctiva trimmed to the proper size. It should be larger than the lost substance.

I now return to the patient and see that the bleeding has subsided and that the parts are in a fit condition to receive the transplanted flap, which has in the meantime become dry like a piece of parchment, and adherent to the dorsum of the hand. It is then lifted by means of a spatula and transferred to replace the lost conjunctiva of the patient. It is secured in its place by six or eight

[15] Nagel's Jahresbericht der Ophth., 1873, p. 250.
[16] Wiener Med. Woch., 1874, No. 46.
[17] Lancet, Dec. 14, 1889, p. 1219.

ligatures, or even more if necessary. This is a very difficult process requiring delicate manipulation, and the assistant must keep the flap in place by a spatula while it is being stitched in its new place. Both eyelids are closed with lint and a bandage, and kept so for four days. The ligatures are left in for six or eight days.

At the present time surgeons lay much less stress upon the employment of sutures.

In ECTROPION, after incision of the cicatrix and correction of the deformity, von Wecker filled in the wound with small grafts; but this is not advisable, as considerable contraction will almost certainly occur. The method of Thiersch, and particularly that of Wolfe, will give much better results. It is at times not advisable to dissect out the cicatrix in these affections, as this would involve too much loss of tissue, but this is a point for judgment in individual cases. It is generally sufficient to make a horizontal incision in the scar at least .5 centimeters from the border if possible, and of sufficient depth to permit the lid to be brought into place, a more or less oval wound of considerable size resulting.

In order to avoid movement and consequent disturbance of the transplanted skin, the lids may be united by several stitches, without paring the edges, which are allowed to remain for from four days to a week. If it is preferred, the lower lid may be attached to the superciliary region or the upper lid to the cheek by one or two sutures sufficiently tense to keep the tissues smooth and immovable. Both eyes should be bandaged.

Thiersch grafts require no sutures, and it is not only unnecessary to stitch fast the Wolfe grafts in the great majority of cases, but it is positively harmful, on account of traumatism and tension. When something seems to be re-

quired to hold them in place, Argyll-Robertson [18] uses what he calls "tethering" or "cradle" stitches, which bind down the graft by passing back and forth across its surface, getting their points of fixation within the skin on either side. This method, however, is seldom necessary.

Where nothing is left but the margin of the lid and the conjunctiva, perfectly satisfactory results may be obtained by either the Thiersch method or by that of Wolfe.

Douthwaite [19] reports a case in which an attempt was made to replace a lost portion of an eyelid with a section of lid from another individual. There seemed to be some show of success until the result was ruined by an accident occurring on the third day.

In ECTROPION Knapp [20] recommends a skin grafting operation in which the skin is obtained from the lid itself, a strip being removed from the loose folds between the margin and the eyebrow, where it will not be missed, and inserted in a longitudinal slit in the intermarginal space. Le Fort obtained grafts in a similar manner for use in cases of symblepharon. Woodruff [21] inserts a Thiersch graft obtained from the red margin of the lower lip.

SYMBLEPHARON can be successfully treated by means of cutaneous Thiersch grafts, as well as with mucous membrane from the lip, conjunctiva from the eyes of rabbits, or grafts from the skin of the lid.

Hotz [22] employs Thiersch grafts obtained from behind the ear as a substitute for conjunctiva, especially after the removal of a PTERYGIUM. For a long time the graft re-

[18] Practitioner, 1893, p. 160.
[19] China Med. Miss. Jour., June, 1892.
[20] Oph. Rev., July, 1895.
[21] Ann. Oph. and Otol., July, 1893.
[22] Jour. Am. Med. Assoc., Sept. 10, 1892; Ann. Oph. and Otol., 1893, Vol. II, No. 2; Ann. Oph., Jan., 1897, p. 10.

mains as "an opaque white strip covered by a thick coat of soft epidermic cells," but finally "loses its cutaneous character, and can be distinguished from the ocular conjunctiva by very close inspection only." He concludes that "the skin grafting method can prevent the recurrence of pterygium, and that it leaves no unsightly mark upon the eyeball. It is a comparatively simple operation, and the grafts so seldom fail to grow fast to their new bed that I feel much disposed in the future to employ this method in all kinds of pterygia, small and large."

After dissecting the pterygium from the cornea and globe, he does not divide its base, but allows the growth to retract into the corner of the eye where it remains. A large wound in the conjunctiva results from upward and downward retraction. The graft is made considerably narrower than the longitudinal diameter of the wound, in order that it may not push out over the cornea, which it is inclined to do, but it reaches the conjunctiva at both ends vertically. Both eyes should be bandaged for 48 hours.

Successful operations by the method of Hotz have been reported frequently. Eversbusch [23] has also used Thiersch grafts upon the ocular conjunctiva, while Le Fort has employed Wolfe grafts from the thin, loose skin of the lid. The writer has suggested that the lining membrane of an egg, or the epithelium raised by a blister, might possibly be employed to advantage in replacing portions of the conjunctiva.

The entire internal surface of THE ORBIT may be covered with epithelium by the Thiersch method, as was done by von Noorden,[24] following the excision of an extensive car-

[23] Münch. Med. Woch., 1887, Nos. 1 and 2.
[24] Berl. Klin. Woch., 1892, No. 41.

cinomatous growth. After the removal of the globe, embarrassing contractions in the socket, which interfere with the wearing of an artificial eye, can sometimes be prevented by judicious grafting.

Numerous attempts have been made to replace a damaged CORNEA in man with the cornea of an animal. For this purpose the rabbit has usually been selected, although Gradinego [25] employed the ordinary barn fowl. Most of the cases do reasonably well for a few days, but the new cornea soon becomes cloudy and useless, at least in part, so that the operation has been discarded by many. Its consideration is hardly in place in the present connection.

The Ear.

Skin grafts have been employed to close PERFORATIONS OF THE TYMPANUM, Berthold [26] being the pioneer in this direction. He designates the operation *myringoplasty,* and reports some lasting cures,[27] in one of which the graft, which had grown thinner than when first applied, lay deeper than the level of the drum. When the tympanum is entirely gone, it is sometimes advantageous to freshen the granulated mucous membrane in the vicinity and cover it with an appropriate graft, but this does not mean that a new drum has been formed.

In 1886, Berthold achieved considerable success in the temporary closure of perforations of the tympanum with portions of the vitelline membranes of hen's eggs. These grafts will often stay in place for months, and in some cases they probably grow fast, as they become more or less pink-

[25] Lancet, June 29, 1889, p. 1319.
[26] Monatschr. f. Ohrenheilkunde, Nov., 1878.
[27] Ber. Klin. Woch., June 9, 1890, p. 523.

ish and cannot be displaced by inflation of the internal ear; in fact, it is otherwise difficult to understand how they can remain so long in position.

The technic of the procedure is simple. The portion of fresh membrane, cut to an appropriate size, is placed in position with a pair of forceps and smoothed out with cotton on a probe; or it may be picked up on the end of a medicine dropper by means of slight suction, and redeposited in proper position by forcing a little air from the instrument.

The troublesome granulating surfaces resulting from operations upon THE MASTOID may be successfully covered with Thiersch grafts as suggested by Siebenmann,[28] as may also fresh wounds, even when the bone is extensively exposed. Mann[29] employs for this purpose scrapings of epidermis mixed with blood, according to the method of Mangoldt (see p. 81). The wound is tamponed with iodoform gauze for five days, and then cauterized with nitrate of silver, bone and all, every two or three days until a good granulating surface is obtained, which will be in about two weeks. An anesthetic may then be given, and the surface curetted, although this is not essential, after which the epithelial paste is applied and covered with rubber protective, which is held in place by inserting into the cavity pellets of gauze the size of a pea. When possible, the dressing should be left undisturbed for a week or more.

[28] Schmidt's Jahrbuch, B. 248, No. 12, p. 266.
[29] Deut. Med. Woch., Nov. 28, 1895, p. 798.

CHAPTER X

LOCAL ANESTHESIA IN SKIN GRAFTING

Skin grafting is essentially a minor operation; hence whenever possible it should be done under local anesthesia, thus sparing the patient the discomforts and dangers of chloroform or ether, although it should be understood that disappointment may result with children and with those who are especially nervous, apprehensive, or hysterical.

The most satisfactory technic is perhaps the following: Have in readiness two syringes which will stand sterilization by boiling—one, an ordinary hypodermic syringe with a small sharp needle, and the other a larger instrument, holding an ounce or more, with a moderately long needle. Also an anesthetizing solution consisting of:

Novocain	0.25 gram.
Normal salt sol.	50.00 grams.
Adrenalin	.3 gram.

This may be designated Sol. No. 2, and when diluted with an equal volume of salt solution, forms Sol. No. 1.

The adrenalin must be fresh, and the solution prepared just before using. Boiling does not injure the novocain, but this should be done before the adrenalin is added. As much as 60 or 90 grams of No. 2 can be used in adults without danger, while No. 1 can be injected in almost any reasonable quantity.

Select an area upon the arm or thigh large enough to

obtain from it easily all the grafts required, and anesthetize a number of spots along its vertical center, an inch or so apart, with Sol. No. 1 (Fig. 24). This is done by thrusting the needle of the small syringe just beneath the epithelium, and parallel to its surface, without penetrating entirely through the skin. When the piston is pressed, a small, white elevation, or wheal, appears, which is immediately anesthetic.

Then through these anesthetic spots the operative field

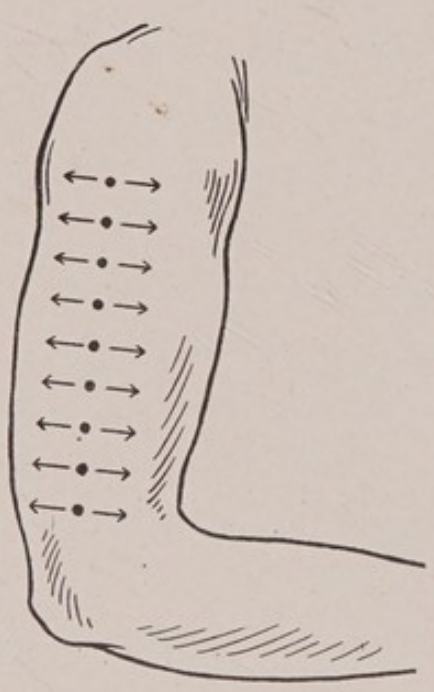

Fig. 24.— Points for insertion of local anesthetic in skin grafting.

is subcutaneously infiltrated by means of the larger syringe, injecting the fluid, in the direction of the arrows (Fig. 24), first to one side and then to the other. This should be done while the needle is being pushed forward in order to avoid depositing the liquid within a vein. Massage of the part will produce a more thorough distribution.

It is necessary to wait for from 5 to 15 minutes before the operation is begun, in order to obtain satisfactory anesthesia, and this time can be occupied in completing the

surgical cleaning of the part. It is interesting to note the blanching of the skin due to vascular contraction under the influence of the adrenalin, the lessening of absorption thus obtained not only increasing the efficiency of the novocain, but decreasing its general poisonous effects.

Sol. No. 1 may be used almost *ad libitum* for this infiltration. Sol. No. 2, however, acts more promptly and thoroughly, but the quantity employed should never greatly exceed two ounces. Anesthesia usually lasts from half an hour to an hour or more.

Some years ago Halsted, of Baltimore, introduced a method for producing anesthesia of the antero-lateral portion of the thigh in skin grafting, by freezing or cocainizing the external cutaneous nerve below the anterior superior iliac spine. The procedure, however, is rather difficult and uncertain and does not compare practically with the method just described.

Thiersch grafts may also be cut, more or less painlessly, after freezing the skin with ethyl chlorid; but considerable discomfort is experienced at the moment the tissues congeal, and the anesthesia is too transitory to be completely satisfactory, hence the method is not in general favor.

CHAPTER XI

HISTOLOGY AND PATHOLOGY

Much work in the histology of skin grafting has been done by Garre,[1] Goldmann,[2] Abraham and Bidwell,[3] Thiersch,[4] and others. Most of the investigations were made with especial reference to the method of Thiersch; but they apply equally well to Reverdin grafts, which are really small Thiersch grafts, and to a considerable extent to other forms of transplantation.

Adhesion and Nutrition.

Epithelial grafts, and those containing in addition more or less of the true skin, become adherent to granulations or fresh wound surfaces much as does the layer of epithelium which floats out on the surface of an ulcer from its borders.

For a time its existence can be said to be parasitic; any extraneous nutrition which it may receive being obtained by a species of imbibition from the subjacent tissues, and from the disintegration of leucocytes which rapidly accumulate beneath the grafts and work their way in a few hours into the interstices and into empty vessels, where they are still to be seen in considerable numbers at the end of eight weeks (Karg). The process was accurately observed in grafts five to eight days old by Armaignach, in

[1] Cent. f. Chir., 1890, p. 226; Beiträge z. Klin. Chir., 1889, Sonderabdruck.
[2] Beiträge Z. Klin. Chir., Bd. XI, Heft. 1, p. 229.
[3] Medical Week, 1894, p. 186.
[4] Verhand. d. deut. Gesell. f. Chir., 1874, p. 69.

1877.[5] The leucocytes, together with exuded fluids, assist also in cementing the new skin in position, as in the healing of an ordinary wound. In the course of eighteen hours (Thiersch), delicate vessels, consisting of endothelial walls alone, from capillary loops of the granulations and from vessels which form parallel to the surface, force their way into the severed capillaries of the graft, sometimes, possibly, directly joining with them; while others pass into the tissues in various directions. The old vessels quickly degenerate (Garre).

The intermediate layer of leucocytes, together with any coagulated blood which may be present, soon disappears, a layer of fibroblasts appearing in its place, and a delicate subcutaneous connective tissue rapidly forms. Garre has discovered a thin panniculus adiposus as early as the twenty-second day.

The grafts become firmly adherent by the tenth day, and the circulation is established sufficiently well to maintain their vitality, although it is many weeks before the reparative process is complete. Inflammation and stasis are the factors which most often contribute to breaking down of the new skin by interfering with its nutrition.

Color.

The grafts are at first dead white in color, although those comprising the entire skin may be of bluish or reddish appearance owing to stagnated blood. Later on they assume a pinkish hue as the circulation becomes reëstablished, which is about the sixth day or even earlier. Rarely, as mentioned by Krause, the vessels dilate until an

[5] Rev. de Sci. Med., Vol. 9, 1877, p. 325.

unsightly vascular network occupies the place of the new skin.

Transplanted skin tends to assume more and more the color of its surroundings, differing in this respect from a cicatrix, which increases in whiteness with its age, due to the presence of contracting fibers in the scar which slowly cut off the circulation.

Enderlen [6] claims to have demonstrated that extensive degenerative changes always take place in transplanted skin, the only portions which survive being the lowermost epithelial layer, some glands and vessels, and perhaps a few connective tissue cells, but this is disputed by others (Braun). Regeneration of epithelium proceeds from these structures, but the new cutis arises from the adjacent and subjacent tissues.

Movability.

Thiersch grafts gradually become movable, often in six or eight weeks, and may be shoved from side to side and even elevated in folds. This movability depends upon the presence of elastic fibers (Zenthoefer), which Garre has found as early as the tenth day, and Goldmann in abundance at the end of four months, the old fibers disappearing and being replaced by new ones. Urban maintains that movability is more apt to be present if grafting is done upon a fresh wound surface.

Grafts comprising the entire skin are, of course, more pliable than those which are thinner, while the skin produced by Reverdin grafting is but little looser than an ordinary cicatrix. Cicatricial tissue contains no elastic

[6] Centralbl. für. Chir., No. 28, 1897, p. 7.

fibers, and consequently, wherever a space is left between two grafts, the cuticle will be more or less bound down at that point. Inflammation retards the formation of elastic fibers and may stop it altogether.

Sensation, etc.

Sensibility to touch and to variations of temperature returns slowly, and may always remain somewhat below normal. It begins near the edge of the graft and appears last at the center.[7] Two or three months are generally required for its complete return.

In Reverdin and Thiersch grafting the hairs and glandular elements of the skin are absent; but in thicker grafts this is not true, although the hairs are apt to be deformed and to fall out easily.

In spite of many assertions to the contrary, Braun[8] maintains that in autoplastic transplantations, where the conditions are favorable, the entire graft maintains its vitality, whether it comprise the entire thickness of the skin, or the epithelial layers only. Other observers, however, claim that the more superficial layers invariably die and are afterwards regenerated.

Cicatricial Contraction.

That some contraction often goes on beneath any sort of skin graft cannot be denied, especially if granulations have been present and have not been thoroughly removed. This contraction is considerable in the Reverdin method, where the grafts are small and far apart, and it is quite noticeable when strips of skin are not placed near enough

[7] Stransky, Wien. Klin. Woch., 1899, Nos. 2 and 3.
[8] Zent. f. Chir., 1911, No. 29, p. 35.

to each other in the method of Thiersch or of Wolfe. Thiersch contended that contraction is due to the transformation of the upper layer of large, soft granulations into connective tissue, and that the thorough scraping away of these granulations would prevent its occurrence.

Examinations made by Garre and by Goldmann demonstrated that even four to eighteen months after a Thiersch transplantation no cicatricial tissue could be detected beneath the grafts; but this is probably not true in all cases. Since then it has been shown that transplantation can often be made directly on a granulating surface with almost as good a result as if the most thorough curetting had been performed.

It seems probable that septic processes have much to do with cicatricial contraction, and that the prevention of suppuration by the application of new epithelium is a matter of prime importance. The statement of Meyer[9] that Thiersch grafting is always accompanied by marked contraction if the entire thickness of the skin has been lost is not strictly true if the grafts have been placed so as to properly overlap each other, although slight shrinking may often be noticed, especially when a considerable portion of a loose structure, such as the eyelid, has been replaced.

The surfaces even of Wolfe grafts may sometimes become wrinkled in the course of time from contraction beneath. An irregular, brownish pigmentation may also occur, or the graft may remain cyanotic from enlarged vessels. These unusual phenomena cause embarrassment to all concerned, unless the patient has been previously warned.

[9] Deut. Med. Woch., No. 16, 1894.

Exfoliation.

Exfoliation of the epidermis may occur in any form of transplantation, and depends largely upon nutrition, hence the sooner the circulation becomes thoroughly established the sooner will the epithelium cease to scale off. According to Jungengel, a layer of clot of a certain thickness will always cause exfoliation, and if too thick the graft will die. Circulatory disturbances may also give rise to the formation of blisters, which may contain more or less blood. None of these accidents necessarily mean that the transplanted skin will not live, for if the rete Malpighii remain, the lost epithelial covering will soon be reproduced.

Depressions.

A remarkable thing about grafting according to Thiersch and Wolfe is the readiness with which depressions fill up to a level with the surrounding skin. This also depends largely upon nutrition, and is commensurate with it. On the nose a depression as deep as the skin is thick may smooth out in two or three weeks, and on the forehead in from four to six weeks; but in the case of a badly nourished leg a hollow may always remain. When Wolfe grafts project above the skin, as they often do when placed upon granulations, they soon become depressed to the general level.

It is quite evident from the above that definite healing of the new skin does not take place for weeks or even months, and that it should not be too much exposed to injury before considerable time has elapsed.

Production of Epithelium.

It was formerly maintained that the new epithelium appearing between skin grafts, especially in the Reverdin method, was produced directly from the embryonic cells of granulation tissue, by what Gubler has termed catabiotic action. In other words, these cells merely receive a sort of stimulus from the transplanted material, which manifests itself not only in proximity to the grafts, but also at the borders of the ulcer. This idea has been supported by many eminent authorities, including Reverdin, Billroth, Cornil and Ranvier, Rindfleisch, Reclus, and others.

Bryant was among the first to assert the untruthfulness of the theory, basing his opinion upon the fact that a portion of skin which he transplanted from a negro to a white man increased considerably in size. Since then it has been abundantly demonstrated that epithelium is always reproduced from epithelium or endothelium and never from connective tissue or anything else, and that the "islands" of epithelium which occasionally appear near the centers of large granulating surfaces arise either from isolated hair follicles and glands, or from stray epithelial cells which have been accidentally transplanted. The process of cell division (caryocinesis) has been observed and studied in grafts.

Epithelium seems to possess a strong independent vitality which renders it almost parasitic. Other tissues possess this also, but to a far less degree; for, if such were not the case, accidentally severed portions of fingers, ears, and noses could not be replaced, as has been so often done,

and the transplantation of bone, nerves, tendons, brain-tissue, etc., would be impossible.

Independent Longevity of Epithelium.

Martin [10] made a number of experiments to determine the length of time during which grafts could live when separated from the body. The longevity increased with the decline of the temperature, the best results being obtained near the freezing point, when vitality was maintained for 96 hours. The time could be increased to 108 hours, however, by keeping the grafts in a confined space instead of in the open air. An amputated limb, for instance, if kept in a refrigerator, can be used for grafting purposes at least 24 hours after its removal from the body.

It is more than probable that these experiments of Martin do not show the duration of vitality of the grafts so much as they do the time of beginning decomposition under varying circumstances. In other words, if the pieces of epithelium had been maintained in an aseptic condition, vitality might have been greatly if not indefinitely prolonged.

Since the researches of Martin, numerous experiments have demonstrated, clinically and otherwise, that skin grafts may be conserved for varying lengths of time before their transplantation (Thiersch, Minnich, Menzel, Brewer, etc.). Hodgen [11] and Lusk [12] have shown that dried epithelium, even when detached from the body, will retain its vitality, and Lusk [13] was able to preserve such desiccated fragments indefinitely and use them successfully in graft-

[10] Thesis, Paris, 1873.
[11] St. Louis Med. and Surg. Jour., July, 1871.
[12] Med. Rec., Dec. 7, 1895, p. 800.
[13] Internat. Jour. Surg., Feb. 1897, p. 39.

ing. This is not surprising when we remember that no greater enemy to bacterial growth exists than dryness.

The experiment reminds one of the dried grain preserved for so many centuries in the pyramids of Egypt, which, under the influence of heat and moisture, is capable of germination and reproduction. It naturally suggests itself whether the epithelium of a mummy would not do likewise under favorable circumstances.

This independent vitality accounts, to a certain extent, for the comparative readiness with which epithelium may be transplanted, and for the manner in which it grows over, or "floats" out, upon a granulating surface; but we must also recognize an ability to imbibe sufficient nourishment for at least temporary maintenance without direct vascular communication with the underlying tissues.

In this connection another interesting fact, first noticed by Klebs, is the power possessed by epithelial cells to "wander" from the borders of an ulcer out on the granulating surface, which may help to explain the independent islands of skin which sometimes appear.

Epithelial Stimulation.

Undoubtedly the epithelium at the edge of an ulcer is stimulated to renewed growth by the presence of grafts within a reasonable distance, and the grafts also stimulate one another; the greater the number of grafts, and the closer they lie to each other, the greater the stimulation.

This can be accounted for by assuming that growth is inhibited by the presence of bacteria and their poisons, as well as by defective circulation and nutrition. When a graft begins to adhere and develop, it destroys the bacteria

over a certain area and weakens those in its immediate vicinity, besides increasing the flow of nutritive fluids. These phenomena turn the balance in favor of the epithelium as against the germs.

It has been claimed by some [14] that this "stimulation" is greatest shortly following transplantation, and hence better results are obtained in the method of Reverdin by grafting in successive stages and by placing a row of grafts near the margin of the granulating surface at each sitting. There is little evidence, however, to support this assertion.

Grafting From the Negro to the White Man.

Under ordinary circumstances no one would think of transplanting the skin of a negro to a white man, or the reverse; so that the question as to whether or not the skin will retain, under such conditions, its original color is of scientific interest only. The experiment has been tried a number of times (once resulting in a lawsuit), but the reports have been strangely conflicting.

That skin removed from an individual of one race and grafted upon a member of a different race will grow without difficulty was demonstrated by Maurel,[15] who performed many experiments in this line, although Thiersch claims that, while skin from the negro will grow perfectly well upon a white man, white skin will not do well upon the negro. Fowler [16] says that when white skin is transferred to a negro the white color remains.

Bryant [17] records an apparently convincing case in which a number of small pieces of negro's skin were grafted

[14] Charles Steele, Brit. Med. Jour., Dec. 10, 1870.
[15] Gaz. Med., 1878, p. 349.
[16] Ann. Surg., Vol. 9, 1889, p. 179.
[17] Figs. 52 & 53, p. 136, Bryant's Surgery.

upon the leg of a white man. These increased to twenty times their original size within ten weeks, and coalesced to form a comparatively large patch of black cuticle. Hodgen confirmed Bryant's conclusion, when the deeper portions of the epithelium were transplanted, but not when superficial epithelial scales were alone employed. The writer once transferred a portion of black skin from the thigh of a negro to the comparatively white sole of the patient's foot. At the end of about three weeks, when the man was lost sight of, the graft still retained its dark color.

Reverdin, and also Coste, declare that black grafts soon lose their characteristic color upon a white man, from absorption of their pigment; and Maurel, whose experience was large, stated that pigmented grafts must be transplanted to individuals whose skins are rich in pigment if they are to retain their color.

Thiersch, in his investigation of the subject, came to the conclusion that skin of one color when transplanted to individuals of another color always changed its hue. Girdner [18] noticed a gradual transformation from black to white in the skin transplanted from a negro to a white man. Maxwell [19] transferred a small graft from his own arm to the face of a colored man; "from the size of a canary seed, it increased to the extent of about a half inch in its greater dimensions and was of irregular form, with narrow points extending into the surrounding black surface." Presently dark lines appeared in the white skin, and in the course of three months it was as black as the remainder of the negro's countenance.

[18] Med. Rec., Oct. 25, 1890, p. 468.
[19] Phila. Med. Times, Oct. 8, 1873, p. 37.

A study of the subject has been made by Karg,[20] who concluded that white skin gradually became black upon a negro, and *vice versa*. He showed that pigment was carried to and from the epidermis by the phagocytic action of large star-shaped connective-tissue cells lying on the border between the corium and epidermis and that it was finally removed by wandering corpuscles. Karg contended that the pigment was formed in the rete, although Thiersch believed that its formation took place still deeper. Of some value in this connection is the undisputed fact that the skin of frogs when transplanted soon loses its pigmentation and almost becomes transparent.

The majority of testimony seems to indicate that the color of grafts finally changes to that of the skin into which they are transplanted; but this transformation takes place slowly, and may not be completed for many weeks. We should expect the time to vary considerably, as the activity of the pigment cells depends largely upon the nourishment of the epithelium in general. Those who claim that this change does not take place may have reported their cases too soon; and in the absence of evidence to the contrary, we shall have to assume that this is true.

Cheloids.

Occasionally a CHELOID growth springs up between the grafts or around the borders of the transplanted area. This has been particularly mentioned by Murray, Lange, Kammerer, McBurney, and Fowler.[21] Sometimes this is a true cheloid, but more frequently merely redundant cicatricial tissue due to spaces being left between the

[20] Arch. f. Anat. and Phys., 1888; Cent. f. Chir., 1888, p. 944.
[21] N. Y. Med. Jour., Feb. 4, 1893.

grafts, which become the seat of irritating bacterial infection.

McBurney is inclined to hold the dry dressing responsible for these cicatricial overgrowths, and recommends the employment of a moist covering for the grafts for at least two weeks. This idea is scarcely tenable, however, as the same formation often occurs under wet dressings. The causes of true cheloid are not at all clear, but they are probably the same in connection with skin grafting as under other conditions.

Fowler records a case in which he removed from the arm a cheloid which had followed vaccination, and grafted the wound with frog's skin. The growth promptly returned. Two more attempts were made, one with the skin of a chicken and the other with cuticle from the patient's own thigh, but each time the cheloid again made its appearance; and following the last operation a growth of the same nature sprang up in the thigh from which the graft was obtained, which discouraged the operator from further interference.

A peculiar case was observed by Pilcher,[22] in which, as soon as the patient got out of bed following a transplantation, an eruption resembling purpura, eventually forming blisters, appeared, not only upon the grafts but upon the surface from which they were obtained. As soon as the bed was resumed, the eruption disappeared, but developed a second time when the patient attempted to walk about.

Intense itching occasionally appears after a few days at the seat of a transplantation, which can often be relieved by massage.[23]

[22] N. Y. Med. Jour., Feb. 4, 1893.
[23] Garré, Brit. Med. Jour., Mar. 9, 1889, p. 560.

An epithelioma was seen by Dunham [24] on the leg of a woman of 53, following Reverdin grafting of an old ulcer. Such an isolated case signifies little, however, as epitheliomata occasionally develop in crural ulcers where no transplantation has been attempted.

[24] Med. Rec., Aug. 3, 1895, p. 170.

CHAPTER XII

BRIEF COMPARISON OF DIFFERENT METHODS OF SKIN GRAFTING

The simplest of all is the METHOD OF REVERDIN. It is easy of execution, causes but little pain, and is but slightly suggestive of a dreaded "operation"; but the results are not always satisfactory. The new epidermis is often but little better than ordinary scar tissue, having a marked tendency to contraction, and breaking down under comparatively slight provocation. This is particularly true when the grafts are small, thin, and far apart. If, on the other hand, they are too thick, the new skin will be more or less "hummocky" on its surface. In addition, the alternation of the darker grafts with the lighter intervening cicatricial areas often produces a mosaic appearance which is sometimes quite objectionable. Movability is seldom obtained, because the epidermis is bound down by connective tissue between the grafts and cannot be loosened by massage.

Hence transplantation according to Reverdin should be reserved for cases in which for some reason it is inexpedient to employ another method, and where the rapid closure of a granulating surface is desired without much reference to anything else. Examples of such instances are: (1) When the patient refuses to have the skin removed from his own person, and it becomes necessary to procure it from another individual; it can then be snipped out in

small pieces where a more extensive operation would be refused. (2) When, after the different operations with their several advantages have been explained, the patient chooses the method in question on account of its comparatively trivial nature. (3) When, in very old or weak or nervous people, a general or a local anesthetic would be undesirable.

Much of course depends upon the situation of the lesion and its nature. A loss of tissue upon the face naturally requires more consideration for cosmetic reasons than an ulcer of the leg, and the chance of embarrassing contractures about the joints and neck must be avoided even at the expense of much inconvenience and some danger. Under the various circumstances just mentioned, one may resort to dead bodies, preferably those of infants, or to amputated limbs; or obtain the necessary material from a case of circumcision, or from the skin of some animal. And just here is where a real use may be found for epidermis obtained from warts, corns, callosities, blisters, etc., and for "epidermal dust," although we must not expect the results to be very brilliant.

THIERSCH GRAFTING has a wider range of applicability than any other method, and its results are quite uniformly good, both functionally and cosmetically, and yet it must give way to other proceedings under certain conditions, where firmer and thicker skin is desirable which more closely resembles the surrounding integument.

In such cases the WOLFE-KRAUSE METHOD should be chosen. This is particularly true upon the palms of the hands, the soles of the feet, the eyelids, and possibly about the face in general, although Thiersch grafts answer the

purpose fairly well in the last-named situation. The thicker grafts, when they can be made to unite, undoubtedly furnish a more durable covering for old leg ulcers, especially of the varicose variety, and to parts about the joints.

The transplantation of hairs can be accomplished only by taking the entire thickness of the skin, and even then the result is apt to be unsatisfactory.

It is seldom desirable to employ grafts comprising the subcutaneous fat, as recommended by Hirschberg.

The skin of animals does not compare in vitality with that derived from the patient's own body or from some other person, and just where its employment would be most serviceable—on the leg ulcers of old people, for instance—it is next to useless.

Mucous membrane, from animals and from man, can be used to repair defects in the urethra, vagina, etc., and the conjunctiva of rabbits makes an excellent substitute for that membrane in the human species; but it has been sufficiently well shown that Thiersch grafts and skin flaps will often answer the same purpose,[1] while they are more easily obtained, are much more likely to be successful, and they can be kept more nearly aseptic. If cutaneous grafts do not actually become transformed into mucosa, they at least come, in the course of time, to resemble it closely. Even in the urethra, skin flaps and Thiersch grafts have been used, although with the former epithelial exfoliation is apt to lead to subsequent annoyance.

In the transplanting of skin and of mucous membrane, it must always be borne in mind that heterogeneous graft-

[1] Witzel, Cent. f. Chir., No. 45, 1890.

ing is much less likely to succeed than autogenous, hence the material should always be obtained from the patient himself if possible.

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