

SKIN GRAFTING

In The Dog

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THERE are several histological factors which have made skin grafting possible in man and animals. First, the comparative ease which epithelium can regenerate is a factor. This new growth of tissue occurs either from the periphery of a wound or it may result from proliferation of the external root sheath of the hair follicles providing the dermis has not been completely destroyed. Another feature of skin is that its constituent cells may be kept alive for several days by means of the tissue fluid from below the graft by the process of osmosis. This affords sufficient time for new vessels to be formed which will then nourish the skin. Also, the ability of the capillaries to proliferate and then anastomose with those of the graft make this feat possible. It is only because of these physiological processes that this type of surgery is successful.

According to Neuhof¹, the first attempts at skin grafting were made centuries ago by some members of the tile makers' caste in India. They used pedunculated skin flaps from the forehead and cheek to reconstruct the nose. The use of this type of graft has since been called the Indian method of rhinoplasty. In 1597 Gaspar Tagliocozzi modified the method of rhinoplasty so as to transplant the skin from

the arm instead of from the forehead. This technique is now known as the Italian method of rhinoplasty. Free skin grafting started early in the 19th century by two charlatans which is related by Baroni, the physiologist, "A woman named Gamba Curat, in order to show the efficiency of an ointment she was selling, cut a piece of skin from her thigh and after passing it around for inspection, replaced it in its original bed, and dressed the area with the ointment. The next evening the graft was so far healed that no further dressing was necessary. The second charlatan also sold an ointment described as a cure for all ills and named by him 'The ointment of the French Army'. He cut a large piece of skin, including some of the underlying muscle, from his forearm and after holding it up for the spectators to see, replaced it, and dressed the wound with his ointment. Eight days later he exhibited his arm, and the scar of the wound could scarcely be seen." This incident suggested to Baroni a series of experiments with autografts on the sheep. Maltz² relates in his book, "Evolution of Plastic Surgery" that Giusepp Baroni, in 1804 "carried out a series of successful experiments on animals (mainly sheep) transplanting pieces of skin 12.5 by 7.5 cm. In his initial experiment, two whole thickness portions of skin of equal size and devoid of subcutaneous tissue were removed from the

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sides of the root of the tail of a sheep. The pieces were transferred directly to the opposite sides. In his second experiment along similar lines, the pieces of skin were placed after an interval of eighteen minutes. In his third experiment Baroni procured a larger piece of skin (5 by 5 inches) including the subjacent tissue and a small muscle fragment. These were not transplanted for an hour."

Davis³ in an editorial entitled "The Nomenclature of Skin Grafting", lists and defines the four skin grafts commonly used today. His definition of a graft might also be quoted: "A mass of tissue cut free to be transplanted where desired which receives its blood supply from the surface on which it is placed." Thus he has reference to free skin grafts when he enumerates the following type of grafts: (1) Reverdin graft or "pinch graft" which are 3-5 mm in diameter and consist of the epidermis and a very small amount of the dermis, (2) small deep graft which is about the same size as the Reverdin, but includes almost the entire thickness of the corium at least in the center, (3) Wolfe-Krause or the whole thickness graft which includes the entire skin and (4) the Ollier Thiersch or "split thickness graft" which consists of the epidermis and only a portion of the dermis.

The pedicle or flap is another type of plastic surgery. In this type of graft, the skin is attached at some portion of its periphery or base by a pedicle through which it receives its blood supply. This graft can be shifted only so far as its pedicle will allow.

Each type of graft has its indications although there are times when one of several could be used with nearly equal results. The Reverdin or "pinch graft" and the small deep graft can be used under similar conditions. These are small pieces of skin 3-5 mm. in diameter which are seeded on a recipient area. The advantage of this method is that a small donor area will go a long way to seed an area as the grafts are placed about 3-5 mm. apart. Epithelization occurs from these seeded areas and eventually covers the area. The grafts are small and hence a better chance of "takes" as they would

be more likely to receive a blood supply. Another advantage of this graft is that the donor area doesn't have to be re-grafted as the small pieces of skin are removed so that intact skin remains between each donor site so that epithelization from the periphery of the intact skin will close the wound. The disadvantage of this type of graft is that the cosmetic appearance results in a "spotted" or "pitted" area, both on the recipient and the donor areas. Another fault is that the donor site cannot be re-used for further grafts due to the appearance it has when healed. Probably in the dog this would not be as serious a fault as in the human.

The whole-thickness or Wolfe-Krause graft is the ideal graft in many respects as it contains the entire skin layers. Advantages of this graft are: that it shrinks less when healing than the other types; it affords more resistance to trauma than any of the other three methods, as a good deposit of subcutaneous tissue will form underneath this graft; it also has an advantage in that it can be used to graft hairy areas, as most of the hair follicles are viable after transplanting. Disadvantages of this graft are several: (1) It is very susceptible to infection and can not be used on infected or even granulating wounds (the latter is true in the human at least), (2) it is more difficult to get satisfactory "takes" due to the thickness of the skin and the establishment of a satisfactory blood supply, and (3) the donor site must be re-grafted or else the skin shifted to cover the area from which it was donated.

The split thickness or Ollier-Thiersch graft consists of the epidermis and a portion of the dermis, but enough of the dermis remains so that epithelization occurs at the donor site. This type of graft is usually obtained from the abdomen and medial aspects of the thigh. Dermatomes or mechanical cutting instruments are usually used to cut this skin for grafting although it can be done free-hand. The advantages are several: (1) The graft is thin and is less likely to die from lack of nutrition during the first few days after transplanting, and (2) the donor area regenerates by itself; in fact, in the hu-

man some areas have been used 4-5 times at intervals of 4-5 weeks. Several disadvantages, however, limit the use of this graft. The cosmetic appearance is not as good as that of the full thickness graft as there is some shrinkage. In our experimental work on dogs we have been cutting the grafts at .030 inches and find that shrinkage is not excessive. The graft will be dry and desquamate for several months during which time it will have to be softened with lotions. Due to it being rather thin, it does not resist trauma very well. A fatty cushion does not develop underneath this type of transplant. Hair will not grow from this type of graft. However, if the skin lesion resulted in destruction of the hair follicles, there would be no hair growth under the normal epithelization process which would occur from the wound edges. Besides, this normal process would result in a much longer recovery time varying from several weeks to months depending on the size of the denuded area.

The pedicle graft in the human is used primarily in reconstructive surgery such as replacing an ear, nose, lower jaw, cheek and the like. In the dog it has excellent application for lesions of the lower extremities where a graft can be reflected from the medial aspects of the leg and eventually grafted in an area such as a granulomatous lesion of the metatarsal region which has failed to heal. It is the graft most likely to "take" as it always has a blood supply from one of its ends. It will also grow on slightly contaminated areas which is not true of the other types of grafts. It does have its limitations as only a limited amount of skin can be removed from a given area at one time. Since the skin removed from the area is full thickness, the donor area must either be undermined and shifted together, if possible, or the denuded area covered with a split thickness graft from another part of the body. Another feature of this graft is that it affords a "padding" to the area as the transplant is full thickness and hence allows for good deposit of fat and connective tissue underneath which does not occur with a split thickness transplant. Also, hair continues to

grow from a graft of this nature as hair follicles are not easily destroyed during this transfer.

Just what occurs after a graft has been transplanted on a recipient area was studied by Davis and Traut⁴ who were interested in whether vessels of the graft anastomosed with those of the grafted area; whether capillaries of the grafted area grew into the graft by extending into the old vessels of the graft or whether capillary up-growth from the grafted areas penetrated the connective tissue of the transplant and thus established a blood supply. This work was done on dogs in which they removed grafts 3 cm. long by 1½ cm. wide, sutured skin to muscle and then closed the wound edges over the graft to apply pressure. They found that a fibrin network was formed in just a few hours. During the next 24 hours there was migration of round cells and wandering cells from the graft bed in the fibrin and then into the graft. These cells found their way into the connective tissue stroma and all parts of the corium but not in the epidermis. During the same 24 hours there was a development of highly vascular granular tissue which replaces the fibrin network. As a result, the graft rests on rich newly formed capillaries transporting blood 18-24 hours after transplantation. There are some degenerative changes also. The epidermis sloughs down to the Malpighian layer.

The endothelium of the blood vessels degenerate except in an occasional area. Hair and sebaceous glands are affected very little. The degenerative process occurs up to 7-8 days which seems to be the turning point since the first vascularization reaches all of the parts at this time. The first blood supply forms by anastomosis of vessels of the granulation tissue to those of the graft. Davis and Traut found that the first blood supply takes place in this way as early as 22-72 hours. The second means of blood supply is slower, according to these authors, but a more voluminous blood supply forms by the upward growth of capillaries of granulating tissue, develops loops and penetrates the connective tissue of the corium. Probably most of the vascularization

forms in these ways. Invading loops reach the Malpighian layer by the 12th day. They are more numerous than in normal skin and are less numerous in older grafts so some must degenerate.

The third means found by Davis and Traut was by the sprouting capillaries in granulating tissue. The capillary finds its way inside the old vessel of the graft and grows rapidly due to less resistance than found in the connective tissue stroma. They found that this only occurs occasionally and that large vessels of the graft are usually absorbed after transplantation. Davis and Traut found that the earliest time in which circulation in the graft was demonstrated was at the end of 22 hours. They stated that adequate circulation was not established until the end of the eighth day. During the interum the graft is nourished by a plasmatic circulation and by early anastomosis of small capillaries.

Very little literature is available concerning skin grafting in the dog and cat. Self⁵ in 1934 reported the use of small pin point grafts on five dogs in which he reported the results as being successful. Keefe⁶ reported a skin graft in the cat which was partially successful.

It is my opinion that skin grafting in the dog has possibilities. Because of the relative loose skin of the dog in the regions of the neck, thorax, flanks and lumbar region, skin grafting would seldom be indicated in these areas. Undermining of the skin and skin shifting usually would suffice unless the wound should be exceptionally large. However, the skin of the legs is not very loose and as a result, a wound in this area of several centimeters is rather difficult to close even by shifting of the skin. The area of the face is another location in which surplus skin would be hard to obtain. "Pentobarbital sloughs" as well as from other irritating drugs being accidentally given perivascularly produce ugly looking wounds for weeks. The removal of tumors from the leg of a dog often results in insufficient skin to bring the wound edges into apposition. It is in these cases that skin grafting would be indicated. Because of the scarcity of literature on the subject



Fig. 1. Delayed pedicle graft 7 days post-operatively.

and the desire to know how effective skin grafting would be when applied to the dog, this study was undertaken.

I have found the use of the delayed pedicle graft very successful in 13 out of 14 cases in which it has been used. Twelve of these successful cases were on experimental dogs and one on a clinical case. This work has been done in the metatarsal region where skin coverage is sometimes a problem. A pedicle or tube was formed on the medial aspect of the tibia by making two parallel longitudinal incisions about one inch apart leaving the skin attached on both ends and elevating this strip of skin from the subcutaneous tissue. This skin was then formed into a tube by placing interrupted sutures of 4-0 braided silk in the skin margins and reflecting the skin edges so they were in apposition to each other, thus forming a tube or pedicle. The area from which the

tube was raised was closed by shifting of the adjacent skin so that the denuded area was covered with skin. Interrupted sutures of medium Vetafil were used. It is surprising to what extent skin can be shifted in this area. The tube was allowed to heal for two or more weeks before further surgery was performed. This method is known as the "delayed pedicle graft" as it allows time for a sufficient blood supply to develop in the tube so that it will be better able to nourish the new graft when it is transplanted. The length of the tube should not exceed three times its width, or necrosis of the pedicle might occur. In order to obtain a better blood supply for the skin which is to be transplanted it is advisable to incise the skin beyond the tube along its lateral margins commensurate with the size of the graft needed. Resuture this skin with interrupted sutures of 4-0 silk. This procedure has a tendency to increase the blood supply to the skin which is to be transplanted.

The recipient area must be free of infection and possess a bed of healthy granulation tissue when used to cover chronic skin lesions. After two or more weeks the tube plus the desired amount of skin needed to cover the recipient area is removed and the tube reflected downward so that it will be at the proximal margin of the recipient area and the un-tubed skin extending over the area to be grafted. Interrupted stitches of 4-0 silk are used. The tension of the skin on the grafted area should be that of normal skin. Several layers of sterile Telfa bandages (Bauer & Black) are placed over the graft due to their non-adhesive properties. Several layers of sterile 3x3 gauze sponges are then applied followed by a layer of cotton surrounding the entire foot. A 2-inch roller gauge bandage is then applied followed by adhesive tape. The toe is allowed to protrude through the bandage. A two inch stockinet is used to protect the tube from injury. The bandage is changed in three days and then every other day until the 8-10th day when no bandaging is required. The pedicle furnishing the blood supply to the new graft may be severed in 10-14 days. With

this technique the hair which grows from the graft will be in the wrong direction. Keeping the hair which grows in the area trimmed to correspond to that of the surrounding area would add to the cosmetic appearance of the graft. The graft area is soft, pliable and resists trauma just as well as the surrounding skin.

Figure 1 shows a "delayed pedicle graft" in place for seven days. This graft was used clinically to cover an area in which the soft tissue was completely denuded so as to expose the metatarsal bones as a result of an automobile injury. Near the distal end there is a little area in which the superficial layer of skin is necrotic. It is doubtful whether all of the layers are involved.



Fig. 2. Two pedicle type grafts 4 and one-half months post-operatively.

Figure 2 shows two pedicle grafts on an experimental dog. The tubes have been removed and the grafts have taken 100 per cent. The grafts have been in place for 4½ months. Cosmetic appearance and function are excellent. Delayed pedicle grafts of this type can usually result in 95-100 per cent "takes" when properly executed.

Figure 3 shows a split thickness graft on an experimental dog. The skin was

removed with a Brown Dermatome (Zimmer Mfg. Co., Warsaw, Indiana) at a thickness of .030. The remaining dermis was removed with a scalpel and then the skin graft replaced over the denuded area. Continuous sutures were used to bring the edges into apposition. Three strips of skin were used to cover the area. Polyotic mastitis ointment (Lederle) was applied to the skin edges. Several layers of sterile Telfa were applied followed by 3 to 4 layers of 4x4 sponges. A 3-inch Tensor Elastic Bandage (Bauer & Black) was placed over the area and continued around the thorax of the dog to apply pressure to the grafted area. A 3-inch roller gauze bandage was then applied followed by 2-inch tape to hold the

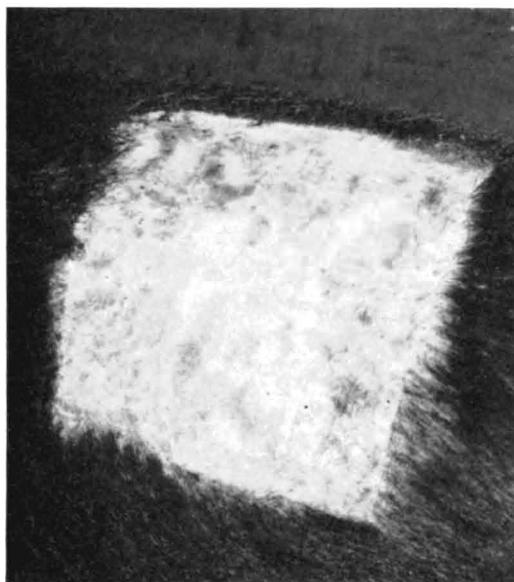


Fig. 3. Split thickness graft in the thoracolumbar region 0.030 inch thick.

bandages in place. The graft was checked in 4 days and rebandaged every third day until the tenth day. The area was rather dry following the tenth day so Moruguent ointment (Massengill) was applied daily for about two weeks. There was some exfoliation of the epithelium during this period which is normal for a graft of this type. This picture was taken 42 days postoperatively and shows a good coverage of the skin which would

be satisfactory in this particular area. This type of graft would have better chances of taking if it were applied to a granulating area which we haven't done in the four cases in which it has been done experimentally.

Free transplantation of full thickness skin grafts have also been attempted using grafts 2x2 inches in size from the thorax. The percentage of "takes" has been very poor probably due to the large size of the graft and the difficulty encountered in removing all of the subcutaneous tissue from the graft prior to transplantation. It is also more difficult to obtain a sufficient blood supply when the graft is of full thickness. Bandaging and restraint are also a problem which make this type of graft very difficult. It is also more susceptible to infection than either the pedicle or the split thickness, so in the dog this is an important factor to consider. Recently we have attempted full thickness grafts on the metatarsal region of the foot, using the medial aspect of the thigh for the donor region. The size of the grafts have averaged 1 and one-half inches long by three-fourths inches wide. To date we have done three with 100 percent "takes." This apparent success is probably due to the fact that we are having less trouble in securing skin free from subcutaneous tissue from the region of the thigh which was more difficult when obtaining it from the thorax due to the large deposit of fat under the skin in that particular region.

From the experimental work which we have done thus far, it appears that the pedicle graft and the split thickness graft are the transplants of choice to use in skin grafting in the dog. Recent research, however, seems to indicate that the free full thickness graft will be successful to cover relatively small denuded areas which are free from infection and in areas where a pressure bandage can be held intact for sufficient time for the grafts to "take."

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Curriculum Committee

Progress Report

THE MACROSCOPIC TUBE-AG-GLUTINATION TEST FOR LEPTOSPIROSIS. Advance in knowledge in the field of leptospirosis is closely correlated with methods of serological testing. Determination of the disease depends on accurate and simplified methods of detecting presence of leptospiral antibodies in serums.

Of the three general types of serological tests which have been developed, none are suitable as an agglutination test which is practical for laboratories not specializing in leptospiral research.

Leptospira pomona, *Leptospira canicola*, and *Leptospira icterohemorrhagiae* organisms were propagated in culture media and formalized when maximum growth had been obtained. In performing the test, ten-fold dilutions of the serum in saline were mixed with the appropriate antigens and incubated. A grossly visible floccule in the bottom of the cone-shaped tubes denoted a positive reaction.

The test was highly specific for leptospiral infections. Serums containing antibodies of various bovine, porcine and canine diseases failed to agglutinate leptospiral antigens. The test compared favorably with the classic agglutination-lysis test.

Howarth, J. A., D.V.M., Ph.D. *American Journal of Veterinary Research*, 17:789-792. (October) 1956.

Cows are less tolerant to heat than man because of their inability to shed heat by perspiring.

There are 800 dressed animal carcasses inspected each hour of an 8-hour work day by the meat inspection service.

THE MEMBERS of the student curriculum committee wish to thank all those who spent the necessary time and effort on the questionnaire to contribute a valuable opinion. Response to questionnaires sent to recent graduates has now exceeded 20 percent, which demonstrates a gratifying degree of interest in the curriculum by those no longer directly affected by it.

As you recall, the student curriculum committee is an undergraduate group charged by the ISC Student Chapter of the American Veterinary Medical Association with the responsibility of obtaining, studying and approving suggestions for improvement of the curriculum made by the students of the division. These suggestions are then to be submitted to the faculty curriculum committee.

This year we have attempted, by use of the questionnaire, to obtain a complete and accurate student opinion and to compare it with a cross-section of alumni opinion.

Our current report to the faculty committee includes suggestions which were quite uniformly favored by those answering the questionnaire—both students and alumni.

The student committee presently is meeting with the staff of each of the departments to discuss those recommendations which apply. It is hoped that the joint discussion of the curriculum by the faculty and student committee will strengthen our course of study which is now one of the best in the country.

—Dean Thackery '57