

PECULIARITIES OF FREE SKIN GRAFTING IN ANIMALS

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Among the numerous methods of plastic surgery, free grafting of partial layer transplants is of fundamental importance

In man, partial transplants of $1/3$, $2/3$, and $3/4$, the skin thickness "take" well, give a full value skin integument, and in sections from which they are taken, regeneration of the epidermis takes place [5, 7, 8, 9, 10].

Regeneration of the epidermis at the site of excision is effected in man simultaneously over the entire lesion surface on account of the residual epidermogenic elements in the intersected hair sheaths and the excretory ducts of the skin glands. This ensures rapid (2-3 weeks) epidermization of extensive lesions at the site of excision of the transplants and is an important advantage in the method of free grafting.

In studying the particular features of skin grafting, we noted that in horses and cattle, at the site of excision of flaps of $2/3$, $3/4$, and in a number of cases, $1/3$ of the skin thickness, epidermization does not proceed simultaneously over the entire lesion surface. The epidermis grows only in the form of a rim surrounding the lesion. For the purpose of checking and clarifying the causes of this phenomenon we conducted a series of experiments.

EXPERIMENTAL METHOD

From the body of a horse and cattle, flaps $1/3$, $2/3$, and $3/4$, of the skin thickness were excised by means of a dermatome and observations were made on the healing of the lesions formed.

The skin thickness at the site of excision of the transplant was determined by a micrometer according to the specimen of skin at the site of the planned excision of the transplant. The thickness of the excised flap was fixed according to the divisions of the dermatome and subsequently confirmed by a micrometer after excision. Histological examinations of the specimens of the transplanted cutaneous flap and specimens cut from the skin layer remaining at the site of excision of the transplanted flap were also made. The cutaneous specimens were placed in gelatine and celluloid and stained with hematoxylin and eosin.

RESULTS

The results of the observations are set out in the table. The data in the table show that at the site of a cut of $2/3$, $1/2$, in a number of cases, and $1/3$, of the skin thickness in horses and cattle a lesion is formed differing from the same type of lesion in man in the absence of epidermogenic elements. Its epidermization in the region of the shoulder-head muscle and the thorax takes place only on account of the epidermis of surrounding skin.

The healing of large lesions, for example, over 90-100 cm² lasted for several months and was accompanied by formation of ulcers, which in the end made it necessary to excise the remnants of the skin up to the subcutaneous cellular tissue and to mobilize the surrounding skin and suture the wound. The absence of regeneration of the epidermis simultaneously over the entire lesion surface at the site of excision of thick partial-layer cutaneous flaps in horses and cattle may be attributed to the peculiarities of the histological structure of the skin of these animals.

In human skin the carriers of the epidermogenic elements (hair follicles, excretory ducts of the sweat glands of the hairy skin) lie deep, in the reticular layer, not infrequently at the border with the subcutaneous cellular tissue. If 1/2, 2/3, and even 3/4, of the skin thickness is excised, at the site of excision a certain number of epidermogenic elements maintain themselves, ensuring rapid (in the course of 2-3 weeks) restoration of the epidermis.

The structure of the skin specimens which we excised from the experimental horses and cows corresponded to the histological picture of the cutaneous integument of horses and cattle described by A. F. Klimov [4], A. A. Braun [1], A. E. Efimov [3]. The skin thickness in horses varies from 1.5-6 mm depending on the part of the body, season and breed. According to A. E. Efimov, the horse epidermis consists of the corneous layer, weakly marked granulated and well marked germinative layers; a lucid layer is absent. The thickness of the epidermis varies from 15-27, 15 before clipping and 24 after it.

The cutis propria in horses is clearly subdivided into pilary and reticular layers. The pilary layer corresponds to the papillary layer and lies directly under the epidermis. In it are located the roots of hairs, sebaceous and sweat glands. The pilary layer is separated from the epidermis by the basement membrane and from the reticular layer by a line running under the hair bulbs. The thickness of the pilary layer varies according to season, for example from 670 μ before clipping to 1800 μ after. The reticular layer contains a large number of thick clusters of collagenic fibers, its greater part being free from hair sacs, sebaceous and sweat glands. The sebaceous glands lie in the upper half of the pilary layer and the sweat glands on the line of the hair bulbs and somewhat deeper.

In cattle the cutis propria is also clearly subdivided into pilary and reticular layers. The pilary layer is finer than in the horse.

If the thickness of the various layers of the skin in horses and cattle are expressed in fraction of the skin thickness one finds that the epidermis amounts approximately to 1/200 - 1/50; the pilary layer 1/7-1/2; the reticular layer to 1/2 - 7/8 of the skin thickness.

As can be seen from the above description of the histological structure of the skin of horse and cattle, the epidermogenic elements are stratified more superficially than in human skin and cannot remain at the site of excisions of 3/4, 1/2, and in some cases 1/3, of the skin thickness, which is confirmed in our table.

The absence of regeneration of the epidermis simultaneously over the whole surface of the lesion at the site of excision of thick partial-layer cutaneous flaps does not make them any less valuable for use in grafting in animals with relative superficial stratification of the epidermogenic cutaneous elements, for example, in horses and cattle.

S. P. Mamadishsky [6] successfully grafted complete-layer cutaneous flaps, without the subcutaneous cellular tissue, in horses and dogs, and V. K. Voskresensky [2] in goats. Alongside proof of successful "taking" of complete-layer autotransplants of skin, these investigators noted defects similar to the defects in grafting of complete-layer cutaneous flaps in man: necrosis of the epidermogenic surface of the transplant, tearing away in the form of rind; frequent cases of partial and even complete necrosis of the transplants, especially in grafting on a granulating surface; the necessity for operational closing of the wounds forming at the site of excision of the transplant.

We conducted in horses a series of autotransplants of partial and complete-layer cutaneous flaps without subcutaneous cellular tissue. The pilary layer with a fine film of reticular layer deeper than the line of stratification of the hair bulbs formed part of the thick partial-layer cutaneous flaps. The subcutaneous cellular tissue and almost the entire reticular layer were removed. We called such flaps "thick epidermopilary transplants" (Fig. 1). The thickness of the thick epidermopilary transplants was from 0.9 to 1.5 mm (1/2, 1/3, and 1/4 total skin

Healing of Lesions at Site of Excision of Skin Flaps

Animals	Site of excision of cutaneous flaps	Number of cases	Total thickness of skin at site of cut in mm	Thickness of flap cut in mm	Area of cut in cm ²	Description of healing
thick epidermopilar transplants						
Horses	region of shoulder-head muscle	5	1.7-2.5	1.0-1.4	90-100	Epidermization in the form of a rim due solely to the surrounding epidermis of the undamaged skin
		4	1.8-2.2	0.9-1.0	40-50	
		3	1.8-2.3	0.7-1.1	18-20	
	lateral surface of thorax	8	2.4-3.2	1.2-1.5	20-30	Concentric scarring not expressed
		5	2.5-3.0	1.2-1.5	50-60	
		2	2.6-3.1	1.2	100	
		1	3.2	1.4	250	
Cattle (bulls and cows)	Back	4	4.1-4.4	1.5-2.2	20-25	Lesions approximating in form to a square of 90-100 cm ² and more are transformed into ulcers. Microscopy of the specimens taken from the skin remnants at the site of the cut showed absence in them of remnants of hair sacs and cutaneous glands.
	Region of shoulder-head muscle	3	3.4-3.8	1.6-2.0	30-40	
		2	3.6	1.6-1.8	90-110	
	upper part of lateral surface of thorax	4	4.3-4.7	1.6-2.2	40-50	
		1	4.4	1.8	90	
thin epidermopilar transplants						
Horses	region of shoulder-head muscle	11	1.7-2.5	0.2-0.30	90-150	Epidermization occurs simultaneously over the entire surface of the cut. The epidermis covers the lesion in the course of 2-3 weeks. Hair grows.
	lateral surface of thorax	21	2.4-3.2	0.2-0.35	90-150	
Cattle	region of upper part of thorax	11	4.3-4.7	0.3-0.35	100-150	Upon microscopy of skin specimen taken from the skin remnants at the site of the cut, intersected hair sacs and skin glands are visible.

thickness) in relation to the region of the body, state, and age of animal. In the complete-layer flaps only the subcutaneous cellular tissue was removed with complete maintenance of the reticular layer.

A total of 22 thick epidermopilary and 5 complete-layer transplants without the subcutaneous cellular tissue were grafted.

The area of the thick epidermopilary transplants varied: 8 cm² in 4; 40-60; cm² in 10; 80-90 cm² in 2; 120-140; cm² in 4; 190 cm² in 1; 320 cm² in 1. Of them 17 transplants completely "took", three (an area of 40-60; cm²) partially "took", and two flaps (8 cm² and 40 cm²) did not "take" and tore themselves away.

The 17 transplants which "took" showed slight exfoliation of the surface of the epidermis. On the 17-18th day of grafting we noted growth of hair sparser than the hair on the surrounding skin. On the 20-25th day the transplanted cutaneous flap could be gripped in an elastic fold.

In three horses we traced the state of the transplants for two years. The grafted cutaneous flaps maintained elasticity and growth of hair. During clipping the hairs on the transplants fell out and grew again.

The area of complete layer transplants was equal to 12-14 cm². Of the 5 transplants, 2 "took" completely, 1 partially, and 2 did not "take".

The clinical picture of the "take" of the complete-layer cutaneous flaps corresponded to that described by S. P. Mamadishsky. The epidermis tore itself away in the form of thick scales in the course of 2-3 weeks, and sparse hair grew towards the 5-6th month after grafting.

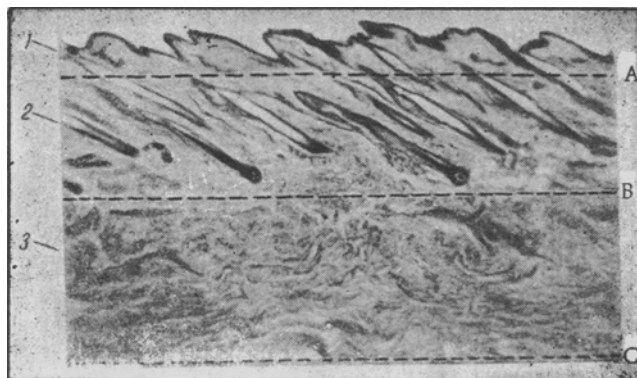


Fig. 1. Lines of cuts of skin transplants in horses.

1) epidermis, 2) pilary layer, 3) reticular layer; A) level of cut of thin epidermopilary transplant, B) level of cut of thick epidermopilary transplant, C) level of complete layer transplant without subcutaneous cellular tissue.

The superior "take" of epidermopilary transplants compared with complete-layer ones and maintenance of growth of hair on the thick epidermopilary transplants, shows that removal of a considerable part of the reticular layer of the horse skin does not disturb the basic dermogenic elements, and probably improves the nutrition of the transplant as a result of removal of the connective tissue stratum situated at the path of the plasmatic impregnation of the transplant, and of the intergrowth of the vessels and nerves.

We also observed successful "takes" of the thick epidermopilary transplants in dogs. The transplants gave an elastic skin on which grew a thick hairy integument (Fig. 2).

In the horses and cattle it was possible to cut such cutaneous flaps at the site of excision in which a rapid (in the course of 2-3 weeks) restoration of epidermis and hair takes place. These flaps, 0.2-0.35 mm in thickness included the epidermis and a fine film of pilary layer cut along the line of the location of the sebaceous glands (see Fig. 1). The description "fine epidermopilary transplants" fits them. In essence these were cutaneous transplants according to Thiersch [11].

In the table, 33 cases of restoration of the epidermis and hair at the site of excision of the fine epidermopilary transplant in horses, and 11 cases in cattle are presented.

The fine epidermopilary transplants, as is peculiar to the flaps according to Thiersch, are viable and adapt themselves well. In 7 cases out of 8 we observed successful adaptation on fresh injured and healthy granulating body surfaces in horses.

The cutaneous integument forming at the site of the grafting of the fine epidermopilary transplants was less resistant to the pressure of the saddle and pad than the cutaneous integuments forming at the site of grafting of thick epidermopilary transplants.



Fig. 2. Showing the "take" of thick epidermopilary transplant in dog 3 months after operation.

The thickness of skin and its layers fluctuates in the animals according to age, region of the body, breed, season, and state of the animal. Therefore upon determination of the thickness of the transplant it is not possible to proceed from constant indices expressed in fractions of skin thickness or in millimeters of thickness of the transplant. It is more correct to determine and designate the thickness of the transplant individually for each case of grafting according to the skin layers included in the thickness of the transplant.

The skin of horses, cattle, dogs, and other domestic animals is covered for almost the entire body surface by a thick hairy integument, in the majority of cases it is pigmented and in it, it is possible, even with the naked eye, to find the borders between the pilary and reticular layer, the reticular layer and the subcutaneous cellular tissue. These peculiarities of structure of the skin make it easier to determine the thickness of the transplant cut by external signs.

We determined the depth of stratification of the line of cut of the transplant by preliminary inspection of the excised skin specimen enlarged four times under a magnifying glass.

Upon cutting of the transplant the line of cut was controlled by the appearance of the surface of the cut and the character of the hemorrhage. Upon cutting of a thick epidermopilary transplant, the razor blade goes deeper than the level of stratification of the hair bulbs, which is clearly perceptible under the magnifying glass, but without damaging them. The surface of the cut is bright gray and is quickly covered with blood.

Cutting of the fine epidermopilary transplant is accompanied by an insignificant capillary hemorrhage. On the cut surface, strands of intersected hair are visible and pigmentation of the given skin is maintained.

The described peculiarities of skin transplantation in animals are a law-governed consequence of their anatomo-physiological differences and naturally, must be taken into consideration in experimental observations, both clinically on animals and in comparing them with the results of clinical observations in human beings.

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