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DIFFERENCES IN REGENERATION OF THE SKIN IN DIFFERENT SPECIES OF MAMMALS

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The healing of full-thickness skin wounds measuring 1.2 cm^2 was studied in mink and sable. In both species of animals the skin defect closed mainly through contraction of the wound. Hairs and sebaceous glands were found in the small area of regenerating skin formed in the center of the primary defect. It is postulated that these hairs developed from bulbs of "old" hairs which migrated into the regenerating zone together with the lower layers of the dermis adjacent to the wound.

KEY WORDS: contraction of skin wounds; regeneration of skin; sable; mink.

Regeneration of the skin in mammals consists of the following series of regenerative processes: epithelization of the wound defect, the formation of young connective tissue and its reorganization, contraction of the wound, and intercalated growth of the skin around the wound. The role of these processes in regeneration of the skin depends on the site of injury and the species of animal. For instance, the closure of full-thickness skin defects in parts of the mammalian body covered with relatively mobile skin takes place mainly through contraction of the wound [5]. Consequently, intact skin moves into the defect and a very small zone of regeneration is formed from the young tissues in the center of the defect. The focus of regeneration may consist of a connective-tissue scar covered with young epithelium, or skin of atypical structure in which, in some cases, hairs and glands can be found [1, 2, 5, 7, 8]. The origin of the hairs and glands found in regenerating skin differs: these structures may develop from "old" hairs and glands injured during the operation or carried in by contraction of the wound together with individual layers of dermis adjacent to the wound [5, 9]. Finally, hairs and glands may be formed *de novo* from intrusions of the regenerating epithelium into

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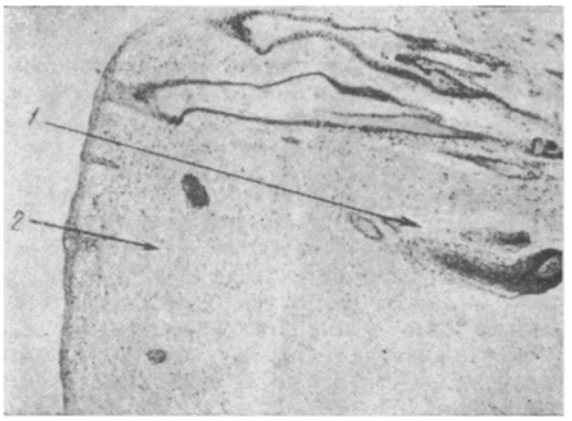

Fig. 1. Vertical section through regenerating skin on thigh of a mink 29 days after operation: 1) hair follicles; 2) connective-tissue basis of focus of regeneration. Hematoxylin—eosin, 70 ×.

the young connective tissue in the zone of the defect [4]. Completeness of repair of the skin has been shown to depend primarily on the species of animal. In rodents (rats and mice), for instance, a small scar is formed at the site of the skin defect, whereas in foxes, arctic foxes, and cats the focus of regeneration formed on the site of a skin wound consists of atypical skin, the connective-tissue basis of which, by the arrangement of its fibrous structures and the presence of hairs and sebaceous glands, resembles intact dermis [6]. However, the number and arrangement of the hairs in the focus of regeneration differ from their number and arrangement in normal skin.

Most investigations of regeneration of the skin have been carried out on rodents but, as the few relevant studies show, in members of other orders of mammals the course and outcome of regeneration of the skin demonstrate characteristic differences [2, 6]. It was accordingly decided to study regeneration of the skin in the mink and sable.

EXPERIMENTAL METHOD

Twelve female mink aged 2 years and 13 female sables aged 7 years were used. Full-thickness square skin wounds measuring 1.2 cm^2 were inflicted on the medial surface of the right thigh, down to the muscle fascia. To study the course of wound contraction, and to determine the location of the focus of regeneration in the late stages and to determine its area, the edges of the skin wounds were tagged with ink in the usual way [3]. The area of the wounds was measured at successive periods of healing. Pieces of tissue were taken for histological analysis from the region of the wound and adjacent areas of intact skin 12, 17, and 29 days after the operation on the mink and 3.5 months after the operation on the sables. Pieces of tissue were fixed in 12% formalin solution. Sections 9-12 μ thick were stained with hematoxylin and eosin.

EXPERIMENTAL RESULTS

Immediately after formation of the defect the area of the wound in the mink averaged 1.7 cm^2 and in the sables 1.9 cm^2. Healing of the wounds took place beneath a thick, dark brown scab. Epithelization of the surface of the wound defect in the mink was complete on the 12th-14th day and in the sables on the 11th-13th day after the operation. The area of the epithelized surface of the defect compared with area of the initial wound was 18-23% in the mink and 26-30% in the sables; 17 days after the operation the figures were 9-11 and 21-24%, respectively, and no further reduction took place. At that time in both the mink and sables a few hairs could be seen in the peripheral part of the epithelized wound surface.

Over the whole epithelized wound surface 29 days after the operation a few pigmented hairs were found in the mink and tufts of thick hairs in the sables. Tufts of hairs in the zone of the defect were also found in the sables 3.5 months after the operation.

Histological examination showed that 12 days after the operation on the mink the epithelium covering the surface of the defect was hypertrophied, especially in the central part of the defect, and formed short intrusions into the underlying young connective tissue. The epithelium in the center of the defect was 1.5-2 times thicker than the intact epithelium. The young connective tissue consisted of thin fibrils and cells. Single bulbs of hair follicles were visible in the lower peripheral layers of the defect. The epithelium covering the central part of the defect 17 days after the operation on the mink was still hypertrophied

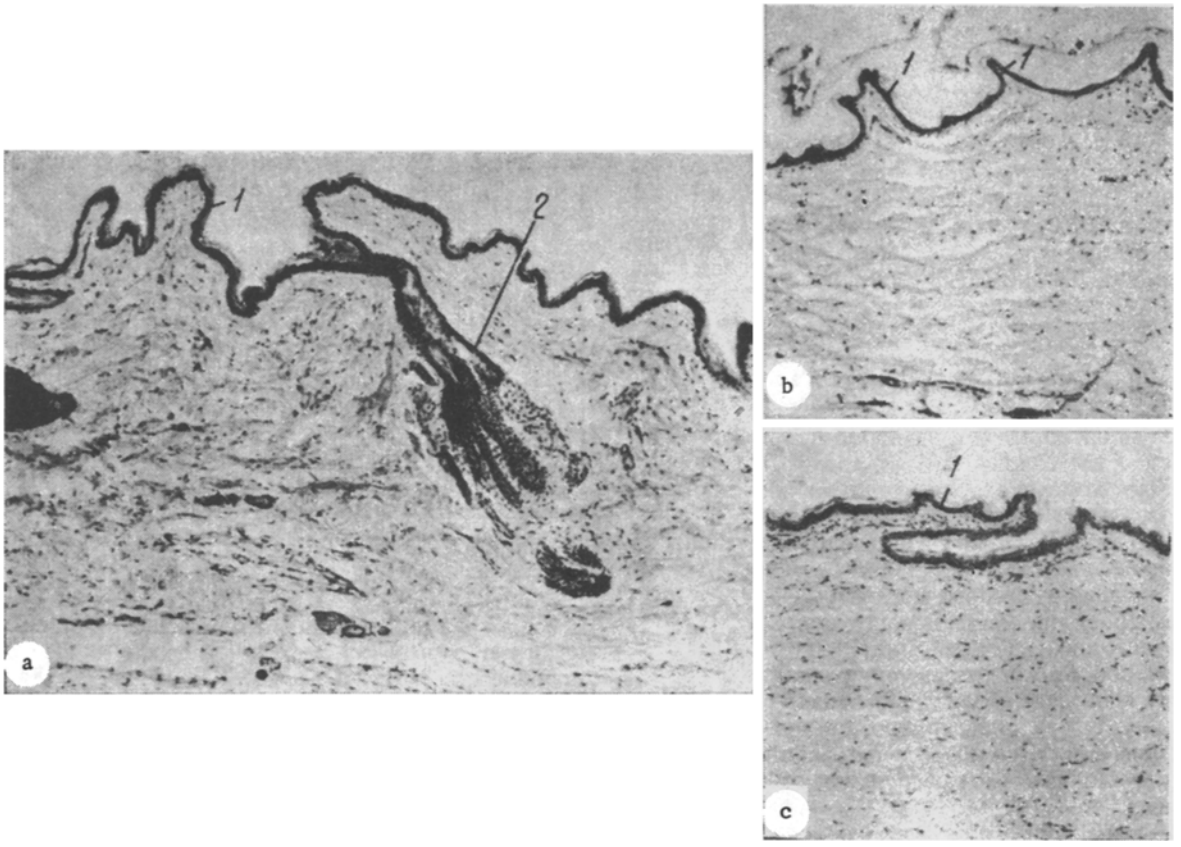

Fig. 2. Skin folds in a sable: a) normal skin; b, c) in focus of regeneration 3.5 months after operation. 1) Skin folds; 2) skin complex. Hematoxylin—eosin, 70 ×.

and formed intrusions into the underlying young connective tissue. The connective tissue of the focus of regeneration consisted chiefly of fibers and cells. The fibers were interwoven but, on the whole, they were arranged parallel to the surface of the defect. Single hair follicles and sebaceous glands were found in the peripheral part of the focus of regeneration. The thickness of the young epithelium 29 days after the operation was similar to that of normal epithelium. The connective-tissue basis of the focus of regeneration consisted of fibers chiefly arranged parallel to the surface of the defect. Cells, still larger than in the intact dermis, were located between the fibers. Throughout the extent of the focus of regeneration hairs and sebaceous glands were found in its deep layers (Fig. 1). The distance between the hair follicles was not strictly regular. In some cases areas of young connective tissue, similar in structure to fibrous tissue, were present between the follicles.

In all the sables 3.5 months after the operation the thickness of the epithelium covering the wound defect was almost the same as that of normal epithelium, and it formed no intrusions into the underlying connective tissue. Fibrous structures of the connective-tissue basis of the focus of regeneration were interwoven. Small skin folds, typical of the intact sable skin, and also hair follicles and sebaceous glands were found in the foci of regeneration; in most cases the follicles and glands were combined into skin complexes, another typical feature of intact sable skin. Extensive areas in which hair follicles were absent were found in the foci of regeneration, but even there skin folds were present (Fig. 2).

Consequently, in mink and sables the wound defect was closed chiefly by contraction. The small focus of regeneration formed as a result of healing of the wound resembled intact skin in several of its structural features: Hair follicles and sebaceous glands and skin folds were found in it; the fibrous structures were interwoven.

The origin of the hairs and sebaceous glands in the sables is not clear, for no histological investigation was made of the regenerating tissues until 3.5 months after the operation. So far as the origin of most of the hairs and sebaceous glands in the mink are concerned, the tongues of "old" dermis in which the hair bulbs were present may possibly have

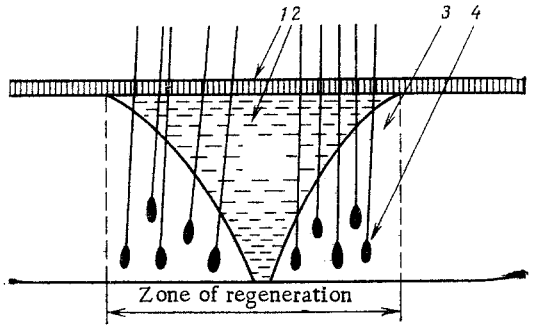

Fig. 3. Diagram showing structure of focus of regeneration in mink skin at late stages of healing: 1) young epithelium covering wound defect; 2) young connective tissue of zone of defect; 3) areas of "old" dermis displaced into zone of defect; 4) hair follicles.

entered the lower layers of the focus of regene ion on account of contraction. Hairs displaced into the zone of regeneration later chan their orientation, grew up through the young connective tissue and came out on the sur e in the zone of the defect. These hairs gave the impression of having been newly formed

This hypothesis is supported by the fact t stages of formation of hair follicles from young tissues were never observed; in the early ages of regeneration only fully formed hairs were discovered in the deep layers of the generating skin.

According to these observations, in mink, ike in rats and mice, the lower layers of intact dermis adjacent to the wound may possibl igrate into the zone of regeneration, whereas in rodents, it was the upper layers of the d is which entered the zone of regeneration [5] (Fig. 3).

This distinctive mechanism of closure of f -thickness skin defects in mink is evidently adaptive in character. Because of it, the woun are closed quickly and recovery of the skin with its specific structures (hairs and sebacec glands) is facilitated, although this recovery takes place chiefly on account of tongue of "old" dermis with hair bulbs, moving into the wound, and not by the formation of new ski d its specific structures from young tissues in the region of the wound defect.

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