HEALING OF SCALP WOUNDS IN MICE

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Healing of full-thickness wounds of the scalp in mice shows a number of unusual features. Healing ends with the formation of new connective tissue which differs from the typical connective-tissue scar in the arrangement of its hair structures and the formation of folds. Contraction of the wound takes place after complete epithelization of the defect.

When studying healing of full-thickness skin wounds, investigators have usually inflicted them on the experimental animals' back. When experiments are carried out in this way, repair ends with the formation of a connective-tissue scar [3,7]. In some investigations healing of full-thickness skin defects on the concha auriculae of rabbits has been studied. In this case the skin is relatively immobile, the base of the wound is formed of cartilage, and healing ends with the formation of a zone of regeneration with restoration of the hairs and sebaceous glands [1,4-6]. Because of these differences between the results, it is interesting to examine the course of skin regeneration in other parts of the mammalian body. No experimental investigations of healing of scalp wounds, in which the base of the wound is formed of bone, have hitherto been undertaken, so far as the writer is aware, yet this feature of such wounds must influence the course and result of the repair process.

The object of the present investigation was to study the healing of scalp wounds in mice.

EXPERIMENTAL METHOD

Square full thickness pieces of skin from the scalp covering the cranial vault were removed from 90 male $CC_{57}B1$ mice weighing 18-20 g, under ether anesthesia. The mean area of skin removed was 0.75 cm^2. Before removal of the skin, the tissues around the wound were marked with ink, keeping 0.5-1 mm away from the edge of the future wound.

The areas of the wounds were measured at successive times of healing. Pieces of tissue were taken for histological analysis from the region of the wound and from adjacent areas of intact skin, 5, 10, 15, 30, and 70 days after the operation. (Pieces of skin taken with the underlying bone were decalcified in nitric acid.) The pieces were passed through celloidin and embedded in paraffin wax. Sections 7-9 μ in thickness were stained with hematoxylin-eosin and orcein.

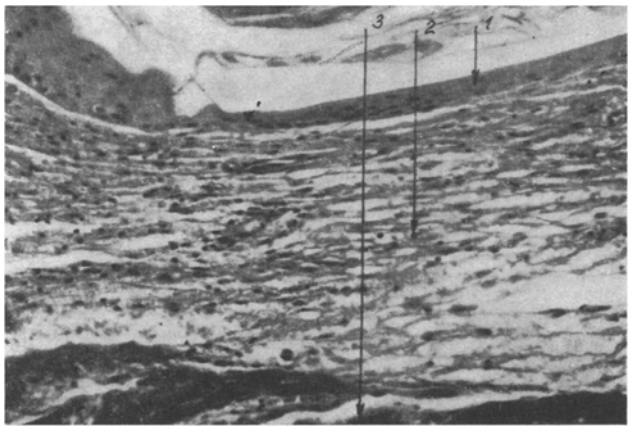

Fig. 1. Vertical section through area of wound defect 10 days after operation: 1) epithelium; 2) young connective tissue; 3) bone. Orcein, 200×.

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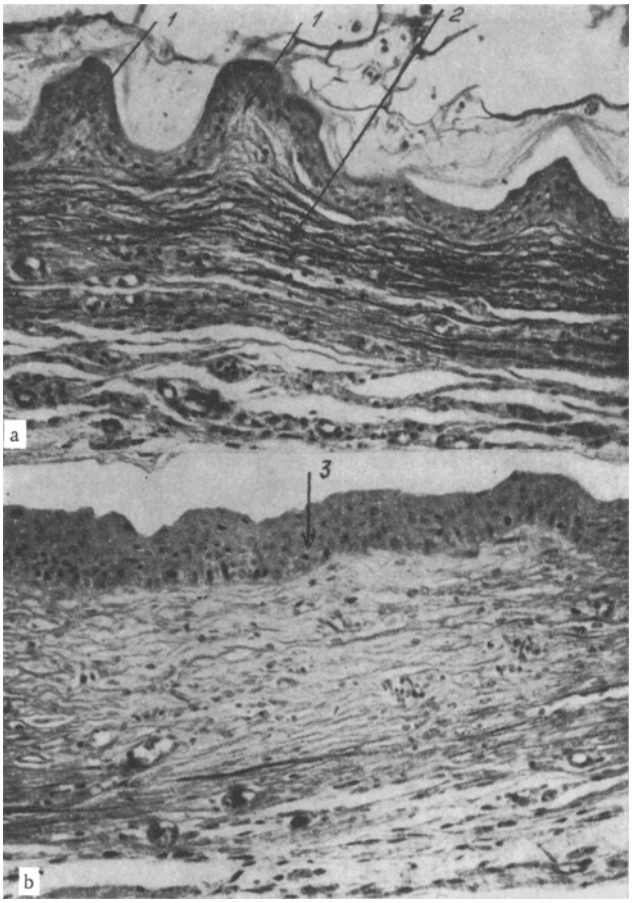

Fig. 2. Vertical section through peripheral (a) and central (b) areas of wound defect 70 days after operation: 1) folds; 2) elastic fibers; 3) epithelium. Orcein, 200×.

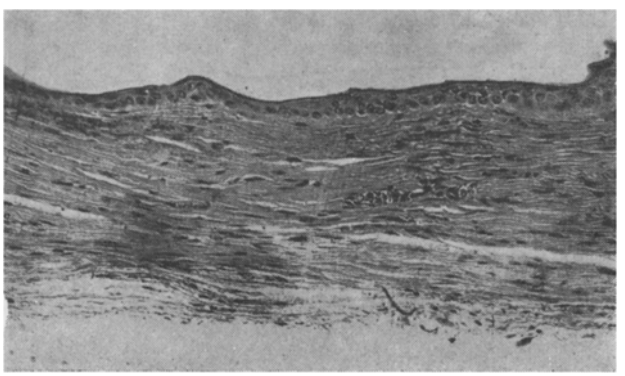

Fig. 3. Vertical sections through central part of defect 56 days after removal of a full-thickness piece of skin measuring 1 cm^2 from a mouse's back. Orcein, 100×.

EXPERIMENTAL RESULTS

During the 14-15 days after the operation no contraction of the wounds took place. Meanwhile contraction of even larger wounds (1 cm^2) on the back of the mice was complete by the eight-ninth day after formation of the defect [2].

Visual observation showed that the wound was covered with a thin pale brown scab, the surface of which lay considerably below the surface of the skin next to the wound. By the 18th day after the operation the area of the wounds had contracted to a mean value of 0.51 cm^2, and by the 22nd day to 0.32 cm^2. By the 30th day the mean area of the wound was 0.18 cm^2, and no further contraction then occurred. By the end of contraction, the marks applied to the skin were 1.5-2 mm away from the wound edge. The increased distance between them and the edge of the defect was evidently due to growth of intervening tissues outside the wound.

Histological study of the material showed that 5 days after the operation the epithelium covering the wound edges and adjacent to the wound was hypertrophied. Its mean thickness was 60 μ and it consisted of 9-10 layers of cells. The edge of the epithelial layer was growing over the wound surface in a narrow wedge. By this time the epithelium had advanced over the wound surface for a distance of 0.3-0.4 mm. The young connective tissue on which the epithelium rested consisted mainly of cells, among which many erythrocytes and thin fibrils could be found.

By the 10th day after operation in most animals, and by the 12th-14th day in the rest, the whole surface of the defect was epithelized. The epithelium consisted of four or five layers of cells and of highly keratinized surface structures (a row of thin plates). The cells were flattened, with elongated nuclei. The long axis of the nucleus was parallel to the surface of the defect. The mean thickness of the epithelium was 19 μ.

The young connective tissue beneath the epithelium consisted of thin fibrils and cells, mainly erythrocytes. It varied from 39 to 85 μ in thickness (Fig. 1).

The epithelized surface of the defect was still lower than the surface of the intact skin surrounding the wound.

The thickness of the young connective tissue 30 days after the operation was increased to an average of 260 μ. Although the hair structures in the young connective tissue were arranged parallel to the surface of the defect, elastic fibers appeared. The number of cells in the young connective tissue at this and the next period showed a marked decrease. The epithelium covering the young connective tissue consisted of 5-6 layers of cells and its mean thickness was 39 μ.

On the 70th day after wounding the young connective tissue filling the peripheral part of the defect formed folds with a mean height of 130 μ. The thickness of the epithelium covering the folds averaged 42 μ. In the upper layer of young connective tissue, thick bundles of elastic fibers were seen (Fig. 2a).

The young connective tissue filling the central part of the defect consisted mainly of fibrous structures which formed crosses and had a reticular appearance. The elastic fibers in this region were mainly found in the lower layers of the young connective tissue. The mean thickness of the young connective tissue was 290 μ.

The epithelium covering the central part of the wound defect was still hypertrophied and consisted of 5-6 layers of cells, while its mean thickness was 58 μ (Fig. 2b). The thickness of the epithelium adjacent to the defect averaged 32 μ, while the thickness of the epithelium in the control animals was 21 μ.

No formation of new hairs and sebaceous glands could be observed. Regeneration was evidently not yet complete at this period (70 days), so that it will be interesting in the future to examine the course of regeneration for longer times.

As this description shows, regeneration of the scalp in mice differs significantly from regeneration of the skin on the back of these animals. Regeneration of the dorsal skin in mice ends with the formation of a typical connective-tissue scar (Fig. 3). Contraction and epithelization of the wounds are completed at about the same time [2]. Regeneration of the scalp, however, is delayed and it ends with the formation of new connective tissue, which differs from the typical connective-tissue scar in the arrangement of its hair structures and the formation of considerable folds. Contraction of the wound takes place after epithelization of the defect is complete.

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