

EXPERIMENTAL AND CLINICAL OBSERVATIONS ON RESTORATIVE CHANGES OF SKIN AROUND A WOUND

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Rabbits have been used by a number of authors [1 - 5] to study the restorative processes in skin around a wound. I. V. Markelova [3] classifies these processes as regenerative hypertrophy due to the fact that the skin around the wound increases in area as the edges of the wound draw together. The skin becomes no thinner in this process, and its structure does not, on the whole, change. In our previous work [2] on the healing of large cutaneous wounds in rats, we showed that this process is attended by intensified growth of the integument in the vicinity of the wound to replace the mass of tissue lost when the animal was wounded. Analogous data were obtained by Cuthbertson [5]. The regenerative growth process observed under these conditions is generally similar to the growth of intact skin in the animal.

The purpose of this work was to determine whether the growth of skin around a wound is a direct result of the wound process or whether it is primarily due to the decrease in the area of the skin caused by the drawing together of the edges of the wound.

EXPERIMENTAL

A square-shaped stencil with sides 2.5-3 cm long was used to cut wounds on the backs of the rats; the wounds were sutured, the edges of the wound being drawn together from front to back. On all sides of the wound, marks were drawn with India ink from the edges of the wound towards the periphery at intervals of 6-8 mm. During the experiment, the marks were traced on transparent celluloid and transferred to graph paper. The experiment lasted for three months.

RESULTS

The data obtained showed that the distances between the marks gradually increased after the operation. The marks moved away from each other due to the growth of the skin around the wound. The fastest-growing parts of the skin were those in the immediate vicinity of the wound, especially those in front and behind it. After three months, for example, the average distance between the first row of marks and the edge of the wound increased from 6 to 12.5 mm, i.e. 106%. The distance between the third and fourth rows of marks, however, only increased from 6 to 10 mm, i.e. 66%. To determine whether the unequal growth of the skin in the operated rats was due to the growth of the animals, we tattooed a square the same size as the wound in the experimental animals on the backs of nine control rats. Rows of marks were drawn on all sides of the square, as in the experimental animals. Measurements showed the increase in the distances between the marks to be less than in the case of the wound, and to be more or less equal on all sides. Table 1 contains the data showing the increase in the distances between the marks three months after the start of the experiment.

Table 1 shows that the distances between the marks drawn crosswise to the long axis of the body increased less than those between the lengthwise rows of marks. The distances between the crosswise rows increased to the same degree as those between the last lengthwise rows of marks. This difference is connected with the fact that the edges of the wounds were drawn together longitudinally rather than laterally. The data given in Table 1 show that the distances between the marks changed differently in the control rats, which were not wounded, than in the experimental animals. The distance between the first row of marks and the square in the control rats, for example, increased

TABLE 1. Increase in Distances between the Rows of India Ink Marks around the Wound (in % of Original Level)

Animal group	Row of marks and direction from wound to periphery					
	first	second	third	fourth	first	second
	lengthwise marks			crosswise marks		
Experimental	106.5	98.3	71.6	66	71.6	53.5
Control	26.5	51	40	43	10	8
Difference between experiment and control	80	46.7	31.6	23	61.6	45.5

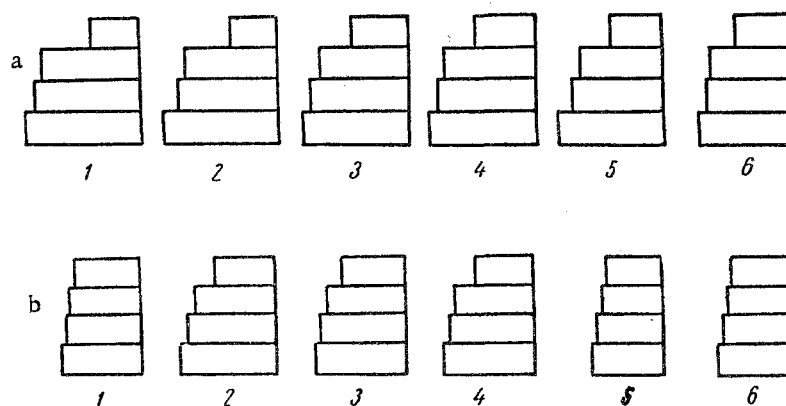


Fig. 1. Increase in distances between marks drawn around wound. a) Experiment; b) control. 1-4th columns represent the distances between the successive lengthwise rows of marks; 5-6th columns represent the distance between the crosswise rows of marks. The results of the initial measurement and three subsequent measurements made 1, 2 and 3 months after the start of the experiment are shown (read from top to bottom).

26.5%, while the distance between the square and the other rows of marks increased 40-50%; i.e., the skin nearest the square grew even less than in the other places (Fig. 1 and 2).

We also performed experiments on monkeys to determine whether signs of regenerative hypertrophy of the skin could be detected in them. The experiments were performed on Pavian hamadryls 3-4 years old*. In the first experiment, we used two females weighing 5-6 kg, in the second, two females weighing 11 and 23 kg. Observations were made on the skin around a cutaneous wound in the animal's back. The experiment lasted 1-1½ years.

A square wound 1300-1600 mm² in area was cut in the backs of the monkeys of the first experiment; squares 60-80 mm² in area were drawn with India ink from the edges of the wound towards the periphery. The squares nearest the wound were drawn 3-5 mm away from it; the squares drawn further away from the wound along the long axis of the body were situated 50-60 mm away from the first square, while those drawn laterally to the wound were 30 mm distant from the nearer squares. Systematic drawings and observations of the changes in the area of the wound and the surrounding squares, and in the distances between the edges of the wound and the squares, and between the squares themselves were made throughout the experiment.

* This part of the work was done in Sukhumi at the AMN SSSR Institute of Experimental Pathology and Therapy.

The data obtained (Fig. 3) showed that the area of the wound (and subsequently of the scar, which formed in a lengthwise direction) decreased to 1.5-2 times less than the original. The squares surrounding the wound, however, increase in area; the area of the squares drawn along the long axis of the body was 1.5-2 times greater, while that of the squares lateral to the wound had increased 1-2.2 times. Therefore, the increase was approximately the same in both cases.

The distance between the edges of the wound and the side of the squares nearest the wound increased 230 % of the original, while the distance between the sides of the first and second row of squares did not increase more than 130 % in any direction. The latter increase can be ascribed to the growth of the animal. Consequently, the wound only caused increased growth of the skin in the immediate vicinity of the wound.

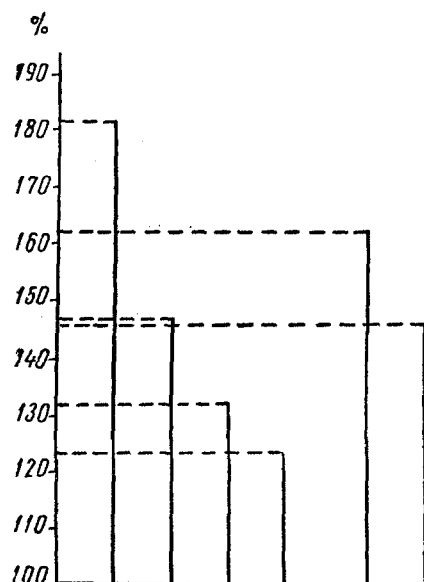


Fig. 2. Increase in distances between rows of marks made along sides of cutaneous wound in the back of experimental rats (in % of corresponding areas on backs of control rats, situated along the sides of a tattooed square). First four columns represent the four consecutive rows of marks extending longitudinally, last two columns represent the rows of marks extending laterally.

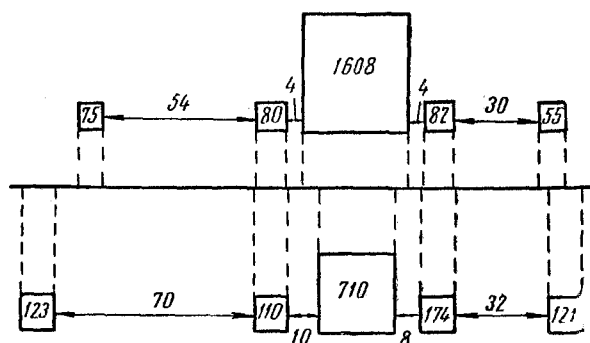


Fig. 3. Diagram showing change in area of wound and India ink squares on monkeys' backs and change in the distances between the squares. The state of the marks at the time of the operation is shown above the horizontal line, and below the line is shown their condition 13 months after the experiment's start. The figure gives the areas of the wound and squares and the distances between the latter (in square millimeters). The squares representing the wound are cross-hatched.

TABLE 2. Distances Between Marks, Surrounding Wound in Living Tissue (mm)

Days after operation	Distance between marks	
	longitudinal	transverse
10- th	11,11,10,10,10	17,16,16,15,11
17- th	13,13,12,11,10	15,14,13,10,10
30- th	13,13,12,11,10	15,15,12,10,10

In the second experiment, a wound measuring 15-20 mm was cut in the skin of the monkey's back, and marks were made along the sides of the wound 3.5 mm away from the edge at intervals of 18-20 mm. The marks and the wound were systematically measured as in the preceding experiment.

The data obtained showed that the skin in the immediate vicinity of the wound grew most intensely, as in the preceding experiment. For example, when the wound had become 1.5-2 times smaller in diameter, the distance between the edge of the wound and the first row of marks had increased 1.5-2 times, while the average distance between the rows of marks only increased 1.2 times. The average distance between the edge of the wound and the last row of marks had increased 1.25 times. In monkeys, therefore, the regenerative hypertrophy process involves only the skin in the immediate vicinity of the wound.

We also conducted preliminary clinical observations on changes in skin around a wound. These observations were made at early and late dates following removal of a skin flap for Filatov's (tube) graft (four cases examined at each date). The suture made after removal of the skin flap was T-shaped, with the cross-piece of the T along the long axis of the body. Marks were made along both sides and above this part of the suture with a 30% solution of lunar caustic, later reduced with hydroquinone. The marks were drawn 10 mm apart. They were measured systematically.

The data obtained showed a great increase in the area of the skin adjacent to the wound during the first three weeks following removal of the skin flap, the increase being greatest on the sides of the wound. Measurements made later than three weeks after the operation showed that practically no change in the distances between the marks occurred after this initial period. We cite one case as an example.

Patient G, aged 16, was operated upon on February 5, 1960 (skin flap removed from stomach for Filatov's graft). The marks were made five days after the operation (February 11, 1960). Measurements were made, first, five days after the marks were drawn and ten days after the operation (February 16, 1960), and then on the 12th and 25th days after the operation. Table 2 gives the results of the measurements.

At later intervals, there was no change in the distances between the marks. The data in the table show that the distances between the marks nearest the suture increased. The distances between the marks further away did not change at any time during the observation period. The increase occurred mainly during the first 10-17 days following the operation. Subjectively, three weeks after the operation, the patient could no longer feel the skin pulling.

The disproportionate growth shown by the skin adjacent to a wound shows, therefore, that the skin of both animals and people grows more intensely when it is injured.

SUMMARY

Skin wounds (2.5 - 3 cm²) were inflicted on the back of rats. They were sutured by approximating the skin in anteroposterior direction. Observations of India ink marks located around the wound, have shown that the distance between the edge of the wound and the marks, as well as between individual rows of the marks, located at a different distance from the wound increases. The distance particularly increases between the marks made in the direction of approximation of the wound edges. For a period of 1 - 1½ years observations were carried out over the India ink marks surrounding the wounds on the backs of 4 monkeys. Only areas of the skin adjacent to the wound showed an intensified growth.

Early and late post-operative observations were also carried out over the changes in distance between the marks made by lunar caustic at both sides of the suture following removal of a skin flap for Filatov's graft. The distances between the marks markedly extended only within the first 3 postoperative weeks.

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All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. Some or all of this periodical literature may well be available in English translation. A complete list of the cover-to-cover English translations appears at the back of this issue.
