THE EFFECT OF MECHANICAL TENSION UPON THE
POLARITY OF GROWING FIBROBLASTS.

By C. H. BUNTING, M.D., AND CHARLES C. EADES, M.D.

(From the Pathological Laboratory of the University of Wisconsin, Madison.)

PLATE 4.

(Received for publication, April 23, 1926.)

In the healing of a sterile surgical skin incision the newly formed fibroblasts show a definite polarity which leads them to grow across the wound parallel to the surface and to all practical purposes parallel to each other. The cause of this polarity is not obvious in sections of such growing tissue. However, other pathological new growths of connective tissue give a hint that mechanical tension plays a part in the process. Thus in an organizing pericardial exudate, fibroblasts grow out parallel to the newly formed capillaries and perpendicular to the surface, and eventually come to lie parallel to the surface unless an adhesion is formed between the two pericardial surfaces, when they maintain their original position parallel to the vessels. The experiments here reported are an attempt to establish the effect of mechanical tension upon the polarity of growing fibroblasts.

For the purposes of the experiments incisions were made into the thick corium of the back of anesthetized rabbits, with aseptic precautions. In order to secure variation in the direction of tension upon the healing wound, a wire fly screen saddle was fitted close to the back, permitting deep sutures, placed at selected points, to be brought through the screen at any desired point and tied above so as to maintain pull in the direction wished. At varying intervals such wounds were excised, fixed in Zenker's fluid, and cut in serial sections parallel to the surface. This procedure was adopted after it was found that strips of adhesive tape would not adhere to rabbit's skin with sufficient firmness to maintain the desired tension.

In Rabbit 4, two incisions about 2 cm. in length were made, one at either side of the midline of the back. In the first, the natural tendency of the skin edges to gape was exaggerated by sutures placed at either side of the wound with the tension applied at right angles to the line of the incision. In the second, the sutures were placed beyond the ends of the incision with tension applied in the line of the cut. 4 days later, the wounds were excised and sectioned. Examination of the

sections showed that in each the main line of fibroblastic growth was in the direction of the applied tension. Repetitions of the experiment gave the same result, and Figs. 1 and 2 show the difference in direction of growth in Rabbit 10, in which excision of the tissue was made 6 days after the primary incision.

In order to test further the effect of tension, a knife point incision of less than 5 mm. in length was made in the skin of the back and four pair of tension sutures arranged about the cut so as to give a simultaneous centrifugal pull perpendicular to the line of incision, parallel to the line, and along the 45° diagonals. The wound which had been stretched into a small oval ulcer was excised at the end of 7 days and sectioned parallel to the surface. Fig. 3 is a photograph taken from as near the centre as possible of this wound and it shows a well marked radial tendency of growth on the part of the fibroblasts.

These experiments seem to indicate that in connective tissue growing under mechanical tension the spindle-shaped fibroblasts will arrange themselves with their long axis parallel to the line of pull. That this is not simply an elongation of the protoplasm of the cell in a certain direction, but is the expression of a definite polarity in the cell is indicated by a study of the mitotic figures occurring in the sections. In the dividing cells found in the tissues, the figures lie in such manner that a line connecting the poles of the achromatic spindle is in the line of tension, and thus the equatorial plane and the plane of cell division are perpendicular. The two daughter cells thus separate in the line of tension.

In view of the behavior of fibroblasts in granulation tissue, it seemed important to determine whether or not a shift in tension would cause fibroblasts to shift their polarity or position after it was once established. As is well known, in granulation tissue the new fibroblasts at first grow out parallel to the capillary sprouts, and thus, in the surface or youngest part of the granulation, lie perpendicular to the free surface. Deeper down in the granulation they lie in an oblique position and at the base in the older part of the tissue they lie perpendicular to the vessels and parallel to the surface, a position found in the ultimate scar tissue. To test the effect of change in tension, traction was applied perpendicular to the line of a skin incision for 2 days; these sutures were then cut and traction made by a second pair of sutures in the line of the incision and at right angles to the first tension. After 4 days, the tissue was excised and sectioned. Fibroblasts in the scar line were all arranged parallel to the line of incision

and to the line of last tension. While no cross fibroblasts were found in the scar line, it seemed possible that this result might be interpreted as indicating merely that the majority of the fibroblasts had been laid down after the shift in tension was made, and had obscured the few laid down earlier. In consequence, in a repetition of the experiment, the interval between the shift in tension and the excision of tissue was cut down from 4 days to 2. In sections from this tissue, while the general direction of the fibroblasts in the scar was parallel to the line of incision and of the last tension, yet many lay in a direction oblique to this line, and the bodies of others were definitely curved as if the cell were in the act of turning. This seemed to clear up any question that might have persisted concerning the result of the earlier experiment.

CONCLUSION.

These experiments seem to justify the conclusion that mechanical tension may determine the polarity of cell division and line of growth of developing fibroblasts, and further that a shift in tension may cause a shift in position of fibroblasts already formed.

EXPLANATION OF PLATE 4.

The figures are photomicrographs of healing wounds, and were made from sections cut in a plane parallel to the skin surface.

FIG. 1. Section of healing wound in which tension was made perpendicular to line of incision which is vertical in the illustration.

FIG. 2. Section of healing wound in which tension is parallel to the line of incision, which is likewise vertical in the illustration.

FIG. 3. Section of knife point incision with radial centrifugal tension.

(Bunting and Eades: Polarity of growing fibroblasts.)