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MAST CELLS IN ENDOSTEAL AND PERIOSTEAL BONE REPAIR

A Quantitative Study on Callus Tissue of Healing Fractures in Rabbits

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After the precise description of the histological picture of a healing fracture by Pritchard & Ruzicka (1950), Pritchard (1964), 14 years after that contribution, concluded that the basic problems of fracture-healing are histogenetic and will remain obscure until the mechanisms of normal developmental processes have been revealed.

The fact that mast cells aggregate in the mesenchymal part of the periosteal callus of healing fractures in rats, has recently been recognized (Lindholm, Lindholm & Liukko 1967).

The following experiments have been performed in order to (A) reveal mast cells in the internal (endosteal) callus and (B) compare the mast cells counts of the endosteal and the periosteal callus, or of the two different kinds of osteo-regeneration called intramembraneous and endochondral osteogenesis.

MATERIAL AND METHODS

The material consisted of 17 rabbits of both sexes, weighing on an average 1568 g. The animals had been reared under the usual laboratory conditions.

In pentothal intravenous anaesthesia the right antebrachium was manually fractured. The leg was left unsplinted and the animals could move around without much disability. The animals were sacrificed and histological specimens were taken on days 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 14, 16, 17 after fracturing. Each time two samples were taken, one from the external (periosteal) callus and another from that part of the internal (endosteal) callus situated just at the end of the open marrow cavity, avoiding any inclusion of bone marrow proper. The preparations were fixed in a 4 per cent aqueous solution of basic lead acetate and stained in a 1 per cent toluidine blue aqueous solution as earlier described (Lindholm, Lindholm & Liukko 1967). No decalcification was performed. The mast cells were counted

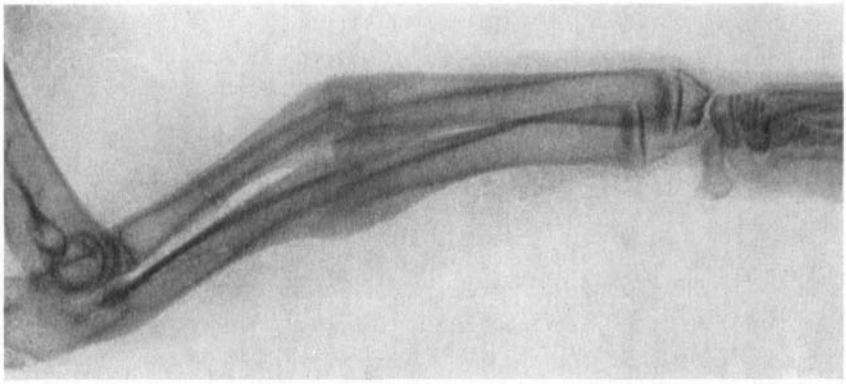

Figure 1. X-rays of a 17-day-old experimental fracture in a rabbit.

in the fibrous part of the callus in perpendicular lines against the newly formed cartilage according to a technique described previously (Lindholm, Lindholm & Liukko 1967).

RESULTS

In the endosteal callus, cartilage and new bone appear about the fourth to fifth day of fracture repair. In the periosteal callus this occurs on an average between the sixth and eighth day. On the seventeenth day the fracture appears both clinically and roentgenologically consolidated (Figure 1). Mast cells could be demonstrated in the fibrous parts of the endosteal callus (Figure 2) as well as in the periosteal callus.

Curves, representing endosteal and periosteal callus (Figure 3), show the mean relationship between the mast cell counts obtained. According to the curves, mast cells in the periosteal callus are twice as numerous as in the endosteal on the fifth to seventh days of callus formation. It has not been possible statistically to state the degree of significance of this trend.

DISCUSSION

The local factor in bone growth responsible for the calcification of the collagen fibril is probably a mucopolysaccharide substance closely related to chondroitin sulphate (Sobel 1955). In the calcifying region of bone there are substances present which can take up S^{35}. The fact has recently been discovered that mast cells are preferential spots of S^{35} up-take in the periosteal callus of healing fractures in rats (Lindholm & Lindholm 1968). The mast cell, unmatched in its remarkably high content of biologically active constituents, is able to carry Ca-ions to calcifying

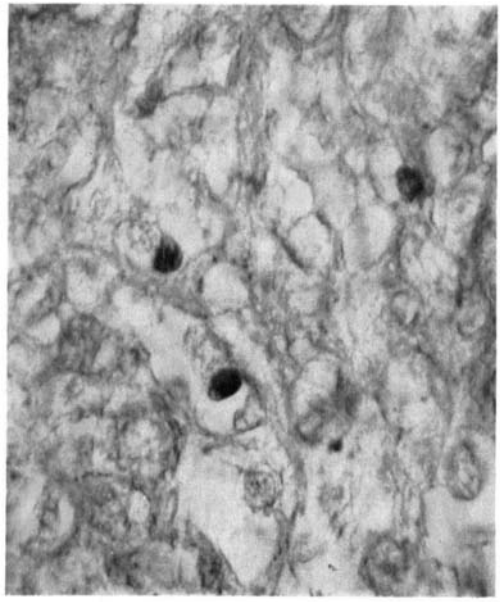

Figure 2. Photomicrograph of mast cells in the endosteal callus of a 5-day-old experimental fracture in a rabbit (× 1000, toluidine blue 1 per cent).

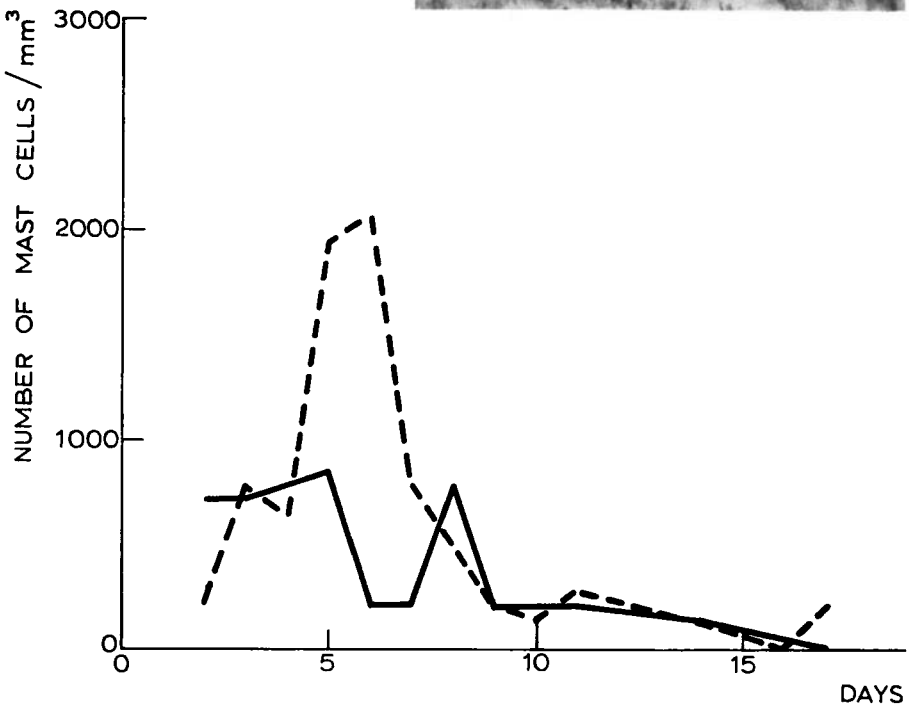

Figure 3. Mast cell counts in the periosteal (external) callus (– – – –) and in the endosteal (internal) callus (———) of experimental fractures in rabbits.

areas, a phenomenon discovered and named calciphylaxis and mastocalcergy by Selye and co-workers (Selye, Gabbiani & Serafimov 1964, Selye & Tuchweber 1965). Mast cells are usually most abundant in callus tissue just before or simultaneous with the appearance of mineralization. To what extent calcification of the callus is related to the phenomena called calciphylaxis and calcergy—in other words, the role of the mast as a potential Ca-ion carrier between circulation and bone under construction—still remains to be proved.

It is possible that the higher mast cell counts in the periosteal callus correlate to the different biomechanical situation in the outer parts of the callus cuff as compared with the inner callus. Movements between the fragments are reflected to the callus mass in direct proportion to the distance between the axis of the long bone and the point of callus under observation. It is known that rigid immobilization of a fracture tends to minimize the formation of cartilage (Lettin 1967), while movements in excess are apt to cause cartilage in abundance (Lindholm, Lindholm, Leino & Toikkanen 1968). The mast cell reaction may only be a compensatory response to unfavourable conditions of healing. It is very questionable to what extent the different types of osteogenesis, the intramembraneous and the endochondral, in fact represent principally different mechanisms biologically. Cartilage formation in excess apparently only represents an unfavourable aberration of the same process. More or less cartilage apparently depends on more or less movement.

SUMMARY

A quantitative study on mast cells in the callus tissue of experimental fractures in rabbits has been performed. Mast cells aggregate in both the endosteal (internal) and the periosteal (external) parts of the callus cuff. Simultaneous counts showed considerably higher counts on the fifth to seventh days in the periosteal callus in comparison with those obtained in the endosteal callus. The speculation is presented that this phenomenon may be due to biomechanical factors and may correlate to the excess of cartilage formation in the case of movements in the fracture site.

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