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THE PERIOSTEAL CONTROL OF LONG BONE GROWTH

An Experimental Study in the Rat

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Longitudinal growth of immature rat femurs was studied in diffusion chambers after circumferential periosteal division and stripping. After 14 days significant ($P < 0.02$) overgrowth of the periosteally divided femurs had occurred. The reason for the observed growth stimulation is discussed.

Key words: bone lengthening; growth; leg length inequality; organ culture; periosteum

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Many investigations have shown that stripping of the periosteum from a long bone is able to stimulate growth plate activity and thus increase longitudinal bone growth (Ollier 1867, Wu & Miltner 1937, Brodin 1955, Sola et al. 1963). This phenomenon has been used clinically to correct leg length discrepancy (Bertrand & Trillat 1948, Taillard 1959, Chan & Hodgson 1970, Jenkins et al. 1975).

It was not until 1972 that Crilly noted that circumferential incision of the periosteum, without extensive stripping, stimulated long bone growth. This has been confirmed by other investigators (Warrell & Taylor 1976, Van de Sandt 1977).

Previous investigations involving periosteum and long bone growth have been carried out on orthotopic living bone. The experiment described below studies the effect of periosteal division on isolated bone growing in diffusion chambers.

MATERIALS AND METHODS

The experimental technique is shown in Figure 1 and was similar to that described by Niv et al. (1976). Six-day-old rat femurs of the Sprague Dawley strain were dissected extra-periosteally utilizing micro-surgical techniques. The periosteum of each right femur was incised circumferentially and the middle one-third stripped; each left femur acted as a control. Before implantation both femurs were measured aseptically using the Vernier on the stage of a microscope. Each end of the femur was lined up with a marker in the microscope eyepiece, and the difference on the Vernier scale taken as the femoral length. Repeated measurement showed the method to be accurate to within 0.1 mm. After measurement, both femurs were placed in the same pre-sterilized millipore diffusion chamber (millipore GS 0.22 μm) and the chamber sealed (millipore MF cement No. 1), and then inserted into the peritoneal cavity of an adult male rat. Two chambers were inserted intraperitoneally into each host rat, and were identified by marking the chamber rim.

The femurs of 38 neonatal rats were used and the growth was measured after sacrifice of the host rats at 7, 14 and 21 days, respectively. Statistical significance was assessed using the Student's *t*-test.

RESULTS

At sacrifice of the host rats it was noted that eight diffusion chambers were infected and the enclosed femurs had grown very little. These infected chambers were therefore not included in the statistical analysis.

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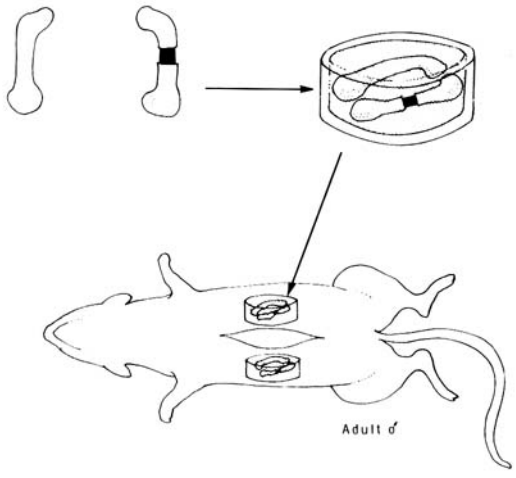

Figure 1. Experimental steps described in the text.

Table 1 shows the mean growth of the femurs at 7, 14 and 21 days, respectively. As can be seen there was little further growth of the femurs after 14 days, and at this stage the periosteally stripped femurs had grown significantly more than the control femurs.

Table 2 analyses the difference in growth between paired periosteally stripped and control femurs. Overgrowth resulted from periosteal stripping in all animal groups, but reached statistical significance ($P < 0.02$) only in the 14-day group. However, no control femur overgrew more than 0.2 mm, which is the accuracy of the method of measurement. If the three groups are analysed together then the larger group shows a highly statistically significant overgrowth of the periosteally stripped femurs ($P < 0.0001$).

Table 1. Mean growth of the femurs in diffusion chambers

Days	*n* (pairs)	Growth (mm) Control	Experimental
7	8	0.78 ± 0.08	0.93 ± 0.07
14	16	0.95 ± 0.09	1.21 ± 0.10*
21	6	0.92 ± 0.21	1.22 ± 0.20

* $P < 0.05$
Mean ± s.e. mean

Table 2. The difference in growth between paired periosteally stripped and control femurs

Days	*n* (pairs)	Overgrowth (mm) ††	s.d.
7	8	0.15	0.19*
14	16	0.244	0.346**
21	6	0.30	0.34*
7–21	30	0.23	0.306***

* $P > 0.05 < 0.10$
** $P < 0.02$
*** $P < 0.0001$
†† Mean overgrowth of the stripped as compared with control femur.

DISCUSSION

The cause of stimulation of long bone growth after periosteal trauma is not known. Trueta believed that the important factor was interruption of the metaphyseal vessels with subsequent medullary ischaemia (Trueta & Amato 1960). Other investigators have shown that there is hyperaemia around the growth plate following periosteal injury associated with fracture (Wray & Goodman 1961). Lacroix in 1947 postulated the release of a local hormone, the growth stimulating substance, which acted on the growth plate of the injured bone only.

More recently, a mechanical theory has been postulated (Crilly 1972). The fibroelastic periosteum is loosely attached to the shaft of a growing long bone, and the periosteal attachment at either end of the bone at the perichondral ring is very strong. It is postulated that during growth the thick periosteum is stretched and its tension exerts a mechanical restraint on elongation of the bone at the growth plate. If this restraint is released by circumferential division of the periosteum, then growth will be accelerated. Our findings support this theory.

The immature femurs in diffusion chambers have no blood supply, so vascular disturbances are not operative. Local produc-

tion of hormones would affect control and experimental femurs similarly.

We therefore conclude that the intact periosteum mechanically checks the growth plate and circumferential periosteal division removes this restraint to increase longitudinal growth.

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