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EFFECT UPON LONGITUDINAL GROWTH OF FEMUR BY INTRAMEDULLARY NAILING IN RATS

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In an experimental study using rats it was found that intramedullary nailing through the distal femoral growth plate resulted in a significant retardation of longitudinal growth. Drilling only and pin removal after 7 weeks also gave significant inhibition of growth after 14 weeks, while drilling only with immediate removal of the pin gave no growth disturbance during the first 7 weeks. The investigation indicates that damage to the central portion of the epiphyseal growth plate in rats leads to inhibition of longitudinal growth.

Key words: epiphyseal plate; femur; growth retardation; intramedullary nailing

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In osteogenesis imperfecta fractures are frequent, leading to bowing of long bones. Straightening of the bone by multiple osteotomies and intramedullary rod fixation was described by Sofield & Millar (1959). Later Bailey & Dubow (1963) designed an elongating intramedullary rod to reduce the number of operations for these patients. This rod, however, penetrates the cartilaginous growth plate, which may result in epiphyseal growth inhibition.

Conflicting observations exist as to damage of growth owing to internal fixation crossing the epiphyseal plate. The purpose of this study was therefore to investigate the effect on longitudinal growth using intramedullary nailing.

MATERIALS AND METHODS

The experiments were performed on growing Wistar male rats (5 weeks old). The rats were divided into weight-matched groups. The right femur was operated upon and the left served as control. The operations were performed under Hypnorm vet.® narcosis using 0.03 ml. The animals were killed under ether narcosis.

In group I (10 animals) the rats were killed at the start of the experiments and the length of both femora measured.

In group II (20 animals) the knee was opened through a lateral parapatellar incision. A smooth metallic pin, 1.5 cm long and 1 mm in diameter, was inserted longitudinally from the intercondylar notch through the center of the epiphyseal plate into the medullary canal of the femur. The pin was then removed immediately. Ten animals were killed 7 weeks later and 10 were killed 14 weeks after the operation. The lengths of both femora were measured.

In group III (25 animals) the rats were operated in the same manner as in group II and the pins were left penetrating the central portion of the epiphyseal plate longitudinally. The distal end of the pin was gently countersunk just below the articular surface, the upper end being in the medullary canal. Ten rats were sacrificed after 7 weeks and 15 rats after 14 weeks.

In group IV (10 animals) a long pin was inserted in the same manner as in the other groups. Its proximal end penetrated the greater trochanter and could easily be removed 7 weeks later. The animals, however, were killed 14 weeks after the operation.

Each rat served as its own control and the statistical probabilities of differences were calculated using the

Table 1. Longitudinal growth in operated and unoperated rat femora 14 weeks after nailing

	Length in cm ± s.d.		
	Group II	Group III	Group IV
Initial length of bone	2.53±0.04	2.53±0.04	2.53±0.04
Length of control bones at the end of experiment	3.44±0.07	3.46±0.08	4.47±0.08
Length of operated bones at the end of experiment	3.35±0.11*	3.23±0.10*	3.33±0.17*

* Significantly different from control ($P < 0.05$).

Wilcoxon test for paired comparisons. Differences were considered significant if $P < 0.05$.

RESULTS

No rats died during the experimental period. No adverse effects were seen from the arthrotomies. The results are given in Table 1. The average length of femur at start of experiments was 2.53 cm, the same for the right and the left sides.

The average femoral length 14 weeks after the operation was shorter than in controls in all groups ($P < 0.05$). The length of the operated femora in the three groups did not show any significant differences.

Seven weeks after operation the femora which were only drilled through the central part of the epiphyseal plate with a smooth pin (group II) were not significantly shorter than controls, and the average length was longer than in the femora with permanent pins (group III). In the latter group the operated femora were significantly shorter than controls ($P < 0.05$).

DISCUSSION

In this study the right femur of 55 rats were operated upon by drilling a smooth Kirschner wire, 1 mm in diameter, through the distal epiphyseal plate from the knee joint. The diameter of the growth plate was 5 mm. In one group the pins were immediately removed, in one group it was removed 7 weeks later while in one group the pins remained in the distal femoral end for 14 weeks. The experiments showed that drilling alone and both the temporary and the permanent nailing significantly retarded the longitudinal growth when the animals were sacrificed 14 weeks later. The extent of growth inhibition was the same in all groups. Drilling alone did not influence growth during the following 7 weeks, while nailing penetrating the growth plate for the same period significantly retarded growth. No additional growth reduction was seen in the group where the pins also penetrated the trochanteric region.

The findings of the present study are to some extent in agreement with the report of Haas (1950) who found that nails passing longitudinally through the epiphyseal plate resulted in a definite growth retardation. If the pins, however, were removed immediately after insertion no loss of growth occurred. This was also the case in our experiments during the first 7 weeks, but later the growth was reduced indicating primary damage to the cartilage cells. Ford & Key (1956) found that small damage to the central portion of the epiphyseal plate created a moderate growth retardation while extensive damage resulted in a marked interference in longitudinal growth. Campbell et al. (1959) concluded that the extent of growth reduction is roughly proportional to the amount of destruction. Siffert (1956), on the other hand, observed no epiphyseal growth inhibition from a wire placed through the upper tibial epiphyses in rabbits. Nor did Baily & Dubow (1963) find any disturbance of growth from moderate central epiphyseal trauma. Elongated intramedullary rods crossing the cartilaginous growth plate are now used in the treatment of osteogenesis imperfecta. Marafioti & Westin (1977) did not observe any adverse effects from this procedure.

It is difficult to explain the conflicting results

from experiments in animals, but it is reasonable to believe that a correlation exists between the extent of central epiphyseal damage and longitudinal growth inhibition.

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