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POST-FRACTURE GROWTH CHANGES IN RATS

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Tibial shaft fractures in man result in a local osteoporosis in the knee region which, at least in females, is irreversible (Nilsson 1966). In children rather the opposite has been demonstrated, so that the bone density in adult age is greater in the fractured limb when the fracture has occurred at an early age. In rats, tibial shaft fractures result in decreased bone density in the femur of the injured limb, this decrease in the mineral mass may, at least to some extent, be a result of a growth disturbance (Nilsson & Saville 1968).

The objective of the present study was to evaluate changes in volume, mineral content, and uptake of mineral tracer in the femur following tibial shaft fractures in rats and to continue the observations far out in time until a steady state was attained.

MATERIAL AND METHODS

In 45 female white albino rats of the Sprague Dawley strain and with a weight distribution of 72 ± 8 grams the tibia was fractured manually under ether anaesthesia. The animals were divided in 6 groups, 6-8 rats of equal weight in each group, and sacrificed from 2 weeks to 7 months after the fracture. Twenty-four hours before death the animals were injected with $3 \mu\text{Ci}$ of ^{85}Sr subcutaneously.

Both femora were dissected, carefully cleaned of soft tissue and weighed in air and in water ($+4^\circ\text{C}$, with some detergent added to decrease the surface tension) suspended by a fine copper wire. The bones were ashed for 48 hours at 550°C in an electric muffler. The ash was weighed and the radioactivity measured in a scintillation well counter.

RESULTS

Volume and Ash Weight

The volume calculated according to Archimedes' principle from the weight in air and in water was less in the femur of the fractured limb

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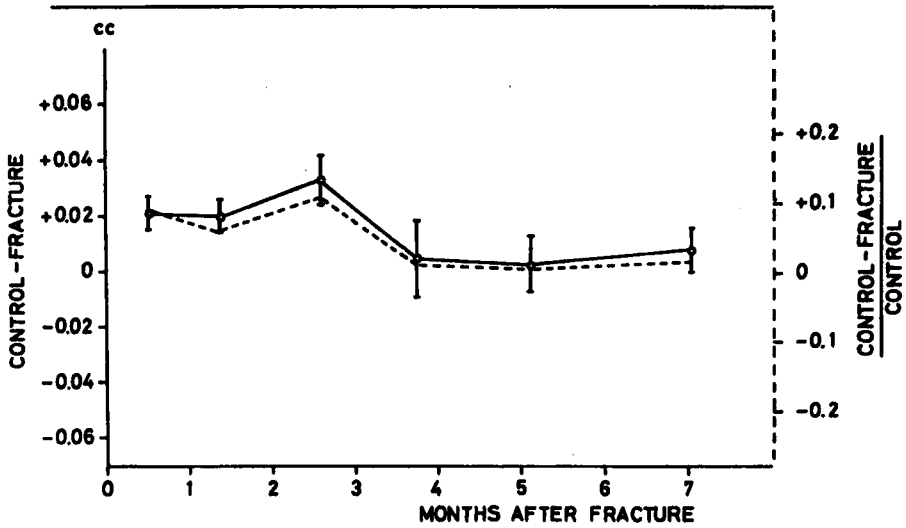


Figure 1. Changes in volume in relation to time (average \pm SE).

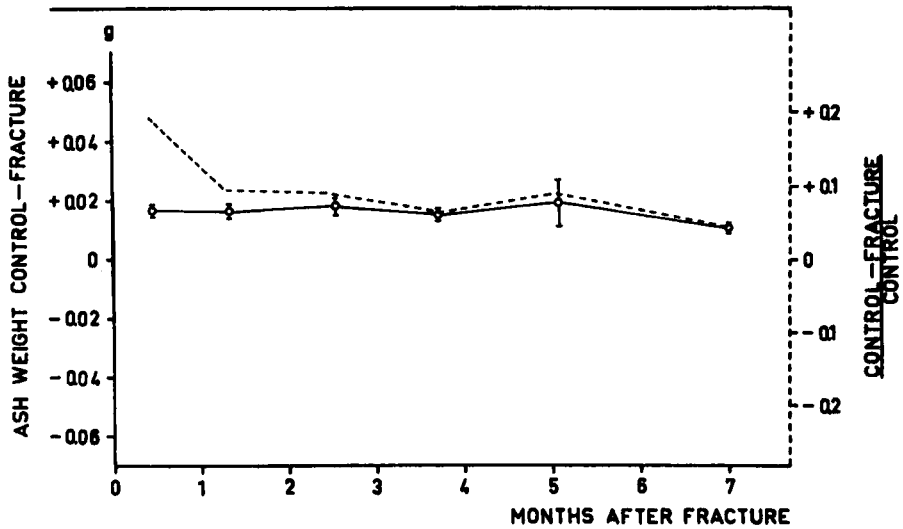


Figure 2. Changes in ash weight in relation to time (average \pm SE).

as compared to the control side for more than 2 months after the fracture, indicating a growth retardation. Before the fourth month the volume returned to normal (Figure 1).

Similarly, the ash weight was decreased in the femur of the frac-

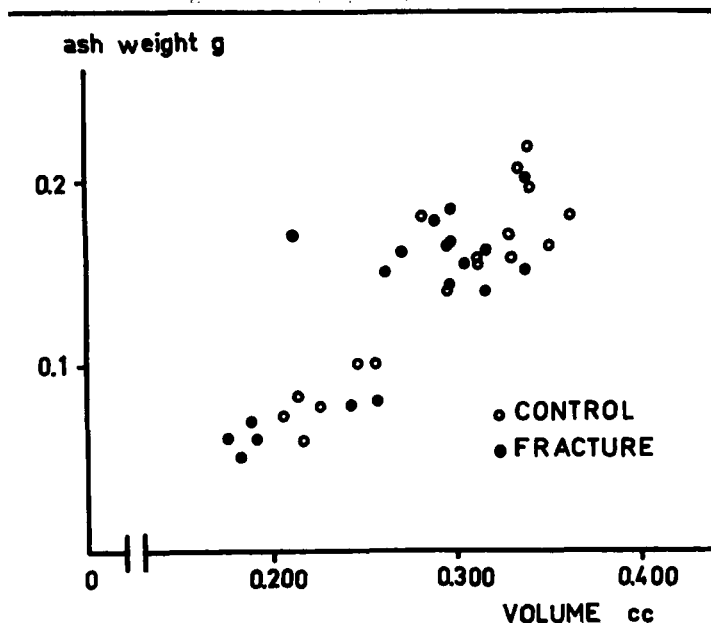


Figure 3. Relation between ash weight and volume in fracture and control femora separately during the first three months.

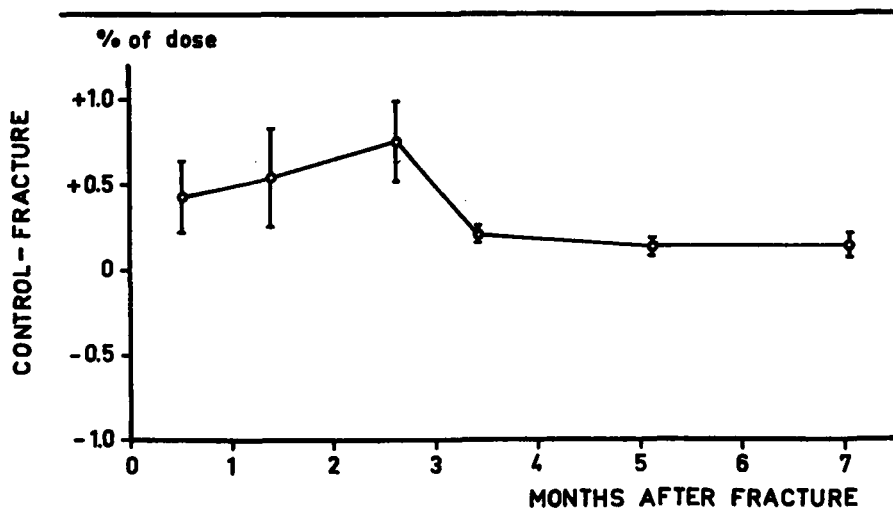


Figure 4. Changes in uptake of ⁸⁵Sr with time (average \pm SE).

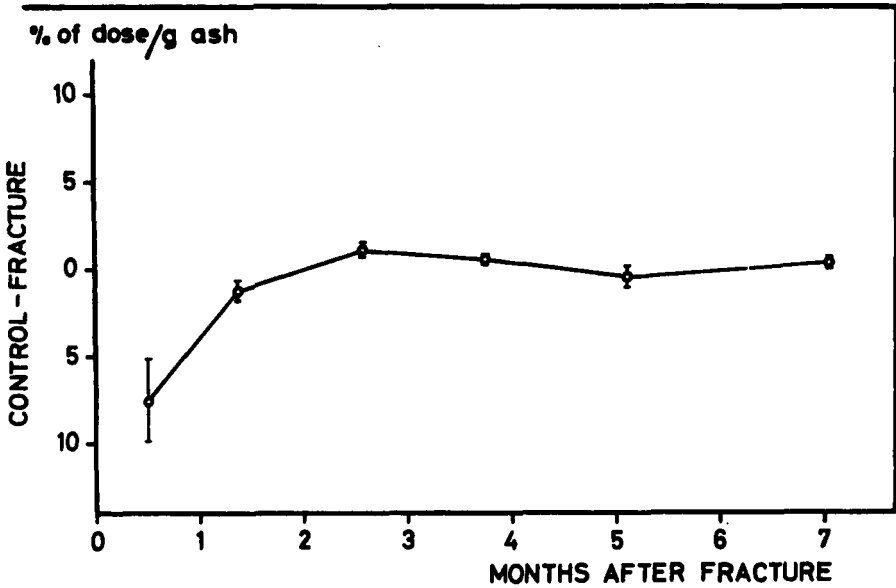


Figure 5. Changes in uptake of ⁸⁵Sr per unit ash with time (average ± SE).

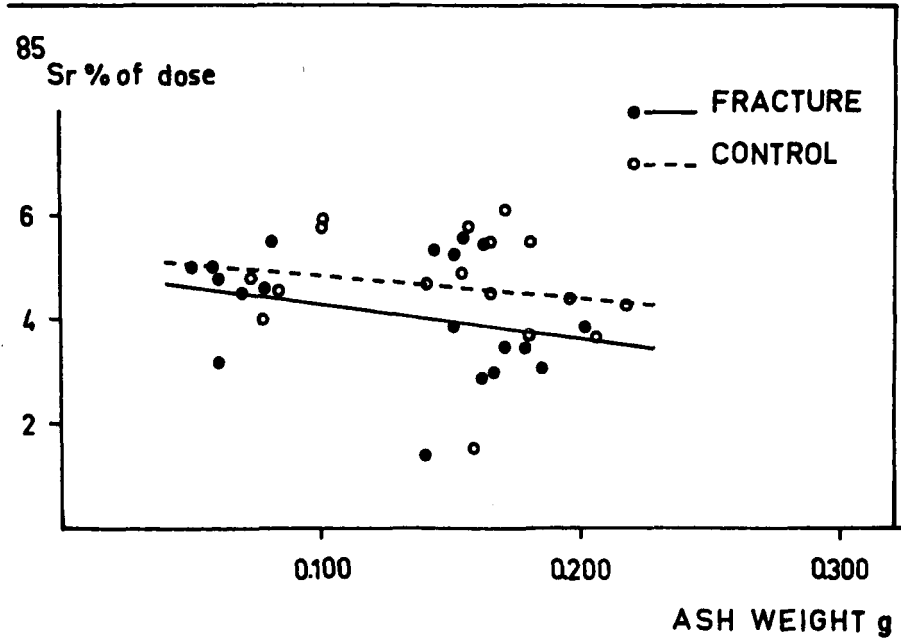


Figure 6. Relationship between ash weight and uptake of ⁸⁵Sr in fracture and control femora separately during the first three months. There is a significant difference in adjusted means ($0.05 > P > 0.01$, analysis of covariance).

tured limb. It did not attain the value of the non-fractured side during the course of the experiment (Figure 2).

During the first three months the mineral content of the femora corresponded to the volume so that for any given volume the bones contained the appropriate amount of mineral (Figure 3).

Uptake of ^{85}Sr

Throughout the experiment but more pronounced during the first months the uptake of tracer was less in the fractured than in the non-fractured side femur (Figure 4). When corrected for mineral content the uptake per mass unit of mineral was greater in the fractured than in the non-fractured side femur and approached normal during the first three months (Figure 5).

However, during this time, the uptake of tracer in the fractured side femur was significantly less than the mineral mass would allow for when the relationship between uptake and ash weight was studied as regressions for fracture and control limbs separately (Figure 6).

DISCUSSION

Previous investigators have found a decrease in the mineral content in the ipsilateral tibia following femur fractures in rats (Bauer 1954, Bohr 1955). This phenomenon was recorded a month or more following the fracture and was believed to be caused by resorption of bone in the injured limb. Nilsson & Saville (1968) claimed that such a decrease in mineral content after fracture could be, at least in part, due to a growth disturbance, in that the volume of the femora was less following fracture of the shaft of the tibia and that rat bones with less volume contain less ash, the relationship between these two variables appears to be a very constant one. The same investigators also failed to change the bone density in the tibia by fracturing the femur in old rats with a slow growth rate. The present investigation appears to support this finding, when the volume is decreased the mineral content is reduced as well and the relationship between mineral content and volume remains undisturbed; later the two variables approach normal.

Wray & Godman (1961) found an overall increased length of the femur following fracture of the tibial shaft in rats, the time period under study was about 6 weeks. According to the findings in the present study this lengthening is not followed by an increase of the total

size of the femur, on the contrary, the volume is decreased for that period of time and even longer.

Bohr & Sørensen (1950) and Bohr (1955) found increased uptake of mineral tracers in the femur following fracture of the shaft of the tibia in rats. Bauer (1954) demonstrated an increased uptake in the femur when the tibia was fractured.

Nilsson & Saville (1968) claimed that these findings, at least in part, could be explained as an effect of growth disturbance. In the present study this concept is supported by the fact that during the period of growth disturbance, before normal volume, equal to the control femur, had been attained, the uptake of ^{85}Sr was less in the fractured than in non-fractured side femora when the relationship of ash content and uptake normally found in rat bones was taken into consideration. The decreased uptake in the fractured limb is probably due to a decreased rate of growth.

The growth of the animals during the course of the experiment is of great importance in the interpretation of the results. For this reason conclusions about post-traumatic changes in rat bones are not directly applicable on man.

SUMMARY AND CONCLUSION

Changes in ash content, volume, and uptake of ^{85}Sr were studied in the femora of rats following fracture of the shaft of the tibia. The volume of the femur of the fractured side was less for 2–3 months after the injury and thereafter approached normal. The bone mineral content and the uptake of ^{85}Sr was changed in relation to this retardation of growth.

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