GROWTH OF THE EPIPHYSES AND VERTEBRAE

By

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In this hospital we have seen 3 patients whose histories and radiological investigations may throw light on some of the problems of ossification and bone growth. We found an unusual double contour in the epiphyses of the long bones of these patients. Similar phenomena were observed in the vertebral bodies of one of them.

Patient no. 1. (9553/45) was a woman who, at the age of 5, contracted a left sided pulmonary abscess and underwent costal resection. The lungcondition was quickly cured by this method. A slight scoliosis is all that is left from this incident, otherwise she has been in perfect health ever since. X-ray examination at the age of 26 (fig. 1a, 1b) shows in each of her vertebral bodies a well defined area of increased density of bone. These lines are placed centrally in the vertebral bodies except posteriorly where they almost reach the cortex of vertebral body. These lines are such in shape and size that they could well correspond to the vertebral bodies found at the age of 5. Similar lines were also found in the long bones of the extremities, best seen in the femoral and tibial epiphyses of the knee joints (fig. 1c, 1d).

Patient no. 2. (17239/56) was a man who, at the age of 7, received a severe trauma, resulting in multiple lesions (i.e. severe contusion of the left inguinal region, comminuted fractura of the left femur and total severance of the left sciatic nerve). The femoral fractura was treated first by osteosynthesis a.m. Lane, later by intramedullary nailing. This procedure was then complicated by the appearance of osteomyelitis and pseudarthrosis. The latter healed after 1½ years but the infection took 3 years to eradicate. The sciatic paralysis proved to be permanent. 4½ years following the injury an epiphysiodesis a.m. Phemister was performed in the right knee region. X-ray pictures of the left knee, taken 3 months after the traumatic incident (fig. 2a), exhibited a severe, diffuse osteoporosis of the epiphyses and a zone of rarefaction between the metaphysis and the epiphyseal line with an uneven garland-like surface towards the epiphysis. The X-ray pictures of the lower extremities, 6 years later (figs. 2b, 2c), display a similar central osteoporotic area in all of the epiphyses of long bones, but most markedly on the left side. It is surrounded by bone of normal structure but seperated from it by a cage of bone of *increased* density. Here again the whole central conformation could well correspond to the epiphysis of a 7 years old boy. We also found lines of thick bone in the diaphyses

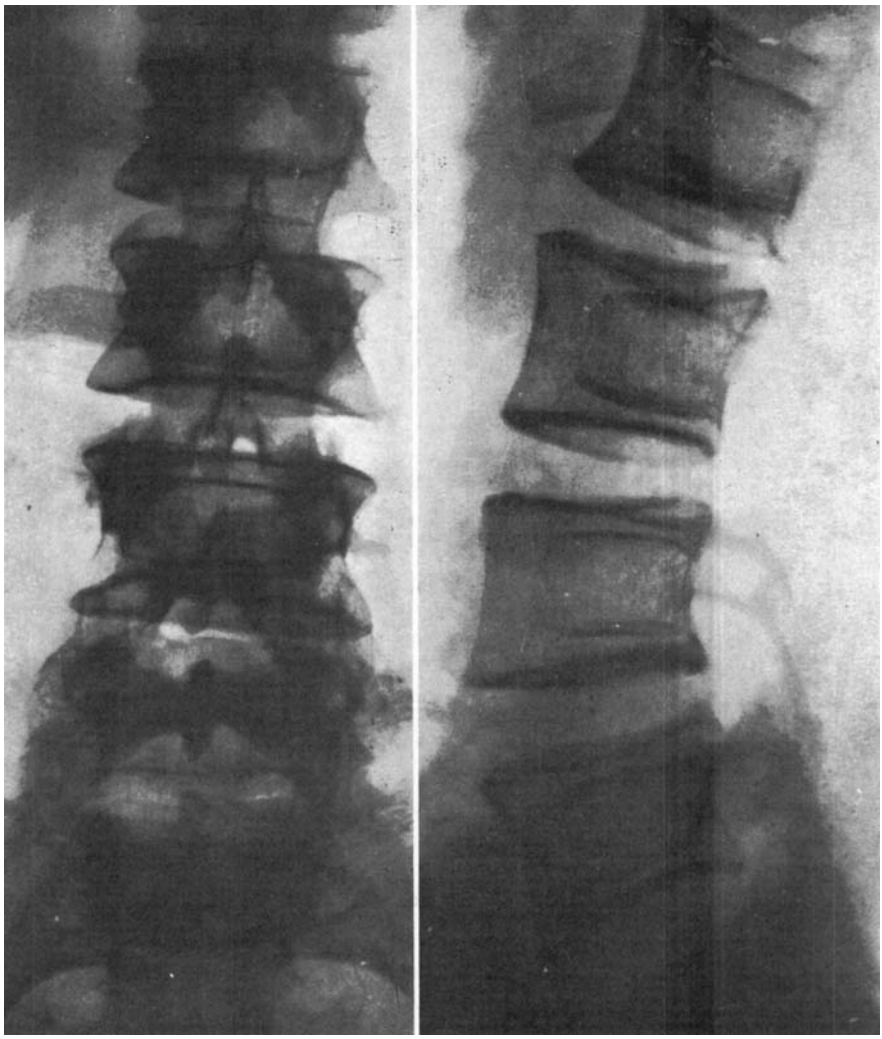

Fig. 1a. *Fig. 1b.*

of femora and tibiae, best seen in the left tibial condyle. On the epiphyseal side of these lines the bone structure seemed to be normal while the adjacent diaphyseal bone was markedly porotic.

Patient no. 3. (16199/54) was a female, 2 years old when congenital dislocation was diagnosed in her left hip. This condition was treated by open reduction, derotation osteotomy and acetabuloplasty. Nevertheless, the optimal position of the hip was not maintained successfully, and, at the age of 5, within 3 months she had 5 operations on it. Two of these were major operations. During the time of hospitalisation she contracted chickenpox, had recurrent attacks of tonsillitis and suf-

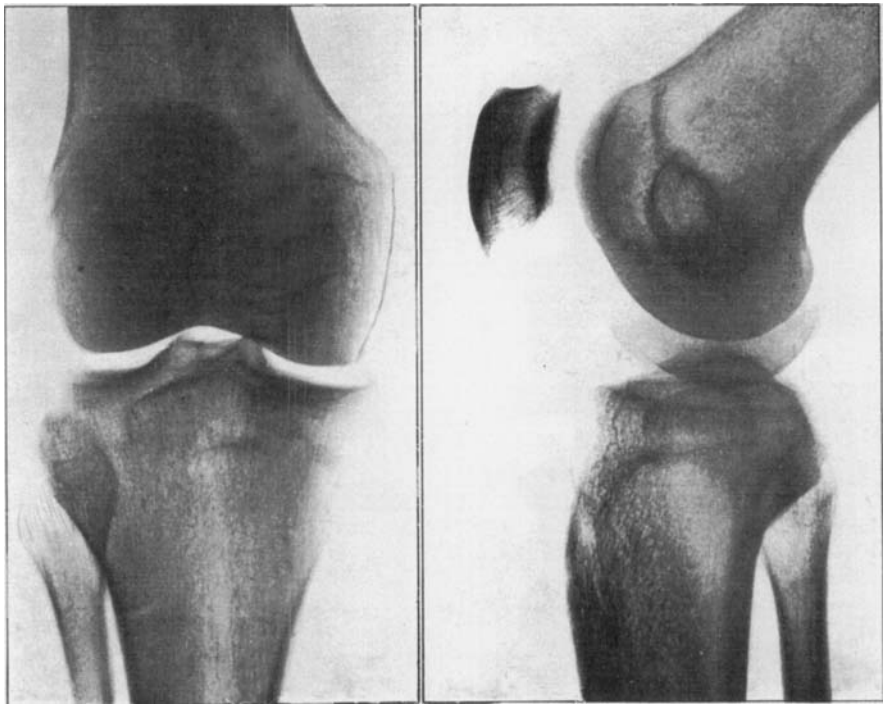

Fig. 1c. *Fig. 1d.*

fered from minor wound infection. An X-ray examination of the knees, at the age of 10, demonstrated centrally placed osteoporosis in the epiphyses, this pathological change being most marked on the left side (fig. 3). The structure of bone, peripheral to this lesion, is apparently normal. Here again, there is an intervening dense zone between the two.

DISCUSSION

The most thorough study of lines of increased density in the shafts of long bones seems to have been undertaken by *Eliot et al.* (1927) who found that these lines consisted of slices of bone in which the trabeculae were thicker and more transversely arranged than normal. These trabeculae model themselves quite accurately to the provisional bone in which they are laid. Though they may undergo resorbtion later, they will never change their form. "Lines of arrested growth" may develop in the metaphyses of any of the long bones when some pathological condition reduces temporarily the intensity of growth (e.g. in infectious diseases or quite banal diseases, even after a small trauma).

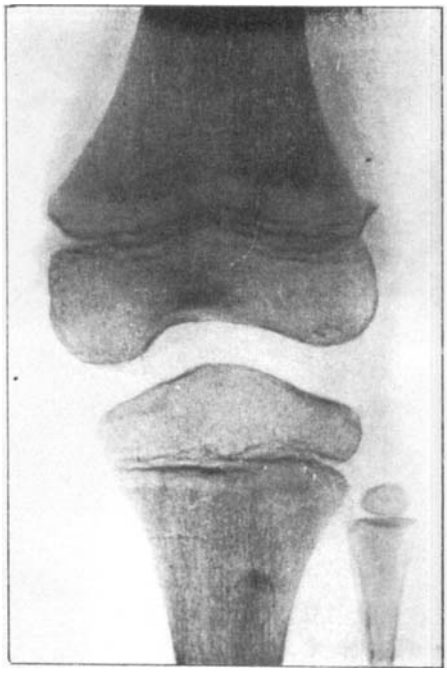

Fig. 2a.

In our experience there is considerable individual variation in the tendency to form such lines. As a rule, the more severe the trauma is, the thicker the line is likely to be, especially in the fastest growing epiphyseal zones.

Growth and ossification of the epiphyses have been investigated, among others, by *Eliot et al.* (1927), *Harris* (1929), *Siegling* (1941), and *Lacroix* (1952). It is generally agreed that epiphyseal growth occurs by enchondral appositional ossification spreading from an ossification center. In the first years of life this spread occurs centrifugally, later, however, it ceases on the surface facing the epiphyseal plate but continues in the other directions. This state of affairs is illustrated on our pictures 1c, 1d, 2b, 2c and 3.

Central epiphyseal osteoporosis similar to figs. 2b, 2c, 3 has been described by *Siegling* (1941) by administration of phosphorised cod liver oil, and by *Goff* (1960) who observed the same phenomena in a case of poliomyelitis. A well defined diaphyseal osteoporosis, as illustrated on fig. 2c, has been seen by *Harris* (1929) whose case was a stillborn child with congenital lues.

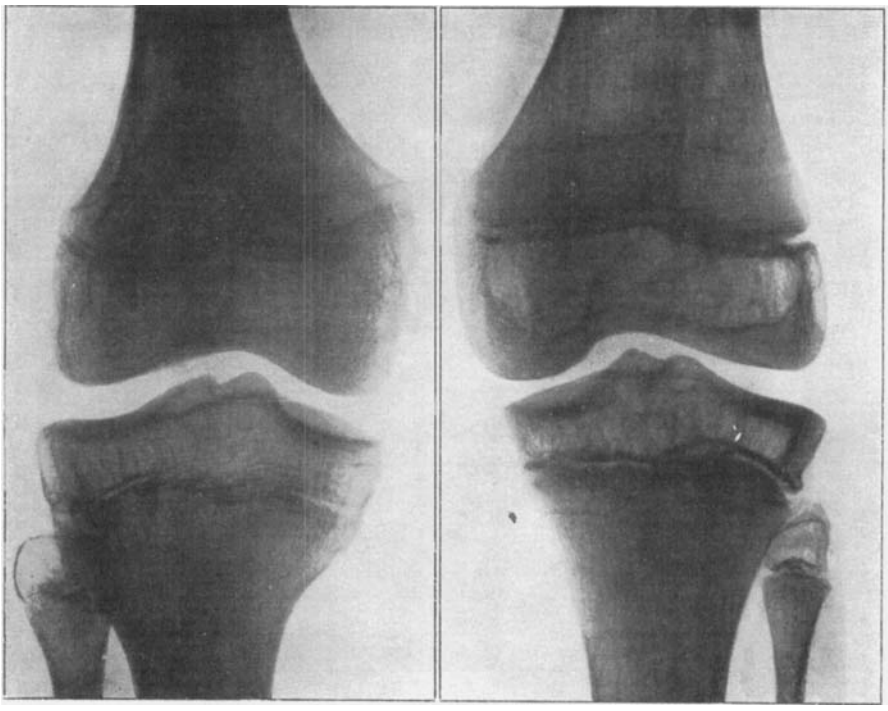

Fig. 2b.

Neither of these authors try to explain why, even after many years, these porotic areas persist, and why the texture of bone surrounding these lesions is normal.

The above described phenomena seem to be quite rare. Over a 10 year period, at the Orthopaedic Hospital in Copenhagen, we have investigated the growth disturbances of 890 children using orthoradiographic methods. Apart from the 2 above reported cases we were unable to find similar abnormities in the rest of the children, although the majority of those examined had suffered from a variety of infectious diseases or received severe traumata.

It is not possible, from our 2 cases, to draw a satisfactory explanation for the persistence of osteoporotic areas so long after the trauma. For at least 3 years previous to the orthoradiographic examinations both children were in perfect health, and in the post-traumam developed bone the ossification took place apparently normally. These two facts lead us to think it very improbable that we were dealing with some lasting, systematic illness. Further, since the peculiar phenomena

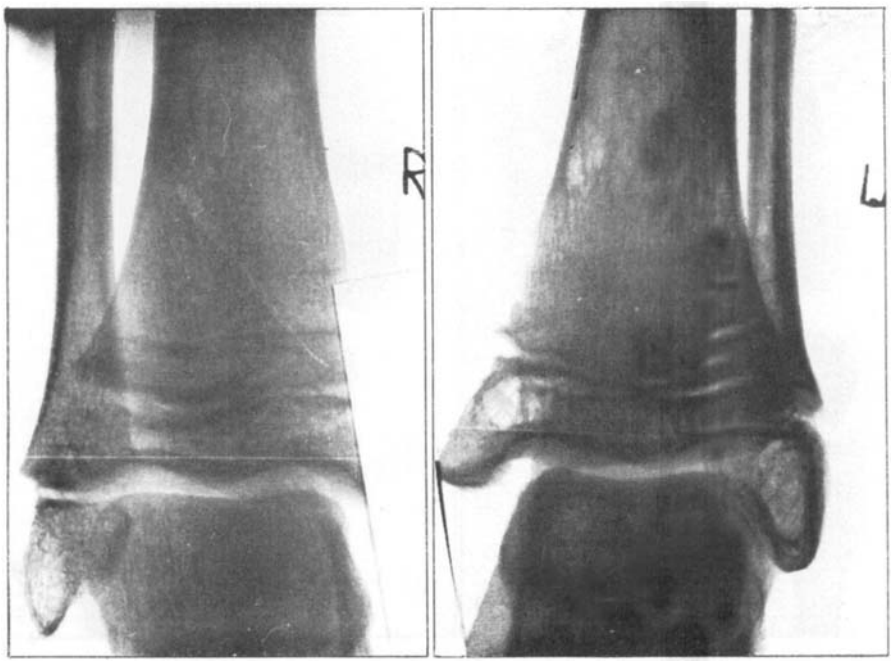

Fig. 2c.

existed on the "healthy" side as well, the resulting pathological changes could not be exclusively due to local causes, e.g. vascular disturbances, inactivity or denervation. A possible explanation may be that the central osteoporotic areas are, in fact, a kind of sequestra, encapsulated by sclerotic bone-boxes that may well hinder normal revascularisation of their captive sequestra.

Concerning similar changes in the vertebral bodies (figs. 1a, 1b) we found only *Harris's* reference (1929) to the above mentioned stillborn, and *Siegling's* (1941) who concluded from his findings that the growth of the vertebral bodies is faster in the anterior than in the posterior direction.

In our case we found that between the age of 5 and the conclusion of growth no enlargement appeared to have taken place in the posterior part of vertebral bodies.

Growth process in the vertebral bodies is considered to be analogous with the longitudinal growth of the diaphyses of the long bones (*Schmorl* (1939), *Haas* (1939), *Bick & Copel* (1950), *Roaf* (1960)). They regard the cartilage caps of vertebral bodies as true epiphyseal plates. The treatment of scoliosis by corporal epiphysiodesis, *Roaf's*

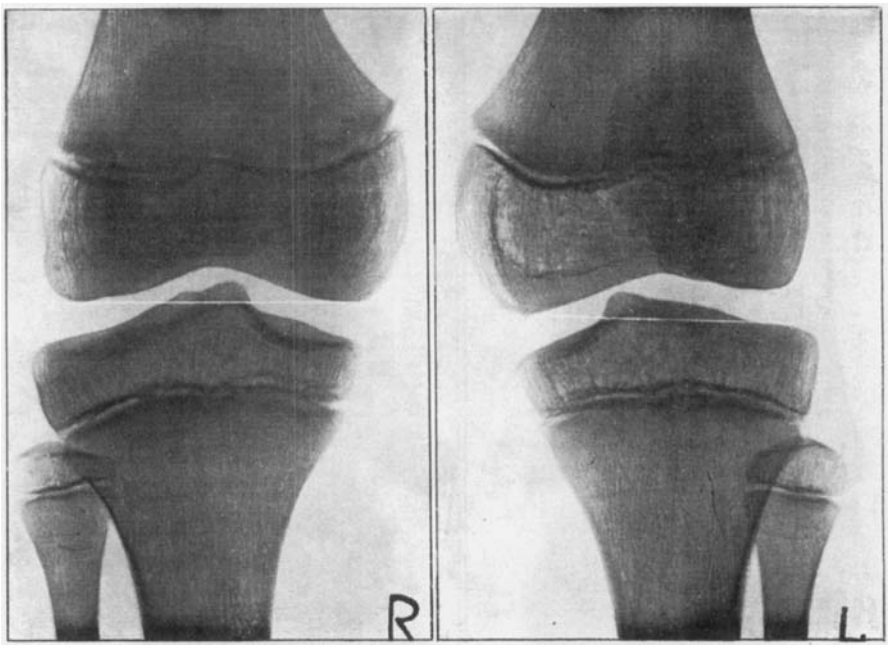

Fig. 3.

technique, is based on this assumption. *Bich & Copel* support the above theory with the observation that the texture of cartilage in the vertebral caps closely resembles that of the epiphyseal plates of long bones.

This morphology cannot be said to be exclusive to these two places, because *Siegling* demonstrated that similar morphology could be found in the central part of the cartilage covering the epiphyseal nuclei. *Lütken* (1947) classified epiphyses and diaphyses according to their surface structure. In his opinion the ends of the vertebral bodies correspond to the epiphyses, and the intermediate, cylindrical part of the vertebra is analogous with the diaphyses of long bones.

The formation of the strange box-shaped zones of dense bone (figs. 1a, 1b) is somewhat difficult to explain by the described theory.

If it were correct, one would expect to find only horizontal lines in the vertebral bodies and no vertical ones. (According to the theories advanced so far, subperiosteal ossification in long bones cannot be inculpated for the genesis of vertical "lines").

Our findings indicate that growth of vertebral bodies takes place according to the fashion of endochondral appositional ossification, and is quite analogous with the growth of epiphyses of long bones.

SUMMARY

3 cases are reported where a severe disease in childhood resulted in temporary halting of bone growth. The "lines of increased density" found in the epiphyses of long bones and vertebral bodies may indicate that growth in the vertebral bodies occurs in the same manner as growth of the epiphyses of long bones, namely, by endochondral appositional ossification.

RESUME

Il est référé trois cas de maladie grave de l'enfance qui a occasionné un arrêt temporaire de la croissance des os. Les lignes de condensation dans les épiphyses et les corps des vertèbres paraissent indiquer que la croissance du corps vertébral se fait d'une manière analogue à celle de l'épiphyse, à savoir comme une ossification endochondrale appositionnelle.

ZUSAMMENFASSUNG

Man berichtet über drei Fälle einer schweren Erkrankung im Kindesalter, die zu einem zeitweisen Stillstand des Knochenwachstums führte. Die auftretenden Kondensierungslienien in Epiphysen und corpora vertebræ könnten darauf hindeuten, dass das Wachstum in den Wirbelkörpern in analoger Weise vor sich geht wie in den Epiphysen, nämlich als eine enchondrale appositionelle Ossifikation.

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