THE PATHOLOGY OF SLIPPED UPPER FEMORAL EPIPHYSIS
A New Concept*

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The weakest part of the epiphysial plate is the layer of cartilage cells nearest the metaphysis. If the overlying periosteum is incised, a separation through this layer is easily produced (Haas 1917). Even if it is conceded, as shown experimentally by Harris (1950), that, in rats treated by growth hormone, broadening of this layer can diminish the cohesion of epiphysis and metaphysis, the resistance to slipping of the upper femoral epiphysis offered by a strong intact periosteum is nevertheless great. Its rupture, necessary before slipping can take place, is likely to produce symptoms more acute than are usual in the case with gradual onset.

It is too easily assumed that slipping is the first recognisable change in position of the femoral head.

From a study of lateral radiographs of slipped epiphyses, I have been impressed by the frequency with which the back of the femoral neck is materially shorter than the front (Fig. 1).

The essential nature of this relative shortening can be seen in Figure 2, in the lateral radiograph of the right hip of a girl of eleven who had an intermittent ache in the thigh for six weeks. The line of the metaphysis, instead of describing a regular ellipse, falls away abruptly behind a point at the junction of the anterior quarter with the posterior three-quarters, and gives the impression of diminished growth of this segment.

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An index of this may be obtained by measuring what I shall term "the angle of tilt." This is the posterior angle enclosed by a line passing through the apices of the anterior and posterior corners of the metaphysis, and one drawn at 90 degrees to the rectilinear shadow cast by the lateral part of the front of the femoral neck. This was measured in twenty normal children, aged twelve to sixteen, and found to average 10 degrees (Fig. 3). It was also measured in thirty-six hips in patients with slipped epiphysis, comprising twenty-two hips with a gradual onset of symptoms, four symptomless contralateral hips, and ten in which, although the onset was definite, symptoms were never severe. The average angle in these thirty-six hips was 30.5 degrees. Cases which presented with sudden displacement without a previous history, and those in which radiographs showed evidence of adaptive changes which would vitiate the measurements, were excluded.

ILLUSTRATIVE CASES

Case 1—A girl aged eleven was admitted to a medical ward in July 1950, because of "rheumatism," having complained of aching in the right thigh for two months and in the left for two days. A lateral radiograph of the right hip (Fig. 4) showed a marked defect of bone growth in the posterior two-thirds of the metaphysis, producing an angle of tilt of 35 degrees.

Eleven months later, premature fusion has taken place across the posterior half of the epiphysial plate, which remained open anteriorly. This has resulted in an increase in the angle of tilt to 47 degrees (Fig. 5).

The left hip of the same child showed a disturbance of growth at an earlier stage (Fig. 6).

Case 2—A girl of twelve was admitted with a typical slipped epiphysis of the left hip. She had no symptoms in the right hip (Fig. 7) which, however, showed notable shortening of the back of the neck and a tilt of 28 degrees.

When the head of the femur becomes tilted its position is unstable, and it is liable to become grossly displaced as a result of minor injury.
Case 3—A boy of fifteen and a half had complained of pain on the outer side of the left hip and thigh for six months. It was at first present only when he got up in the morning, but had recently become severe. Two years previously he had fallen off a pony, and had been dragged some distance with his left leg entangled in the reins.

A 50 per cent recent slip has been preceded by an angle of tilt of 42 degrees (Fig. 8).

Two objections will immediately be raised. The first is that the angle will depend largely on the position of the patient. Actually I have found that slight alterations in position in taking a lateral radiograph have produced little change in the angle. The validity of this was further tested by taking four lateral views of an anatomical specimen in different degrees of lateral rotation (Fig. 9).

It will also be objected that the relative increase in the length of the front of the neck is not primary, but secondary to callus laid down in the wake of an epiphysis which has already slipped. This does occur, but must surely be preceded by severe disability. It is difficult to believe that this can take place quietly with only minor symptoms. Slight pain, or the presence of a painless limp, is more compatible with a gradual alteration in the axis of the head.
It is my contention that the relative increase in the length of the front of the femoral neck is due to a primary failure of growth of the back of the femoral neck.

Why should the back of the neck fail to grow, while normal anterior growth takes place? The most likely cause is compression of the back of the epiphysial plate. This is in keeping with the known effect of acute compression of an epiphysial plate, of which varus of the ankle is a well known example (Fig. 10). Such compression could be applied acutely by forced lateral rotation in extension. In twelve of these patients there was, in fact, a history of a considerable injury at intervals varying from three to twenty-four months before admission to hospital.

Acute compression cannot, however, explain the tilt in the others. According to Frazer (1933), the line of incidence of gravity of the upright trunk passes through the back of the hip, and would tend to bend the trunk backwards were it not for the anterior iliopoplural ligament. The compression force capable of being exerted on the back of the epiphysial plate must be considerable. I believe, therefore, that it is probable that a static compression force plays a part in the majority, and especially in those patients who are overweight.

I have found evidence of diminished or arrested growth in other joints in patients with slipped upper femoral epiphyses where this concept of compression of an epiphysial plate is applicable.

**ILLUSTRATIVE CASES**

**Case 4**—A girl of fifteen with marked hypopituitary characteristics, who had never menstruated, was admitted in 1952 with a slipped epiphysis of the left hip (Fig. 11). In 1955, after two years as a fish-worker, she complained of painful wrists and was found to have a Madelung's deformity, due to growth arrest of the medial part of the lower radial epiphysis, with continued growth of the ulna (Figs. 12 and 13). The following year she had genu recurvatum on the left side from fusion of the anterior part of the upper tibial epiphysis (Fig. 14).

**Case 5**—A girl of twelve was admitted to hospital in August 1950 with a slipped epiphysis which had given symptoms for nine months (Fig. 15). While in bed she complained of backache. A radiograph of the lumbar spine two months later showed wedging of the first lumbar vertebra (Fig. 16).

There was one other case of exactly similar wedging of the first lumbar vertebra, in a tall girl of fourteen, who was treated in hospital in 1947 for slipped epiphysis, and whose left patella was removed the following year for severe chondromalacia.

**Case 6**—A boy of fourteen was seen as an out-patient in March 1957, complaining of thoracic backache. This was found to be due to "osteochondritis" of the ninth thoracic vertebra (Fig. 17).
In July 1958 he was admitted to hospital with a slipped epiphysis of the left hip. Symptoms had been present for one month (Fig. 18). In November 1958 he complained of pain in the left ankle. There was slight swelling on the inner side of the ankle, and tenderness in the line of the joint. A radiograph showed a slight varus deformity. Fusion of the medial part of the epiphysis had occurred, but the epiphysial plate was still open laterally.

Case 7—This patient, aged seventeen, had complained of pain in the right hip for nine months before admission to hospital in September 1958. A lateral radiograph (Fig. 19) showed a posterior slip. In this case the whole of the epiphysial plate was irregular, and growth of the front and back of the femoral neck were alike diminished, producing a shortening of half an inch which could not be explained by the degree of slip. In the thoracic spine (Fig. 20) there was diffuse epiphysial irregularity with wedging of several vertebrae.

Case 8—A boy aged fourteen was first admitted to hospital in September 1943, complaining of pain in the right hip of two weeks' duration. In addition to a slipped epiphysis he had a gross bilateral genu valgum, severe enough to be treated by supracondylar osteotomy.

In 1944 he developed a slipped epiphysis on the left side. For the next fifteen years he was able to work as a farm servant, although with increasing stiffness of the left hip. In April 1959 he was readmitted to hospital because of severe pain in the left hip. It was then noticed that he had a marked thoracic kyphosis. Radiographs showed old bilateral slipped epiphyses (Fig. 21) and wedging of several thoracic vertebrae (Fig. 22).
Case 6. Figure 17—A year after the diagnosis of osteochondritis of the ninth thoracic vertebra this boy was admitted with a slipped epiphysis (Fig. 18).

Case 7. Figure 19—The whole of the epiphysis of the left hip is irregular. Figure 20—There is also a diffuse irregularity in the epiphyses of the thoracic spine.

Case 8. Figure 21—This man has old bilateral slipped epiphyses, and also a marked thoracic kyphosis (Fig. 22).
Routine radiographs of the spine of patients with slipped epiphysis have only been taken in recent months. Of the earlier patients, only those with backache had radiographs of the spine. Otherwise, it is probable that further examples of wedged vertebrae would have been found. The front of the vertebral epiphysial plate and the back of the epiphysical plate of the upper end of the femur are in one respect alike, both being exposed to severe compression forces.

Enough evidence has been adduced to show that, whatever the exact nature of the abnormality of the epiphysial plate of the upper end of the femur in slipped epiphysis, it is also commonly present in other bones. This is in keeping with the findings of Ponseti and McClintock (1956), who stated that "skeletal studies have shown widening and irregularities of other epiphysial plates which suggest that the lesion is not restricted to the upper portion of the femur," and that metabolic studies in cases of slipped epiphysis show an abnormality in protein metabolism similar to that found in "adolescent scoliosis."

One might indeed go further. If the cartilage of the epiphysial plate is abnormally sensitive to compression, is it not possible that articular cartilage may also, on occasion, be affected, and that early severe stiffness of the hip associated with a narrow joint space, but without increased density of the femoral head, may be due to this cause and not to avascular necrosis?

**SUMMARY**

1. Epiphysial tilt commonly precedes slipping.
2. This tilt is due to a diminished or arrested growth from compression of the back of the epiphysial plate.
3. The stresses on the upper end of the femur are such that the upper femoral epiphysial plate is peculiarly liable to compression.
4. A primary abnormality of the cartilage of the epiphysial plate renders it susceptible to the effect of compression.
5. Because this abnormality is diffuse, deformities due to a similar pathology may be found elsewhere, notably in the spine.

I am indebted to the other consultants of the Orthopaedic Service of the North-East region of Scotland for referring to me their cases of slipped epiphysis.

**REFERENCES**


