**SLIPPED UPPER FEMORAL EPIPHYSIS AFTER RADIOTHERAPY**

J. A. CHAPMAN, D. P. DEAKIN, J. H. GREEN

*From Royal Manchester Children’s Hospital and Christie Hospital and Holt Radium Institute, Manchester*

Eight slipped upper femoral epiphyses in patients who had had radiotherapy are described. These cases involved five patients in an “at risk” population of 48. This increased incidence is highly significant.

The lethal effect of radiation on cells has been used therapeutically for many years: The more rapid the cell turnover the greater is the effect of the radiation. One of the main problems with radiotherapy is that ionizing radiations cannot differentiate between normal and pathological tissue. Thus unwanted effects such as leucopaenia or rectal stricture may be produced in tissues with rapid cell turnover.

The epiphysial growth plate is an area with a relatively high cell turnover, and the damaging effects of radiation on this tissue have been demonstrated experimentally (Rubin et al. 1959). There has been only one report of a possible association of radiotherapy with slipping of the upper femoral epiphysis (Wolfe et al. 1977); we report eight further occurrences of slipped upper femoral epiphyses in five patients.

**CASE REPORTS**

**Case 1.** This child presented at the age of three years with an abdominal mass. She had a left nephrectomy for a Wilms’ tumour and was given a course of radiotherapy with a dose of 3000 rads at four millivolts over 26 days. Shielding along the inguinal ligament was used. She did not have chemotherapy.

At the age of 12 years she complained of pain in the right hip and a limp. A slipped upper femoral epiphysis was diagnosed and pinned. Almost a year later she developed left-sided symptoms and the left upper femoral epiphysis was shown to have slipped (Fig. 1). This was pinned and at the same time the pins in the right hip were removed. The pins on the left were removed eight months later and her progress has been uneventful.

**Case 2.** This child presented at the age of three years with diarrhoea and infected warts on the anus and vulva. An abdominal mass was noted and an inoperable neuroblastoma was found at laparotomy. She was given a course of 3000 rads at four millivolts over 29 days. No shielding was used and she did not have chemotherapy. The tumour responded well. The parents initially refused permission for further surgery, but subtotal removal of the tumour was possible at a further laparotomy two years later.

Her progress was then satisfactory for about six years when at the age of 11 years she was noted to have another large tumour. A biopsy, however, did not produce any evidence of malignancy. At the age of 12 years she developed pain in her left hip. A slipped upper femoral epiphysis was pinned. One year later a slipped upper femoral epiphysis on the right was diagnosed (Fig. 2) and pinned. There have been no further problems from her hips although her general condition has been poor due to the underlying disease.

**Case 3.** This child was born with an imperforate anus and jaundice. An anal cutback was performed and she had an exchange transfusion. She then required a colostomy, which was closed after a rectal pull-through. At the age of three years a large tumour in the pelvis was diagnosed: histologic examination showed yolk sac tumour. She was exposed to a total of 3000 rads at four millivolts over 27 days. Shielding from the pubis to the anterior superior iliac spine was used. She also had a course of vincristine, actinomycin D and cyclophosphamide.

Two months after the first laparotomy a residual tumour was resected at a second laparotomy. She then had several courses of

![Fig. 1](image1.png)  
Case 1. Radiograph showing slipping of the upper femoral epiphysis in the left hip. The right femur has been pinned.

![Fig. 2](image2.png)  
Case 2. Radiograph showing slipping of the upper femoral epiphysis in the right hip. The left femur has been pinned.
vincristine, actinomycin, cyclophosphamide and adriamycin over the following two years. An examination under anaesthesia two years later revealed no residual tumour. At the age of seven years she developed pain in the right hip. Radiography showed slipping of the right upper femoral epiphysis with the early changes of the same condition in the left hip (Fig. 3). The right hip was pinned and one month later the left was pinned. Her progress has been uneventful.

**Case 4.** At the age of three years this boy was noted to have a swollen scrotum. An orchidectomy was performed and a rhabdomyosarcoma of the scrotum was excised. He was given a course of 3000 rads at four millivolts over 27 days without shielding. He also had a 10-day course of actinomycin D. At the age of 12 he developed pain in the right hip and was found to have a slipped upper femoral epiphysis (Fig. 4), which was pinned. His progress has been uneventful.

**Case 5.** At the age of three years this boy had a large retroperitoneal neuroblastoma shelled out. He was given a course of 3000 rads at four millivolts over 35 days. There has been no recurrence of the tumour. At the age of 12 he developed pain in the right hip and a limp. A slipped upper femoral epiphysis was diagnosed (Fig. 5) and was pinned. He made an uneventful recovery.

**DISCUSSION**

Slipping of the upper femoral epiphysis is a condition which classically affects boys between the ages of 12 and 15 years and girls between 10 and 13 years. It can also be a problem in calves (Hamilton et al. 1978) and dogs (Lee 1976). The cause of the condition is poorly understood. The various aetiological factors which have been proposed can be divided into two broad categories: those which increase the stress on the epiphysial plate, and those which decrease the strength of the plate to resist this stress.

In the first category come cases in which a single injury is said to be responsible (Burrows 1957). A certain percentage of patients are overweight although it is not clear whether this is due to obesity or to "heavy bones" (Kelsey 1973). Alexander (1966) demonstrated that in the sitting position there is increased stress particularly in the contralateral hip during writing and that this may account for the higher incidence on the left side.

Factors which decrease the strength of the epiphysial plate may be genetic, hormonal or metabolic. There have been many reports of slipped capital femoral epiphysis occurring in parents and children, sibs (Rennie 1967) and twins (Gorin 1977), and it has been agreed that the familial incidence is higher than would be expected by chance (Kelsey 1973). Harris (1950) demonstrated that in the rat the shearing strength of the upper epiphysis of the tibia was decreased by growth hormone and increased by oestrogen. Rennie and Mitchell (1974) reported a case of slipped upper femoral epiphysis occurring during treatment with growth hormone; however, Razzano, Nelson and Eversman (1972) measured the levels of growth hormone in five patients and found that they were normal. The tendency for the condition to occur in individuals who are short and overweight or tall and thin has been put forward as evidence of endocrine imbalance. Several cases have been associated with primary hypothyroidism (Crawford, MacEwen and Fonte 1977; Hirano et al. 1978) and the condition has also been found in a hypopituitary dwarf (Semple and Goldschmidt 1969) and in a pituitary giant (Burrows 1957).

Epiphysial strength is decreased in uraemic patients, and there have been several reports of slipped upper femoral epiphysis in association with renal osteodystrophy, particularly if untreated (Kirkwood, Ozonoff and Steinbach 1972; Mehls et al. 1975). Other epiphyses, particularly those in the radius and the ulna, are also often affected. Kirkwood et al. (1972) felt that the epiphysial displacement was caused by fracture of the metaphysis due to hyperparathyroid bone disease secondary to the renal disease rather than being simply an expression of renal osteodystrophy.

Irradiation presumably affects the strength of the epiphysial plate rather than the stress put on it. Two
points must be considered: does the radiotherapy cause the slipping and, if so, what is the mechanism? There has been one report of slipped upper femoral epiphysis in children who had been irradiated (Wolf et al. 1977); their ages when slipping occurred were seven, nine, 11, 11 and 14 years respectively. Four of the children in our study were 12 and one was seven years old when slipping occurred. Seven is certainly very young for this condition to occur idioopathically, but it could be argued that the other cases would have occurred without the radiotherapy. However, over a period of 10 years 141 children had radiation to the pelvis and might therefore have had radiation to their femoral epiphyses. As most of these patients had widespread malignancy the majority died within two weeks to two years after treatment. There were 48 long-term survivors. There were thus eight cases of slipped upper femoral epiphysis in five patients out of a population of 48, which is an extremely high incidence when compared with other reports. There were 150 cases of slipped upper femoral epiphysis in 127 patients over 10 years in a population of 1.5 million in Malmo, Sweden (Andrén and Borgström 1958) and it has been estimated that the annual incidence in Gothenberg is 0.52 per 10,000 population aged between seven and 16 years, or five cases per 10,000 in 10 years (Henrickson 1969). The increased incidence in children who have had radiotherapy is highly significant \((P=0.001)\). Also, 60 per cent of our cases were bilateral as compared with the usual incidence of 20 to 25 per cent (Kelsey 1973). It would therefore seem probable that these cases were related to the radiotherapy.

How does radiation affect the epiphysis? There is no doubt that it can directly affect the growth plate. Franz (1950) reported the case of a boy whose leg was 9.75 inches shorter after irradiation for a haemangioma in the thigh. In the rat, specific irradiation of the epiphysis produces a significant decrease in growth whereas irradiation of the diaphysis and metaphysis does not (Rubin et al. 1959). De Smet et al. (1976) described the radiological changes in epiphyses which had been irradiated during the treatment of Ewing’s tumours. It is possible that the epiphyseal plate is weakened by the direct action of the radiotherapy. It is certainly known that in the adult radiotherapy can affect the femoral neck, as there have been several reports of high subcapital fractures of the femoral neck in women who had irradiation for carcinoma of the cervix (Stephenson and Cohen 1956). The effect on the epiphysis could, however, be an indirect action. All the affected children had total dosage irradiation to their gonads and had unrecordable levels of sex hormones. Harris (1950) showed that the shearing strength of the epiphyseal plate was increased by oestrogens and decreased by growth hormone. It may be that irradiation of the gonads sufficiently alters the hormonal balance to affect the strength of the epiphysis.

Whatever the mechanism it would seem likely that, with the increasing survival of children with malignancy, slipping of the upper femoral epiphysis after radiotherapy may be seen more frequently. Whether this complication can be prevented by shielding is difficult to say, as two of our patients had shielding. With regard to the management of these cases, there are no specific precautions. After pinning, the epiphysis appears to fuse satisfactorily and there were no problems with wound healing as might have been expected in irradiated tissues.

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