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# BONE SCINTIGRAPHY IN EARLY DIAGNOSIS OF PERTHES' DISEASE

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$^{99m}$Tc-pyrophosphate bone scintigraphy was performed in patients with Perthes' disease in the radiological initial stage and within 4 months after the onset of symptoms, and in patients with transient synovitis of the hip joint. In Perthes' disease there was decreased activity in the capital femoral epiphysis. In cases with synovitis a diffusely increased activity was found. A correct diagnosis of Perthes' disease was possible at a time when the radiological findings were minimal or even prior to any radiological findings. Increased activity might have been expected if the aetiology of the disease was an aseptic coxitis, or if the increased radiological density was due to new bone formation. Also in abortive forms of Perthes' disease a decreased activity was found. This indicates that a period of decreased blood flow to the epiphysis is not bound to be followed by the typical radiological course of the disease.

*Key words:* bone; epiphysis; hip; Legg-Perthes' disease; osteochondritis; necrosis; radioisotopes

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The pathology of Perthes' disease can be described as a vascular disturbance leading to necrosis and subsequent revascularization of the capital femoral epiphysis (Jonsäter 1953, McKibbin & Ráliš 1974, Jensen & Lauritzen 1976). Death of bone does not produce immediate changes in its radiographic density and in the early stages standard radiographs are normal. Therefore diagnosis and treatment are often delayed. To establish an early diagnosis of bone necrosis, bone isotope techniques have been tried for many years (Tucker 1950), but were not generally accepted for clinical use until the introduction of $^{99m}$Tc labelled bone seeking components. The degree of tracer uptake is primarily a function of the blood supply to the bone (Garnett et al. 1975), and may thus be used for the detection of areas with both decreased and increased vascular supply. This method has been used successfully in studying necrosis of the femoral head following fractures (Korvald & Sundsfjord 1974). The radiation dose is low and the method can therefore be used in investigating paediatric bone diseases as well. The purpose of the present paper was to investigate the possibility of using bone scintigraphy to make an early diagnosis in Perthes' disease.

## MATERIAL AND METHODS

From 1974 to 1977 bone scintigraphy was performed in patients with suspected Perthes' disease. They were examined clinically, radiologically and with bone scintigraphy as early as possible. Only patients examined within the first 4 months after the onset of symptoms, having either radiographical signs of Perthes' disease in the initial stage or no positive radiographical findings at all, a total of 26 patients, were included in the present material. However, two patients were excluded because scintigraphic images were not taken with the hips in the standard position, leaving a total of 24 patients for further study.

$^{99m}$Tc-pyrophosphate was prepared by adding 5 ml saline eluate from a $^{99m}$Tc generator to the contents of a bottle of Isokit Nyco containing polyphosphate 2.4 μmol, Na-pyrophosphate 22.4 μmol, $Sn^{II}$ (as chloride) 2.2 μmol. Each patient received from 2 to 6 mCi calculated according to the age [10 mCi × (age + 1)/(age + 7)] intravenously 3 hours before scintigraphy. The patients were encouraged to drink a lot to reduce the concentration in the urogenital tract, and to urinate frequently to minimize the radiation in the bladder. No adverse reactions to the injected pharmacon were observed. The scintigraphic examination was performed with a gamma-camera (Pho/Gamma III, Nuclear Chicago) connected to a computer unit (Nuclear Data, fifty fifty MED). Bone scintigraphic images were taken of the pelvis and both hips with a parallel hole collimator, and of both hips in strict AP position using a pinhole collimator. When using the parallel hole collimator it was possible to compare the uptake of the tracer in the two hip regions, and a detailed study of the radioactivity in the epiphysis was possible using the enlarged image produced with the pinhole collimator. In normal hip scintigrams the acetabular roof and the epiphyseal plates reveal a high activity, whereas the capital epiphysis and the femoral neck show a relatively lower uptake (Figure 1).

## RESULTS

*Perthes' disease* developed in 20 hips of 18 out of the 24 patients. Three were females and 15 males. The age varied from 2½ to 11 years, mean age 5.4 years. The right hip was involved in 13 cases and the left hip in 7 cases. The patients presented with a limp and/or pain in the involved hip. The mean duration of symptoms was 2.6 months. The

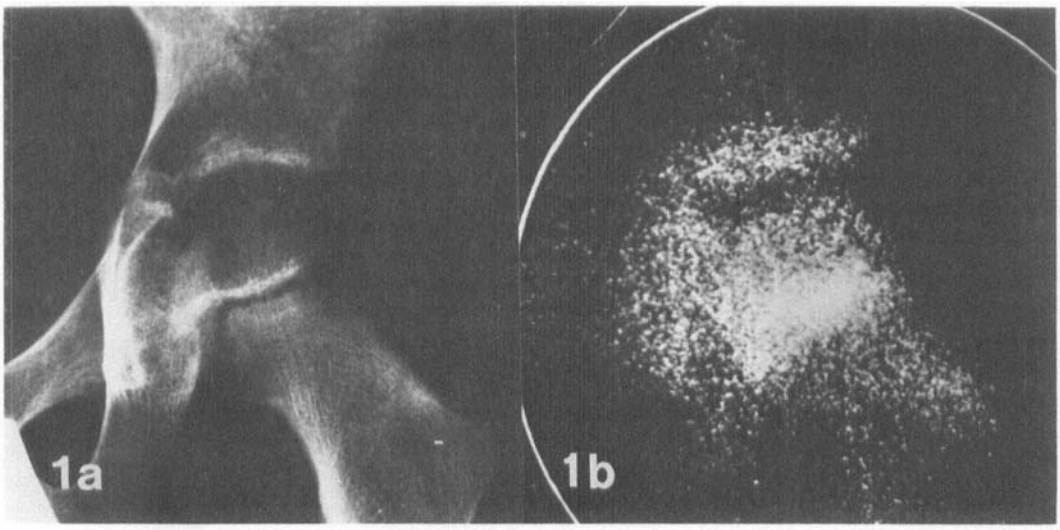


*Figure 1. A 7-year-old boy with pain in the left hip region for about 2 months and restricted mobility of the hip joint. (a) Radiograph reveals no pathological findings. (b) The bone scintigraphic image with a pinhole collimator showed slightly increased activity in the hip region, but no areas with decreased uptake of tracer. The acetabulum, femoral head, epiphysial plate and greater trochanter can easily be identified.*

range of movement of the affected hip joint was reduced. Radiographs showed Perthes' disease in the initial stage in 18 hips, 13 of which showed sclerosis. Normal radiographs at the first examination were found in two hips.

Scintigraphy revealed a pathological uptake with *decreased activity* in the capital femoral epiphysis in all cases with Perthes' disease. Decreased radioactivity throughout the entire epiphysis was observed in half of the hips (Figure 2). The others had decreased activity in parts of the epiphysis. Increased activity in the hip region was not observed in any case with Perthes' disease in the early stage investigated.

Three patients had radiographically unilateral Perthes' disease at the *first* examination whereas scintigraphy revealed distinctly decreased activity in *both* hips. In one case (Figure 3) symptoms had been present for 1 month in the radiographically normal hip. Later on, radiographs showed both hips passing through the usual stages of fragmentation and remodelling. In a second patient, with symptoms from one hip only, radiographs showed bilateral involvement 4 months later. In the third patient, no radiographical changes nor any symptoms developed in the hip with decreased scintigraphical activity only.

*No radiological signs* of Perthes' disease were found in six patients at the time of scintigraphy. Radiographs at follow-up 4 months later were normal as well. All suffered from limping and/or pain. Decreased mobility of the hip joint was demonstrated in all these cases, and in two patients the decreased mobility remained at the time of scintigraphy. Scintigraphy revealed no signs of decreased uptake of the tracer. On the contrary a slightly *increased activity* affecting both the proximal femoral epiphysis, the metaphysis and the acetabulum was found (Figure 1).

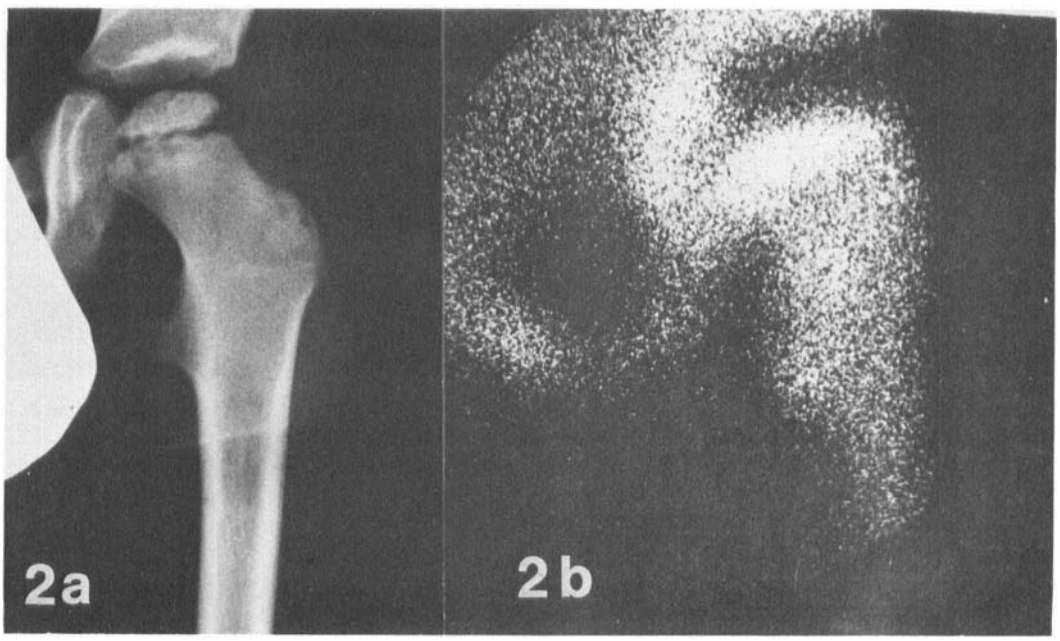


*Figure 2. A 4-year-old boy who had been limping with his left leg for about 2 months. (a) Radiograph of the left hip shows Perthes' disease in late initial stage with sclerosis and slight flattening of the epiphysis. (b) The bone scintigraphic image with a pinhole collimator shows decreased activity in the whole epiphysis.*

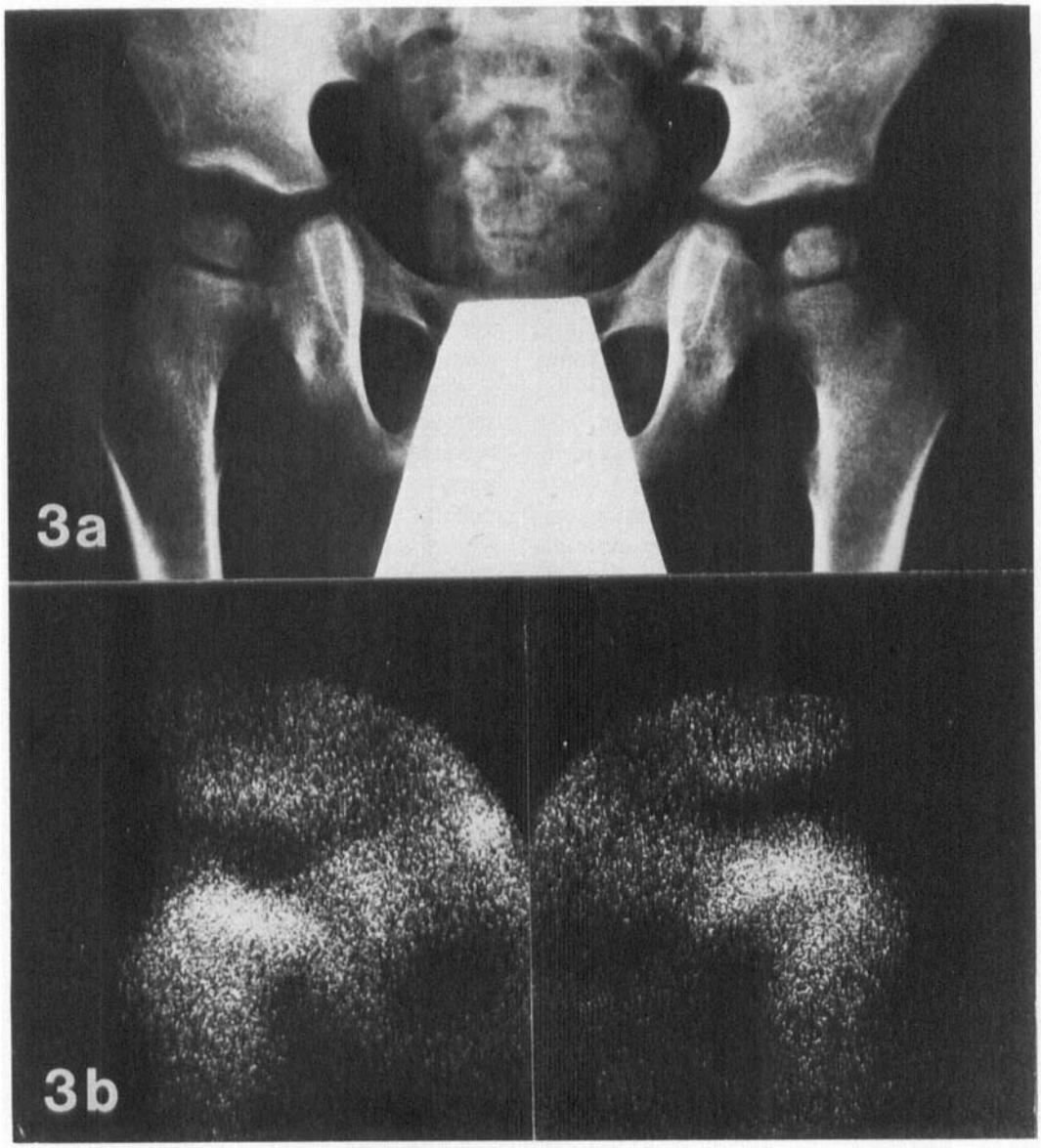


*Figure 3. A 3-year-old boy with limping on the right leg for 1 month in addition to symptoms from the left hip. (a) Radiograph shows changes in the left hip with Perthes' disease in the late initial stage. The right hip is normal. (b) Bone images with a pinhole collimator show decreased activity not only in the left capital epiphysis, but also in the right radiologically normal hip.*

## DISCUSSION

In Perthes' disease symptoms and clinical findings are not conclusive, and *diagnosis* is based on radiographs only. However, the earliest radiographical changes are usually first seen several weeks after onset of the symptoms (Edgren 1965). In the present investigation it has been possible to demonstrate a pathological scintigram in all cases of Perthes' disease examined during the first 4 months after onset of symptoms. They

all had a decreased uptake of $^{99m}$Tc-pyrophosphate in all or part of the capital femoral epiphysis. These findings which confirm the results of Danigelis et al. (1975), were present before any changes could be seen on radiographs.

The exact location of $^{99m}$Tc-pyrophosphate in bone is unknown, but it seems to be linked to the hydroxyapatite crystals (Garnett et al. 1975, Greif 1976). The degree of uptake probably depends on many factors such as the capillary permeability and receptors available. But the degree of regional bone blood flow is a major determinant for the degree of tracer uptake (Siegel et al. 1976). The decreased uptake in Perthes' disease may therefore be a sign of decreased blood flow to the epiphysis. If the onset of symptoms is related to a vascular disturbance leading to necrosis of the epiphysis it is reasonable to assume that $^{99m}$Tc-pyrophosphate uptake decreases immediately after the impairment of the blood supply. A positive scintigraphic examination should therefore be expected at the very beginning of the symptoms, and bone scintigraphy may thus be of great importance in the early diagnosis of Perthes' disease.

The cause of the *radiological sclerosis* in the initial stage of Perthes' disease has been a matter of dispute (Jonsäter 1953, Larsen & Reiman 1973). In an investigation using $F^{18}$ scintigraphy, Bohr (1973) found increased uptake even in the initial stage and supported the opinion that the increased density was due to appositional bone formation. In the present material the examination did not show any sign of increased activity in any parts of the capital femoral epiphysis even in cases with radiological sclerosis. As $F^{18}$ and $^{99m}$Tc-pyrophosphate accumulate in the same areas (Garnett et al. 1975), these two reports seem to contradict each other. However, the examination with $F^{18}$ was performed relatively late and the image possibly represents a phase passing on to the fragmentation stage with revascularization and new bone formation. In the present material the examinations were performed very early in the initial stage within 4 months of the onset of symptoms and prior to any revascularization and new bone formation. The results in this investigation therefore are in agreement with the histological findings of Jonsäter (1953) and indicate an initial phase of decreased blood supply to the epiphysis.

The *aetiology* of the decreased blood flow is obscure. Vascular occlusions, alterations in blood coagulability and a relatively insufficient blood supply to a growing epiphysis have been discussed (Hipp 1962, Chung & Ralston 1969, Rodegerdts 1969, Bjerkreim & Trygstad 1976, Jensen & Lauritzen 1976). Furthermore, transient synovitis of the hip joint has been proposed as a cause (Spock 1959, Emr 1966, Barz & Torklus 1976). In the present investigation none of the cases with clinical synovitis had any decrease in the uptake of tracer; on the contrary, some had a diffusely increased uptake often found in cases of inflammatory disease (Hoffer & Genant 1976). The patients with Perthes' disease had no signs of increased uptake of the tracer. This would be expected if an inflammatory reaction was the primary cause of the disease.

The radiological findings in Perthes' disease change in a rather typical manner with progress and eventual healing of the disorder. However, cases with minor radiological changes and a relatively rapid improvement have been described. Sundt (1949) called these cases *"abortive" Legg-Calvé-Perthes' disease*, a term also used by Katz (1965). Meyer (1964) named these involvements "dysplasia epiphysialis capitis femoris", and believed they represented a separate syndrome. However, it is still uncertain whether this is merely a variant of Perthes' disease or a growth disturbance. In the present study one hip had radiographical changes corresponding to an abortive form of Perthes' disease, and the scintigraphic image showed decreased uptake of the $^{99m}$Tc-pyrophosphate. In another case with decreased uptake in an asymptomatic hip and in whom treatment was started very early owing to involvement of the other hip no

radiographic changes occurred. This indicates that abortive forms of Perthes' disease may be caused by vascular disturbances. Furthermore, it indicates that a period of decreased blood flow to the epiphysis is not bound to be followed by the typical Perthes' disease which probably is due to a late revascularization and reinfarction (Sanchis et al. 1973, McKibbin & Ráliš 1974, Jensen & Lauritzen 1976, Inoue et al. 1976).

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