Acta orthop. scand. *54*, 872–877, 1983

EMISSION TOMOGRAPHY IN FEMORAL NECK FRACTURE FOR EVALUATION OF AVASCULAR NECROSIS

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Two cases of operated femoral neck fractures are presented, in whom an intact femoral head isotope uptake was found with conventional Tc-MDP scintimetry. In both patients, emission tomography using the rotating slant-hole technique was diagnostic.

Key words: femoral head necrosis; femoral neck; osteonecrosis; radionuclide imaging; scintimetry

Accepted 25.v.83

Many investigators have used technetium-labelled compounds to try to clarify the pathogenesis of posttraumatic femoral head collapse and to establish this diagnosis in the preradiographic stage (Bauer et al. 1980, Greiff et al. 1980, Lucie et al. 1981). The late hypermetabolic stage of segmental femoral head collapse was noted by Alavi et al. (1977) and deficient femoral head isotope uptake after fracture nailing was seen by D'Ambrosia et al. (1976). The significance of fracture line uptake was investigated by Oda et al. (1980). In a long-term study (Bauer et al. 1980, Strömqvist et al. 1983b), scintimetry was used to follow the healing course after osteosynthesis of femoral neck fractures. In about half of the patients, a femoral head defect was found at Tc-MDP scintimetry performed within 3 weeks of the operation; virtually every patient with a primarily defective uptake later developed complications to healing. In the majority of cases in this series, a repeat scintimetry 4 months later demonstrated increased isotope uptake appearing in the place of the previously empty femoral head. The question has been raised, whether this hyperactivity is due to activity in the femoral head itself or is caused by hypermetabolism in the surrounding bone tissue. Revascularization of the femoral head would be expected to occur through creeping substitution, a procedure which would take far more than 4 months for the entire femoral head (Charnley et al. 1957).

Another interesting question is whether local circulatory defects may exist after a femoral neck fracture, and if so, whether it is possible to detect them by means of scintimetry.

An attempt was made in two patients to answer the two questions posed above using emission tomography and technetium-labelled compounds. The results are presented below.

METHODS

Scintimetry was performed 3–4 h after the intravenous injection of 370 MBq of ^{99}Tc-M-labelled methylenediphosphonate (MDP, osteolite, New England Nuclear, North Billerica, Mass., USA). An anterior static image centered over the pelvic-hip area was obtained using a large field-of-view scintillation camera with a general purpose, parallel hole collimator (Sigma 410S, Technicare Corp., Cleveland, Ohio, USA). Count information

was also stored on a dedicated computer (MCCS-560, Technicare) for region of interest analysis. Regions of interest were selected over the femoral head and neck as described by Strömqvist et al. (1983b), and ratios of the fractured to the intact side were obtained for these regions.

Following the static image, the collimator was changed to a general, all-purpose, rotating, slant-hole collimator (Technicare) and tomographic registration was performed in the anterior projection over the hip joint of interest. Acquisition was performed in six views, each corresponding to a rotation of the collimator core, after which the reconstruction process began. The result was obtained as 12 consecutive, 1 cm thick, 64 × 64 slices that were stored on transparent film, as well as on floppy discs.

Case reports

Case 1. A 70-year-old, previously healthy male sustained a left-sided femoral neck fracture with considerable displacement (Garden type IV) when he slipped and fell on the pavement. He was admitted to his local county hospital where closed reduction and nailing with a four-flanged nail (Rydell 1964) was performed the following day.

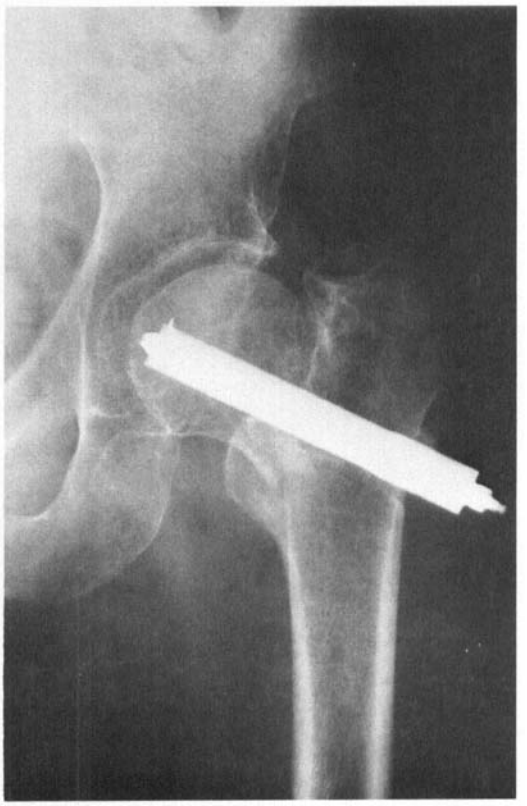

Figure 1. Anterior radiograph of case 1, 8 months after fracture.

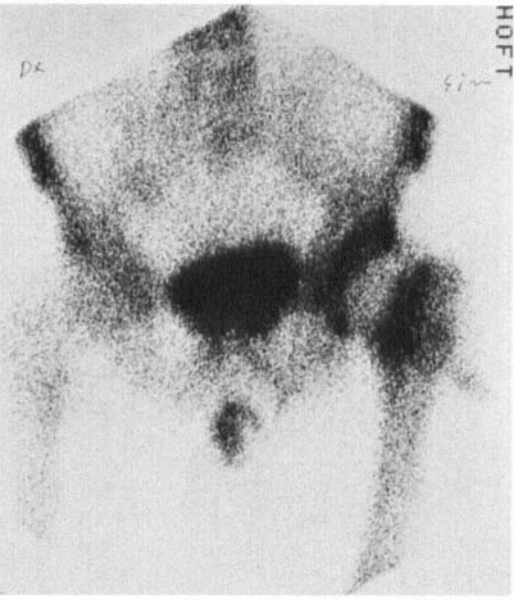

Figure 2. Tc-MDP scintimetry in case 1 performed 8 months after fracture, AP view. Femoral head uptake ratio fractured/intact side 1.31.

The postoperative course was uneventful and the patient was able to return home within 2 weeks. After 4 months, at a routine check-up, the patient was satisfied, had only minor pain and could walk without any walking aid.

After another 4 months, he was using a crutch on walking and his hip pain had increased somewhat. Radiographically, union seemed doubtful, but no changes in the femoral head were revealed (Figure 1). The patient was therefore referred for skeletal scintimetry. Registration in anterior projection demonstrated a high fracture region uptake (left/right ratio 3.06) and a satisfactory femoral head uptake as compared to the intact side (ratio 1.31) (Figure 2). The patient was also investigated using the rotating slant-hole collimator tomographic technique in the anterior projection (Figure 3). This examination disclosed a high isotope activity corresponding to the entire acetabulum as well as in the anterior parts of the femoral head. In the posterior parts of the femoral head, on the other hand, isotope uptake was markedly reduced. There was evidence of a large necrotic portion in the posterior part of the femoral head – a finding that could not be revealed by conventional scintimetry.

The patient still suffers pain on weight-bearing though not to the extent that he would accept a total hip arthroplasty. Eighteen months after the operation, nonunion of the fracture was evident (Figure 4).

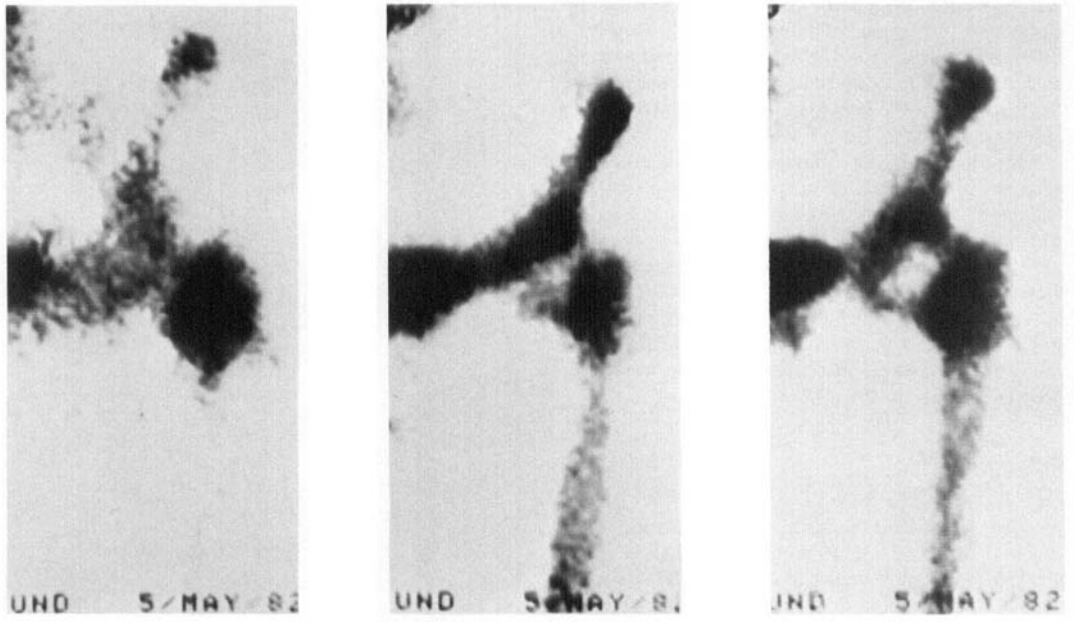

Figure 3. Emission tomography using Tc-MDP in case 1 performed 8 months after fracture. Anteriorly (3a) and centrally (3b) in the femoral head, isotope uptake is present, but posteriorly (3c) an uptake defect is revealed.

Case 2. A 45-year-old, male, icehockey referee fell on the ice and sustained a heavy blow to his right hip. Radiographs showed a femoral neck fracture with moderate displacement (Garden type III). Pin traction was applied and on the next day closed reduction and osteosynthesis with two Hansson nails (Hansson 1975) was performed.

Mobilization without weight-bearing followed. Ten days postoperatively, scintimetry was carried out, showing a pronounced uptake defect corresponding to his right femoral head (ratio fractured/intact side 0.67) (Figure 5).

After 4 weeks of non-weight-bearing, partial weight-bearing started, and 2 months later the patient stopped using crutches. At the routine 4-month control he was working full-time and denied hip pain. Radiographs revealed some fracture line compression and signs of healing (Figure 6). Conventional scintimetry showed a high fracture line uptake, ratio 3.92, and the femoral head uptake on the fracture side was equal to that on the intact side (ratio 1.05) (Figure 7).

To evaluate this activity pattern more closely, emission tomography was performed (Figure 8). This investigation disclosed hyperactivity anteriorly as well as posteriorly to the femoral head, probably corresponding to the acetabular walls, but strong suspicion of low activity in most of the femoral head.

Figure 4. Anterior radiograph of case 1, 18 months after fracture with obvious non-union.

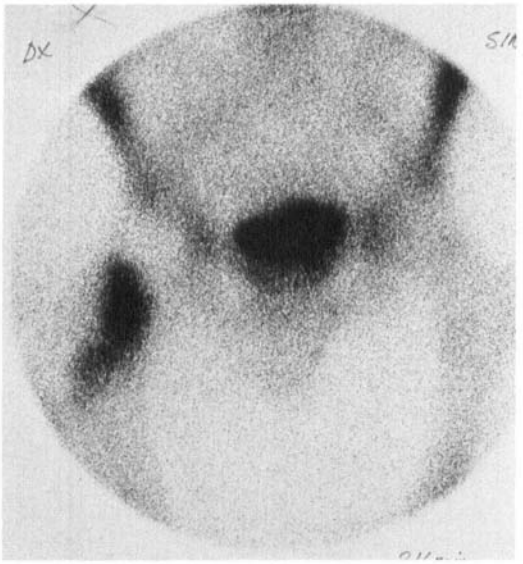

Figure 5. Tc-MDP scintimetry in case 2 performed 10 days after operation, AP view. Femoral head uptake ratio fractured/intact side 0.67.

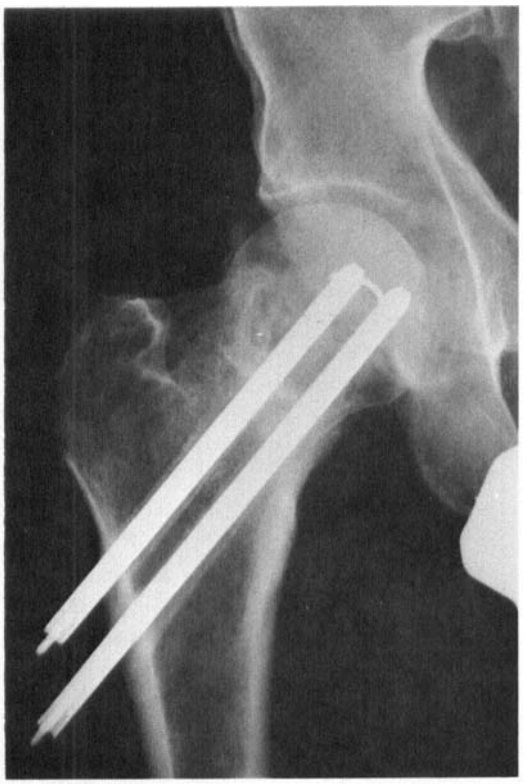

Figure 6. Anterior radiograph of case 2, 4 months after fracture.

After a long asymptomatic period, during which the patient returned to refereeing icehockey, pain in his right hip had been present for 2 months when radiography 2 years after fracture (Figure 9) revealed a minor collapse of a large apical part of the femoral head; the fracture had undoubtedly healed.

DISCUSSION

Because of its ability to demonstrate vascular and metabolic disturbance of the femoral head considerably earlier than radiography, scintimetry using technetium-labelled compounds has become an important diagnostic and prognostic aid following femoral neck fracture (Strömqvist 1983) and has been added to the postoperative routines in many orthopaedic departments. The precision of the investigation has been improved by higher resolution and also by the possibility of numerical evaluation (Bauer et al. 1980, Strömqvist et al. 1983b).

The prognostic accuracy of technetium scintimetry performed within 3 weeks of operation has proven high; a femoral head uptake exceeding that on the healthy side implying normal healing, and deficient uptake being connected with

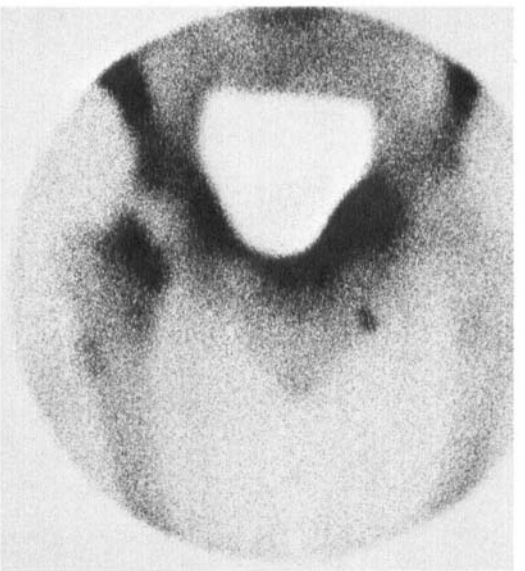

Figure 7. Tc-MDP scintimetry in case 2 performed 4 months after fracture, AP view. Femoral head uptake ratio fractured/intact side 1.05.

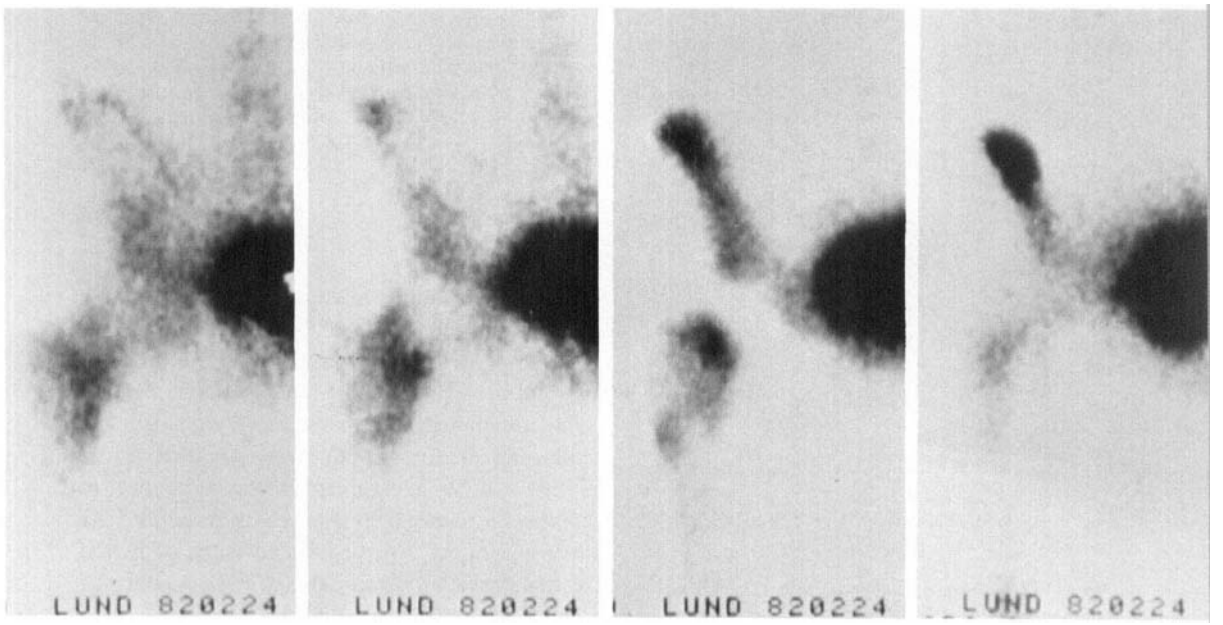

Figure 8. Emission tomography using Tc-MDP in case 2 performed 8 months after fracture. Anteriorly to the femoral head (8a) as well as posteriorly (8d), uptake is seen but the anterior part of the femoral head (8b) and the posterior part (8c) reveal deficient uptake.

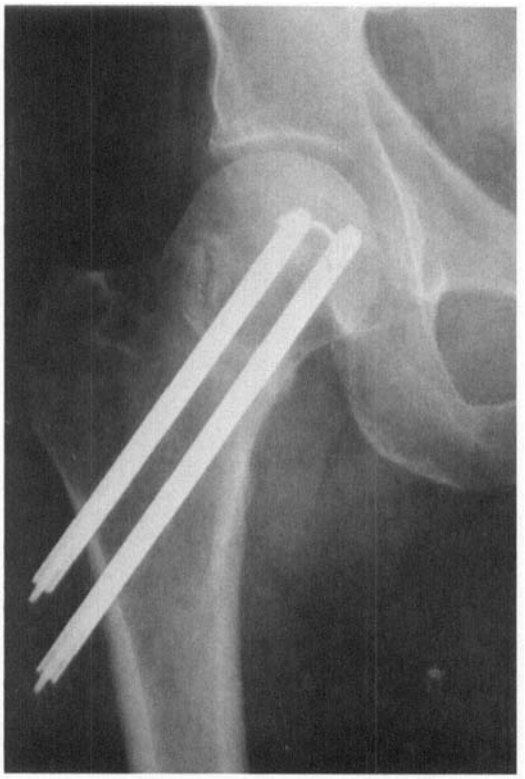

Figure 9. Anterior radiograph of case 2, 2 years after fracture. A minor collapse of the apical part of the femoral head is noted.

healing complications (Bauer et al. 1980, Strömqvist et al. 1983b).

The overall frequency of postoperative femoral head defects in a study of 134 patients comparing two different types of osteosynthesis (Strömqvist et al. 1983a) was 48%, while 48% showed satisfactory uptake and 4% borderline values with uncertain prognosis. These figures, as well as the healing complication figures of 30–55% noted by others at clinical follow-ups (Banks 1962, Garden 1971, Barnes et al. 1976), are considerably lower than those of histological investigations of Sevitt (1964) and Catto (1965) of 84 and 66%, respectively. Fifty-five out of 66% in Catto's investigation represented patients with partial necrosis and a reason for the discrepancy between the figures noted may be that partial necrosis sometimes does not give rise to clinical problems. Emission tomography offers new possibilities to disclose local necrotic regions as in case 1. The incidence of such regions as well as

their clinical implication remains to be determined; in the case presented, non-union followed.

The finding in case 2 of a low-activity femoral head, not detected by conventional bone scintimetry because of surrounding hyperactivity, may partly account for the high frequency of uptake increase noted 4 months postoperatively in femoral heads that were avascular scintimetrically in the early postoperative course – 10/13 patients in the series of Bauer et al. (1980). Furthermore, the risk of not detecting the avascular femoral head is probably considerable when pronounced femoral neck resorption is at hand and most of the proximal fracture fragment is contained within the acetabulum.

Emission tomography during the healing course after femoral neck fracture seems to increase the diagnostic possibilities as well as the prognostic accuracy, as illustrated by the case reports presented. The value of this technique, however, has to be tested in a larger material.

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