

Prognostic precision in postoperative ^{99m}Tc -MDP scintimetry after femoral neck fracture

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A 2-year follow-up regarding healing complications, such as redisplacement, nonunion, and segmental collapse of the femoral head, was performed in 306 patients operated on for femoral neck fracture and examined with ^{99m}Tc -MDP scintimetry within 2 weeks postoperatively. Scintimetric evaluation was performed by selecting regions of interest over the femoral head on the fracture side and the intact side and by comparing the uptake. A femoral head ratio fractured/intact side thus was obtained.

Of 199 patients with an intact femoral head uptake (ratio ≥ 1.0), 181 showed no signs of healing complications at 2 years, whereas 18 had developed healing complications. Of 107 cases with a deficient femoral-head uptake (ratio < 1.0), 96 had developed healing complications within 2 years from the operation, while 11 cases had no signs of radiographic complications.

We conclude that ^{99m}Tc -MDP scintimetry performed within 2 weeks from femoral neck fracture can predict the outcome of the healing course with a prognostic accuracy of 91 per cent.

Preoperative scintimetry with technetium-labeled compounds has proven of great prognostic value (Turner 1983, Holmberg & Thorngren 1984, Strömqvist et al. 1984b), as has scintimetry performed in the early postoperative period (D'Ambrosia et al. 1976, Strömqvist 1983, Strömqvist et al. 1984a, Alberts 1985). Later in the course, the prognostic precision has proven somewhat inferior (Greiff et al. 1980, Alberts 1985).

We report the prognostic value of early postoperative ^{99m}Tc -MDP scintimetry performed routinely after femoral neck fracture in Lund since 1981.

Patients and methods

At our regional hospital, about 150 femoral neck fractures are treated annually. Postoperative scin-

timetry is performed in all cases except those with severe physical or mental illness or otherwise short postoperative life expectancy. Through 3 years, 306 of these patients were investigated and followed up for 2 years postoperatively or until healing complications occurred. The median age of the patients was 79 (18-91) years. The female/male ratio was 3/1, and the ratio undisplaced/displaced fractures was 1/3.

Displaced fractures were treated with tibial traction on admittance. In the absence of medical contraindications, the fractures were operated on the day after admittance. Fracture reduction (when necessary) and fixation were performed on an extension table and with the aid of fluoroscopy, usually biplane. The methods of osteosynthesis were either a 4-flanged nail (Rydell 1964) or two hook-pins (Hansson 1975, 1982). Immediate postoperative weight bearing was allowed except in patients less than 50 years of age with displaced fractures; these patients were instructed a 6-week period of nonweight bearing.

The postoperative follow-up included clinical and radiographic examinations 1 week, 4, 12, and 24 months postsurgery. As radiographic healing

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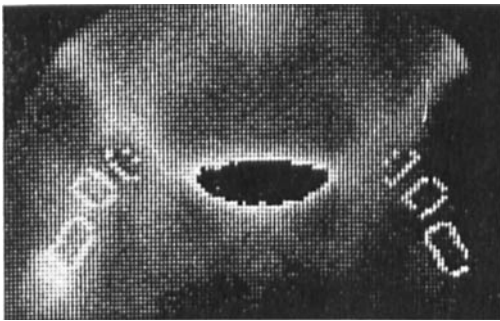


Figure 1. Standardized method of selecting regions of interest (ROI) over the proximal femur. The femoral head uptake on the fracture side (right) is compared with that on the intact side. In this case the femoral head ratio was 0.91.

complications were regarded redisplacement of the fracture, nonunion of the fracture, and segmental femoral head collapse.

$^{99m}\text{Tc-MDP}$ scintimetry was performed within 18 days after osteosynthesis in all the cases. Three to 5 hours after the intravenous injection of 330–370 MBq of the isotope, the activity was recorded with a gamma camera with a large field of view collimator. Regions of interest were selected over the femoral head of the fractured, as well as the intact, side (Figure 1). Uptake per picture element was determined and a ratio fractured/intact side calculated, yielding a femoral head ratio (intact value 1.0). The scintimetric evaluation was performed by a physicist who was not involved in the clinical and radiographic follow-up of the patients. In patients with contralateral hip disease (11 with recent fracture, 3 with coxarthrosis, and 2 with total hip arthroplasty), influencing the ratio determination, evaluation was performed as a ratio femoral head/femoral shaft on the intact side as described previously (Strömqvist 1983), and a ratio > 1.4 was regarded as a good prognosis in accordance with this investigation.

Results

Prognostic precision. Of 199 cases with a femoral head ratio ≥ 1.0 , 181 showed no signs of healing complications 2 years after the operation (Table 1), whereas 16 had developed redisplacement/nonunion and 2 segmental femoral head collapse. Of 107 fractures with a femoral head ratio < 1.0 ,

Table 1. Healing course in relation to scintimetric femoral head ratio after femoral neck fracture.

Complications	Femoral head ratio		Total
	< 1.0	≥ 1.0	
No	11	181	192
Yes	96	18	114
Total	107	199	306

96 had developed healing complications within 2 years after surgery (22 redisplacement, 35 nonunion, and 39 segmental collapse). The remaining 11 patients showed no signs of healing complications. This gives a prognostic accuracy of 91 per cent. Femoral head avascularity (ratio < 1.0) as a sign of healing complication yields a sensitivity of 90 per cent and a specificity of 91 per cent for the procedure. No other ratio level than 1.0 gives so high a prognostic precision (Figure 2). The precision did not differ in undisplaced and displaced fractures.

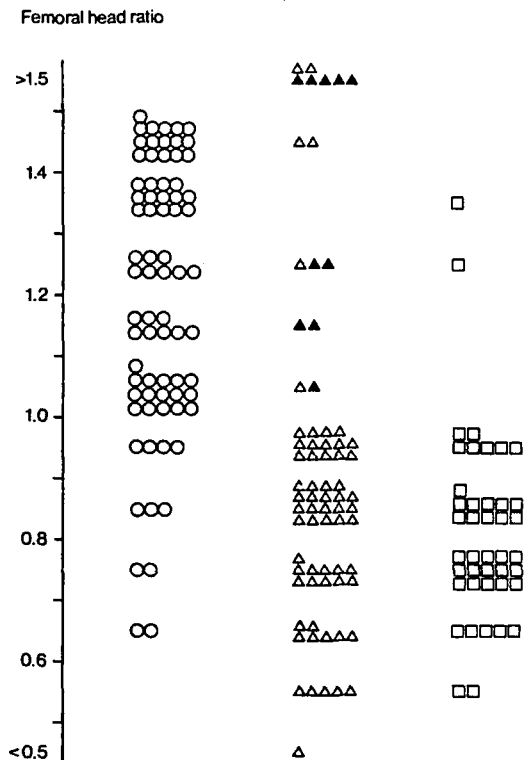


Figure 2. Femoral head ratio for cases with uncomplicated healing ○, redisplacement/nonunion △, and segmental femoral head collapse □. Cases with healing complication due to operative failure are solid symbols. N 119.

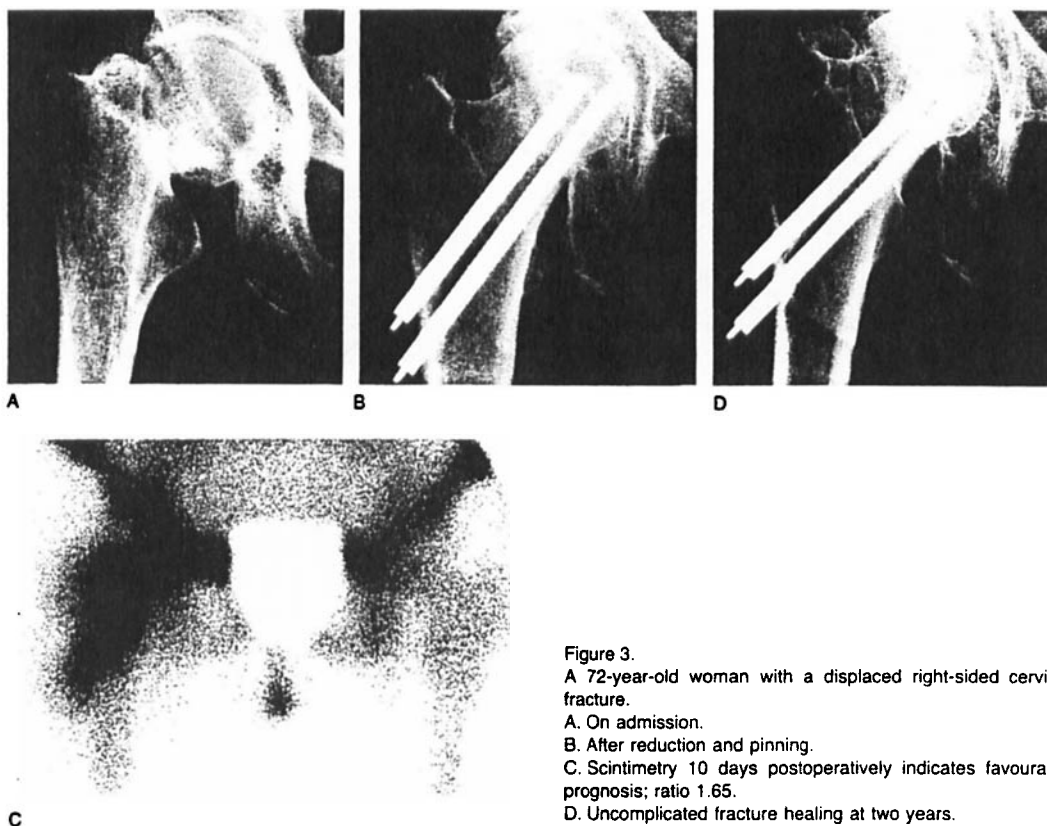


Figure 3.

A 72-year-old woman with a displaced right-sided cervical fracture.

A. On admission.

B. After reduction and pinning.

C. Scintimetry 10 days postoperatively indicates favourable prognosis; ratio 1.65.

D. Uncomplicated fracture healing at two years.

Incorrect predictions. The radiographs and scintimetric images of the 29 patients where the radiographic outcome did not correspond to the scintimetric prediction, were rescruetized. Among the 11 cases with uncomplicated healing at 2 years in spite of a scintimetric ratio < 1.0 , no explanation was found for the incorrect prediction. Among the 18 cases who in spite of a ratio > 1.0 developed healing complications, 3 cases had developed redisplacement before the scintimetric investigation, making evaluation difficult to interpret. In 6 other cases of redisplacement, this was an effect of inadequate fracture reduction and fixation, i.e., technical failure. One fracture was 6 weeks old when surgery was performed. If these 10 cases could be excluded, the prognostic accuracy would increase to 94 per cent (sensitivity 90 per cent and specificity 96 per cent). In the remaining 8 cases (6 cases of nonunion and 2 of segmental collapse), no explanation of the discrepancy between the predictive test and the final outcome was found.

Discussion

The predictive value of scintimetry for the healing course after femoral neck fractures has been demonstrated recently in several investigations (D'Ambrosia et al. 1976, Bauer et al. 1980, Greiff et al. 1980, Lucie et al. 1981, Strömqvist 1983, Turner 1983, Holmberg & Thorngren 1984). The results of these investigations have, in this presentation, been confirmed in a large material with an increased prognostic precision.

Using technetium-labeled compounds, skeletal scintimetry is superior to bone marrow scintimetry (Alberts et al. 1984), and numerical evaluation is preferable, as it makes possible a statistical evaluation. Furthermore, visual evaluation has low discrimination and correlates poorly with the numerical evaluation (Strömqvist 1983, Holmberg & Thorngren 1984). The error of the method of region of interest determination when using standardized regions of interest has been shown to be below 10 per cent (Strömqvist 1983, Alberts 1985).

Preoperative scintimetry as advocated by Turner (1983) and Holmberg & Thorngren (1984) is a more strenuous examination for the patient and puts increased demands on the department of nuclear medicine unless it is regarded as acceptable that the operative procedure may be delayed. It is only to be considered if it is to affect the primary treatment of the patient, such as the choice between internal fixation and primary arthroplasty. The postoperative scintimetric femoral-head vitality of the individual patient not seldom differs from the preoperative one (Strömqvist et al. 1984b); this is probably a result of hip-joint tamponade (Wingstrand et al. 1986) or perioperative trauma to the femoral head vascularization (Strömqvist & Hansson 1983).

Scintimetric examination after femoral neck fracture should be restricted to the second postoperative week and to patients who would later benefit from a secondary hip arthroplasty in case of healing complications. The increased resources required for these examinations may be compensated for by excluding further routine radiographic examinations. Early major redisplacement of the fracture is easy to recognize radiographically, whereas the significance of minor redisplacement

may be hard to estimate and the diagnosis of nonunion is often uncertain until late in the course (Barnes et al. 1976). Segmental femoral head collapse most often is not radiographically apparent until the second postoperative year (Brown & Abrami 1964, Jacobs 1978, Holmberg et al. 1987), but is often preceded by many months of hip pain. For these patients, an early postoperative scintimetry with an unfavorable outcome may lead to the decision to make a secondary hip arthroplasty already when symptoms are severe enough, irrespective of the radiographic appearance. This will relieve the elderly patient with a hip fracture complication that is about to develop from many months of suffering and will also decrease the risk of functional deterioration and social dependency.

In conclusion, this investigation shows that the prognostic precision of early postoperative scintimetry after femoral neck fracture is so high that further routine radiographic investigations may be excluded. The patient with an unfavorable scintimetric examination should be treated with secondary hip arthroplasty as soon as hip symptoms develop instead of having to wait for the ultimate radiographic diagnosis.

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