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Comparison of skeletal and bone marrow radionuclide scintimetry of femoral neck fracture

Twenty-six patients with late complications following femoral neck fracture were examined with both skeletal and bone marrow radionuclide scintimetry. There was no correlation between the methods with respect to the quantitative assessment of femoral head vascularity based on different uptake ratios comparing the fractured and the intact side. Skeletal scintimetry always had good image quality and permitted reliable differentiation between nonunion of the fracture and late segmental collapse, in contrast to bone marrow scintimetry which gave poor image quality. Skeletal scintimetry thus seems superior to bone marrow scintimetry for assessment and differential diagnosis of late complications following femoral neck fracture. It is emphasized that the physiological mechanisms for radionuclide uptake must be taken into account when comparing scintimetric studies using different tracers.

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Assessment of vascularity and viability of the femoral head following femoral neck fracture by radionuclide imaging is technically simple and clinically relevant (Strömqvist 1983). Two methods have been used, based on different principles. In skeletal scintimetry (Strömqvist 1983, Alberts et al. 1984) the bone-seeking tracer, a Tc-99m phosphate compound, is deposited with the bone mineral. In bone marrow scintimetry (Meyers et al. 1977, Turner et al. 1982), the tracer, Tc-99m sulfur colloid, accumulates in the reticuloendothelial cells (RES) of the bone marrow, the liver, and the spleen.

Webber et al. (1977) presented case reports of patients with femoral head osteonecrosis studied by scintimetry using both technetium colloid and technetium phosphate compounds. They noted increased uptake of the technetium phosphate compound and decreased uptake of the technetium colloid around the involved hip joint.

The aim of the present study was to compare the two methods with respect to the accuracy of differential diagnosis between late complications following femoral neck fracture, i.e. delayed union, nonunion, and late segmental collapse of the femoral head.

Patients and methods

Patients

The study included 26 patients who had sustained displaced (Garden III and IV) femoral neck fractures more than 4 months previously, with clinical and radiographic signs of late complications, as determined by the criteria in a previous study (Alberts et al. 1984). Their average age was 65 (54–80) years, and 23 were women. All patients were primarily operated within 3 days after admission, with reduction and internal pin fixation of the fracture.

Scintimetry

The mean time between operation and scintimetry was 15 (4–61) months. A modified version of the procedure described by Webber et al. (1977) was used in this study. Thirty minutes after intravenous administration of 120 MBq of technetium sulfur colloid, the patients were placed in the supine position with the hip joints in internal rotation. The isotope uptake distribution was recorded anteriorly with 300 000 counts over the pelvis and the hip joints with a General Electric 400 T or 535 gamma camera equipped with a high resolution large-field 200 KeV collimator.

All but three of the patients, in whom skeletal scintimetry was postponed until the following day, received an intravenous injection of 400 MBq of tech-

netium methylene diphosphonate (Tc-99m MDP) on the same day. The uptake distribution was recorded as described above, but with 400 000 counts and 3–4 h after injection of the isotope. The data were processed as described in a previous study (Alberts et al. 1984). The activity recorded for skeletal scintimetry was corrected for residual activity and exposure time of the preceding bone marrow scintimetry prior to calculation of the head-to-head ratio (HHR) and the head-to-neck ratio (HNR). Difficulties in locating the anatomic structures of the pelvis and hip joints were graded as marked, moderate, or none.

Final diagnosis

The final diagnosis of the three different types of late complications was based on radiographic criteria (Alberts et al. 1984).

Results

The residual activity from bone marrow scintimetry within the different regions of interest (ROI) was calculated for each individual patient. For the 23 patients evaluated by both methods on the same day, it averaged 5 ± 3 per cent of the total activity recorded at skeletal scintimetry over the femoral head and 6 ± 5 per cent over the femoral neck on the fracture side, as compared to 11 ± 7 per cent over the femoral head and 14 ± 10 per cent over the femoral neck on the intact side.

The average number of counts per pixel on the fracture side was much higher with technetium MDP than with technetium colloid scintimetry (Table 1). The standard deviation expressed in per cent of the mean varied between 49 and 69 per cent for the different ROI in bone marrow scintimetry, and between 53 and 61 per cent in skeletal scintimetry. No difficulties were encountered in locating the anatomic structures with technetium MDP, but with technetium colloid there were moderate difficulties in seven cases, and marked difficulties in three cases due to poor image resolution and low isotope uptake.

No significant correlation was found for either the HHR or the HNR when comparing the two different methods, but the ratios within each of these two techniques did show a correlation ($p < 0.05$ for Tc MDP scintimetry, and $p < 0.01$ for Tc colloid scintimetry; Table 2).

The final diagnosis was nonunion in 15/26, delayed union in 3/26, and late segmental collapse in 8/26 patients (Table 3). The mean

Table 1. Counts per pixel in regions of interest (ROI, fracture side) for skeletal and bone marrow scintimetry

ROI	Number of counts (mean ± SD)[a]	
	Skeleton	Bone marrow
Upper head	326±183 (56)	85±42 (49)
Lower head	341±208 (61)	85±43 (51)
Neck	302±161 (53)	104±72 (69)

[a] Numbers within brackets denote SD expressed in per cent of the mean.

Table 2. Uptake ratios (mean ± SD)[a] in skeletal and bone marrow scintimetry

	Skeleton	Bone marrow
Head-to-head	1.18±0.59 (50)	0.89±0.21 (24)
Head-to-neck	2.22±0.74 (33)	0.83±0.20 (24)

[a] Numbers within brackets denote SD expressed in per cent of the mean.

Table 3. Uptake ratios (mean ± SD) for skeletal and bone marrow scintimetry related to final diagnosis and time between fracture and scintimetry

Final diagnosis	Time between fracture and scintimetry (months)	Skeleton		Bone marrow	
		HHR	HNR	HHR	HNR
Nonunion (n=15)	10± 5	0.88±0.37	1.94±0.62	0.86±0.24	0.83±0.19
Delayed union (n=3)	26±21	1.73±0.59	2.74±0.80	0.87±0.15	0.78±0.25
Late segmental collapse (n=8)	10± 7	1.21±0.50	2.18±0.46	1.11±0.09	0.95±0.10

HHR = Head-to-head ratio.
HNR = Head-to-neck ratio.

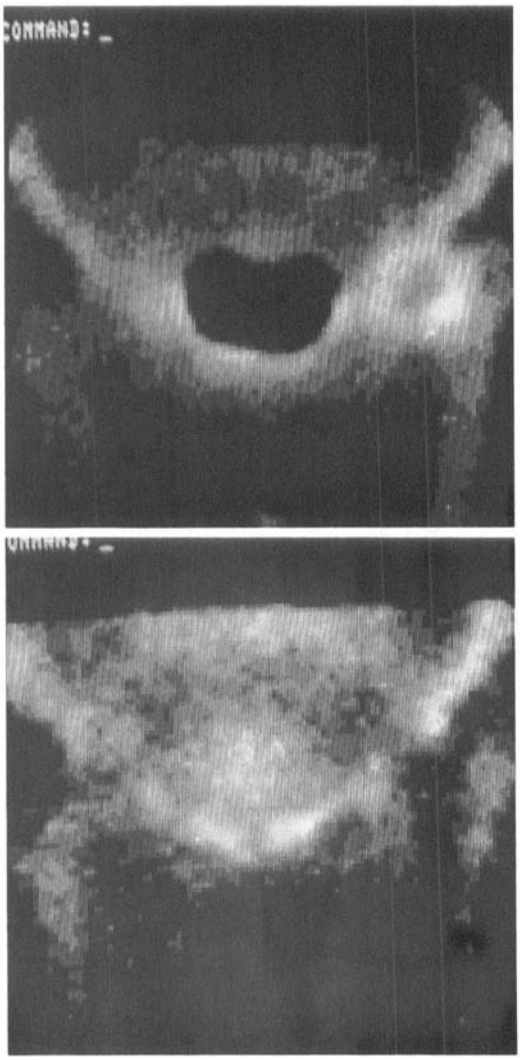

Figure 1. Digital images in patient with left-sided nonunion. Head-to-head ratio for Tc-99m MDP scintimetry is 1.90 (top) and for Tc-99m colloid scintimetry 0.65 (bottom).

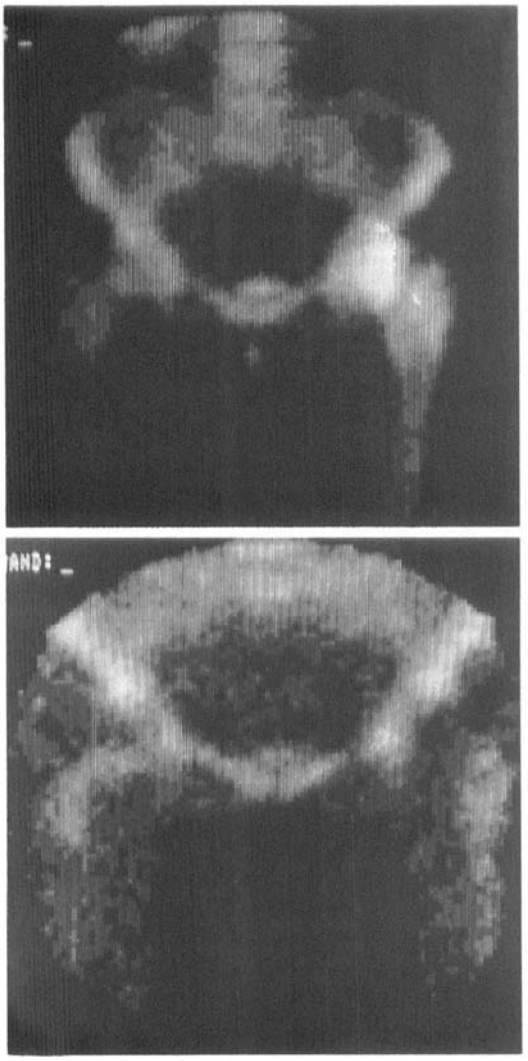

Figure 2. Digital images in patient with left-sided segmental collapse. Head-to-head ratio for Tc-99m MDP scintimetry is 3.18 (top) and for Tc-99m colloid scintimetry 0.56 (bottom).

HHR calculated from technetium MDP scintimetry was less than 1.0 only in the nonunion group. Significant differences for the HHR and HNR were found between patients with nonunion (Figure 1) and late segmental collapse (Figure 2); no other significant differences were noted. The HHR and HNR were almost identical and less than 1.0 for the nonunion and delayed union groups in technetium colloid scintimetry. The differences for the late segmental collapse group were not significant either.

Discussion

The advantage of technetium MDP scintimetry is the higher isotope concentration in the skeleton and thus better image quality allowing more reliable numerical assessment. Poor image quality, especially in the superior part of the femoral head, has been reported from earlier studies with technetium colloid scintimetry; Spencer et al. (1983) noted uptake in only about 50 per cent of adults without hip disease. In this study low isotope uptake bilaterally,

which made identification of the exact location of the hip joints difficult, was noted in 10 of 26 cases.

The difference in isotope accumulation and the time interval between injection of the two tracers allowed the second imaging to be performed on the same day without interference from residual radiocolloid activity.

Colloid scintimetry has been described as a reliable method for assessment of femoral head vascularity (Meyers et al. 1977, Turner et al. 1979), and unlike Tc MDP scintimetry the results are not liable to be distorted by isotope uptake due to reactive bone formation in hypermetabolic areas. The present study confirmed the finding of Webber et al. (1977) that bone marrow scintimetry only shows decreased femoral head uptake to indicate hip pathology. Skeletal scintimetry, on the other hand, showed both increased and decreased femoral head activity, which offers diagnostic alternatives (Strömqvist 1983, Alberts et al. 1984). Bone marrow cells are more sensitive to anoxia than osteocytes (Catto 1965, Kenzora et al. 1978), and thus a false negative bone marrow scan may result even though there may be sufficient vascularity for the bone tissue to survive. The different accumulation mechanisms of the two radioactive agents may consequently explain the lack of correlation between the uptake ratios recorded by bone marrow as compared to skeletal scintimetry in the present study.

Skeletal scintimetry using bone-seeking radionuclides such as Tc-99m MDP, combined with digital recording of the isotope distribution, appears to be superior to bone marrow scintimetry for assessment of late complications following femoral neck fracture. When comparing results from studies based on different radionuclides, the pharmacodynamics of the tracers must be taken into consideration.

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