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Correlation of ^{99m}Tc-MDP scintimetry and histology in cervical hip fracture

In 20 cases of fresh cervical hip fracture, treated with primary prosthetic replacement, preoperative ^{99m}Tc-MDP scintimetry was compared with histologic findings of the extracted femoral heads. The radionuclide uptake was classified into three types according to the activity distribution; overall increase, focal decrease, and overall decrease. Histologically, the location and extent of ischemic necrosis in the femoral heads were closely related to the distribution of decreased activity.

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In cervical hip fracture, ^{99m}Tc-MDP scintigraphy has been reported to be of value for assessing femoral head vitality and predicting healing complications (Bauer et al. 1980, Strömqvist 1983, Strömqvist et al. 1984a, Jacobsson & Dalén 1985). However, the correlation between scintigraphic and histologic findings of the femoral head has not been elucidated.

We investigated whether the site of decreased ^{99m}Tc-MDP activity is related to the location of ischemic necrosis in extracted femoral heads.

Materials and methods

The series included 18 women and 2 men with fresh cervical hip fractures; the mean age was 71 (53-90) years. The fractures were classified radiographically according to Garden's (1961) criteria as Stage II-1 case, Stage III-4 cases, and Stage IV-15 cases. All the patients received the Austin-Moore type of prosthesis within 3 weeks after admission.

Preoperative scintimetry was performed 4 hours after intravenous injection of 740 MBq of ^{99m}Tc-MDP. The distribution of 10^6 counts was recorded over the pelvis and both hips anteriorly using an Ohio Nuclear Σ410S gamma camera with a high resolution parallel collimator. The scintigraphic appearance of the affected femoral head was compared with the contralateral side. In comparison with the unaffected hip, three types of *scintigraphic* patterns were identified: Normal increased (Type A), partially decreased (Type B), and generally decreased (Type C) uptake (Figure 1). In Type B, a distinction was made between a band-like decrease along the fracture (B1) and a decrease in the weight-bearing area (B2). For *scintimetry*, isotope counts were determined with the aid of a VIP 450 computer system. Regions of interest of equal size were selected in the center of both femoral heads, and the uptake ratio, affected/intact side, was calculated

For histologic examination, thin coronal sections were cut from the anterior, middle, and posterior portions of the extracted femoral heads and stained in hematoxylin-eosin. To assess the distribution of ischemic changes, necrotic and viable areas were traced and outlined using microscopy. The percentage of necrotic area in relation to the whole projected area was calculated in a Wacom WT500 digital analyzer.

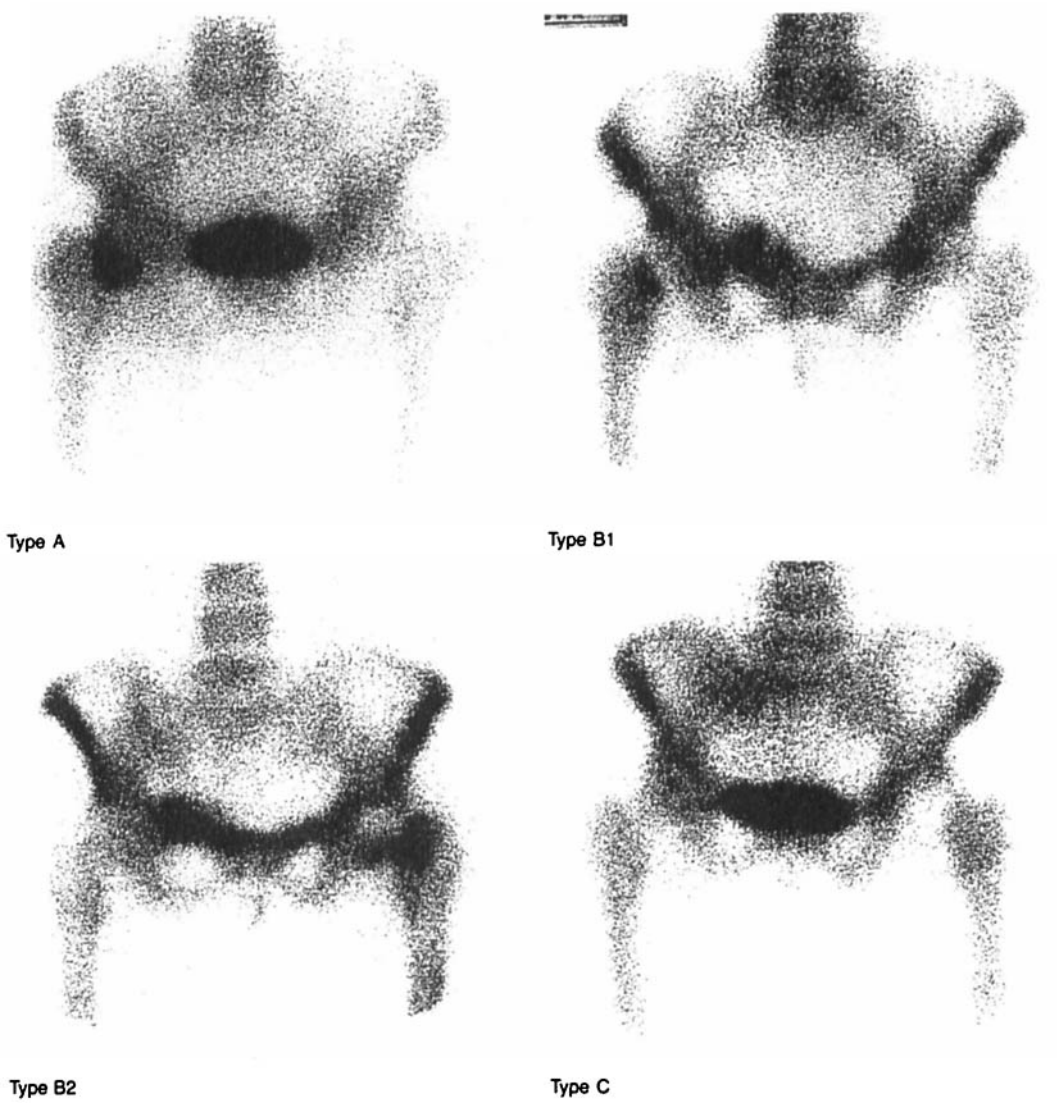


Figure 1. Representative scintigraphs. Type A. Increased activity (uptake ratio 1.61), Type B1. Bandlike decrease along the fracture (uptake ratio 1.08), Type B2. Decrease in the weight bearing area (uptake ratio 1.00), Type C. Generally decreased (uptake ratio 0.47).

Results

Increased activity of the whole femoral head (Figure 2) was seen in 4 cases (Type A). Seven cases showed focal decrease (Type B); 4 of these were B1 and 3 were B2. The remaining 9 cases exhibited decreased activity throughout the entire femoral head (Type C). Although most Garden's Stage IV fractures were of type C, there was no clear relationship between the two classifications (Table 1).

Scintimetrically, the mean uptake ratios of Types A, B, and C were 1.45 (1.07-1.88), 1.03 (0.91-1.29), and 0.77 (0.47-1.02), respectively.

Microscopically, there were small scattered necrotic foci within the femoral heads in all cases of Type A; the necrotic foci were distinguished from the viable areas by the absence of cell nuclei and destruction of blood vessels and cell membranes in the marrow (Figure 3). The foci were surrounded by erythrocytes, histiocytes, lymphocytes, and fibroblasts. Bone trabeculae rimmed with abundant plump osteoblasts were observed close to the necrotic

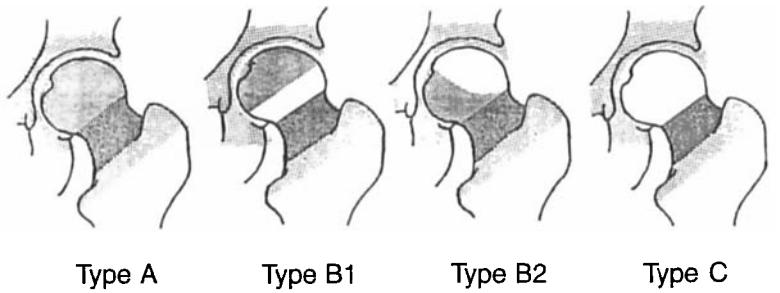


Figure 2. Schematic presentation of each scintigraphic type.

Table 1. Comparative scintigraphic and radiographic classification of 20 cases.

Scintigraphic Type	Radiographic Stage II	III	IV
A	1	2	1
B1			4
B2		1	2
C		1	8

areas. Signs of active fibroblastic proliferation and osteoid formation were noticed in the fracture site. All femoral heads of Type B1 exhibited widespread necrotic foci in the fracture area, whereas those of Type B2 had massive necrosis in the weight-bearing area (Figure 4). Type C femoral heads were almost totally necrotic except for the articular cartilage; a narrow viable area at the insertion of the teres ligament was seen in 4 of the 9 cases, but signs of fracture repair such as fibrosis and new bone formation could not be found.

The mean percentages of necrotic area in Types A, B, and C were 1.8 (0.8-3.1), 35 (20-52), and 86 (82-89), respectively.

Discussion

Several methods for assessing femoral head viability have been applied. Venography or arteriography do not provide conclusive results (Rook 1953, Hulth 1958, Harrison 1962). Arnoldi et al. (1977) measured the intramedullary pressure of the femoral head. However, a clear correlation between intramedullary pressure and late segmental collapse was not established.

From long-term studies, Bauer et al. (1980), Holmberg & Thorngren (1984), and Strömq-

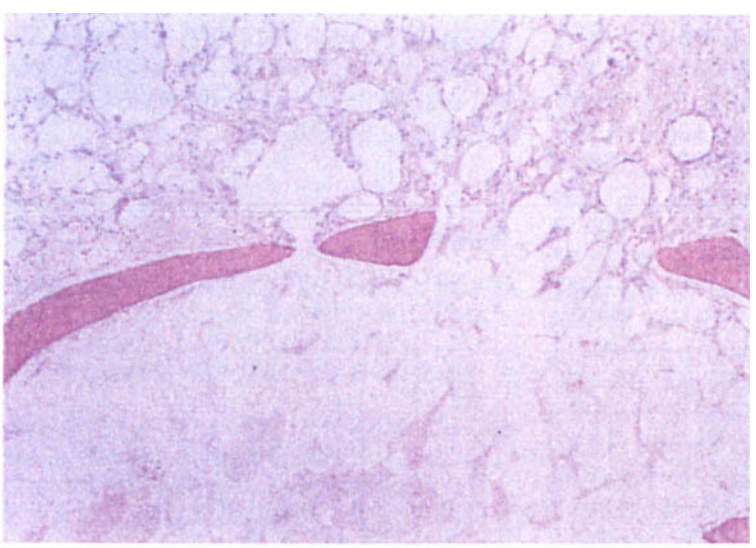
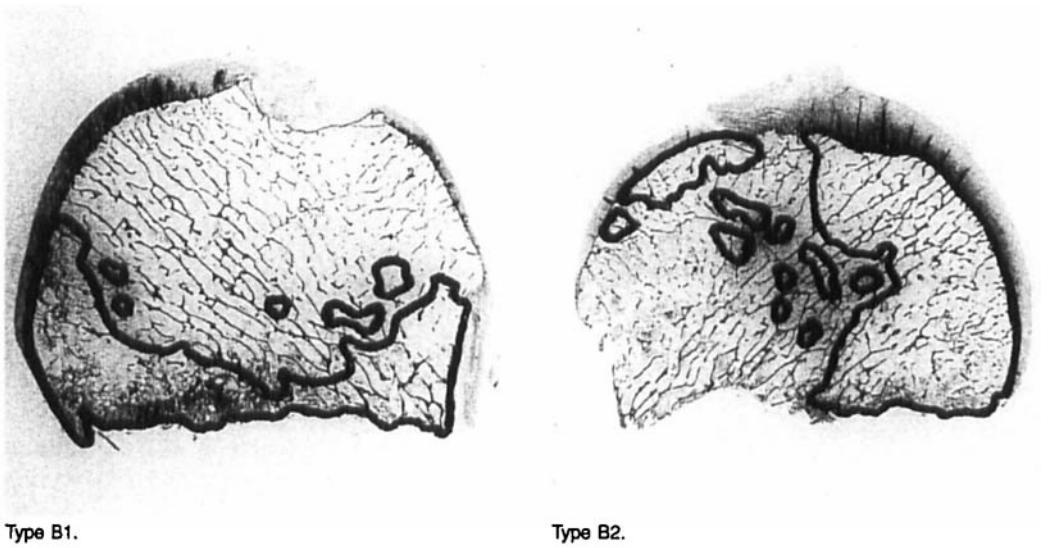


Figure 3. Histologic section of borderline area between viable and nonviable tissue. H & E stain, x80.



Type B1. Type B2.

Figure 4. Cross-sections of femoral heads with outlined areas of ischemic necrosis as assessed histologically.
Type B1. Necrosis along the fracture.
Type B2. Necrosis in the weight-bearing area.

vist et al. (1984a, c) reported that patients with increased activity of the affected femoral head, corresponding to Type A in our classification, had normal healing. However, in patients with late segmental collapse or nonunion, there was a marked decrease of the activity preoperatively or early postoperatively. Hence, scintimetry has proved valuable for predicting the healing course in cervical hip fracture. Strömqvist (1983) and Strömqvist et al. (1984 b) demonstrated a close correlation between ^{99m}Tc-MDP activity and tetracycline labeling in femoral head biopsies and concluded that ^{99m}Tc-MDP scintimetry reflects viability of the femoral head after fracture. However, the distribution of ^{99m}Tc-MDP activity has not been compcompared yet with the histologic changes of the femoral head after fracture. In our study, necrotic foci were small and scarce in Type A; the blood supply was probably preserved through retinacular arteries and/or the vessel of the teres ligament, and increased activity might be explained by osteoblastic activity adjacent to necrotic areas. Although the relationship between area of necrosis and vascular distribution is unclear in Type B1, all 4 cases of this type were Garden's Stage IV, indicating damage to all the retinacular arteries. Sevitt & Thompson (1965) demonstrated significant blood supply through the teres ligament to the femoral head by arteriography. The viable area found in Type B1 might be explained by circulation through the teres ligament (Catto 1965); the location of ischemic necrosis in Type B2 distinctly corresponded to the distribution of superior retinacular arteries. The histopathologic findings in femoral heads of Type C were probably due to complete loss of the blood supply.

Our histologic observations thus confirmed that ^{99m}Tc-MDP scintigraphy may be used to assess the location and extent of ischemic necrosis of the femoral head. The predictive clinical value of our scintigraphic classification remains to be investigated.

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