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Stress osteopathy of the femoral head

10 military recruits followed for 5–11 years

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I present 10 cases of spongious bone injury of the femoral head induced by physical stress. All patients were young military recruits who complained of hip pain from weight bearing which had started during physical exertion. Increased uptake in a radionuclide bone scan was regarded as the criterion for stress osteopathy. 7 hips were radiographically normal. In 3 cases a subcortical lateral cystic lesion of the femoral head was observed. MRI was performed in 6 cases. A decreased signal intensity in T1-weighted images in 5 cases and high signals in T2-weighted and IR signals (2 patients) indicated bone marrow edema. A lateral osteophyte of the femoral head developed in 1 case during 8 years' follow-up. After a median of 6 years, 9 patients still had occasional slight hip pain.

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Stress fractures, both of the cortical and spongious bones, are common in joggers and military trainees. Of spongious bone in the lower extremity, the calcaneus was affected in one fifth in a large Finnish series of stress fractures, whereas the incidence in the femur was only 6% (Meurman 1981). Most of the stress fractures of the hip occur in the femoral neck (Fullerton and Snowdy 1988, Visuri 1990). Even the femoral head can be damaged by cyclic physical stress (Visuri et al. 1988a). I describe clinical and radiographic findings in stress osteopathy of the femoral head.

Patients and methods

The patients were 10 young male conscripts treated at the Central Military Hospital in 1984–1991. The mean age of the patients was 20 (19–26) years. All patients were physically healthy with no predisposing factors for avascular necrosis of the femoral head. Case 6 had an inherited polycystic disease of the kidneys, but his renal function was normal.

All patients developed hip pain during physical exertion in the military service. In most cases the hip pain started during a march of 20–25 km, when the conscripts had to carry a heavy pack on their backs. They complained of pain in the groin and 3 also reported pain at rest. The patients were referred to the hospital from 2 days to 3 months after the start of the pain. In addition to the painful hip, an increased uptake of the radionuclide of the femoral head in the bone scan with 7.0–10.7 mCi of ^{99m}Tc-diphosphonate was regarded as a criterion for stress osteopathy of the femoral head (Table).

Clinical, radiographic, scintigraphic, and MRI findings in 10 patients with stress osteopathy of the femoral head

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	20	r	m	8	–/–	–	2.5	n	1	3	3	3	2
2	20	r	b	8	–/–	9	10	c	3	2	1	2	1
3	26	l	m	12	+/–	3	4.5	n	2	1	2	3	2
4	20	r	m	36	–/–	–	10	n	1	3	3	3	2
5	20	l	m	0.3	+/–	–	1	n	1	3	3	3	2
6	19	l	m	12	+/–	3	4	c	2	1	1	3	3
7	20	r	m	6	+/+	2	4	n	2	3	3	1	2
8	19	r	m	6	+/–	3	3.5	n	3	2	3	3	2
9	20	l	m	3	+/–	3	3	n	2	2	3	1	2
10	20	l	r	2	+/+	4	10	c	3	2	2	3	3

A Age
B Side
C Previous event
  b battle exercise
  m marching
  r running
D Weeks to diagnosis
E Palpation/rotation tenderness
F Use of crutches, months
G Unfit for military service, months
H Radiographic findings
  n normal
  c cystic lesion
I Scan uptake
  1 weak
  2 intermediate
  3 strong
J T1-weighted MRI signals
  1 intermediate
  2 low
  3 not performed
K T2-weighted or IR MRI signals
  1 intermediate
  2 high
  3 not performed
L Previous or concomitant stress fracture of the femoral neck
  1 concomitant
  2 previous
  3 not stated
M Pain at follow-up
  1 no pain
  2 during severe exercise
  3 during or after walking 2 km

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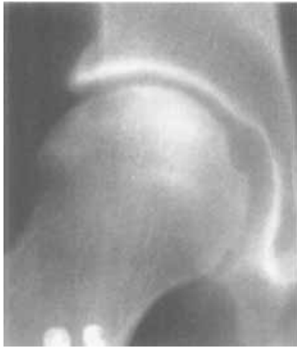
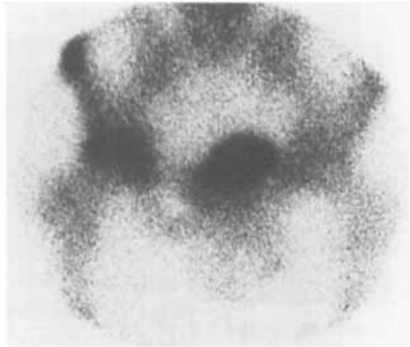
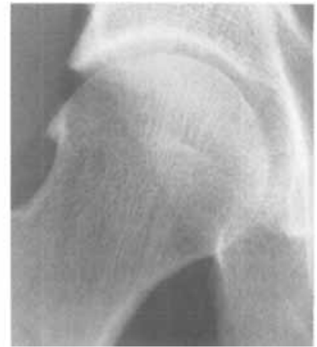
Figure 1. Case 2.



Tomography 8 weeks after battle exercises. A subchondral lateral cyst of the femoral head is seen.



Bone scintigraphy shows an intense accumulation of the radionuclide in the femoral head.



8 years later, a lateral osteophyte of the femoral head inferior to the lesion has developed. The patient is symptom-free.

A conventional radiographic a-p examination of the hips was performed in all patients. The Lauenstein projection was used in cases 2 and 6. A conventional coronal tomography with 0.5 cm slices was performed in 2 patients: in case 2, 1 and 6 months, and in case 9, 6 months after the onset of symptoms. The hip of case 10 was also investigated with CT 4 weeks after the symptoms started.

Various MRI techniques were used in 6 patients. Cases 2, 3, and 6 were investigated with an ultra low-field MRI (0.01 T) using 5–10 mm thick T1-weighted (TR 250–500 ms and TE 40–60 ms) and T2-weighted (1000/40) coronal slices. Cases 8, 9, and 10 were studied with a low-field MRI (0.1 T), using coronal and coronal oblique sections along the axis of the femoral neck and 1 patient (case 10) was also studied with transverse sections. Section thickness was 5–7 mm. Only T1-weighted (70/30) images were obtained in cases 8 and 9. In case 10, fat saturation and short inversion time (IR) sequences (1000/30) were also used in 1 coronal section. Sequential MRI studies 1, 2, 3, and 6 months after the injury were performed in this case. A 0.1 T MRI examination was also done in case 6, 6 years after the injury with T1- and T2-weighted (70/30 and 1500/40) 5 mm coronal and transverse sections.

Cases 2 and 6, with subcortical cystic lesions of the femoral head in the initial radiographs, were re-examined 8 and 6 years after the injury. A questionnaire was sent to the other patients. The median follow-up time was 6 (5–11) years.

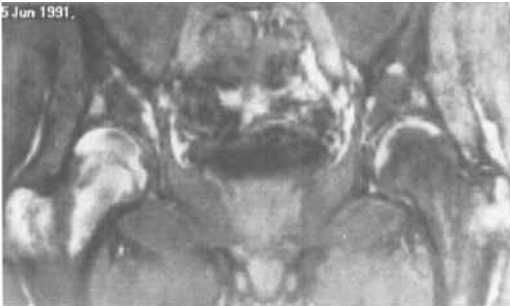
Results

At the first clinical examination 3 hips were normal. 7 hips had painful rotation, but normal range of the movements. In 2 hips, there was tenderness on palpation in the groin and trochanteric area. All patients were freed from heavy military service, according to their symptoms and 7 patients were told to use crutches for an average of 4 months to take some load off the hip. The median duration of symptoms during military service was 4 (1–10) months (Table).

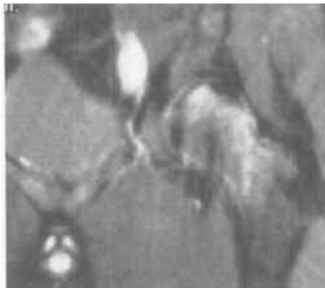
In case 3, the stress osteopathy developed after a grade I stress fracture of the femoral neck (Blinkenstaff and Morris 1966); hip pain recurred after he had been pain-freee for 1 month. In cases 7 and 9, the stress osteopathy developed at the same time as a grade I stress fracture of the femoral neck. In 7 cases, the radiographs were normal. In 2 patients, subcortical cystic lesions in the anterolateral part of the femoral head were observed (Figure 1). CT revealed also a 2 mm lateral cyst in the femoral head of case 10, whose conventional radiographs were normal. The cystic lesion of the femoral head in case 2 had filled with trabecular bone after 6 months, as seen on radiographs and tomography. This patient was followed annually for 4 years and developed a slowly growing lateral osteophyte of the femoral head (Figure 1). The osteophyte remained unchanged during the following 4 years. In case 6, there was still a minor subcortical osteoporosis and thickening of the cortical bone at the site of the lesion, but no osteophyte formation after 6 years.

The intensity of the uptake of the bone tracer varied from low to high. In 8 cases, it was concentrated in the head of the femur (Figure 1). In addition, cases 7 and 9 showed uptake on the medial aspect of the neck.

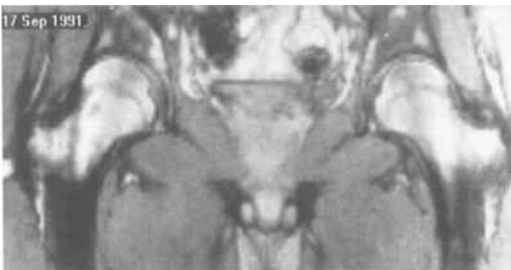
In 5 patients, the signal intensity of the bone marrow in T1-weighted images was unevenly reduced. In cases 2 and 3, low signals were located in the femoral head and in cases 8, 9, and 10 also in the area of the femoral neck (Figure 2). Of the 2 patients studied



Low-field T1- weighted MRI of the hips of a conscript 8 weeks after running with tank mines. Wide, uneven decrease in the signals in the bone marrow of the left femoral head and neck.



Same case. MRI inversion recovery image shows irregular high-signal intensity in the corresponding area.



10 weeks later, the T1-weighted MRI image is normalized.

with T2-weighted images, case 2 showed correspondingly high T2 signals indicating bone marrow edema, whereas the T2 signals were normal in case 3. In case 6, the MRI was normal, but it was done 4 months after the start of the symptoms. Case 10 was followed with 4 MRI examinations and the signals became normal in 10 weeks (Figure 2). In this case, the high IR signals indicated bone marrow edema. The femoral head of case 6 demonstrated slightly increased T1- and T2-weighted low signal zones in the femoral head indicating some increased sclerosis 6 years after the injury.

At the final evaluation, 7 patients reported inconstant and slight pain during strenuous exercise, 2 patients had marked pain on or after walking more than 2 km and 1 patient was pain-free. No one reported any functional restrictions.

Discussion

Trabecular fatigue fractures of the femoral head are usually associated with age-related osteoporosis, but they can occur occasionally in young, normal individuals (Freeman et al. 1974). Marching on hard ground with a full pack means high stress and low-cycle loading on the hip joint. Fractures of only a small number of trabeculae may cause a substantial reduction in the elastic modulus of trabecular bone (Guo et al. 1994). An injury to the femoral head spongious bone in stress osteopathy can be extensive, as shown by the scintigraphic and MRI examinations. Fractured trabeculae may prevent the intraosteal fluid flow and cause venous congestion of the bone marrow, which may explain the finding suggestive of edema on the MRI.

The diffuse decrease in the signals in the bone marrow in the T1-weighted images is a nonspecific finding, but it corresponds well to the signals that are seen in association with stress fractures (Lee and Yao 1988), early avascular necrosis of the femoral head (Turner et al. 1989) and transient osteoporosis (Takatori et al. 1991). Hofman et al. (1993) ascribed transient osteoporosis to the bone marrow edema syndrome and showed a correlation of the histologic bone marrow edema to the MRI findings. The edema of the stress osteopathy seems to last for 2–3 months, as demonstrated in case 10.

The bone scan uptake varied from low to high and at first we interpreted the lesion as transient osteoporosis of the femoral head (Visuri et al. 1988a). Stress osteopathy, using bone scan and MRI, clinically resembles transient osteoporosis of the hip (Bloem 1988, Takatori et al. 1991, Urbanski et al. 1991).

In conventional radiographic examinations, transient osteoporosis appears to be a generalized osteoporosis of the femoral head, even of the acetabulum (Bramlett et al. 1987). In most of my cases, the radiograph were normal. Furthermore, transient osteoporosis usually affects middle-aged men (Lakhanpal et al. 1987)—or women during the third trimester of pregnancy (Beaulieu et al. 1976).

The symptoms and clinical findings in stress osteopathy are similar to those in stress fractures of the femoral neck. They can exist at the same time or one after another, as in 3 of the present cases. The short-term prognosis of the osteopathy is good, but the

stress fracture of the femoral neck may become dislocated, resulting in avascular necrosis of the femoral head (Fullerton and Snowdy 1988, Visuri et al. 1988b).

Approximately 80% of the patients with non-traumatic avascular necrosis of the femoral head have predisposing factors (Guerra and Steinberg 1995). All of my patients were healthy young men without predisposing factors. Physical stress from the military training was the only common factor for the development of the stress osteopathy. In at least 1 patient, stress osteopathy caused a permanent lesion of the femoral head, an osteophyte.

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