Diffusely increased bone scintigraphic uptake in patellofemoral pain syndrome

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Objectives: Painful disorders of the patellofemoral joint are one of the most frequent complaints in orthopaedic and sports medicine. The aims of this study were to determine whether bone scintigrams of patients suffering from patellofemoral pain syndrome (PFPS) show diffuse uptake and in what bony compartment of the knee uptake, if any, was localised.

Methods: Fifty eight patients with chronic PFPS were examined. All patients underwent a detailed clinical history and a thorough physical examination of the knee. Anterior and lateral static images of both knees were made using a gamma camera 3 h after injection of 550 MBq of $^{99m}$Tc-HMDP. Two experienced radiologists visually evaluated the scans blindly and separately. As 51 patients had bilateral pain, 109 painful knees are included in the results.

Results: Diffuse uptake on bone scintigrams was found in 48 knees in 30 of the patients. In 33 knees the uptake was localised to only one bone compartment, in 10 knees diffuse uptake was found in two of the bones forming the knee joint, and in six knees all three bone compartments (the distal femur, the patella, and the proximal tibia) exhibited diffuse uptake.

Conclusions: Scintigrams of approximately half of the patients with PFPS will show diffuse uptake in one or more of the bony compartments of the knee joint and radioactive tracer accumulation will occur as often in the proximal tibia as in the patella.

Patellofemoral pain syndrome (PFPS), also called anterior knee pain (AKP), is one of the most common musculoskeletal disorders and is reported to affect 15–33% of the adult population and 21–45% of adolescents. Athletes and non-athletes of both genders are affected. Among adolescents the incidence is reported to be higher for girls.

PFPS is characterised by pain in the front of the knee, which is often worsened by climbing or descending stairs and by sitting for long periods. There has been no consensus on the definition, classification, assessment, diagnosis, or management of PFPS. The literature suffers from a lack of standardisation in terms of diagnoses, pain scales, small sample size, absence of blinding, absence of stratification for severity, duration of symptoms, and patient age. Although the cause of PFPS is obscure, it has been generally accepted as being secondary either to the presence of chondromalacia or to patellar malalignment. Studies, however, have reported that chondromalacic changes can be asymptomatic but also that patients with normal articular cartilage can experience AKP.

Reports have also questioned a causal relationship between malalignment and knee discomfort in the majority of PFPS patients. A different aetiology that takes the pain mechanism into consideration has been proposed by Dye et al. The authors suggested that PFPS may be attributed to a possible loss of both osseous and soft tissue homeostasis. Patellofemoral synovial and fat pad irritation secondary to mechanical or biochemical factors are reported to be a common cause of pain. High intraosseous pressure has been suggested as a pain mechanism. Although PFPS is considered to be one of the most typical forms of nociceptive pain, a contribution of a neurogenic mechanism has also been mentioned. Merchant suggested that one subgroup of PFPS was reflex sympathetic dystrophy of the patella. Butler-Manuel reported an involvement of the sympathetic nervous system in PFPS.

Bone metabolism and bone remodelling can be evaluated by specific bone seeking radionuclides in a scintigraphic measurement. A positive bone scintigraphy indicates an increase in bone metabolism, but the method cannot determine whether the final result will be a net loss or a net gain in bone. A pathophysiologically increased bone scintigraphy indicates an aetiological relationship between the area with increased bone metabolism and the patient’s symptoms. The method can distinguish between localised skeletal conditions, such as stress fractures in the bone, and diffuse increased bone turnover.

Bone scintigraphy has been suggested as one method that can be used in the evaluation of patients with AKP because it depicts physiological features whereas radiography presents biomechanical information. Studies have reported tracer uptake to be located in the tibiofemoral compartment, the patellar compartment, and both. The aims of this study were to determine whether the bone scintigrams of patients suffering from PFPS show diffuse uptake and in what bony compartment in the knee the uptake, if any, was localised.

METHODS
Information about our clinical study was sent out to the orthopaedic departments in two local hospitals and to 12 local health care centres. Fifty eight patients, who fulfilled the inclusion criteria, gave informed consent to the study. The study was approved by the research ethics committee of the Faculty of Medicine, University of Lund.

Patients
Inclusion criteria
Patients aged 20–50 years were included in the study in order to avoid misinterpretations in the scintigraphic assessments due to immature bone tissue or osteoarthritis. Patients were

Abbreviations: AKP, anterior knee pain; BMD, bone mineral density; MTSS, medial tibial stress syndrome; PFPS, patellofemoral pain syndrome
included if they had activity induced pain for more than 6 months, in two out of the following three situations: (i) when climbing stairs; (ii) on squatting; or (iii) after prolonged sitting. Patient characteristics are given in table 1.

**Exclusion criteria**
Patients were excluded if the clinical examination revealed any symptoms suggesting other pathology of the knee joint such as ligament or meniscus tears, synovial plica, tendinopathy, apophyseal arthritis, osteochondritis dissecans, neuroma, or fat pad impingement. Pathology discovered on radiographic or scintigraphic examinations also led to exclusion. Diffuse uptake on scintigraphy was not regarded as pathologic. Focal uptake patterns were excluded but were only found in one of the patients originally examined.19

**Scintigraphy**
Static anterior and lateral images of both knees were obtained using a gamma camera 3 h after injection of 550 MBq of \(^{99m}\)Tc-HMIP (fig 1). The scans were visually evaluated blindly and separately by two experienced radiologists who then reached a consensus.

**Statistics**
Data are presented as binomial: diffuse uptake or no diffuse uptake.

**RESULTS**
Of the 58 patients, seven experienced unilateral pain and 51 bilateral pain. A total of 109 painful knees are included in the study.

Diffuse uptake on bone scintigraphy was found in 48 knees (48/109, 44%) in 30 patients (30/58, 52%). In 33 knees, uptake was localised to only one bone compartment, in 10 knees diffuse uptake was found in two of the bones forming the knee joint, and in six knees all three bone compartments (the distal femur, the patella, and the proximal tibia) exhibited diffuse uptake (fig 2).

When diffuse uptake was found to be distributed into the bony compartments, the patella was the bone that was most affected. Of the 48 affected knees, uptake in the patella was found in 27, uptake in the proximal tibia in 25, and uptake in the distal femur in 19. Uptake in the femur and the tibia only occurred in the condyles.

None of the scintigrams of the seven patients reporting unilateral pain exhibited any diffuse uptake at non-painful sites.

**DISCUSSION**
In this study we were able to confirm previous studies reporting diffuse uptake on bone scintigraphy of patients diagnosed with PFPS. We found that the scintigrams of 44% of the painful knees and 52% of the patients showed diffuse uptake. This is in agreement with previous studies13 15 17 which reported uptake in 40–55% of the patients.

Loberboym et al.,20 using single photon emission computed tomography, found diffuse and focal uptake in 100% of the patellae and in 67% of the distal femurs examined.

For ethical reasons, we examined no control group scintigraphically in our study. However, diffuse uptake in control groups is reported to be between 4% and 9%.15 17 Historically, use of bone scintigraphy to gather information on the knee has been limited. \(^{99m}\)Tc labelled methylene diphosphonate, which has an affinity for hydroxyapatite and is correlated to the activity of the osteoblasts, has been used. Increases in osteoblastic activity as low as 10% can be detected with this method.21 Sensitivity is reported to be about 95%, but specificity is poor as every disease or injury with increased bone metabolism will be detected.22 The ability of bone scintigraphy to detect, with high sensitivity, early changes in bone metabolism and bone vascularisation is the basis of its clinical usefulness.22

It is not known whether the diffuse uptake observed on bone scintigrams of patients with PFPS is related to the cause or is a result of the syndrome. Although scintigraphy is

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<th>Table 1 Patient characteristics</th>
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What is already known on this topic

Patellofemoral pain syndrome (PFPS) is one of the most common musculoskeletal disorders and is characterised by pain in the front of the knee. It is possible that such uptake is caused by a change in physical activity. Our patients had a long history of pain (median 8.4 years) and a low activity level (table 1). On the other hand, other studies have reported diffuse uptake on bone scintigraphy in patients suffering from PFPS despite different inclusion criteria.15 17 This could indicate that bone metabolism is involved in approximately half of the patients diagnosed with PFPS and AKP.

Butler-Manuel,13 Hejgaard and Diemer15 and Dye and Boll17 have reported diffused uptake on bone scintigraphy in approximately 40–55% of patients with PFPS. The authors, however, interpreted this finding differently. Butler-Manuel13 meant that his patients suffered from reflex sympathetc dystrophy, and he used sympathetic blockade in the treatment of his patients. Hejgaard and Diemer15 believed that diffuse uptake was secondary to increased intra-medullar pressure and used decompression as the treatment of choice. Dye and Boll17 proposed a different interpretation of positive findings on a bone scintigram. They developed a theoretical model of osseous homeostasis where one or more triggering factors may increase remodelling activity in bone, which is detectable with scintigraphy. Diffuse uptake on bone scintigraphy has been interpreted as a change in bone turnover that could be due to ischemia or overuse.21

We could speculate that the findings of diffuse uptake on bone scintigraphy in approximately half of the patients suffering from PFPS may indicate regions of ischaemic stress. This is in accordance with Dye et al16 who summarised that the genesis behind PFPS is a loss of homeostasis, particularly in peripatellar soft tissue but also in the intraosseous environment of the patella. The ischaemia could be caused by higher intraosseous pressure,24 by redundant axial loading,25 or by decreased arterial blood flow.26

PFPS, stress fractures, and medial tibial stress syndrome (MTSS) can be visualised on bone scintigraphy.27 28 The appearance of mild increased uptake on bone scintigraphy relates to the mildest form of bone stress and is a sign of accelerated remodelling. Sites where remodelling is occurring contain regions with a temporary loss of bone, measured by dual energy x ray absorptiometry, and show osteopeni. Magnusson et al29 concluded that MTSS, with diffusely increased scintigraphic uptake, is associated with low bone mineral density (BMD). The lower BMD was found only in the region corresponding to the pain and diffuse uptake on bone scintigraphy and increased after recovery. Leppala et al30 found significantly decreased BMD in the distal femur, the patella, and the proximal tibia in patients with PFPS. The differences were small and could result from a remodelling process during the resorption phase. This is in accordance with our study and proposes that the proximal tibia could also be involved in this syndrome.

AKP is a symptom, but recently it has been categorised as a distinct syndrome.31 The disorder is also called patellalgia.23 PFPS,3 idiopathic AKP,35 patellofemoral malalignment,35 patellofemoral arthralgia,36 extensor mechanism disorder,37 femur-patellar pain syndrome,38 patella compression syndrome,39 overuse patellofemoral pain,40 and previously, chondromalacia patellae.38 Most of these terms indicate that the pathophysiology is to be found in the patella or in the femur. However, we found radioactive tracer accumulation just as often in the proximal tibia (25/48) as in the patella (27/48). Some practitioners who find no identifiable background to the pain use the terms AKP as well as patellofemoral pain. These terms are best reserved for describing the pain who has yet to be evaluated. As the proximal tibia may also be a site for homeostatic changes, patellofemoral tibial pain appears to be a suitable term. This is also supported by the clinical picture as our patients did not report subjective complaints of discomfort or pain in a specific region or were tender to palpation at a specific site.19 Until the pain mechanism has been more fully explored, a generic term should be used.

In summary, scintigrams of approximately half of the patients with PFPS show diffuse uptake in one or more of the bony compartments of the knee joint and radioactive tracer accumulation will occur as often in the proximal tibia as in the patella.

What this study adds

Scintigrams of approximately half of the patients with PFPS will show diffuse uptake in one or more of the bony compartments of the knee joint and radioactive tracer accumulation will occur as often in the proximal tibia as in the patella.

REFERENCES


