Scintigraphic image patterns in dysplastic coxarthrosis

Evaluation with reference to radiographic findings in 210 hips

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ABSTRACT **Little is known about scintigraphic image patterns in the various stages of coxarthrosis. We assessed bone scintigraphy in 159 patients (210 hips) with dysplastic arthrosis of the hip. Scintigraphic images were divided into 5 types related to the radiographic stages of the disease.**

The scintigraphic images showed little, if any, uptake in the stage of prearthrosis. In the early stage, we found an increase in uptake in the weight bearing area in 30% of cases. In the advanced stage, more than half of the cases had an increase in uptake in the medial side of the joint and in the weight bearing area. In the terminal stage, a marked increase in uptake in the weight bearing area was commonest. Since the osteoblastic reaction intensified, a marked increase in uptake was seen not only in the weight bearing area, but also throughout the entire joint. These types of scintigraphic patterns, which change with the stage of coxarthrosis, seem to reflect the natural course of the disease. All hips with rapid progression of the disease showed a marked increase in uptake of radionuclide the entire joint at earlier stages.

Bone scintigraphy a better method than radiography for diagnosing arthrosis of the knee (Thomas et al. 1975) and hand (Hutton et al. 1986). 6 patterns of scintigraphic images in knee arthrosis have been found and each pattern correlates with clinical and radiographic features. (McCrae et al. 1992). Scintigraphic images can also predict the occurrence of arthrotic changes several years later in knee (Dieppe et al. 1993) and hand arthrosis (Hutton et al. 1986). We have reported that preoperative bone scintigraphic images can foretell failure of Chiari pelvic osteotomy for coxarthrosis (Nakamura et al. 1996). However, little is known about the accuracy of bone scintigraphy in detecting coxarthrosis, as compared to radiography, or the patterns of scintigraphic images in the various stages of arthrosis. To clarify these matters, we compared more than 200 scintigraphic images in patients with dysplastic coxarthrosis of varying degrees of severity to the radiographic stages of their disease.

Methods

Between 1981 and 1998, we performed bone scintigraphy in 159 patients (210 hips, 142 women, mean age 46 (14–78) years), with coxarthrosis secondary to hip dysplasia (Nakamura et al. 1989), who were waiting for hip osteotomy or total hip arthroplasty. Radiographs were routinely taken several months before the operation. According to the radiographic staging system of the Japanese Orthopaedic Association (Anwar et al. 1993) (Table 1), 29 hips were prearthrotic, 42 were in the early stage, 37 were in the advanced stage, and 102 were in the terminal stage. The interval between the radiographic and scintigraphic examinations was 3 weeks or less in all cases. The time between the scintigraphic examination and operation was, on average, 5 weeks. Most of the patients (94%) were operated on within 3 months of the scintigraphic examination. The latter examination was

Table 1. Modified radiographic staging system of coxarthrosis, according to the Japanese Orthopaedic Association

Stage	Criteria
Preradiographic (Pre-A)	Acetabular dysplasia No other abnormal findings
Early	Slight joint space narrowing Abnormal subchondral sclerosis
Advanced	Marked joint space narrowing with or without cysts or sclerosis
Terminal	Obliteration of the joint space

done by giving 20 millicuries (740 MBq) of technetium-99m hydroxymethylene bisphosphonate intravenously. Images were taken 3 hours after the infusion. They were divided into 5 types (Figure 1): type 1, little, if any, increase in uptake around the hip joint; type 2, moderate increase in uptake in the joint space of the weight bearing area; type 3, moderate increase in uptake in the joint space of both the weight bearing area and the medial side of the hip joint; type 4, marked increase in uptake in the upper half of the femoral head; and type 5, marked increase in uptake throughout the joint.

We compared the radiographic stages and the scintigraphic types. The terminal stage was divided on the radiographs into 3 types, using Bombelli's method (Bombelli 1983, Saito et al. 1987) (Figure 2): hypertrophic with marked formation of osteophytes and a large capital drop, atrophic without formation of osteophytes, and normotrophic with moderate formation of osteophytes. The chi-squared test was used for the statistical analysis and $p < 0.05$ was considered statistically significant.

Interobserver and intraobserver reliability of the scintigraphic classification were assessed by 4 of the authors, using 38 randomly-selected scintigraphic images, with Kappa coefficients.

Results

Of the 210 hips, 62 were classified as type 1, 24 as

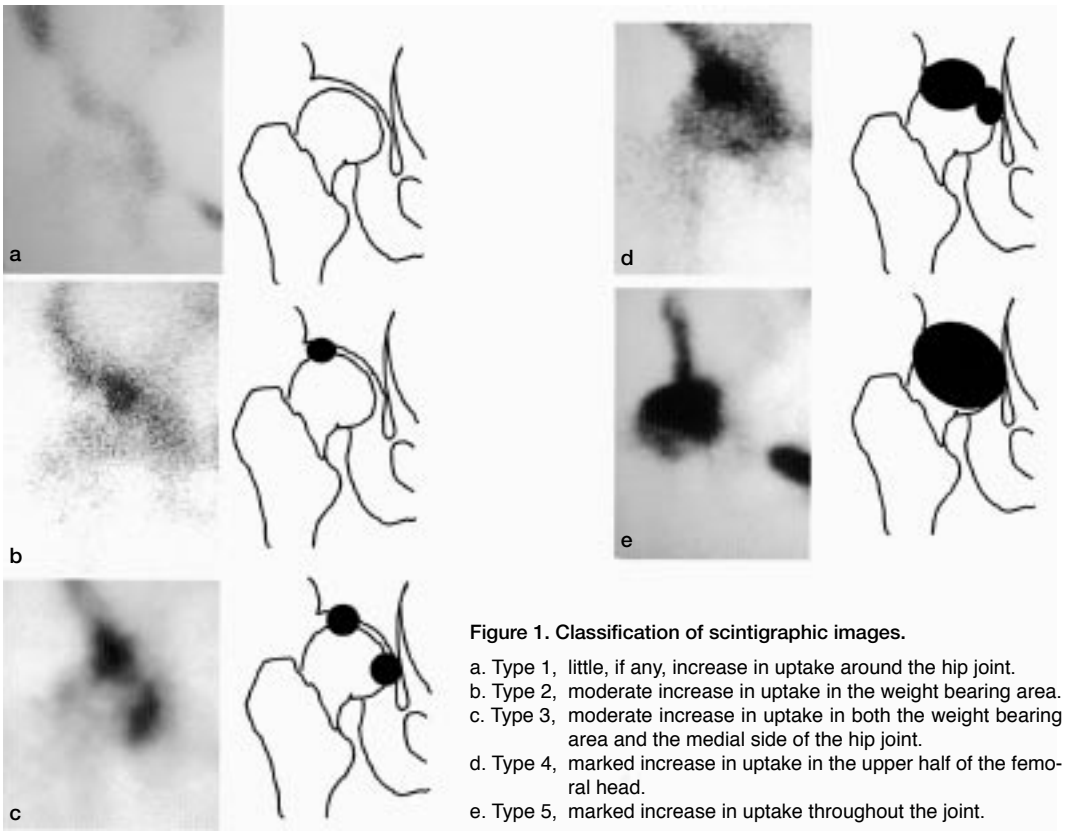
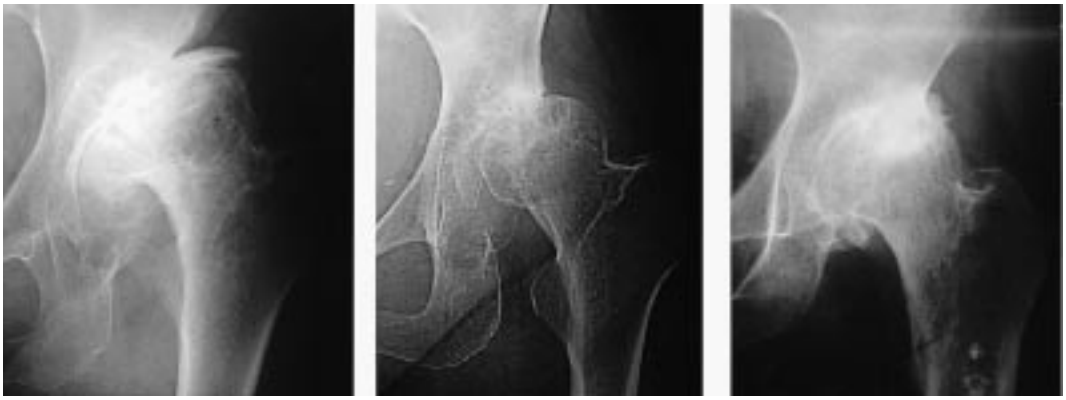


Figure 1. Classification of scintigraphic images.

a. Type 1, little, if any, increase in uptake around the hip joint.
b. Type 2, moderate increase in uptake in the weight bearing area.
c. Type 3, moderate increase in uptake in both the weight bearing area and the medial side of the hip joint.
d. Type 4, marked increase in uptake in the upper half of the femoral head.
e. Type 5, marked increase in uptake throughout the joint.

Figure 2. Types of response in osteoarthrosis.



a. Hypertrophic with marked osteophyte formation and a large capital drop.

b. Atrophic without formation of osteophytes.

c. Normotrophic with moderate formation of osteophytes.

Table 2. Relationship between radiographic stages and scintigraphic types

Radiographic stages of arthrosis		Scintigraphic types 1	2	3	4	5
Pre-	(n 29)	28	1	0	0	0
Early	(n 42)	29	12	0	0	1
Advanced	(n 37)	4	10	20	1	2
Terminal	(n 102)	1	1	19	45	36
Total	(n 210)	62	24	39	46	39

Table 3. Relationship between radiographic types of terminal stage arthrosis and scintigraphic types

Radiographic types of terminal stages arthrosis		Scintigraphic types 1	2	3	4	5
A	(n 26)	0	0	3	17	6
N	(n 32)	0	1	8	14	9
H	(n 44)	1	0	8	14	21
Total	(n 102)	1	1	19	45	36

type 2, 39 as type 3, 46 as type 4, and 39 as type 5. Of the 29 prearthrosis hips, all scintigraphic images were type 1, except 1 (Table 2). Of the 42 early stage hips, 29 (69%) were type 1 and 12 (29%) type 2. Of the 37 advanced stage hips, the predominant image was type 3 (20 hips; 54%), followed by type 2 (10; 27%). Of the 102 terminal stage hips, type 4 (45 hips; 44%) was the main image, followed by type 5 (36; 35%), and type 3 (19; 19%).

The radiographic images of the 102 terminal stage hips were further divided into 3 types (Table 3). 44 hips were classified as hypertrophic, 26 as atrophic, and 32 as normotrophic. Of the terminal stage atrophic and normotrophic hips, scintigraphy type 4 was commonest, but scintigraphy type 5 dominated in the hypertrophic hips. One of these hips with a type 1 image had spontaneous ankylosis.

An increase in uptake in the medial side of the hip joint was associated with the formation of osteophytes in this area, such as capital drop and floor osteophytes (Bombelli 1983) ($p < 0.001$, Chi-squared test). Of the 91 hips with osteophytes in the medial side of the joint, 75 hips (82%) showed an increase in uptake in this area. Of the 119 hips without medial osteophytes, 88 (74%) had no increase in uptake in that region. However, the remaining 31 hips (26%) showed an increase in uptake in the medial side of the joint, although there were no medial osteophytes.

A marked increase in uptake in the upper half of the femoral head was commoner in cases with obliteration of the joint space ($p < 0.001$, Chi-squared test). Of the 102 terminal stage hips, 81 (79%) had a marked increase in uptake in the upper half of the femoral head. Uptake appeared to increase after obliteration of the joint, since only 4 of 108 hips with preserved joint space showed a marked increase in uptake in the upper half of the femoral head.

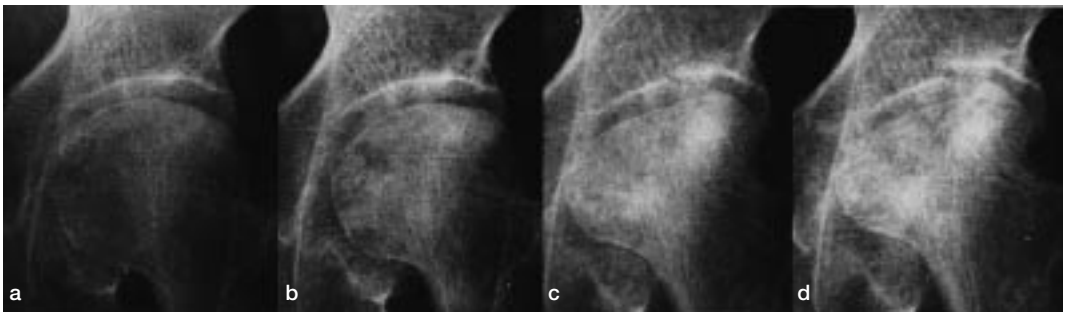


Figure 3. A patient diagnosed with a rapidly destructive left-sided coxarthrosis.
a. Initial radiograph.
b. 3 weeks later.
c. 7 weeks later.
d. 8 weeks later.
e. Bone scintigraphy 3 weeks after initial radiograph. No osteonecrosis was found in the femoral head on histological examination after total hip arthroplasty.

In summary, scintigraphic images showed little, if any, uptake in the radiographic stage of prearthrosis. In the early stage, an increase in uptake was seen in the weight bearing area in about 30% of cases. In the advanced stage, more than half of the hips showed an increase in uptake confined to the weight bearing area and the medial side of the joint, which was due to the formation of medial osteophytes. When the joint space obliterated in the terminal stage, a marked increase in uptake in the upper half of the femoral head became the predominant image. As the osteoblastic reaction intensified from atrophic to hypertrophic, we found a marked increase in uptake not only in the upper half of the femoral head, but also throughout the joint.

5 hips showed a rapid progression of the disease. According to the characteristics reported by Postel and Kerboull, all were considered to have a rapidly destructive arthrosis (Postel and Kerboull 1970). All these hips showed type 5 scintigraphic images (Figure 3). When the bone scintigraphies were taken, one hip was in the early stage and 4 were in the terminal stage atrophic type. Conversely, when no osteophytes were seen on the radiographs, but the scintigraphic image showed type 5, 5 of 7 hips (71%) progressed along a rapidly destructive course.

The mean interobserver reliability of the scintigraphic classification was 80 (76–84)% and the mean kappa coefficient was 0.72 (0.67–0.77), which indicates fair reliability. The mean intraobserver reliability was 89 (84–95)% and the mean kappa coefficient was 0.87 (0.79–0.93), which indicates good reliability.

Discussion

Only a few authors have studied the relationship between progression of coxarthrosis and corresponding scintigraphic findings. In 1963, Danielsson et al. found that ^{47}Ca and ^{85}Sr uptake correlates with the radiographic severity of coxarthrosis (Danielsson et al. 1963). However, since scintillation counters were the only methods for measurement, uptake patterns were not available. The use of ^{99m}Tc phosphate complexes and gamma cameras with high resolution collimators has permitted detection of the isotopes in the joints (Christensen 1985). In the present study, we found relation between 5 characteristic scintigraphic patterns and the coxarthrosis stage on radiographs.

In most cases, radionuclide uptake was associated with the radiographic severity of coxarthrosis. In the early stage of arthrosis, the radionuclide first appears in the weight bearing area, where the joint stresses concentrate and metabolic activity of subchondral bone increases. When the arthrosis becomes more severe, a second uptake pattern usually develops in the medial side of the joint. This uptake indicates the beginning of osteophyte formation in this area, as a result of superolateral subluxation of the femoral head (Bombelli 1983,

Nakamura et al. 1996). In the terminal stage, uptake at the weight bearing area increases markedly, but varies in the medial side of the joint, which is probably due to the speed of subluxation and the osteoblastic response. Both findings accelerate so that uptake involves the upper half of the joint and, finally, the entire joint. We believe that these changes in bone scintigraphic images reflect the typical natural course of dysplastic coxarthrosis.

Although bone scintigraphy has been shown to be better at detecting early arthrosis than conventional radiography in some studies (Thomas et al. 1975, Christensen 1983, Hutton et al. 1986), we found that only 30% of early stage arthrotic hips exhibited radionuclide uptake. A similar finding has been reported in the knee—i.e., joint space narrowing by as much as 50% was seen in a scintigraphically normal knee (Egund et al. 1988). These findings suggest that bone scintigraphy does not detect early arthrotic change as well as previously thought. This finding seems reasonable because in the early stage, articular cartilage degeneration would be the main pathological change, rather than acceleration of bone turnover. However, another explanation may be that only hips that are active and progressing to the next stage show uptake. Dieppe et al. (1993) found that none of their 55 arthrotic knees with no abnormalities on the scan had progressed after a 5-year follow-up. Furthermore, when studying hand arthrosis, Hutton et al. (1986) reported that 14% of the joints that had abnormalities on the radiographs alone progressed, while 70% of the joints that had abnormalities on the scan alone became worse in 3–5 years.

A marked increase in uptake in the upper half of the femoral head was associated with obliteration of the joint space in our study. An increase in uptake in the medial side of the joint was associated with the formation of osteophytes at the same place. These findings correspond to the histological findings that the bone-seeking agents accumulate in the weight bearing, denuded areas and at the osteochondral junctions in the osteophytes (Christensen and Arnold 1980). Our study also suggests that uptake in the upper half of the femoral head increases markedly after obliteration of the joint, since there were only a few hips that showed a marked increase in uptake in this area before the joint space had become obliterated.

31 of 119 hips (26%) showed an increase in uptake medially before the osteophytes became radiographically visible in this region. We have previously reported that hips with an increased in uptake in this area on preoperative bone scans had a high incidence of medial osteophyte development (87%) and subluxation (60%) after Chiari osteotomy (Nakamura et al. 1996). We suggest that scintigraphic images may be more accurate than radiographic ones in detecting medial osteophyte development, which is followed by subluxation of the joint and terminal stage arthrosis.

5 hips that showed rapid progression of the disease did not follow the ordinary scintigraphic course. All of these hips had a marked increase in uptake throughout the joint at a relatively early radiographic stage. In our view, when there are no osteophytes on the radiographs and the scintigraphic image is type 5, one should suspect a rapidly destructive coxarthrosis.

No competing interests declared.

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