Bone scintigraphy as an indicator for dome osteotomy of the pelvis

Comparison between scintigraphy, radiography and outcome in 57 hips

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We performed dome pelvic osteotomy in 57 hips (54 patients) because of acetabular dysplasia. All patients had preoperative scintigraphy and were followed for more than 2 years. Excellent or good results were obtained in 49 hips, but 8 hips deteriorated. All hips which deteriorated had preoperatively a spotty isotope uptake image localized to the weight bearing area and the medial area of the joint. No hip without this image deteriorated, even when preoperative radiography showed advanced arthrosis. Our findings indicate that bone scintigraphy may be a more reliable predictor of failure for this operation than radiography.

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Acetabular dysplasia with secondary arthrosis is common in Japan. The goal of early joint preserving operations is to correct the underlying mechanical disorder. Dome pelvic osteotomy, which was originally devised by Kawamura in 1958 (Kawamura et al. 1982), provides a dome-shaped iliac bone support to the femoral head. Our group has shown excellent results maintained for more than 5 years in cases with no evidence of joint space narrowing on preoperative radiographs (Anwar et al. 1993). However, in hips with a moderate loss of joint space, restoration was maintained in some hips, while others developed advanced arthrosis. This fact suggests that there may exist a stage in the disease process of arthrosis which could determine prognosis after dome pelvic osteotomy. We examined whether preoperative bone scintigraphy has prognostic value.

Patients and methods

In 1978, we initiated dome pelvic osteotomy for the treatment of skeletally mature patients with acetabular dysplasia or congenital subluxation with or without secondary arthrosis. Since 1984, we have routinely performed technetium-99m hydroxymethylene bisphosphonate bone scintigraphy of the hips before surgery.

To date, 57 hips in 54 consecutive patients have been analyzed by bone scintigraphy, and followed up for more than 2 years.

There were 9 men and 45 women with a mean age of 32 (16–55) years. The mean follow-up period was 6 (2–11) years. According to the modified radiographic staging system of arthrosis by the Japanese Orthopaedic Association (Anwar et al. 1993), 16 hips had prearthrosis, 16 had early and 25 had advanced arthrosis at admission. Hips at a terminal stage of arthrosis were not considered suitable for this operation. For scintigraphic examination, 20 millicuries (740 MBq) of technetium-99m hydroxymethylene bisphosphonate were administered intravenously, and images obtained 3 hours postinfusion.

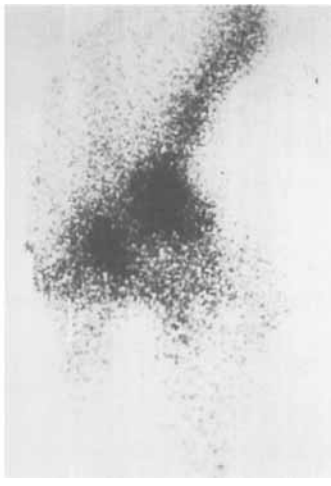
The scintigraphic images were classified into 3 types (Figure 1): type 1, diffuse and mild increases in uptake around the hip joint; type 2, markedly increased uptake localized at the weight bearing area; type 3, markedly increased uptake localized in both the weight bearing area and the medial side of the hip joint, which hereafter is referred to as the "double hot sign". Of the 57 hips, 28 hips were classified as type 1, 14 as type 2, and 15 as type 3.

The surgical procedure followed a modification of Kawamura's method (Anwar et al. 1993). Briefly, through a lateral transtrochanteric approach, a dome-shaped oblique osteotomy was performed along the acetabular rim by use of an oscillating saw. After medialization of the hip, the greater trochanter was reat-

Figure 1. Types of scintigraphic images.

Type 1. Diffuse and mild increase in ^{99m}Tc uptake around the hip joint. the medial side of the hip joint.

Type 2. Markedly increased uptake localized at the weight bearing area.



Type 3. Markedly increased uptake localized at both the weight bearing area and

tached to the femur at a site 2 cm lower and 1 cm more lateral relative to the original position to increase the length of the abductor and the lever arm of the gluteus medius. Postoperatively, the hip was immobilized in 20 degrees of flexion and 30 degrees abduction in a hip spica for 3 weeks. Partial weight bearing was allowed at 6 weeks and full weight bearing at 12 weeks postsurgery. Varus or valgus osteotomy was added when the preoperative anteroposterior radiographs showed better congruity in abduction (9 hips) or adduction (3 hips), respectively. There were no serious problems with deep infection, nerve palsy, thromboembolic disease or nonunion.

The hip function of the patients was assessed according to the Merle d'Aubigné scoring system in the preoperative period and at final follow-up. Excellent results were recorded when the hip had 18 or 17 points, good results 16 or 15, fair 14 or 13, and poor 12 points or less. The last two categories were regarded as clinical failures. Radiographic failure was defined as progressive narrowing of the joint space that developed postoperatively, with or without progressive subluxation.

We compared the reliability of the preoperative scintigraphic classification with that of the radiographic staging of arthrosis in predicting the outcome of surgery. For evaluation of the reliability of each imaging examination, accuracy (the percentage of patients in whom the diagnosis based on the preoperative imaging was correct), sensitivity (the percentage of patients in whom the final poor clinical result had been predicted by the preoperative imaging), and specificity (the percentage of patients in whom the final good clinical result had been predicted by the preoperative imaging) were calculated.

The chi-square test and Student's t-test were used for statistical analysis and $p < 0.05$ was considered significant.

Results

The mean Merle d'Aubigné hip score improved from 13 preoperatively to 16 at the final follow-up examination, with pain relief from 3.1 to 5.2 points. The result was excellent in 40 hips, good in 9, fair in 1, and poor in 7.

Radiographically, 9 hips showed progression to more severe arthrosis, with poor clinical results in 7, fair in 1, and an excellent result in 1 hip.

According to the preoperative radiographic staging, 32 hips had preradiographic or early stage arthrosis and all had excellent or good results. However, 8 of the 25 hips with advanced arthrosis had fair or poor results (Table 1). The sensitivity, specificity, and accuracy of radiographically advanced arthrosis in predicting clinical failure were 100%, 65%, and 70%, respectively (Table 2).

According to the scintigraphic classification, all 42 hips with either type 1 or type 2 had excellent or good results at the final follow-up, but 8 of the 15 hips with type 3 had fair or poor results (Figure 2, Table 3). If type 3 was assumed to predict clinical failure, sensitivity, specificity, and accuracy were 100%, 86%, and 88%, respectively. The difference in specificity between radiography and bone scintigraphy was 0.20

Table 1. Preoperative radiographic stages and clinical results at final follow-up

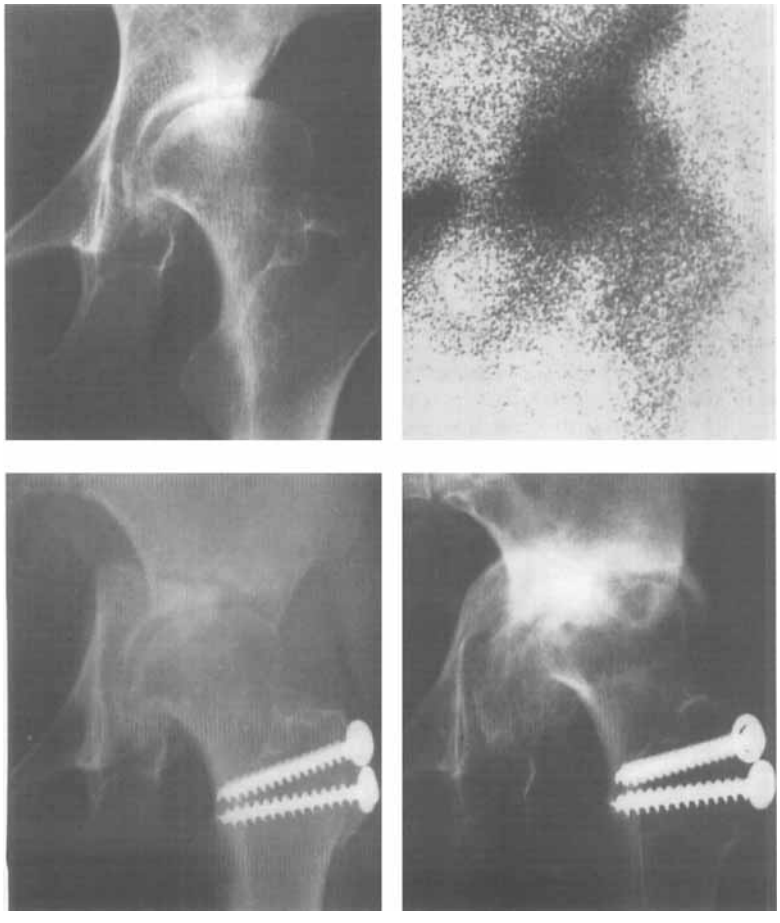
Radiographic stages of arthrosis	Merle d'Aubigné score			
	Excellent (18 or 17)	Good (16 or 15)	Fair (14 or 13)	Poor (12 or less)
Pre- and early (n 32)	28	4	0	0
Advanced (n 25)	12	5	1	7
Total (n 57)	40	9	1	7

Table 2. Percentage validity of prediction of the final clinical results of radiographic staging and scintigraphic types

Validity	True positive (hips)	True negative (hips)	False positive (hips)	False negative (hips)	Sensitivity (percent)	Specificity [a] (percent)	Accuracy [b] (percent)
Radiographic stage (advanced)	8	32	17	0	100	65	70
Bone scintigraphy (type 3)	8	42	7	0	100	86	88

[a] 95% confidence interval 0.02–0.4
[b] p 0.01 (chi-square test)

Figure 2. A 43-year-old woman with arthrosis of both hips. Right hip had been treated with total hip arthroplasty.



Preoperative radiograph shows advanced arthrosis and the hip score was 12 points (left).

Preoperative bone scintigraphic image shows a double hot sign (type 3) (right).

2 months postoperatively, there is good coverage by the new acetabular roof (left).

3 years and 10 months after the operation, marked capital-drop formation and superolateral subluxation of the femoral head are seen as well as joint space obliteration. The clinical result was poor and the hip score was 10 points (right).

Table 3. Clinical results and scintigraphic types

Scintigraphic types	Merle d'Aubigné score			
	Excellent (18 or 17)	Good (16 or 15)	Fair (14 or 13)	Poor (12 or less)
1 (n 28)	25	3	0	0
2 (n 14)	10	4	0	0
3 (n 15)	5	2	1	7
Total (n 57)	40	9	1	7

Table 4. Comparison between radiographic stages and scintigraphic types

Radiographic stages of arthrosis	Scintigraphic types		
	1	2	3
Pre- (n 16)	14	2	0
Early (n 16)	10	6	0
Advanced (n 25)	4	6	15
Total (n 57)	28	14	15

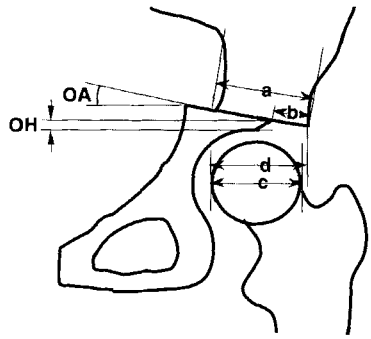


Figure 3. Diagrammatic representation of measurements, angles and ratios. OA, angle of osteotomy; OH, height of osteotomy; b/a ×100, percentage displacement; d/c ×100, acetabulum-head index.

Table 5. Details of patients and hips of advanced stage OA, according to the scintigraphic types

	Scintigraphic types	
	1, 2 (n 10)	3 (n 15)
Age at operation (yrs)	41	38
Follow-up periods (months)	77	78
Preoperative		
Merle d' Aubigné score	13	12
Radiography		
Angle of osteotomy (degrees)	15	14
Height of osteotomy (mm)	6.2	4.6
Displacement (percent)	37	43
Acetabulum-head index (percent)		
preoperative	58	56
postoperative	92	93

Table 6. Postoperative radiographic changes in hips of advanced stage OA, according to the scintigraphic types

	Scintigraphic types		P-value
	1, 2 (n 10)	3 (n 15)	
Capital drop developed [a]	3	13	0.007
Superolateral subluxation [a]	0	9	0.002

[a] Chi-square test

(95% confidence interval 0.02–0.4) (Table 2). Therefore, to predict clinical results, bone scintigraphy was more reliable than radiography.

All 15 hips that showed type 3 images on bone scintigraphy were classified as with advanced arthrosis on radiography (Table 4). However, there was no specific radiographic finding that distinguished between scintigraphic type 3 hips and type 1 or type 2 hips at preoperative periods (Figure 3, Table 5). All 9 hips with radiographic failure showed type 3, while no failure was observed in hips with other types. In type 3 hips, a high incidence of capital drop osteophyte development and subluxation was observed postoperatively (Table 6).

Discussion

Bone scintigraphy has been reported to be more sensitive in detecting early arthrosis than conventional radiographs both clinically (Thomas et al. 1975, Suzuki 1979, Coventry 1985, Hutton et al. 1986) and experimentally (Christensen 1983). The uptake of the bone-seeking radionuclide becomes wider and more in-

tense as the arthrosis change progresses (Thomas et al. 1975, Suzuki 1979), as we also found in our series. A speculative interpretation of what the scintigraphic images represent may be as follows: type 1 reflects the metabolic activity of subchondral bone accommodating a stress overload on the dysplastic joint; type 2 indicates that there is a substantial reactive bone remodeling in response to the overload at the weight bearing area: type 3 could be an osteoblastic reaction at the medial part of the joint as well as the weight bearing area. This could explain the high incidence of capital drop osteophyte formation. Bombelli (1983) proposed that capital drop developed as the result of superolateral subluxation of the femoral head. Indeed, in our study, 9 of 15 hips which were classified as type 3 by scintigraphy had progressive subluxation postoperatively. It is possible that superolateral migration commenced in type 3 hips and after initiation it may not be prevented by a surgical approach, such as dome osteotomy alone.

In summary, we propose that bone scintigraphy is a more accurate indicator of dome osteotomy of the pelvis than is conventional radiographic staging. In cases where advanced arthrosis is revealed by type 3 scintigraphic images, an operative procedure that prevents superolateral subluxation (i.e., valgus osteotomy) should be added. Further prospective studies will be needed to prove the validity of this conclusion.

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