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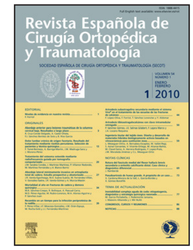

ORIGINAL ARTICLE

Distribution of periprosthetic osteolysis in the hip: A study using magnetic resonance☆

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KEYWORDS
Hip arthroplasty;
Osteolysis;
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Abstract
Introduction: Magnetic resonance imaging (MRI) is useful in assessing bone and soft tissue lesions due to the production of wear particles. Our objective was to study the distribution of lesions in patients with one type of cementless acetabular component with this technique.
Material and methods: We included 40 total hip arthroplasty with press-fitted hydroxyapatite porous-coated cup and multiple optional screw holes performed over a mean of 13 years. We studied the presence, extent and continuity of the granulomatous lesion and osteolysis with MRI using special pulse sequences to reduce metal artefacts.
Results: One hip was not amenable to analysis. An isolated granulomatous lesion was found in 3 hips, associated osteolysis in 32, in the pelvis only in 10, in the femur only in 3 and in both segments in 19. By zones, the pelvis involvement was supra-acetabular ilium in 15, ischium-pubic branch in 24, ischium in 12 and retro-acetabular ischium in 21. Only two hips and two screws central lesions were isolated from the granulomatous mass.
Comments and conclusions: MRI osteolysis and soft tissue lesions secondary to wear to be studied. The distribution of osteolytic areas show a peripheral pattern typical of non-perforated acetabular cups frequently coexisting with proximal femoral involvement, highlighting few isolated lesions in the holes or around the implanted screws.

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PALABRAS CLAVE
Artroplastia de cadera;
Osteólisis;
Cúpula acetabular;
Resonancia magnetica

Distribución de la osteólisis periprotésica en la cadera. Estudio con resonancia magnética

Resumen
Introducción: Con resonancia magnética es posible evaluar las lesiones óseas y de partes blandas secundarias a la producción de partículas de desgaste. Nuestro objetivo ha sido estudiar con este método la distribución de las lesiones en pacientes con un mismo tipo de componente acetabular no cementado.
Material y método: Se incluyeron 40 artroplastias de cadera no cementadas con un cotilo poroso revestido de hidroxiapatita y multiperforado para anclaje opcional de tornillos con una evolución media de 13 años. Mediante estudios de imagen con resonancia magnética utilizando secuencias especiales de pulsos para disminuir los artefactos metálicos, se estudió la presencia, extensión y continuidad de la lesión granulomatosa y de las zonas de osteólisis.
Resultados: Una cadera no fue susceptible de análisis. Se detectó lesión granulomatosa aislada en tres caderas y asociada a osteólisis en 32, sólo en pelvis en 10, sólo en el fémur en tres y en ambos segmentos en 19. En la pelvis la afectación fue, por zonas: ilion supraacetabular en 15 caderas, rama isquio-pubiana en 24, isquion en 12 e isquion retro-acetabular en 21. Solo dos caderas y dos tornillos presentaban lesiones centrales aisladas del resto del granuloma.
Comentarios y conclusiones: Con resonancia magnética ha sido posible estudiar las lesiones óseas y de partes blandas secundarias a desgaste. La distribución de las zonas de osteólisis ha seguido un patrón periférico propio de cotilos no perforados, destacando la existencia de escasas lesiones aisladas sobre los orificios o alrededor de los tornillos implantados coexistiendo con frecuencia afectación femoral proximal.

Introduction

As a result of improvements in prophylaxis against infection, in materials used, and in fixation methods, osteolysis caused by wear particles has become the primary limiting factor in the longevity of total hip arthroplasties (THA).[1] Intensive research into the manufacture of and sterilization method for the polyethylene, along with the development of alternative metal or ceramic friction couples, enable us to predict—though with some questionings—that we are close to solving this problem.[2,3] However, some arthroplasty patients have a metal-polyethylene couple—above all, those who underwent the surgery at the end of the last century—and show high rates of wear and pelvic and femoral osteolysis.

Because osteolysis caused by wear particles is often asymptomatic and difficult to evaluate radiologically,[3-5] proposals have been made that it be studied with computerized tomography (CT)[6] and, more recently, with magnetic resonance imaging (MRI)[7]—techniques that are more sensitive for its detection and volumetric evaluation.[8] It has been recommended that any of these complementary studies be done routinely on THA patients during follow-up,[9] using CT to determine lesion volume in studies prior to the revision surgery and MRI to facilitate detection of the condition, since this is a more sensitive technique that also keeps the patient from being repeatedly exposed to radiation.[7-10] However, practical experience with this method and even the experience reflected in the literature[7,9,10] is currently quite limited.

Knowledge of the osteolytic lesion sites and patterns of extension for each arthroplasty model can have significant implications for diagnosis and treatment. In this regard, a linear distribution with loosening of the components is known to be more common in cemented arthroplasty; however, extensive focal lesions are known to occur in cementless arthroplasty that, unless they are massive, allow the implant to remain stable.[11] This explains, at least in part, how it is possible for extensive bone destruction to occur in the cementless models prior to the wear-particle disease coming to light on routine clinical and/or radiological follow-up studies. In a CT study on cementless, porous, hemispherical acetabular components differing in design as to the number and position of orifices on its surface,[12] it was determined that osteolysis occurs primarily through these holes (the typical central images appearing in the supra-acetabular area, in this case) and through the edge only when those are not present (other images appearing at the acetabular edges, in that case).

The objective of this study was to determine whether it is possible to use MRI to evaluate lesions associated with the granulomatous reaction and osteolysis caused by wear particles and, if so, to describe the lesions and study their distribution pattern in an acetabular component with multi-hole biological anchoring.

Materials and methods

We proposed this work as an initial study within a wider research project currently underway, in which we were

Table 1 Epidemiological and clinical variables

	Age	Sex	Aetiology	Pain	Mov.	Gait	Merle score	Charnley grade	Year of surgery	Screw	Approach
1	65	Female	Idiopathic	5	4	4	13	2	1994	1	Anterior
2	66	Female	Idiopathic	6	4	4	14	2	1995	2	Anterior
3	53	Female	Idiopathic	6	6	6	18	2	1998	None	Anterior
4	48	Female	Idiopathic	6	5	5	16	2	1992	None	Anterior
5	29	Female	Dysplastic	4	4	4	12	1	1993	3	Anterior
6	61	Male	Idiopathic	6	5	5	16	2	1992	1	Anterior
7	61	Female	Idiopathic	6	6	6	18	1	1995	2	Posterior
8	61	Male	Idiopathic	5	5	5	15	1	1997	None	Anterior
9	48	Male	ANFH	6	5	6	17	2	1994	2	Anterior
10	49	Male	ANFH	6	5	6	17	2	1994	2	Anterior
11	66	Female	Idiopathic	6	5	5	16	2	1993	2	Anterior
12	65	Female	Idiopathic	6	5	5	16	2	1994	3	Anterior
13	51	Male	Idiopathic	6	5	5	16	2	1992	3	Anterior
14	46	Female	Dysplastic	6	6	6	18	1	1995	2	Lateral
15	62	Male	Dysplastic	6	5	5	16	2	1994	2	Anterior
16	62	Male	Dysplastic	6	5	5	16	2	1994	2	Anterior
17	68	Female	ANFH	6	6	6	18	1	2001	None	Posterior
18	62	Male	Idiopathic	6	6	6	18	1	1999	None	Posterior
19	56	Male	Idiopathic	6	6	6	18	1	1994	2	Anterior
20	55	Male	Idiopathic	6	6	6	18	1	1995	None	Anterior
21	60	Female	Idiopathic	6	6	6	18	2	2000	None	Posterior
22	61	Female	Idiopathic	6	6	6	18	2	2001	None	Posterior
23	69	Female	Idiopathic	6	6	6	18	2	2007	None	Posterior
24	60	Female	Idiopathic	6	6	6	18	2	1999	2	Lateral
25	48	Male	Idiopathic	6	6	6	18	1	1998	3	Anterior
26	64	Female	Dysplastic	6	5	5	16	2	1993	2	Anterior
27	47	Female	Idiopathic	6	6	6	18	2	1999	3	Posterior
28	48	Female	Idiopathic	6	6	6	18	2	2000	None	Posterior
29	61	Female	Idiopathic	6	5	6	17	1	1997	None	Anterior
30	64	Male	Other	6	6	6	18	1	1994	2	Anterior
31	65	Female	Idiopathic	6	5	5	16	2	1995	1	Anterior
32	63	Female	Idiopathic	4	4	4	12	2	1993	2	Anterior
33	62	Male	Idiopathic	5	4	4	13	1	1995	2	Anterior
34	34	Female	Idiopathic	6	5	5	16	1	1994	2	Anterior
35	35	Male	ANFH	6	6	6	18	1	1995	3	Anterior
36	50	Male	Idiopathic	3	4	3	10	1	1998	None	Anterior
37	65	Male	Idiopathic	6	4	4	14	2	1993	3	Lateral
38	58	Male	ANFH	5	6	6	17	1	2000	2	Posterior
39	54	Male	Idiopathic	6	6	6	18	1	1994	2	Anterior
40	55	Male	Idiopathic	6	6	6	18	1	1999	None	Posterior

attempting to evaluate whether MRI would be helpful in making surgical decisions with regard to osteolysis caused by wear particles. In accordance with our objectives, we included a THA group known to have osteolysis by previous CT study (17 hips) and another random group (23 hips) from among patients in whom the possibility of osteolysis was suggested by x-rays taken at their periodic follow-up visits—independently of the length of follow-up and whether they had undergone another surgery, given the chance of early-onset or aggressive disease. The patients were informed of the nature of and objectives for the procedure, and they signed a specific consent.

We studied 40 THA implanted between 1992 and 2007, with a mean elapsed time of 13 years (maximum 17 and minimum 2 years). The THAs represent 29 patients (11 bilateral THAs), with a mean age at the time of surgery of 57 years (maximum 69 and minimum 29 years). Of the hips implanted, 22 were on the right and 18 on the left side; 19 were in male patients and 21 in female patients. The indication for arthroplasty was osteoarthritis of the hip, of primary aetiology in 29 and secondary to dysplasia in 5; aseptic necrosis of the femoral head in 5; and 1 case of absence of consolidation of a femoral neck fracture and failure of a threaded acetabular component. The remaining patients had undergone surgery as a primary procedure.

The surgical approach was anterior in 27 hips, lateral in 3, and posterior in 10. A hydroxyapatite-coated, porous,

Table 2 Results

	Degree of disease	Location	P1	P2	P4	P5	F1	F7	Pattern of involvement
1	Non-severe osteolysis	Pelvic osteolysis only	No	Yes	No	Yes	No	No	Not supra-acetabular
2	Non-severe osteolysis	Pelvic osteolysis only	No	Yes	Yes	Yes	No	No	Not supra-acetabular
3	Non-severe osteolysis	Osteolysis in pelvis and femur	Yes	Yes	No	No	No	Yes	Supra-acetabular
4	Severe disease	Osteolysis in pelvis and femur	Yes	Yes	No	No	Yes	No	Supra-acetabular
5	Severe disease	Osteolysis in pelvis and femur	Yes	Yes	Yes	Yes	Yes	Yes	Global
6	Severe disease	Pelvic osteolysis only	Yes	Yes	Yes	Yes	No	No	Global
7	Granulomatous lesion w/o osteolysis	Granulomatous lesion w/o osteolysis	No	No	No	No	No	No	
8	Severe disease	Osteolysis in pelvis and femur	Yes	Yes	Yes	Yes	Yes	Yes	Global
9	Granulomatous lesion w/o osteolysis	Granulomatous lesion w/o osteolysis	No	No	No	No	No	No	
10	NE	NE	NE	NE	NE	NE	NE	NE	NE
11	Non-severe osteolysis	Pelvic osteolysis only	Yes	Yes	No	No	No	No	Supra-acetabular
12	Non-severe osteolysis	Osteolysis in pelvis and femur	Yes	Yes	No	No	Yes	No	Supra-acetabular
13	Non-severe osteolysis	Osteolysis in pelvis and femur	No	Yes	No	Yes	Yes	No	Not supra-acetabular
14	Severe disease	Pelvic osteolysis only	No	Yes	Yes	Yes	No	No	Not supra-acetabular
15	Non-severe osteolysis	Osteolysis in pelvis and femur	No	Yes	No	Yes	Yes	No	Not supra-acetabular
16	Non-severe osteolysis	Pelvic osteolysis only	Yes	No	No	No	No	No	Supra-acetabular
17	Non-severe osteolysis	Pelvic osteolysis only	No	No	Yes	Yes	No	No	Not supra-acetabular
18	Granulomatous lesion w/o osteolysis	Granulomatous lesion w/o osteolysis	No	No	No	No	No	No	
19	Non-severe osteolysis	Osteolysis in pelvis and femur	No	Yes	No	Yes	Yes	Yes	Not supra-acetabular
20	Non-severe osteolysis	Femoral osteolysis only	No	No	No	No	Yes	No	Femur only
21	Severe disease	Osteolysis in pelvis and femur	Yes	Yes	Yes	Yes	Yes	No	Global
22	No disease	No	No	No	No	No	No	No	
23	No disease	No	No	No	No	No	No	No	
24	Non-severe osteolysis	Pelvic osteolysis only	No	No	No	Yes	No	No	Not supra-acetabular
25	No disease	No	No	No	No	No	No	No	
26	Non-severe osteolysis	Osteolysis in pelvis and femur	Yes	No	No	Yes	Yes	No	Supra-acetabular
27	Severe disease	Osteolysis in pelvis and femur	Yes	Yes	No	No	Yes	Yes	Supra-acetabular
28	Non-severe osteolysis	Femoral osteolysis only	No	No	No	No	Yes	No	Femur only
29	Granulomatous lesion w/o osteolysis	Granulomatous lesion w/o osteolysis	No	No	No	No	No	No	
30	Non-severe osteolysis	Osteolysis in pelvis and femur	Yes	Yes	No	Yes	Yes	No	Global
31	Non-severe osteolysis	Osteolysis in pelvis and femur	No	Yes	No	No	Yes	Yes	Not supra-acetabular
32	Severe disease	Osteolysis in pelvis and femur	Yes	Yes	Yes	Yes	Yes	Yes	Global
33	Non-severe osteolysis	Osteolysis in pelvis and femur	No	Yes	Yes	Yes	Yes	Yes	Not supra-acetabular
34	Severe disease	Osteolysis in pelvis and femur	Yes	Yes	Yes	Yes	No	Yes	Global
35	Non-severe osteolysis	Pelvic osteolysis only	No	Yes	Yes	Yes	No	No	Not supra-acetabular
36	Severe disease	Osteolysis in pelvis and femur	Yes	Yes	Yes	Yes	No	Yes	Global
37	Non-severe osteolysis	Osteolysis in pelvis and femur	No	Yes	No	No	No	Yes	Not supra-acetabular
38	Non-severe osteolysis	Femoral osteolysis only	No	No	No	No	Yes	No	Femur only
39	Non-severe osteolysis	Osteolysis in pelvis and femur	No	Yes	No	Yes	Yes	No	Not supra-acetabular
40	Non-severe osteolysis	Pelvic osteolysis only	No	No	No	Yes	No	No	Not supra-acetabular

Pelvis (P) and femur (F) zones: P1 - supra-acetabular ilium; P2 - superior pubic ramus; P4 - ischium; P5 - retro-acetabular ischium; F1 - major trochanter; F7 - minor trochanter. NE - Not Evaluated.

titanium, hemispherical, cementless acetabular component was implanted in all hips, with multiple holes for screw anchoring; a central orifice to facilitate its impacting; and 3 peripheral flanges for improved primary stability (Bihapro® Biomet, UK). Regarding screws for supplementary fixation, they were not used in 13 acetabular cups and were used in 27 (1 in 3, 2 in 17, and 3 in 7). In 37 cases, the same model of cementless, titanium femoral rod was implanted, with anatomical design, proximal anchoring, and hydroxyapatite-coated porous finish over its entire circumference at this level (Bihapro® Biomet, UK). Two rods were of other cementless models with proximal anchoring for primary surgery, and another was a modular with distal anchoring implanted following failure of a cemented femoral component. The friction couple was metal-polyethylene, in all cases, with chrome-cobalt head 28 mm in diameter and ultra-high-molecular-weight polyethylene, sterilized in air (in the 27 cases whose surgery was prior to 1997) or in nitrogen (in the remaining 13 cases who underwent surgery after that year).

Five patients had undergone a repeat surgery on the hip being studied prior to the MRI: in 1 (case 21), for instability (revision of the femoral head and polyethylene insert and placement of a constrained acetabular component); and in 3 for failure of the polyethylene, 2 due to excessive wear (cases 4 and 33) and 1 due to its uncoupling from the metallic component (case 24), the femoral head and polyethylene being changed. In another patient—the one in whom the femoral component was revised—the polyethylene insert was also changed, preserving the acetabular component (case 38). In none of these 5 cases was loosening of the acetabular component or pelvic or femoral osteolysis detected prior to or during the surgery, nor had a bone graft been inserted during the surgical procedure, so we thought they were not interfering with our objectives and should not be excluded.

All patients in our study who were being evaluated clinically and by x-ray, systematically and periodically in the outpatient clinic, were evaluated again when the MRI was done. At that time, an anterior-posterior x-ray of the pelvis centred on the symphysis pubis was taken, and clinical and functional status was evaluated via the Merle d'Aubigne score modified by Charnley.[13] Table 1 details the variables described for each case.

A 1.5 Tesla Philips MRI was used for all studies, following Potter's recommendations[7,9] for minimizing metallic artefacts. The mean study duration per hip was 20 minutes (minimum 15 and maximum 25). At least 3 sequences were absolutely necessary: T1-weighted axial FSE, T1 coronal FSE, and T2 coronal FSE—all with a 3-mm slice thickness. In cases requiring a more precise evaluation of areas of lysis in the periacetabular region, an additional T1-weighted sequence was taken in the sagittal plane with 3-mm slice thickness. If the T2 axial FSE sequence showed changes of a cystic nature in the visible skeleton as well as in the soft tissues in the area, a final T2-weighted sequence was taken in the coronal plane for a more precise delimitation of these changes. In choosing the acquisition parameters, spatial resolution took precedence over other interests (with a slice thickness of 3 mm in all cases and an acquisition matrix of 384×317). In those cases where, because of the patient's

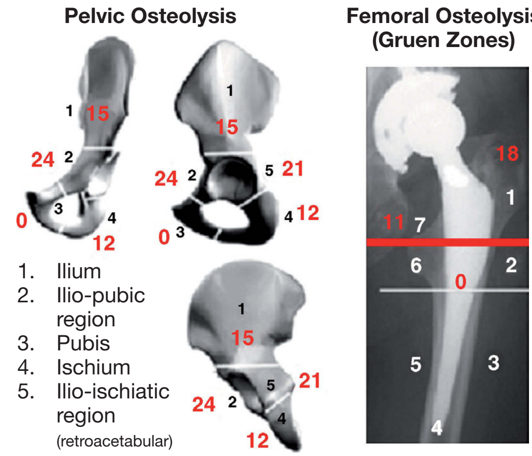

Figure 1 Diagram for situating lesions in the pelvis and femur, showing the number of cases and involvement for each zone.

body constitution, more than the usual number of slices were required, a reduced NSA was used (from the usual 6 down to 4), which significantly shortened the study. The same strategy was used in those cases where the patient was not tolerating the study well because of restlessness, discomfort, or claustrophobia. In summary, the following were the mean parameters for a T1-weighted sequence: TR = 550, TE = 16, Turbo FSE = 3, NSA = 6. Acquisition matrix 384×317, which permitted a reconstruction matrix of 512. The T2 parameters: TR = 5700, TE = 140, FSE = 19, NSA = 4, Matrix 384×319.

An MR image evaluation protocol was followed that defined the criteria to be met by the osteolytic and granulomatous lesions, along with their extent and severity[6,10]:

Osteolytic lesion

Zone of intermediate signal, surrounded by a more or less hypointense area, that replaces the usual fat signal (hyperintense) of bone and communicates with the joint.

Granulomatous lesion

Area of soft tissue having the same signal characteristics as the osteolytic lesion and occupying or extending from the joint but without replacing bone. It may or may not coexist with the osteolytic lesion.

The extent of the osteolytic lesion is evaluated according to a diagram (fig. 1) that shows the pelvis divided into 5 zones:

1. Supra-acetabular ilium
2. Superior pubic ramus
3. Pubis
4. Ischium
5. Retro-acetabular ischium, and the femur in the well-known Gruen zones.[14]

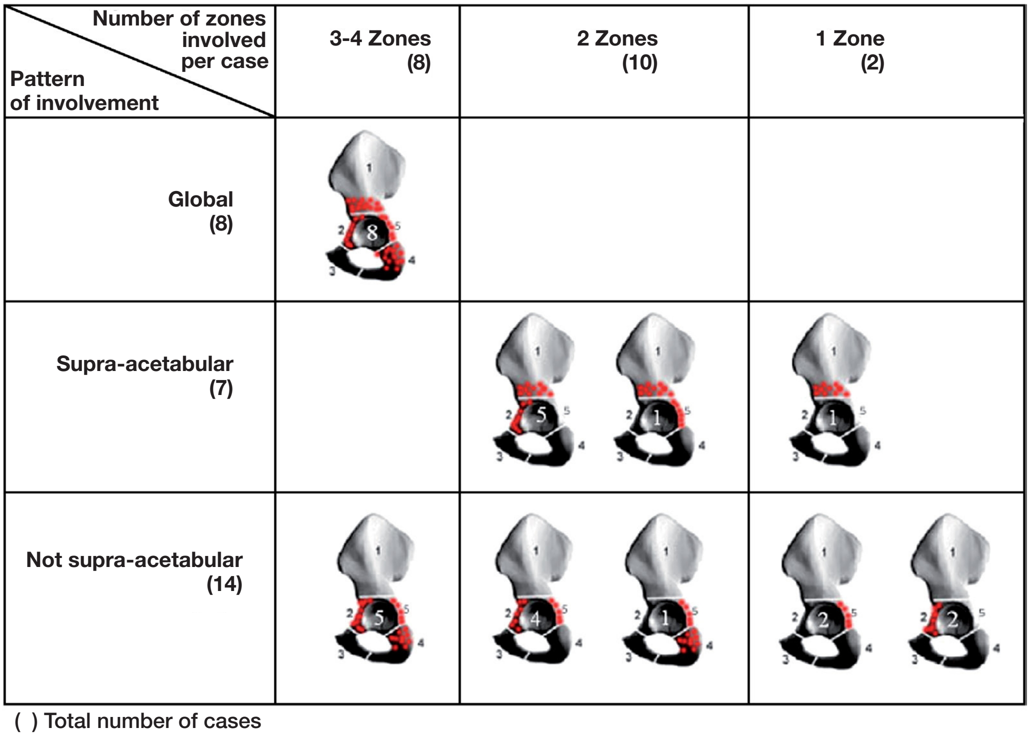

Figure 2 Pattern of pelvic involvement and number of zones affected for each case.

Table 3 Intra-observer concordance in MRI diagnosis of osteolysis

	GL	PO	FO	OD	SEV
OMD	0.9	0.86	0.88	0.9	0.9
RX	0.8	0.88	1	0.87	0.86

OMD - orthopaedic surgeon; OD - osteolytic disease; SEV - severity of OD; GL - granulomatous lesion; FO - femoral osteolysis; PO - pelvic osteolysis; RX - radiologist.

Table 5 Intra-observer concordance in situating osteolysis by MRI

	PO1	PO2	PO4	PO5	FO1	FO7
OMD	0.93	0.86	0.85	0.92	0.79	0.61
RX	0.85	1	0.73	0.92	1	0.89

OMD - orthopaedic surgeon; RX - radiologist
Pelvis (P) and femur (F) zones: P1 - supra-acetabular ilium; P2 - superior pubic ramus; P4 - ischium; P5 - retro-acetabular ischium; F1 - major trochanter; F7 - minor trochanter.

The existence of "osteolytic disease" was established when either of the 2 types of lesions described—granulomatous and osteolytic—was present. The disease was defined as "severe" if there was suspicion that revision surgery could be required within a relatively short period of time (from a few months to 2 or 3 years) due to the risk of component loosening or fracture.[3]

Using these criteria, 2 observers—an orthopaedic surgeon (ASV) and a radiologist (MVLP)—were asked to respond to

Table 4 Inter-observer concordance in MRI diagnosis of osteolysis

	GL	PO	FO	OD	SEV
OMD1RX1	0.61	0.73	0.94	0.6	0.62
OMD1RX2	0.68	0.62	0.94	0.68	0.61
OMD2RX1	0.67	0.74	0.94	0.67	0.71
OMD2RX2	0.77	0.75	0.94	0.77	0.71

OMD - orthopaedic surgeon; OD - osteolytic disease; SEV - severity of OD; GL - granulomatous lesion; FO - femoral osteolysis; PO - pelvic osteolysis; RX - radiologist.

Table 6 Inter-observer concordance in situating osteolysis by MRI

	PO1	PO2	PO4	PO5	FO1	FO7
OMD1RX1	0.72	0.79	0.6	0.55	0.79	0.51
OMD1RX2	0.72	0.79	0.7	0.63	0.79	0.66
OMD2RX1	0.66	0.93	0.73	0.61	0.86	0.61
OMD2RX2	0.66	0.93	0.84	0.71	0.86	0.76

OMD - orthopaedic surgeon; RX - radiologist
Pelvis (P) and femur (F) zones: P1 - supra-acetabular ilium; P2 - superior pubic ramus; P4 - ischium; P5 - retro-acetabular ischium; F1 - major trochanter; F7 - minor trochanter.

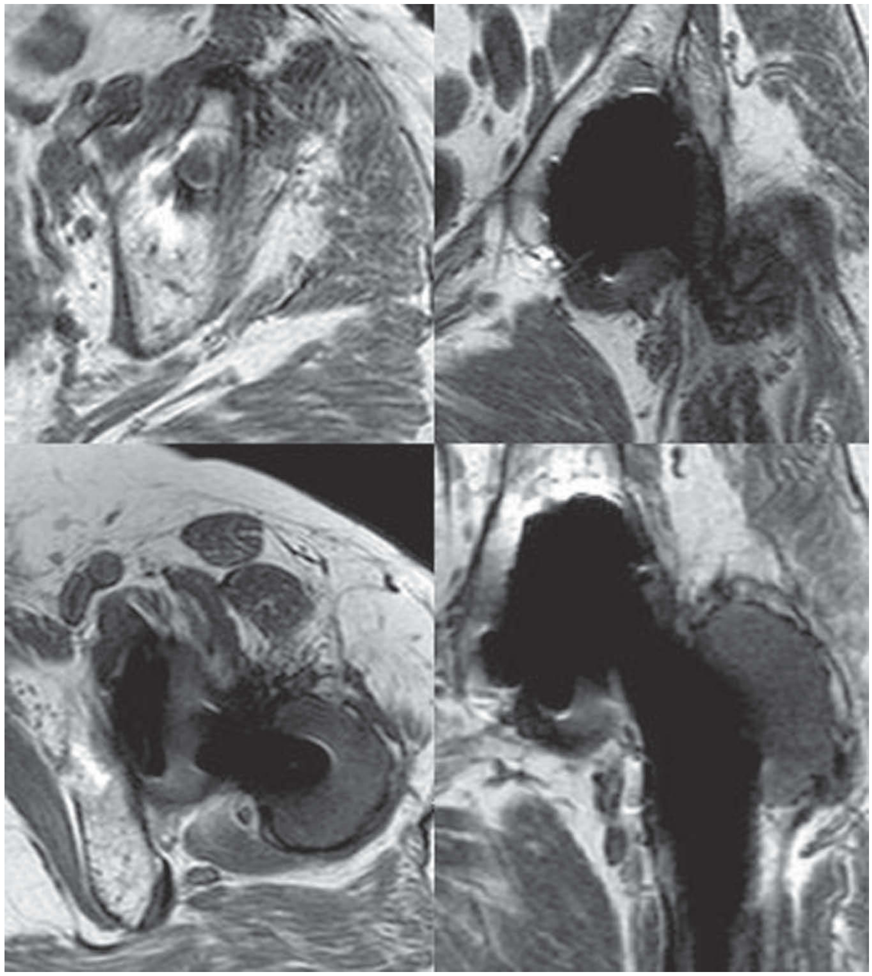

Figure 3 Case 4. Top: central supra-acetabular lesion. Bottom: involvement of major trochanter. Left: transverse slices. Right: frontal slices.

the following questions, independently and repeatedly, after studying the MR images for each case:

1. Is there a granulomatous lesion? 1. No 2. Yes
2. Is there osteolysis in the pelvis? 1. No 2. If yes, specify zones (1 to 5)
3. Is there osteolysis in the femur? 1. No 2. If yes, specify zones (1 to 7)
4. Is there osteolytic disease? 1. No 2. Yes
5. Is there severe disease? 1. No 2: Yes

Subsequently, the images were studied by the 2 observers together, and they discussed the findings on which they did not agree.

After the study to situate the lesion zones, the findings were classified into 4 groups for interpretation purposes:

1. Global involvement of the pelvis, with lesions in zones 1, 2, 4, and 5, whether or not associated with other lesions in the femur.
2. Supra-acetabular involvement with lesions in zone 1, whether or not associated with involvement of other pelvic or femur zones, without meeting the criteria for global involvement.
3. Absence of supra-acetabular involvement: when osteolysis does not affect zone 1 but does affect any of the other zones, and also whether or not there is femoral involvement.
4. Isolated femoral involvement.

They also checked for osteolysis around the screws and for communication between the lytic lesions as revealed by continuity of the granuloma either directly through the orifices (central lesion) or from the edges (peripheral lesion) of the acetabular component.

The data obtained was coded and entered into an SPSS database (Windows program, version 10, SPSS, Inc., Chicago, IL) for a descriptive statistical analysis as well as for an intra- and inter-observer qualitative concordance study (kappa index) on the MRI findings.

Results

For the 32 patients, the global score on the Merle d'Aubigne scale modified by Charnley[13] was 15 points or higher (maximum 18). In terms of pain, only 1 patient scored a 3 (tolerable enough to permit limited activity); 2 scored a 4

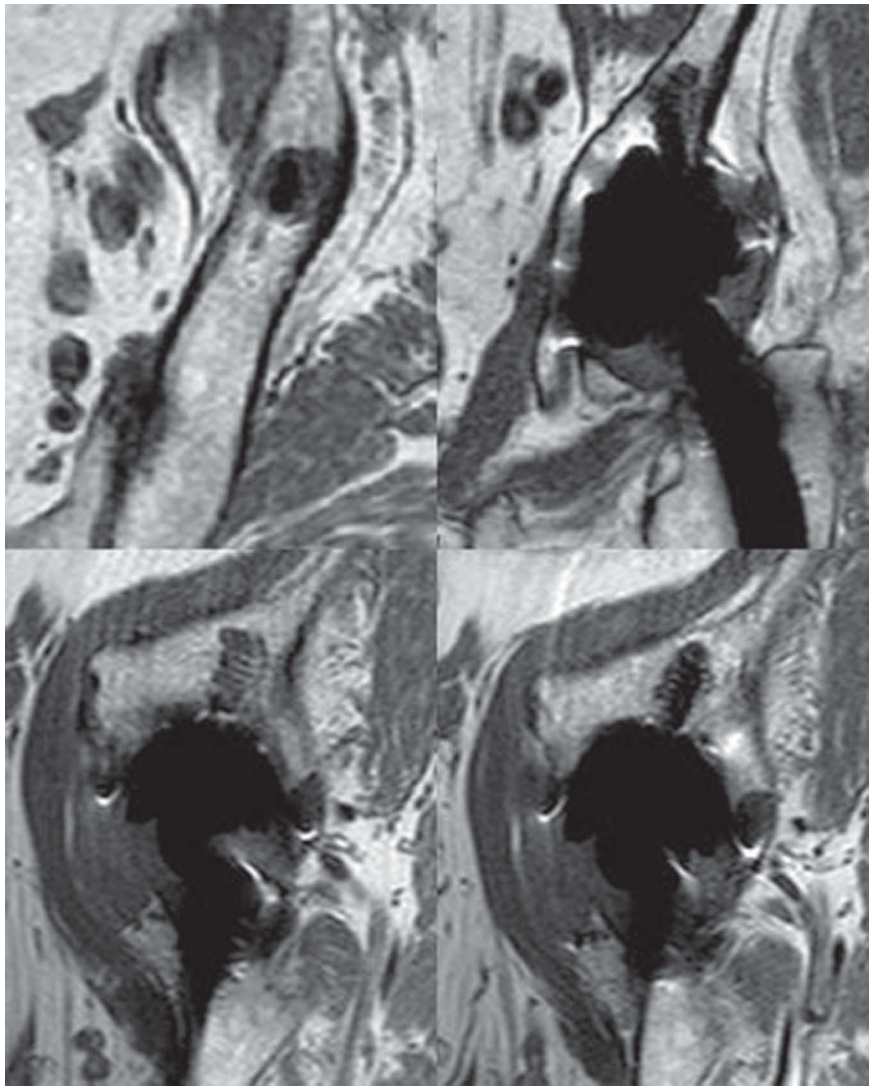

Figure 4 Case 26. Central lesion around a screw. Top left: transverse slice. Top right: frontal slice. Bottom: sagittal slices.

(only after activity and quickly disappears with rest); 4 scored a 5 (mild or intermittent pain when beginning to walk but permits normal activity); and the remaining 23 patients did not present this symptom (table 1).

After the MRIs had been evaluated by each of the 2 observers alone, 1 case (case 10) was discarded because the image quality was considered insufficient for the study (table 2). Tables 3 and 4 show the mean kappa index reflecting concordance for each observer and between observers with regard to evaluating the presence of a granulomatous lesion, pelvic osteolysis, femoral osteolysis, and osteolytic disease. Using the same index, tables 5 and 6 show the concordance with regard to situating it in the different pelvic and femoral zones. Strength of concordance was good (0.61-0.80) or very good (greater than 0.81).

When the 2 observers together reviewed the cases where there was discrepancy, in 3 cases the existence of wear-particle disease was not confirmed. In 4 cases, granulomatous lesion without osteolysis was detected; the osteolysis distribution pattern was analysed on the MRIs of the other 32 hips (pelvis only in 10, femur only in 3, and in both segments in 19).

Table 2 gives case-by-case details of the degree of osteolysis, the lesion locations, and the involvement of the different zones defined for the pelvis (excluding zone 3, which was not affected in any of the cases) and for the femur (limited to zones 1 and 7, which were the only ones affected). Figure 1 shows the grouping of cases by zone affected.

Figure 2 relates the zones affected for each case with the pattern of pelvic involvement. Of the 10 hips with severe disease in the pelvis, 7 had global involvement; of the other 3 hips with severe disease, 2 of them were severe essentially because of involvement of the major trochanter (fig. 3) and the other because of pelvic involvement with neither a femoral nor a supra-acetabular lesion. This last zone was not affected in 14 hips. Only 2 hips presented lesions that could be considered a central lesion (communication with the joint via the component orifices, isolated from the rest of the granuloma); these were cases 4 and 26 (figs. 3 and 4).

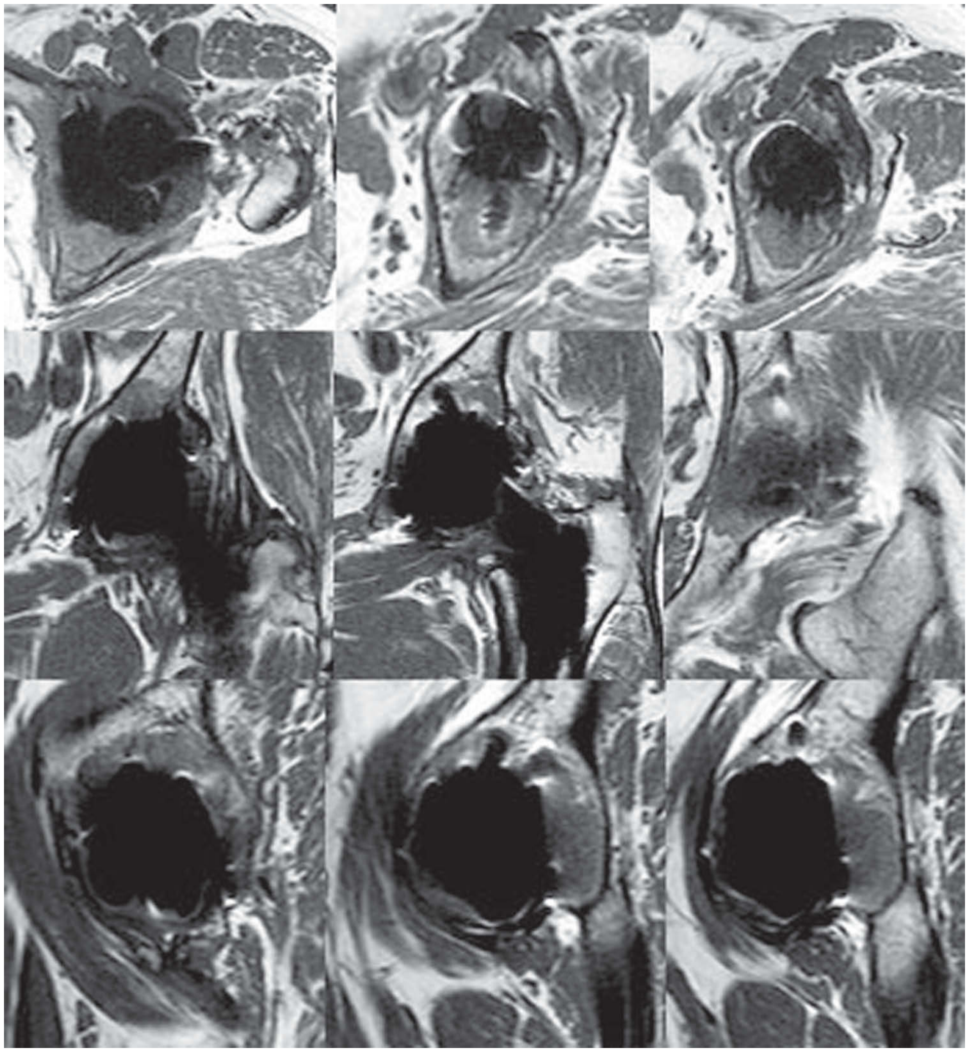

Figure 5 Case 14. Top: transverse slices. Middle: frontal slices. Bottom: sagittal slices. An apparently central lesion around a screw (top and middle), where communication with the rest of the osteolytic granuloma can be seen in frontal and sagittal slices.

The remaining lesions were communicating with the joint and were considered peripheral (fig. 5). Osteolysis was appreciated in 12 of the 58 screws inserted, in 10 forming part of the extension of a peripheral lesion (fig. 5) and, in 2, in the same hip as a central lesion (fig. 4).

Two patients (cases 5 and 8) underwent surgical revision after the MRI, which served as its planning (change of polyethylene and prosthetic head and filling the lytic lesions with bone graft); another is pending surgery (case 6). The other 7 cases with severe disease, currently asymptomatic, refused to undergo surgical intervention and are being seen at frequent follow-up visits. In 4 of the 5 cases where there had been previous surgery, the MRI showed the presence of osteolysis when this complication had not been detected in the surgical procedure, with severe disease in 1 of them (case 4) due to involvement of the trochanteric region (fig. 3). In case 38, where the femoral component was revised, keeping the original metallic acetabular cup, this complication was not detected.

Discussion

The most noteworthy aspect of our study was that, with a special MRI technique, we were able to reveal the presence or absence of osteolysis, its severity, and its distribution pattern in 39 of the 40 THAs studied—thus confirming exactly what had been described.[7] The images detect not only the areas of bone loss but also all the granulation tissue formed as a reaction to the wear particles within the joint itself and its extension to the bony tissue adjacent to the arthroplasty. Despite this being an initial study and the observers having no prior experience, there was good concordance in the interpretation of the lesion, which confirms that it is possible to use this type of diagnostic evaluation.

Contrary to what would have been expected based on the characteristics of the acetabular components studied, we were surprised to find that the osteolytic lesions did not primarily involve the supra-acetabular region and that the

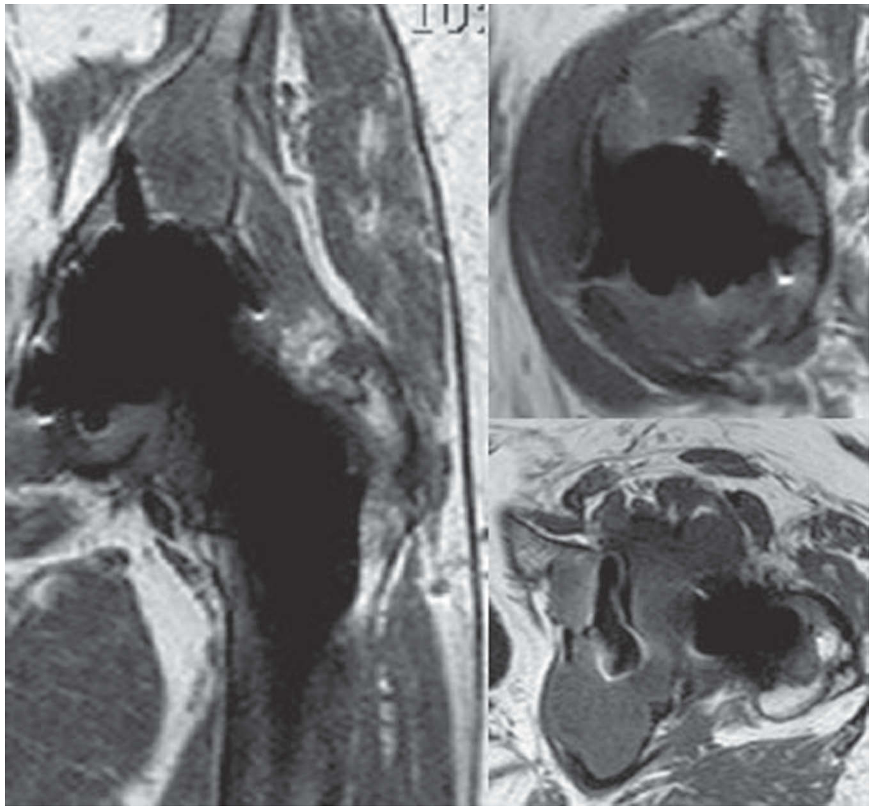

Figure 6 Case 32. Extensive granuloma with continuity of the bone and joint involvement. Left: frontal slice. Top right: sagittal slice. Bottom right: transverse slice.

typical, isolated, cavitary lesions arising from orifices of the acetabular component or around the screws were not common. Lesion distribution is more favourable to production of a granulomatous tissue mass in the joint that extends "wherever it can," probably in relation to the intra-articular hydrostatic pressure (fig. 6).[15]

Using CT on non-hydroxyapatite-coated porous acetabular cups, Kitamura et al[13] classified lesions as "central" or "peripheral" according to whether their communication with the joint was directly through the cup orifices or from the acetabular edge. In our study, only 2 pure central lesions were appreciated (figs. 3 and 4), small in size, 1 related to screws and the other isolated. In the remaining cases with involvement of the supra-acetabular region, continuity with the articular granuloma was via the periphery of the acetabulum, this being widespread in the most extensive cases (figs. 5 and 6). Although there is no assurance that the lesions in continuity with the orifices of the acetabular component were, at some point in their evolution, independent of the articular granuloma, this seems very unlikely in view of the pattern described. In any case, this has very little clinical relevance because, in the most severe cases with the typical cavitary involvement in the area above the acetabulum, the lesions are global, extending around the entire acetabular component. In the bibliography reviewed for this study, we found no series published on MRI evaluation of hydroxyapatite-coated acetabular components, so we are unable to compare our findings.

It is possible that this difference in behaviour is caused by the hydroxyapatite coating on the acetabular components studied in our work. It has been confirmed at an experimental level that, compared to pure plasma-spray coatings, hydroxyapatite protects against wear particle migration and promotes better bone growth over the implant.[16] Its sealing effect could have limited the formation of the granuloma around the central orifices, until the peripheral extension negated this effect and facilitated its extension as of that time. Further studies are required, however, to confirm this hypothesis.

According to the pattern of involvement described, limiting the orifices for screws, their utilization, and closure of the central orifice for component impaction do not appear to be so important in the type of implant studied. The new acetabular cup models even have a threaded cap for closing the unused screw orifices. The most important factor in osteolysis prevention is limiting to the extent possible the production of wear particles and other mechanisms that may be involved in the appearance of osteolysis.[17]

One of the main limitations of our study is that it is a relatively short and non-consecutive series of cases evaluated retrospectively. It is conceptually contradictory to use emerging technology, as is MRI in this case, in conducting prospective studies on a consecutive series of cases evaluated on a long-term basis. The systematic use of MRI in THA follow-up may very well enable prospective studies on osteolysis to be conducted in the future that would confirm or refute our results. This study is of value only in the context in which it was conducted—a particular model of acetabular component in a limited number of cases—but it has elucidated a pattern of involvement that may be useful in managing this problem with similar components. In this regard, and in terms of planning for surgery, we see it as very important that not only can very precise information on the lesions be obtained (volumetric measurements can be taken relatively simply) but also there is opportunity to view the osteolysis as a "continuous granuloma" with communication between the different lesions, which is meaningful for resecting and filling them.

We confirmed in our study that there was no clinical symptomatology despite extensive bony lesions—a fact that, without question, complicates the surgical decision. Although the appearance and progression of polyethylene wear and the appearance of lytic lesions can be evaluated on serial x-rays, there is much less diagnostic confidence with x-rays than with the MRI, in our experience. Clinical check-ups and periodic x-rays of THAs should be evaluated in terms of their profitability[9,18] and the advisability of replacing them with other studies that more decisively address the problems of osteolysis and THA failure. It appears that, given the radiation involved, repeating simple x-ray examinations is not appropriate, if the current major problem with THAs—periprosthetic osteolysis—cannot be properly evaluated using this technique. Given a correctly implanted and clinically asymptomatic THA, possibly the most reasonable and most cost-efficient recommendation would be to perform an MRI starting at 5 years.

Our study confirms that, with MRI and without the need of special computer support, it is possible to evaluate lesions resulting from reactions to wear particles in THA. As evaluated with this method, the distribution of osteolytic lesions in acetabular components like the one studied followed a peripheral pattern similar to that seen in acetabular components without holes, with few lesions across the orifices or around the screws inserted and usually a coexisting involvement of the proximal femur. Our results did not confirm that the presence of orifices for screws in the acetabular cups facilitates osteolysis.

Evidence level

Evidence Level III.

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Conflict of interest

The authors declare that they have no conflict of interest.

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