Infiltration of sarcomas into the hip joint

Comparison of CT, MRI and histologic findings in 67 cases

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ABSTRACT – We analyzed the incidence, route, and characteristics of hip joint infiltration in pelvic or proximal femoral sarcomas. 67 patients with a sarcoma that originated around the hip joint (50 pelvic and 17 femoral) were included in this study. Preoperative CT and MRI were matched with the histological findings in tumor specimens. Tumor infiltration into the hip joint was suspected on the basis of preoperative imaging in 29 patients due to articular cartilage disruption, diffuse signal changes in the acetabulum or femoral neck, signs of a tumor in the joint, or markedjoint effusion. Of these 29 patients, 15 showed tumor invasion on histological examination. 12 of 31 chondrosarcomas, none of 12 Ewing's sarcomas, and 3 of 24 osteosarcomas infiltrated into the hip joint (p = 0.008). 10 of 26 low-grade sarcomas and 5 of 41 high-grade sarcomas infiltrated into the hip joint (p = 0.02). The joint infiltration rate of the chondrosarcomas was related to their size. Of 10 tumors originating in the acetabulum, 9 penetrated through or around the osseous-ligamentous junction and one through the acetabular cartilage. In 5 proximal femur lesions, all infiltrated the joint through the femoral neck, 3 of them also through the ligamentum teres.

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Infiltration of bone sarcomas into joints occurs in 3 ways, namely: 1) penetration through the joint cartilage, 2) extension around the articular cartilage beneath the joint capsule, and 3) via intraarticular structures, such as through an osseous-tendinous junction of an intraarticular ligament (Simon and Hecht 1982, Sato et al. 1993, Schima et al. 1994). However, transarticular spread of tumor cells to the opposite side of the joint is uncommon except in the sacroiliac joint (Abdelwahab et al. 1991, Ozaki et al. 1997b, Drnovsek et al. 1999). The characteristics of hip joint infiltration by sarcoma of the pelvis or femur is poorly understood and the literature is limited. While involvement of the ligamentum teres may be an important route for transarticular spread (Alkalay et al. 1998), the influence of tumor size and histologic diagnosis or joint infiltration is unclear.

In this study, we examined the macroscopic specimens and microscopic sections of periacetabular tumors and compared these results with the radiological findings to determine the incidence and characteristics of hip joint infiltration by bone sarcomas.

Patients and methods

103 patients with pelvic sarcoma invading the acetabulum or proximal femoral sarcoma underwent excision of the tumor between 1993 and 1998 in this hospital. Of these patients, 67 (35 women) patients with sarcoma (50 pelvic and 17 femoral) fulfilled the selection criteria of tumor growth less than 2 cm from the acetabulum or from the top of the femoral head. 31 patients had a chondrosarcoma (CS), 24 an osteosarcoma (OS), and 12 patients Ewing's sarcoma (ES) (Table 1). The median age of patients with CS was 50 (25–73) years, with OS 23 (7–73) years, and with ES 18 (8–40) years. All OSs were high grade and all CSs were primary lesions. 37 tumors originated in the ilioacetabulum, 3 in the ischioacetabulum, 10 in the pubioacetabulum, and 17 tumors in the proximal

Table 1. Data on the 67 cases

Diagnosis	Grade	n	Age		Location				Invasion
			average	range	ilium	ischium	pubis	femur	+
Chondrosarcoma		31	50.3	25–73	20	1	5	5	12
	1	8			3	1	1	3	3
	2	18			15	0	3	0	7
	3	5			2	0	1	2	2
Osteosarcoma		24	22.8	7–73	12	2	0	10	3
Ewing's sarcoma		12	17.8	8–40	5	0	5	2	0

femur. Since preoperative treatment of ES and OS affects the volume of the tumor, we evaluated the volume of 31 CSs using Göbel et al.'s method (1987). A tumor with volume ≥ 100 mL is classified as a large tumor. CS was graded according to Evans et al. (1977). There were 8 grade 1 CSs, 18 grade 2, and 5 grade 3 CSs. All OSs, ESs, and grade 3 CSs were classified as high grade.

Preoperative staging studies included plain radiographs, bone scans, CT, and MRI with a 1.5-Tesla imager composed of T1- and T2-weighted images and Gadolinium-DTPA enhanced T1-weighted images. In patients with OS and ES, MR images before and after preoperative treatment were obtained with T1- and T2-weighted images and Gadolinium-DTPA enhanced T1-weighted images. In each study, 3 orthopedic oncologists evaluated the MR images without referring to the clinical data concerning the patients. The assessment was based on a consensus of at least 2 of them. Radiological features of intra-articular extension were defined as presence of joint cartilage disruption by a tumor, a mass inside the joint, diffuse signal change in almost all parts of the acetabulum or femoral head on MR imaging or massive joint effusion. After surgery, all available surgical specimens from the acetabulum, ligamentum teres, and proximal femur were histologically evaluated. One orthopedic surgeon who had taken part in the opration was present to select the most important plane and parts of the resected specimen for the pathologist. The histological results were matched with the radiological findings. Histologic infiltration of tumor cells into the ligamentum teres was also defined as joint infiltration.

In patients with ES, chemotherapy was given in accordance with the protocol of the European Intergroup of Ewing's sarcoma Study 92 (EICESS 92) (Paulussen et al. 1999). In patients with OS, chemotherapy was given in accordance with the protocol of either the Cooperative Osteosarcoma Study (COSS) 91 or COSS 96 (Bielack et al. 1999).

Resection margins were wide in 39, marginal in 12, and intralesional or contaminated in 16 patients (Enneking et al. 1980). In 17 patients with proximal femoral sarcoma, 9 underwent endoprosthetic implantation, 4 underwent allograft implantation, 2 underwent resection alone, and 2 had hindquarter amputations. In 50 patients with pelvic sarcoma, 23 underwent resection with/without hip transposition (Ozaki et al. 1998), 13 implantation of a prosthesis, 5 implantation of allograft, 8 amputation, and 1 patient implantation of an allograft with prosthesis.

The clinical follow-up for local relapse was a minimum of 2 years in 54 patients.

In the statistical analysis, we evaluated the significance of differences in the ratio between or among groups with the chi-square test with/without Fisher's correction. The Mann-Whitney U-test was used to evaluate differences in the mean rank between 2 and among 3 groups, respectively. Statistical software was the Macintosh Stat View version 5.0.

Results

On preoperative imaging, tumor infiltration into the hip joint was suspected in 11 patients with a proximal femur tumor and 18 with an acetabular tumor (Figures 1–3). 18 patients had CS, 10 OS, and 1 ES. Before preoperative chemotherapy, 1 ES

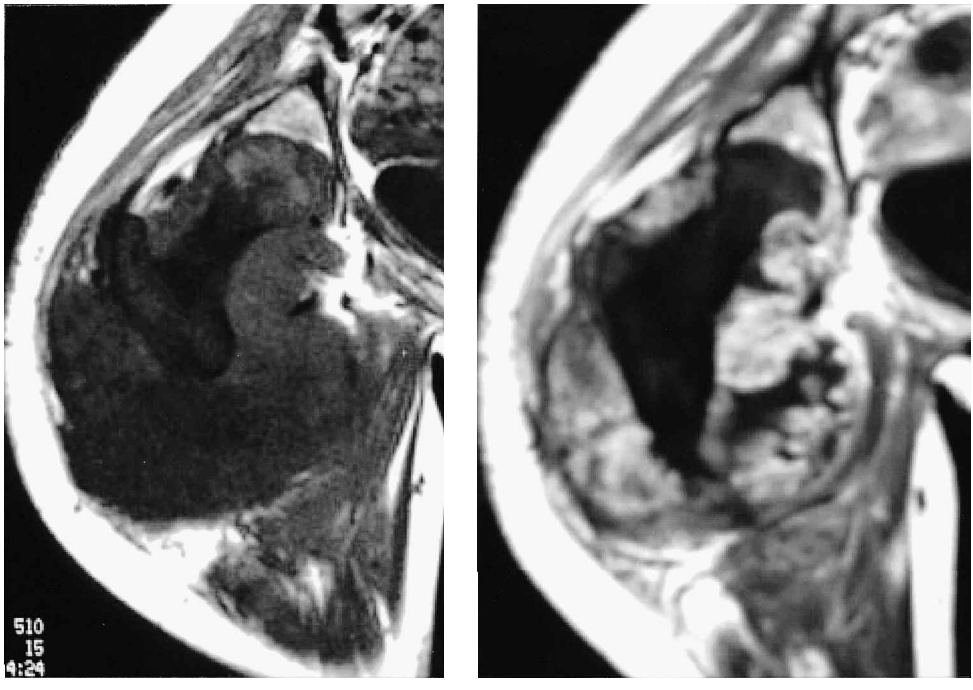


Figure 1. 17-year-old boy with chondroblastic OS of the proximal femur.
A. T1-weighted imaging showed a low signal intensity area in and around the proximal femur. The acetabulum had a high signal intensity area which means no tumor infiltration. Histology showed tumor in the joint.
B. Gadolinium-diethylenetriaminepentaacetic acid (DTPA) enhanced T1-weighted image showed diffuse enhancement around the proximal femur. The femur was not enhanced due to marked bone formation. Around the femoral neck (tumor), enhancement was evident.

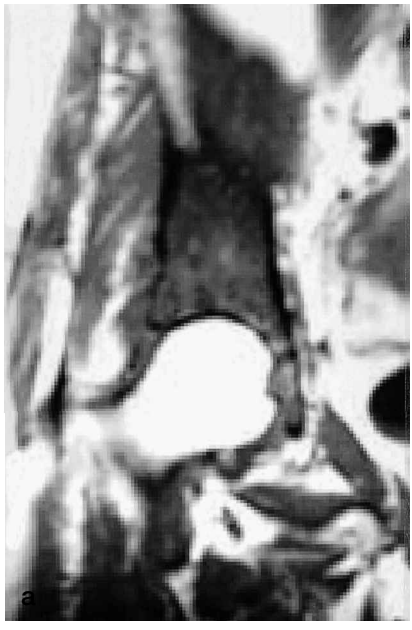
and 10 OSs were positive for joint infiltration. After preoperative treatment, no change occurred in the number of radiologically positive findings. Histological examination of the 29 specimens showed an infiltrative tumor in 15 patients. Of 38 patients with radiological negative findings, none had a tumor on histological examination (sensitivity 100%, specificity 73% and predictive accuracy of a positive test 52%). 25 tumors had a single finding and 4 tumors had 2 (Table 2). 3 of 3 cases with articular disruption, 5 of 7 cases with a mass in the joint, and 8 of 15 cases had a diffuse signal change on MR imagings. 3 of 8 cases with severe joint effusion had intraarticular tumor cells.

Table 2. Radiologic findings and joint infiltration

Radiological findings	n	Positive histology
Cartilage disruption	3	3
Presence of a mass inside the joint	7	5
Diffuse signal change	15	8
Severe joint effusion	8	3

8 of 37 sarcomas in the ilioacetabulum, 2 of 13 in the ischioacetabulum or pubicoacetabulum and 5 of 17 in the proximal femur had infiltrated the hip joint ($p = 0.6$). Of the 10 acetabular lesions, 9 infiltrated the joint through the osseous-tendinous junction of the ligamentum teres and 1 tumor penetrated through the acetabular cartilage outside the acetabular fossa. Of the 5 proximal femoral lesions, 2 grew through the proximal femur (around the femoral neck) into the joint space and 3 through both the femoral neck and the ligamentum teres. 1 OS infiltrated from the femoral head, through the ligamentum teres, into the acetabulum. 6 of 32 male patients and 9 of 35 female ones showed infiltration ($p = 0.5$). 12 of 31 CSs, none of 12 ESs, and 3 of 24 OSs infiltrated the hip joint ($p = 0.008$). 10 of 26 grade I or II sarcomas and 5 of 41 grade III infiltrated the hip joint ($p = 0.01$).

The 31 CSs and 24 OSs were also analyzed separately; we found no significant correlations



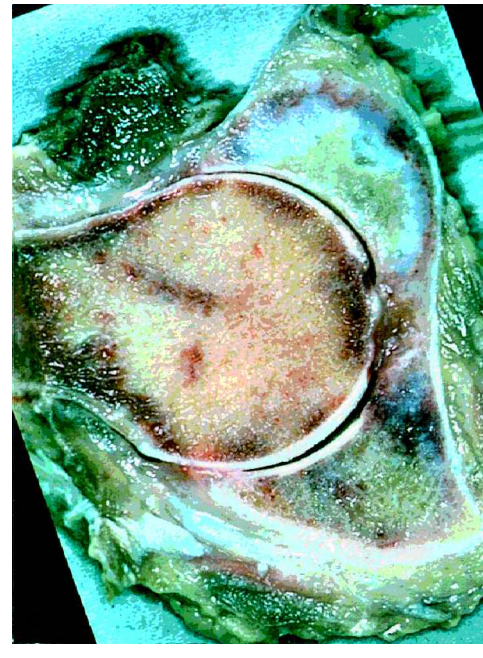


Figure 2. 58-year-old woman with grade II CS.
A. T1-weighted MR imaging showed a diffuse low signal intensity area in the acetabulum.
B. T2-weighted image had a high signal area in both the acetabulum and the small part of the femoral head.
C. Macrospecimen of the hip joint showed tumor at the site of insertion of the ligamentum teres in the acetabulum. Histology also showed a tumor from the ligamentum teres into the acetabulum.

between joint infiltration and rate and sex, age, and tumor grade. In 31 CSs, none of 6 small tumors and 12 of 25 large ones infiltrated the hip joint ($p = 0.03$). 10 of 26 grade I or II CSs and 2 of 5 grade III CSs invaded the hip joint.

In 29 patients with positive radiological findings, all underwent extraarticular resection. In the 15 patients with joint infiltration on histological examination, 4 had an intralesional margin, 1 a marginal margin, and 10 a wide margin. In 52 patients with negative histological findings, 12 had intralesional margins, 11 had marginal margins, and 28 wide margins ($p = 0.4$). In the 54 patients with follow-up ≥ 2 years, a local relapse developed in 5 of 12 patients with joint infiltration and 8 of 42 without it ($p = 0.1$).

Discussion

Accurate preoperative assessment of tumor extension is essential for limb salvage surgery in malignant lesions because joint involvement requires extraarticular resection for local control. This is important because an extraarticular resection of a hip joint is technically more demanding and has

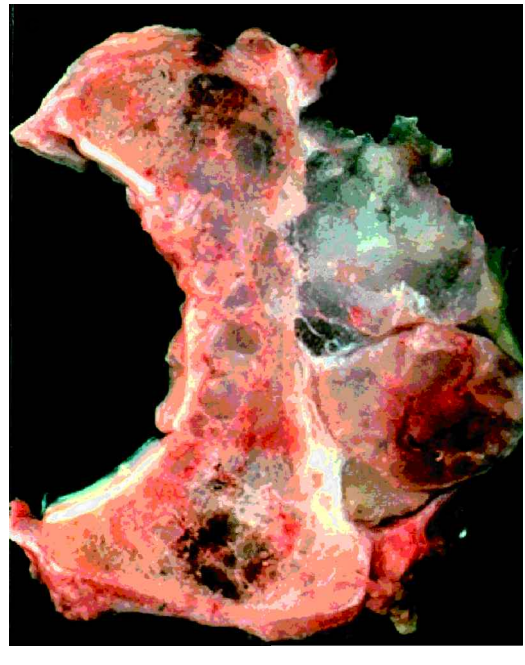


Figure 3. 54-year-old man with grade I CS.
A. T2-weighted image shows high signal area in the acetabulum.
B. T1-weighted coronal and axial images have a diffuse low signal intensity area in the acetabulum. Tumor protruded into the medial side of the acetabulum. Joint infiltration seemed very likely.
C. Macrospecimen shows a tumor extending from the acetabulum into the acetabular fossa. Micro section shows that a single layer of the soft tissue not composed of tumor covers the protruding tumor.

a substantially poorer functional long-term result than an intraarticular resection (Simon and Hecht 1982, Tsuboyama et al. 1993).

Radiological examination with CT or MR imaging showed joint invasion in 22–32% of bone sarcomas (Bloem et al. 1988, Schurawitzki et al. 1989, Seeger et al. 1991, Schima et al. 1994). In our study, rates for hip joint infiltration varied with the diagnosis; almost half of the CSs, one tenth of the OSs, but none of the 12 ESs showed histological evidence of an intraarticular tumor. All patients with OS or ES received preoperative chemotherapy. However, the number of radiologically positive findings were the same before and after chemotherapy.

Findings indicating joint infiltration included articular disruption, diffuse signal changes in acetabular tumors, existence of a mass around the femoral neck, and massive joint effusion. As the space between the acetabulum and the femoral head is minimal, the presence of a tumor mass between the 2 surfaces may be difficult to detect. In the hip joint, radiological detection of a sarcoma inside the ligamentum teres may be difficult; this differs from the cruciate ligament of the knee joint (Schima et al. 1994). Some cases were radiologically very

likely cases of an intraarticular tumor; however, they were histologically negative (Figure 3). The use of MR to distinghuish between intraarticular tumor invasion and reactive joint effusion is sometimes difficult on T1-weighted images (Schima et al. 1994). In such cases, enhanced images are helpful (Figure 1) (Schima et al. 1994). It may also be difficult to distinguish between inflammatory changes and the tumor itself with enhanced T1-weighted or T2-weighted MR images, which may lead to false-positive diagnoses of joint involvement (Figure 2).

In general, 3 growth patterns of articular penetration have been described for malignant tumors (Simon and Hecht 1982): 1) direct invasion through the articular cartilage, 2) extension around the articular cartilage, beneath the joint capsule, and into the joint, and 3) direct extension of the tumor through or around an osseous-tendinous junction of an intra-articular ligament. Local extension into or through articular cartilage has been reported to occur in more than one-third of patients (Simon and Hecht 1982). However, in the hip joint especially regarding acetabular tumors. We found that tumor extension through or around the ligamentum teres junction is commonest; 9 of 10 acetabular tumors extended along the ligamentum teres. On the other hand, all femoral tumors infiltrated the hip joint through the femoral neck, but not necessarily through the ligamentum teres.

Wide extraarticular resection for intraarticular grade 2 or 3 CS is mandatory because of its high incidence of local relapse after inadequate surgery and ineffective adjuvant modalities. In grade I CS, the decision is difficult (Bauer et al. 1995, Ozaki et al. 1996); however, a wide resection may be better because effective curettage is sometimes difficult due to anatomical characteristics of the acetabulum, upgrading after recurrence is frequent (Bjornsson et al. 1998), and reestablishment of adequate surgical margins after local relapse is difficult in the acetabular region. In ES, an inadequate surgical margin can be improved by brachytherapy and postoperative radiotherapy (Ozaki et al. 1997a). Molecular genetic analysis (Turc-Carel et al. 1988, Zoubek et al. 1994, 1996) of the joint fluid in patients with ES may also help to detect a tumorous effusion because of the presence of specific fusion gene types in ES. If no tumor cells are found with molecular analysis, intraarticular resection may be justified in ES around the hip joint. However, the surgical margin for ES needs to be studied.

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