Septic Arthritis versus Transient Synovitis at MR Imaging: Preliminary Assessment with Signal Intensity Alterations in Bone Marrow

PURPOSE: To find any differential magnetic resonance (MR) imaging findings between septic arthritis and transient synovitis in pediatric patients.

MATERIALS AND METHODS: The MR imaging findings in nine pediatric patients with septic arthritis and 14 with transient synovitis were retrospectively studied. The diagnoses were made by means of joint aspiration with bacteriologic study, arthrotomy, and clinical evaluation. MR imaging findings were analyzed with emphasis on the grade of joint effusion and alterations in signal intensity in the soft tissue and bone marrow of the affected hip joint.

RESULTS: Signal intensity alterations in bone marrow (ie, low signal intensity on fat-suppressed gadolinium-enhanced T1-weighted spin-echo images and high signal intensity on fat-suppressed T2-weighted fast spin-echo images) were seen in eight of nine patients with septic arthritis. These signal intensity alterations consisted of mild juxtaarticular changes in six patients without osteomyelitis and extensive changes in the femoral head and neck in two patients with coexistent osteomyelitis. Signal intensity alterations in bone marrow were not seen in the 14 patients with transient synovitis.

CONCLUSION: Signal intensity alterations in the bone marrow of the affected hip joint are useful in the differentiation of septic arthritis from transient synovitis.

Early diagnosis of septic arthritis is crucial because any delay in the initiation of appropriate treatment can result in a poor outcome such as destruction of the femoral head, degenerative arthritis, or permanent deformity (1). The most common diagnostic dilemma is that septic arthritis cannot be confidently differentiated from transient synovitis, the most common disease entity in pediatric patients with an irritable hip, on the basis of clinical, laboratory, and radiographic findings (2–4).

Although ultrasonography (US) is highly accurate in the detection of hip effusion, differentiation of septic arthritis from transient synovitis or other arthritides cannot be achieved with US (5,6). Many investigators have discussed the feasibility of US-guided aspiration of the hip effusion for diagnostic and therapeutic purposes (7,8).

During the past decade, magnetic resonance (MR) imaging has become increasingly important in evaluation of musculoskeletal infections in children (9,10). MR imaging is highly sensitive in the detection of bone marrow and soft-tissue lesions, as well as joint effusion (11). Nevertheless, to our knowledge, the role of MR imaging in the differentiation of septic arthritis from transient synovitis has not been fully established. Therefore, we performed a study to find any differential MR imaging findings between septic arthritis and transient synovitis in pediatric patients with an irritable hip.
MATERIALS AND METHODS

Patients

During a 2-year period from May 1995 to April 1997, MR imaging of the hip was performed as part of the clinical evaluation of 38 pediatric patients with acute hip pain or limping. The final diagnoses in these patients were transient synovitis (n = 14), septic arthritis (n = 9), Legg-Calvé-Perthes disease (n = 5), osteomyelitis (n = 3), soft-tissue infection (n = 2), mucocutaneous lymph node syndrome (Kawasaki disease) (n = 2), and noninfectious inflammatory arthritis (n = 3). The nine patients (six boys and three girls) with septic arthritis and the 14 patients (12 boys and two girls) with transient synovitis were included in the study.

The mean age was 11 years 9 months (range, 7 months to 19 years) for patients with septic arthritis and 5 years 9 months (range, 4–11 years) for patients with transient synovitis. Many patients with transient synovitis did not undergo MR imaging; thus, a small number of patients with transient synovitis were included in the study. The mean interval between the onset of symptoms and MR imaging was 6.0 days (range, 1–13 days) for patients with septic arthritis and 5.5 days (range, 1–10 days) for patients with transient synovitis. The mean duration of hospitalization was 27 days (range, 8–63 days) for patients with septic arthritis and 7 days (range, 3–14 days) for patients with transient synovitis.

Diagnosis

Septic arthritis was diagnosed by means of joint aspiration with bacteriologic study (positive culture for bacteria from synovial fluid or blood) in four patients and arthroscopy (positive culture for bacteria in two patients and histologic findings of acute suppurative inflammation in one patient from arthrotomy specimens) in three patients (Table). In the remaining two patients, septic arthritis was strongly suggested by frankly purulent synovial fluid and a fluid white blood cell count above 20,000/mm³ (20 × 10⁹/L) with a predominance of polymorphonuclear cells (>90%) (Table). Transient synovitis was diagnosed on the basis of clinical and laboratory findings and results of joint aspiration.

Joint aspiration was performed in all patients with septic arthritis and 10 patients with transient synovitis. At gross analysis, the joint fluid was turbid in four and purulent in five patients with septic arthritis and serosanguineous in six and turbid in four patients with transient synovitis. Four patients with septic arthritis had a positive culture (three from synovial fluid and one from blood) for S aureus or coagulase-negative Staphylococcus. No patients with transient synovitis had a positive culture from synovial fluid or blood. Joint aspiration was not performed in four patients with transient synovitis who had minimal joint effusion and in whom analgesics and bed rest alone sufficiently improved clinical manifestations.

Arthroscopy was performed in five patients with septic arthritis. However, arthroscopy was not performed in four patients with septic arthritis, in whom clinical improvement was achieved with joint aspiration, antibiotic therapy, and absolute immobilization.

In the nine patients with septic arthritis, the mean peripheral white blood cell count was 13,850/mm³ (13.85 × 10⁹/L) (range, 6,100–27,070/mm³ [6.10–27.07 × 10⁹/L]) with a mean erythrocyte sedimentation rate of 73.3 mm/h (range, 20–126 mm/h). The 14 patients with transient synovitis were treated conservatively without surgical drainage. The mean peripheral white blood cell count in this group was 8,660/mm³ (8.66 × 10⁹/L) (range, 3,700–15,500/mm³ [3.7–15.5 × 10⁹/L]) with a mean erythrocyte sedimentation rate of 20.6 mm/h (range, 4–48 mm/h). The patients were followed up clinically and radiographically to monitor delayed sequelae of septic arthritis and transient synovitis.

MR Imaging

MR imaging was performed with a 1.5-T unit (Signa; GE Medical Systems, Milwaukee, Wis). A body or head coil was used according to the size of the patient. The following imaging parameters were used: 400–600/10–12 (repetition time msec/echo time msec) for T1-weighted spin-echo imaging, 2,500–3,500/96–108 (effective) with an echo train length of eight for T2-weighted fast spin-echo imaging, and 400–650/10–12 for gadolinium-enhanced T1-weighted spin-echo imaging. A fat suppression technique based on a frequency-selective excitation was used in T2-weighted fast spin-echo imaging and gadolinium-enhanced T1-weighted spin-echo imaging. For both T1- and T2-weighted images, a 3.0–7.0-mm section thickness with a 0.25–5.0-mm intersection gap, two to four signals acquired, and a 256 × 192 matrix...
were used. The field of view was 180–340 mm depending on the body size and section planes. Axial and coronal images were obtained with each pulse sequence.

Coronal and axial contrast-enhanced T1-weighted spin-echo images were obtained 4.7–6.7 minutes (mean, 5.6 minutes) and 10–16 minutes (mean, 12.6 minutes), respectively, after intravenous administration of gadopentetate dimeglumine (Magnevist; Berlex Laboratories, Wayne, NJ) in a dose of 0.1 mmol/kg of body weight.

MR images were evaluated by a pediatric radiologist (S.K.L.) and a musculoskeletal radiologist (K.J.S.) by means of consensus as regards the grade of joint effusion and alterations in signal intensity in the soft tissue and the bone marrow of the affected hip joint. The amount of joint fluid in each affected hip was classified according to the grading system proposed by Mitchell et al (12). In this grading system, 0 = none, 1 = minimal, 2 = enough to surround the femoral neck, and 3 = distention of the capsular recesses (Fig 1).

Statistical analysis was performed with the $\chi^2$ test for grade of joint effusion and with the two-tailed Fisher exact test for signal intensity alterations in the soft tissue and bone marrow of the affected hip joint.

RESULTS

Grade of Joint Effusion

Joint fluid had low signal intensity on T1-weighted spin-echo images and high signal intensity on fat-suppressed T2-weighted fast spin-echo images (Fig 1). Joint effusion could not be distinguished from synovial membrane on nonenhanced images (Fig 2a, 2b). An enhancing rim of inflamed synovial membrane could be differentiated from the hypointense joint fluid on contrast-enhanced images (Figs 2c, 3d). On most of the axial contrast-enhanced images (Figs 2c, 3c), the enhancing rim appeared thicker than on the coronal contrast-enhanced images, which were obtained about 7 minutes earlier (Fig 3d). This finding could be explained by enhancement of joint fluid adjacent to the inflamed synovial membrane on more delayed images.

A minimal amount of joint fluid and mild synovial membrane enhancement were seen in the majority of normal contralateral hips (Fig 3b, 3c). In contrast, more intense enhancement and thickening of synovial membrane were seen only in the hip joints affected by transient synovitis or septic arthritis (Figs 2c, 3c, 3d).

Among patients with septic arthritis, one had grade 2 and eight had grade 3 joint effusion. Among patients with transient synovitis, two had grade 1, two had grade 2, and 10 had grade 3 joint effusion. In regard to the grade of joint effusion, there was no statistically significant difference between patients with septic arthritis and those with transient synovitis ($P = .46$).

Signal Intensity Alterations in Soft Tissue

Signal intensity alterations in the soft tissue around the affected hip joint appeared as poorly defined areas of high signal intensity on fat-suppressed T2-weighted fast spin-echo images (Fig 2b) and enhanced after contrast material administration (Figs 2c, 3c). These areas were not clearly seen on T1-weighted spin-echo images (Figs 2a, 3a). Fat-suppressed gadolinium-enhanced T1-weighted spin-echo images (Figs 2c, 3c) were more sensitive in the detection of signal intensity alterations in soft tissue than were fat-suppressed T2-weighted fast spin-echo images (Figs 2b, 3b).

Most of these signal intensity alterations in soft tissue were located within the muscles and surrounding fascial planes just lateral to the femoral head on higher sections (Figs 2b, 2c, 3c) and around the femoral neck on lower sections. These signal intensity alterations tended to be confined to the pericapsular regions except in one case of septic arthritis and coexistent osteomyelitis, in which more extensive signal intensity alterations in soft tissue were noted along with a complicated soft-tissue abscess.

Signal intensity alterations in the soft tissue around the affected hip joint were seen in eight of nine patients with septic arthritis and 10 of 14 patients with transient synovitis. In regard to these signal intensity alterations in soft tissue, there...
was no statistically significant difference between patients with septic arthritis and those with transient synovitis ($P = .61$).

**Signal Intensity Alterations in Bone Marrow**

Signal intensity alterations in the bone marrow of the affected hip joint appeared as poorly defined areas of low signal intensity on T1-weighted spin-echo images and high signal intensity on fat-suppressed T2-weighted fast spin-echo images and enhanced after contrast material administration (Figs 2, 4, 5). In one patient with septic arthritis, signal intensity alteration in the femoral head was not seen on T1-weighted spin-echo images but was definitely seen on fat-suppressed T2-weighted fast spin-echo images and fat-suppressed gadolinium-enhanced T1-weighted spin-echo images (Fig 4).

Signal intensity alterations in the bone marrow of the affected hip joint were seen in eight of nine patients with septic arthritis. However, such signal intensity alterations were not seen in any of the 14 patients with transient synovitis (Fig 3). In regard to these signal intensity alterations in bone marrow, there was a statistically significant difference between patients with septic arthritis and those with transient synovitis ($P < .001$).

In six of nine patients with septic arthritis, subtle but definite signal intensity alterations were seen in the bone marrow of the affected hip joint. These signal intensity alterations were located in the acetabulum in two patients (Fig 2), the femoral head in two patients, and both the acetabulum and femoral head in two patients (Fig 4). All of these signal intensity alterations were limited adjacent to the articular surfaces (Figs 2, 4). Three of these patients subsequently underwent arthrotomy for drainage. At surgery, osseous surfaces around the affected hip joint were intact in all three cases, but bone biopsy has not been performed. Follow-up MR imaging was performed in one of these patients and showed complete resolution of the joint effusion and restoration of the normal signal intensity in bone marrow.

In two of nine patients with septic arthritis, extensive signal intensity alterations were seen in the bone marrow of the femoral head and neck (Fig 5). It was notable that these signal intensity alterations were not limited adjacent to the articular surfaces but involved the femoral metaphysis. At surgery, these signal intensity alterations were confirmed to be coexistent osteomyelitis.

In one of nine patients with septic arthritis, there was no signal intensity alteration in the bone marrow of the affected hip joint.

**DISCUSSION**

The prognosis of septic arthritis worsens with increasing duration of symptoms before treatment because lytic enzymes in the purulent articular fluid destroy the articular and epiphyseal cartilages (13). Pus in the joint also increases intraarticular pressure and compromises blood flow to the epiphysis with resultant osteonecrosis (13–15). In septic arthritis in infants and children, imaging is essential for prompt diagnosis and prevention of complications.

Transient synovitis of the hip remains a common diagnostic problem for the clinician. The physical signs are not pathognomonic and laboratory tests and conventional radiography may be of little help, although radiography is indicated to exclude osseous pathologic conditions (6).

The classic radiologic work-up of septic arthritis includes plain radiography and bone scintigraphy (13). US is considered the best noninvasive technique for detection and follow-up of hip effusion. Nevertheless, US does not help narrow the differential diagnosis of joint effusion (5,6). Furthermore, US does not allow one to rule out osteomyelitis or soft-tissue infection (7). US-guided aspiration is helpful in identifying effusions suggestive of septic arthritis, which are characterized by turbid or frankly purulent synovial fluid, a fluid white blood cell count above 20,000/mm$^3$ (20 $\times$ $10^3$/$\mu$L) with a predominance of polymorphonuclear cells, or a positive result of a Gram stain (7). In addition, US-guided aspiration of the hip reduces excessive intraarticular pressure.
and thus prevents vascular compromise (8). However, US-guided aspiration is an invasive procedure that requires local anesthesia, and complications such as contamination of joint fluid can occur. A “dry tap” may be a problem when joint effusion is minimal in the anterior recess, a usual site of US-guided aspiration.

According to the literature (16,17), MR imaging findings in transient synovitis of the hip joint consist of simple effusion without specific changes in bone marrow. Contrast-enhanced MR imaging allows distinction...
between an enhancing rim of inflamed synovial membrane and hypointense joint effusion, although the joint effusion may contribute to the enhancing rim, particularly on delayed images (18–20). In addition to joint effusions, intense enhancement and hypertrophy of synovial membrane were consistently encountered in hip joints affected by transient synovitis or septic arthritis in our study. However, differentiation of septic arthritis from transient synovitis was not possible on the basis of changes in synovial membrane. Many of our patients with transient synovitis or septic arthritis demonstrated signal intensity alterations in the soft tissue around the affected hip joint, a finding that probably represented reactive soft-tissue edema. These signal intensity alterations were more consistently seen on fat-suppressed T2-weighted images than on conventional T1-weighted images or fat-suppressed T2-weighted fast spin-echo images.

MR imaging is extremely sensitive in the detection of bone marrow-based pathologic conditions (16,20,21). MR imaging has been used to detect coexistent osteomyelitis in patients with septic arthritis (22–24). In previous studies of MR imaging of septic arthritis (17,22), joint effusion was the only finding and the signal intensity of bone marrow was normal unless there was involvement by osteomyelitis. Conversely, in patients with coexistent osteomyelitis, bone marrow demonstrated decreased signal intensity on T1-weighted images and increased signal intensity on T2-weighted spin-echo and short inversion time inversion-recovery images (23,24). However, Erdman et al (23) reported six cases of septic arthritis without coexistent osteomyelitis that demonstrated abnormal signal intensity in the bone marrow of the affected hip joint on T1-weighted and short inversion time inversion-recovery images. These authors prospectively misinterpreted these signal intensity changes as indicating osteomyelitis. This unexpected finding suggests that septic arthritis may cause abnormal signal intensity in the bone marrow of the affected joint on T1-weighted and short inversion time inversion-recovery images even though the bone is not infected.

In our study, six cases of septic arthritis demonstrated subtle but definite signal intensity alterations in the bone marrow of the affected hip joint on T1-weighted spin-echo images and fat-suppressed T2-weighted fast spin-echo images; the areas of abnormal signal intensity enhanced after contrast material administration. In contrast to two cases of septic arthritis with coexistent osteomyelitis, in which the signal intensity alterations in bone marrow were more extensive and involved the femoral metaphysis, the signal intensity alterations in the six cases of septic arthritis alone were less extensive and mainly limited adjacent to the articular surfaces of the femoral head or acetabulum. In three of these six cases, surgical drainage was performed, and the surgeon noticed that osseous surfaces around the affected hip joint were intact. Therefore, we retrospectively speculated that the signal intensity alterations were probably caused by reactive bone marrow edema rather than actual osteomyelitis. Whether due to reactive bone marrow edema or early active osteomyelitis, signal intensity alterations in bone marrow were more frequently encountered in our study than in previous studies (17,21–23). We did not find signal intensity alterations in bone marrow in any of the 14 patients with transient synovitis. Therefore, the results of our study suggest a potential role for MR imaging in the differentiation of septic arthritis from transient synovitis on the basis of signal intensity alterations in the bone marrow of the affected hip joint.

Our study clearly had some limitations. First, we accepted the presence of frankly purulent synovial fluid as an indication of septic arthritis in two patients who had received antibiotics before joint aspiration. This approach might overestimate the number of children with septic arthritis, although clinical and laboratory findings strongly suggested that these patients had septic arthritis. Second, because of the small number of patients, this was only a preliminary study; the results require further assessment in a large num-

Figure 5. Coronal MR images of a 16-year-old boy with septic arthritis of the right hip and coexistent osteomyelitis of the proximal right femur. (a) T1-weighted spin-echo image (400/11) shows subtle but extensive low signal intensity (arrowheads) in the femoral head and neck that involves the metaphysis, a finding that suggests coexistent osteomyelitis. (b) Fat-suppressed T2-weighted fast spin-echo image (2,500/96 [effective]) shows joint effusion (*) and high signal intensity (arrowheads) in the bone marrow of the femur and acetabulum. The signal intensity alteration is more clearly demonstrated than on the T1-weighted spin-echo image (a). Also note the hyperintense soft-tissue edema (arrow) adjacent to the right femoral neck. (c) Fat-suppressed gadolinium-enhanced T1-weighted spin-echo image (550/10) shows enhancement of the bone marrow (arrowheads) and soft-tissue (solid arrow) lesions and thickened synovial membrane (open arrows).
ber of patients or prospective assessment for validation.

We presumed that the amount of joint effusion and signal intensity alterations in the soft tissue around the affected hip joint might play a role in the differentiation of septic arthritis from transient synovitis. However, these factors did not result in statistically significant differences between the two patient groups.

In conclusion, MR imaging may play an important role in noninvasive differentiation of septic arthritis from transient synovitis in the pediatric patient with an irritable hip. Signal intensity alterations in the bone marrow of the affected hip joint are useful in the differentiation of septic arthritis from transient synovitis.

References