



Comparison of MR Findings between Patients with Septic Arthritis and Acute Gouty Arthritis of the Knee

급성 통풍성 슬관절염과 패혈성 슬관절염의 자기공명영상 소견 비교

Su Young Yun, MD , Hye Jung Choo, MD ,
Hae Woong Jeong, MD , Sun Joo Lee, MD*

Department of Radiology, Busan Paik Hospital, Inje University College of Medicine, Busan, Korea

ORCID iDs

Su Young Yun <https://orcid.org/0000-0001-5064-1082>
Hye Jung Choo <https://orcid.org/0000-0003-3941-6989>
Hae Woong Jeong <https://orcid.org/0000-0002-4912-9302>
Sun Joo Lee <https://orcid.org/0000-0001-6210-9720>

Purpose To compare the MR findings of septic and acute gouty arthritis of the knee joint.

Materials and Methods This retrospective study included patients who underwent knee MRI for septic or gouty arthritis at our hospital between October 2012 and October 2018. The MR findings were analyzed for the presence of bone marrow edema, soft tissue edema, abscess, pattern of synovial thickening (frondlike, lamellated, diffuse linear), maximum thickness of the synovium, and joint effusion volume. The gouty ($n = 5$) and septic arthritis ($n = 10$) groups were compared using the Wilcoxon rank-sum test and Fisher's exact test.

Results No statistically significant differences were observed for each item. One patient in the gouty arthritis group and seven in the septic arthritis group had bone marrow edema. Soft tissue abscess formation was only observed in the septic group. The incidence of each synovial thickening pattern was as follows: 100% (diffuse linear) in the gouty arthritis group and 20% (frondlike), 50% (lamellated), and 30% (diffuse linear) in the septic arthritis group.

Conclusion Differentiation of gouty arthritis and septic arthritis based on imaging findings is difficult. However, lamellated synovial thickening patterns, bone marrow edema, and soft tissue abscess formation are more commonly observed in patients with septic arthritis than in those with gouty arthritis.

Index terms Arthritis; Magnetic Resonance Imaging; Arthritis, Infectious; Gout

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*Corresponding author

Sun Joo Lee, MD
Department of Radiology,
Busan Paik Hospital,
Inje University College of Medicine,
75 Bokji-ro, Busanjin-gu,
Busan 47392, Korea.

Tel 82-51-890-6549
Fax 82-51-896-1085
E-mail sunjulee98@gmail.com

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INTRODUCTION

Septic arthritis and crystal-induced arthritis can result in a painful, swollen peripheral joint (1). Both conditions may cause inflammation of the affected joint, and it is difficult to distinguish these conditions from one another (2). However, it is important to diagnose these acute arthritides accurately in the initial management, because delay in diagnosis of septic arthritis may cause destruction of the affected joint (3). Acute gouty arthritis improves within two weeks with adequate anti-inflammatory drugs such as nonsteroidal anti-inflammatory drugs, colchicine, or glucocorticoids (4, 5). In contrast, delayed or inadequate treatment of septic arthritis can lead to irreversible joint destruction and thus substantial morbidity and mortality (6-12).

Acute gouty arthritis most commonly involves a single joint or multiple joints in the lower extremities such as the first metatarsophalangeal, midtarsal, ankle, or knee joints. Acute gout can cause a high fever and leukocytosis and may be difficult to distinguish from acute septic arthritis (13).

Several studies compared MR findings of septic arthritis and other inflammatory arthropathies (14-19), including gouty arthritis (4). However, in these previous studies, which compared MR findings of septic arthritis and gouty arthritis, we could not find comparisons between the two groups based on the pattern of synovial thickening. The purpose of our study was to statistically analyze and define the characteristic MR findings that would be useful for distinguishing between acute gouty arthritis and septic arthritis.

MATERIALS AND METHODS

PATIENTS

This retrospective study was approved by our Institutional Review Board. The need for informed consent was waived (IRB No. 2019-01-066). Patients who were diagnosed with septic arthritis or acute gouty arthritis, experienced the first acute attack of knee pain as monoarthritis, and underwent knee MRI at our hospital between October 2012 and October 2018 were eligible for study inclusion. We excluded patients who complained of polyarthritis or had a past history of gout. A total of 24 patients were identified during the study period. Of these 24 patients, 9 patients were excluded. Patients diagnosed with both gouty and septic arthritis through arthrocentesis were also excluded ($n = 5$). Fifteen cases of final diagnosis of gouty arthritis or septic arthritis of the knee were collected and reviewed retrospectively in terms of patient age, sex, clinical findings, radiographic findings on MRI, laboratory studies, and the results of arthrocentesis. Our study included 5 patients with gouty arthritis without septic arthritis and 10 patients with septic arthritis without gouty arthritis. The mean interval between symptom onset and MRI acquisition was 6.2 days (range, 3-14 days) for the gouty arthritis group and 5.3 days (0-14 days) for the septic arthritis group. The mean interval between arthrocentesis and MRI acquisition was 1.4 days (1-2 days) for the gouty arthritis group and 1 day (0-2 days) for the septic arthritis group. All patients with septic arthritis underwent surgery within 5 days after MRI acquisition.

DIAGNOSIS

The initial diagnostic workup included a history, physical examination, laboratory studies, and arthrocentesis results. Blood cultures and arthrocentesis cultures were performed at the discretion of the physician and according to the clinical presentation.

In 10 cases of septic arthritis, the diagnosis was established when there was purulent joint fluid (white blood cell [WBC] count ≥ 50000 cells/ μL) with more than 90% polymorphonuclear cells (1). In 4 cases, there were bacterial growths on culturing synovial fluid. Growth of *Staphylococcus aureus* from synovial fluid was noted in 3 cases, and *Klebsiella pneumonia* was observed in 1 case. In 5 cases of gouty arthritis, the diagnosis was made when monosodium urate (MSU) crystals were found in joint fluid (5, 20). In these 5 cases, the joint fluid WBC count was less than 50000 cells/ μL with negative culture results.

IMAGING ACQUISITION

Knee MRI studies were obtained using three various MR scanners (Signa Genesis or Signa Excite; GE Medical Systems, Milwaukee, WI, USA for 1 case, MAGNETOM Skyra; Siemens Healthcare, Erlangen, Germany TIM TX TrueShape; Siemens Healthcare for 11 cases, Achieva; Philips Medical Systems, Best, the Netherlands for 3 cases) with a dedicated 15-channel knee coil in a neutral position of the knee. For conventional 2D MR imaging, fat-suppressed axial proton-density fast spin-echo (FSE), fat-suppressed coronal proton-density FSE, sagittal proton-density FSE, coronal T1-weighted FSE, and fat-suppressed sagittal T2-weighted FSE images were obtained. After intravenous administration of contrast medium (Gadovist; Bayer Schering Pharma AG, Berlin, Germany) at a dose of 7.5 mL, axial and coronal fat-suppressed spin-echo T1-weighted images were obtained. Details of the MR protocol are described in Table 1.

IMAGE ANALYSIS

Knee MR images of 15 patients were retrospectively evaluated by two musculoskeletal radiologists with 11 and 16 years of experience, who were blinded to the diagnosis at the time of review.

Table 1. MR Imaging Parameters

	Axial PD FSE FS	Coronal PD FSE FS	Sagittal PD FSE	Coronal T1 FSE	Sagittal T2 FSE FS	Axial Gd Enhanced T1 FSE FS	Coronal Gd Enhanced T1 FSE FS
Repetition time, ms	2527–3718	2710–3628	2500–4960	150–720	1000–3700	540–719	452–645
Echo time, ms	30–33	25–30	22–30	9–20	34–105	7.4–20	6.5–20
Field of view, mm	150 × 150– 160 × 160	150 × 150– 180 × 180	180 × 180– 210 × 210	150 × 150– 180 × 180	180 × 180– 210 × 210	150 × 150– 160 × 160	150 × 150– 180 × 180
Section thickness, mm	3–4	3–4	3–4	3–4	3–4	3–4	3–4
Intersection gap, mm	0.3–0.4	0.3–0.4	0.3–0.4	0.3–0.4	0.3–0.4	0.3–0.4	0.3–0.4
Acquisition matrix	268 × 205– 448 × 314	392 × 325– 448 × 269	456 × 357– 512 × 384	400 × 310– 512 × 358	448 × 269– 500 × 418	320 × 308– 448 × 314	392 × 325– 448 × 314
Number of sections	20–32	26–33	34–36	26–33	34–36	30–32	26–33

Gd = gadolinium, FS = fat-suppressed, FSE = fast spin-echo, PD = proton-density

Analyzed MR findings included the presence of bone marrow edema, soft tissue edema, abscess formation, maximum thickness of synovium, pattern of synovial thickening and total volume of joint effusion. Low signal intensity lesions were observed in the bone marrow of the affected knee on unenhanced T1-weighted images, whereas a T2 hyperintense lesion is defined as bone marrow edema. The maximum thickness of the synovium was evaluated on fat-suppressed spin-echo gadolinium (Gd) enhanced T1-weighted images. After selection of the slice that showed the most thickened area of synovium, the maximum thickness of the

Fig. 1. 77-year-old male with septic arthritis of knee.

A. Axial fat suppressed proton density image shows fluid collection in knee joint with frondlike synovial thickening (arrow). It also shows extensive soft tissue edema.

B. Axial fat suppressed enhanced T1-weighted image shows enhancement at thickened synovium in knee (arrow).

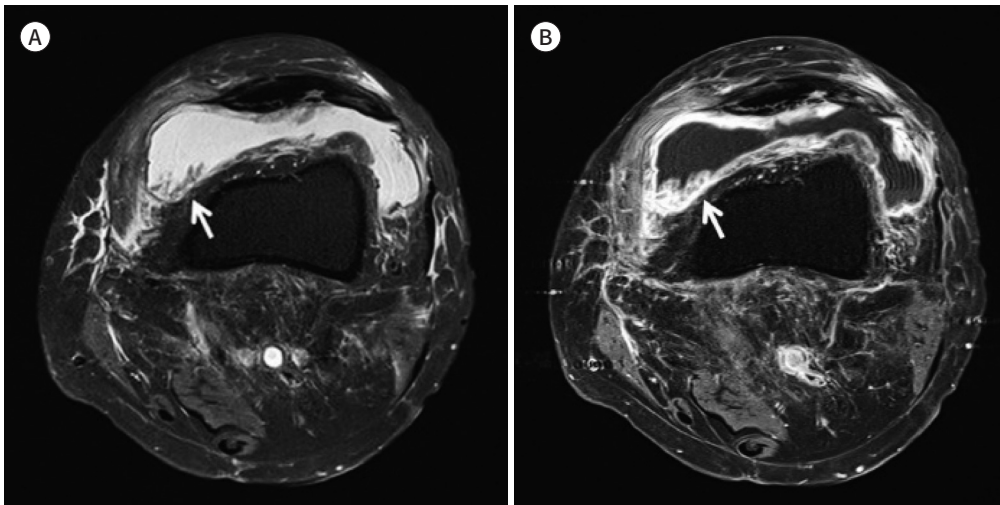
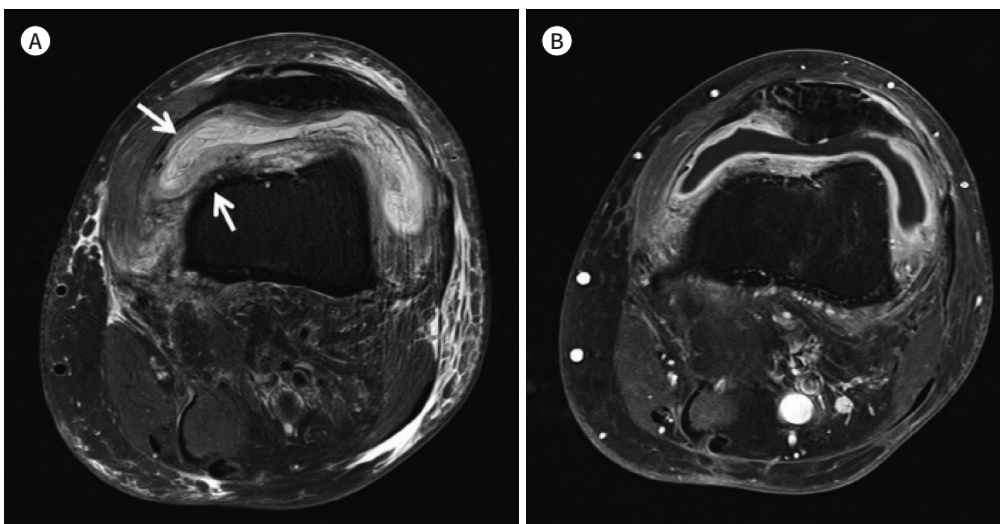


Fig. 2. 63-year-old male with septic arthritis without gouty arthritis of knee.

A. Axial fat suppressed proton density image shows fluid collection in knee joint with lamellated synovial thickening (arrows). It also shows extensive soft tissue edema.

B. Axial fat suppressed enhanced T1-weighted image shows enhancement of thickened synovium in knee.



enhanced synovium was then measured (in mm). The MR findings of synovial thickening were assessed on fat-suppressed spin-echo Gd enhanced T1-weighted images and categorized into one of the three following groups: frondlike, lamellated, and diffuse linear (14). The frondlike pattern (Fig. 1) was defined as small punctuate or linear low signal intense foci within the joint fluid, and the lamellated pattern (Fig. 2) was defined as a thickened synovium composed of multiple layers. A diffuse linear pattern was defined as a thickened synovium with a single layer (Fig. 3). The total volume of joint effusion was calculated using software (Aquarius iNtuition; TeraRecon, San Mateo, CA, USA) with the dynamic region growing tool.

STATISTICAL ANALYSIS

Two groups of cases were compared using nonparametric analysis of variance (Wilcoxon rank-sum test) for continuous variables and the Fisher's exact test for categorical variables. A p value less than 0.05 was considered to be significant. Statistical analyses were performed with SPSS software (version 20.0; IBM Corp., Armonk, NY, USA). Interobserver agreement in the evaluation of MR images was calculated using the κ statistic. Here, κ values of 0.20 or less, 0.21–0.40, 0.41–0.60, 0.61–0.80, and 0.81–1.00 indicated poor, fair, moderate, good, and excellent interobserver agreement, respectively.

RESULT

DEMOGRAPHICS

Age and the frequency of clinical symptoms in each of the two groups were not significantly different between the two groups (Table 2). The mean age was 61.3 years (range 18–84). The sex of the two groups showed significant differences ($p = 0.044$). Everyone in gout group was male ($n = 5$). On the other hand, the septic group consisted of four males and six females.

Fig. 3. 66-year-old male with gouty arthritis of knee.

A, B. Axial fat suppressed proton density image (A) and axial fat suppressed enhanced T1-weighted image (B) show fluid collection in knee joint with diffuse homogeneous synovial thickening.

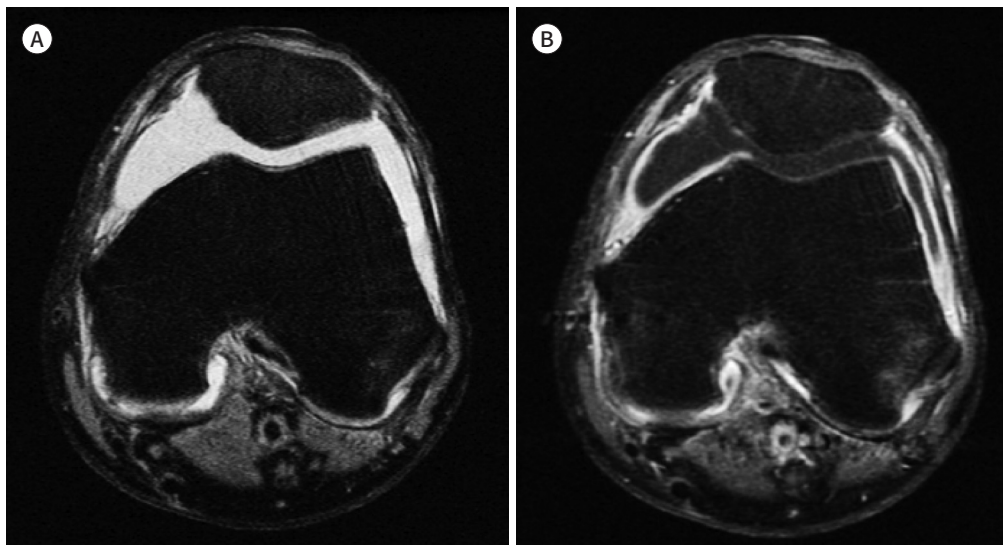


Table 2. Demographic Characteristics of Patients

	Gout Group (n = 5)	Septic Group (n = 10)	p-Value	All (n = 15)
Age, years	61.60 ± 22.94	61.10 ± 18.95	0.965	61.27 ± 19.53
Sex			0.044	
Male	5 (100.0)	4 (40.0)		9 (63.2)
Female	0 (0.0)	6 (60.0)		6 (36.8)
Positive on synovial culture	0 (0.0)	4 (40.0)	0.231	4 (26.7)
Symptom				
Swelling	3 (60.0)	10 (100.0)	0.095	13 (86.7)
Redness	3 (60.0)	1 (10.0)	0.077	4 (26.7)
Heat	1 (20.0)	8 (80.0)	0.089	9 (60.0)

Data are reported as means ± standard deviations or numbers (percentages).

Table 3. Incidence of MR Findings in Each Group

	Gout Group (n = 5)	Septic Group (n = 10)	p-Value	κ Value
Bone marrow edema	1 (20.0)	6 (60.0)	0.282	1.000
Pattern of synovial thickening			0.058	0.815
Fron-d-like pattern	0 (0.0)	2 (20.0)		
Lamellated pattern	0 (0.0)	5 (50.0)		
Diffuse linear pattern	5 (100.0)	3 (30.0)		
Soft tissue edema	5 (100.0)	10 (100.0)		1.000
Soft tissue abscess formation	0 (0.0)	2 (20.0)	0.524	1.000

Data are reported as numbers (percentages).

TOTAL VOLUME OF JOINT EFFUSION

The mean value of knee joint effusion was 77.00 mL in the gout group and 80.48 mL in the septic group. The difference between the two groups was not significant ($p = 0.800$).

SYNOVIAL THICKENING

The mean value of the maximum thickness of the synovium was 3.6 mm in the gout group and 3.0 mm in the septic group. The difference between the two groups was not significant ($p = 0.610$).

The pattern of synovial thickening, in the gout group revealed 5 cases with the diffuse linear pattern (100%) only. The septic group showed 2 cases of frondlike patterns (20%), 5 cases of lamellated patterns (50%) and 3 cases of diffuse linear patterns (30%). The difference was not significant ($p = 0.058$) (Table 3).

SOFT-TISSUE LESION

All patients showed T2 hyperintensity in the soft tissues around the affected knee joint. Only 2 cases in the septic group showed soft tissue abscess formation (Fig. 4, Table 3).

BONE MARROW EDEMA

One patient in the gout group (20%) and 6 patients in septic group (60%) showed bone marrow edema. The difference was not significant ($p = 0.282$) (Fig. 5, Table 3). Bone marrow ede-

Fig. 4. A 45-year-old male with septic arthritis of the knee.

A, C. Axial fat-suppressed proton density image (**A**) and sagittal fat-suppressed T2-weighted image (**C**) show several high signal intensity lesions at the popliteus muscle (asterisks).

B. Axial fat-suppressed Gd-enhanced T1-weighted image shows marginal enhancement at lesions (asterisk), suggesting abscess pockets.

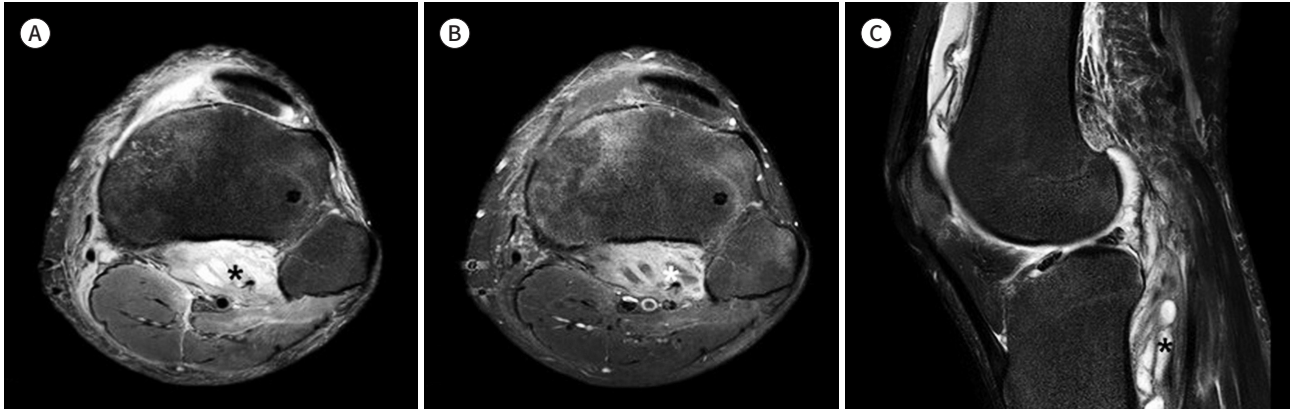


Fig. 5. A 63-year-old male with septic arthritis of the knee.

A, B. Axial (**A**) and coronal fat-suppressed proton density images (**B**) show increased bone marrow signal intensity at the distal femur and proximal tibia. These sequences also demonstrate soft tissue edema and a small amount of knee joint effusion.

C. Coronal T1-weighted image shows decreased signal intensity at the same lesion, suggesting bone marrow edema. Note underlying osteoarthritic change of the knee.



ma exhibited the following distribution pattern: intercondylar eminence of the tibia in the gout group and femoral condyle ($n = 5/10$) and tibial plateau ($n = 1/10$) in the septic group.

INTEROBSERVER AGREEMENT

The interobserver agreement was excellent for the evaluation of arthritis of the knee. κ values ranged from 0.815 (pattern of synovial thickening) to 1.000 (soft tissue and bone marrow edema, soft tissue abscess formation).

DISCUSSION

The differential diagnosis of gouty arthritis and septic arthritis can be difficult and is often overlooked when these two diseases are concomitant (21). In particular, in cases in which the

other joints are involved, other than the first metatarsophalangeal joint, which is the most frequently affected joint, clinical findings may be similar, and it is difficult to distinguish gouty arthritis from septic arthritis (4).

In a previous study, the presence of bone marrow edema was thought to help distinguish gouty arthritis from septic arthritis (4). In our study, the difference between groups was not significant. However, bone marrow edema was demonstrated in 20% ($n = 1/5$) of gouty arthritis patients and 60% ($n = 6/10$) of septic arthritis patients.

Similar to a previous study, our study showed soft tissue edema in both gouty arthritis and septic arthritis (4). In contrast, soft tissue abscess formation was only observed in the septic group not in the gouty group. Thus, soft tissue abscess formation was thought to be a meaningful finding.

The synovial thickening pattern of gouty arthritis tends to be heterogeneous but predominantly hyperechoic on US images because of MSU deposits (22). To our knowledge, no previous report has analyzed the synovial thickening pattern of acute gouty arthritis on MRI. In our study, the gouty arthritis group showed a nonspecific diffuse linear synovial thickening pattern that was not in a frond-like pattern nor in a lamellated pattern. Microscopic findings of acute synovial inflammation in gouty arthritis are known to occur in the form of diffuse and perivascular inflammatory cell infiltration (23). These findings are considered to have a relationship with a nonspecific diffuse linear synovial thickening pattern in MRI. On the other hand, the septic arthritis group showed the highest ratio of lamellated patterns. A lamellated synovial thickening pattern is thought to be a suggestive finding of infection in knee arthroplasty patients (14). Although our study did not include patients who underwent arthroplasty, this result is consistent with previous research. In contrast, no lamellated synovial thickening pattern was noted in the gouty arthritis group. Thus, the pattern of synovial thickening can be helpful to distinguish septic and gouty arthritis.

Similar to previous research results comparing septic arthritis and transient synovitis of the hip, the difference in the volume of joint effusion and thickness of the synovium was not significant in our study (16). Septic arthritis cannot be excluded based on the joint effusion volume or synovial thickness.

This study had several significant limitations. First, this was a retrospective study of a small number of patients at a single institution. Additional multicenter studies including larger populations are required. Second, MRI machines, acquisition protocols and the interval between symptom onset and MRI acquisition were variable. Third, MRI acquisition was performed after arthrocentesis. These factors could affect the MR findings. Fourth, contrary to our expectations, it was impossible to differentiate between septic arthritis and gouty arthritis based on MRI findings. It is therefore necessary to perform further research with more cases.

In conclusion, none of the MR findings assessed in this study, including joint effusion volume or synovial thickness, were useful in differentiating septic arthritis of the knee from gouty arthritis. Although not statistically significant, a lamellated synovial thickening pattern, bone marrow edema and abscess formation in soft tissue were more commonly observed in patients with septic arthritis. These findings might be helpful to differentiate septic arthritis and gouty arthritis.

Author Contributions

Conceptualization, L.S.J.; data curation, L.S.J., C.H.J., Y.S.Y.; formal analysis, L.S.J., C.H.J., Y.S.Y.; investigation, L.S.J., C.H.J., Y.S.Y.; methodology, L.S.J.; project administration, L.S.J.; resources, L.S.J.; software, L.S.J., C.H.J., Y.S.Y.; supervision, L.S.J.; validation, all authors; visualization, L.S.J., Y.S.Y.; writing—original draft, Y.S.Y., L.S.J.; and writing—review & editing, all authors.

Conflicts of Interest

The authors have no potential conflicts of interest to disclose.

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급성 통풍성 슬관절염과 패혈성 슬관절염의 자기공명영상 소견 비교

윤수영 · 추혜정 · 정해웅 · 이선주*

목적 급성 통풍성 관절염과 패혈성 관절염의 자기공명영상 소견 차이를 알아본다.

대상과 방법 2012년 10월부터 2018년 10월까지 패혈성 혹은 통풍성 관절염으로 확진된 자기공명영상을 촬영한 환자를 대상으로 연구하였다. 패혈성 관절염과 급성 통풍성 관절염의 자기공명영상 소견으로 골수부종, 연부조직 부종, 농양 형성 여부, 활액막 비후 양상(엽상체, 증판, 미만성 선형 모양), 활액막 최대 두께와 관절액 양을 평가하였다. 통풍성 관절염(5명)과 패혈성 관절염(10명)을 월콕슨 순위합 검정과 피셔 정확 검정으로 비교하였다.

결과 자기공명영상으로 평가된 각 소견은 두 군 사이에 유의한 통계학적 차이는 보이지 않았다. 골수부종은 통풍성 관절염군에서 1건, 패혈성 관절염군에서 7건 관찰되었다. 연부조직 농양은 패혈성 관절염군에서만 관찰되었다. 활액막 비후양상은 통풍성 관절염군은 모두 미만성 선형 모양(100%), 패혈성 관절염군은 엽상체 모양(20%), 증판 모양(50%), 미만성 선형 모양(30%)으로 나타났다.

결론 통풍성 관절염과 패혈성 관절염은 자기공명영상 소견만으로 감별은 어려울 것으로 생각된다. 그러나 증판 모양 활액막 비후나 골수부종, 연부조직 농양의 경우 패혈성 관절염에서 더 흔히 보였다.

인제대학교 의과대학 부산백병원 영상의학과