

Can short tau inversion recovery image replace contrast-enhanced T1 weighted magnetic resonance image in the assessment of inflammatory changes of psoriatic arthritis?

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Abstract Objective: To evaluate whether short tau inversion recovery (STIR) magnetic resonance (MR) image can replace contrast enhanced (CE) T1-weighted (TIW) MR image for evaluation psoriatic arthritis (PsA).

Materials and methods: Data were collected from twelve adult PsA patients. MR imaging of the affected hand was obtained with both STIR image and CE TIW with frequency-selective fat saturation MR image in the coronal and axial planes. The images were scored independently by two musculoskeletal radiologists. The scoring was performed in accordance with the Outcome Measure in Rheumatology Clinical Trial (OMERACT) Psoriatic Arthritis Magnetic Resonance Imaging Scoring System (PsAMRIS)¹⁾.

Results: Twenty-two MR examinations of the hands in 12 patients were analyzed. Weighted kappa value in the assessment of synovitis, tenosynovitis, bone marrow edema and periarticular inflammation between two radiologists was 0.43, 0.58, 0.72, and 0.73, respectively. Sensitivity to detect synovitis, tenosynovitis, bone marrow edema, and periarticular inflammation with STIR image was 28.6%, 58.3%, 50.0%, and 75.9%, respectively by using method one, and 40.8%, 70.8%, 81.8%, and 75.9%, respectively by using method two.

Conclusion: Administration of contrast medium remains essential for optimal assessment of synovitis, tenosynovitis, and bone marrow edema.

Advantages in Knowledge: Previous studies reported that contrast enhancement is still needed in the assessment of rheumatoid arthritis. However, psoriatic arthritis is different from rheumatoid arthritis in terms that primary target tissue of psoriatic arthritis is enthesitis whilst that of rheumatoid arthritis is synovium. Our results have proved that administration of contrast medium is essential also in optimal evaluation of psoriatic arthritis.

Keywords ; magnetic resonance imaging, psoriatic arthritis, short tau inversion recovery imaging, hand, contrast enhancement

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Introduction

Psoriatic arthritis (PsA) is a chronic inflammatory disease in which the cutaneous manifestation of psoriasis coexists with arthritis, usually in the absence of rheumatoid factor ²⁾. Tumor necrosis factor (TNF) alpha plays a central role in the pathogenesis of PsA. Treatment with anti-TNF alpha agents such as infliximab and adalimumab are indicated in all forms of PsA, which are resistant to traditional therapeutic approaches ³⁾. Recently, new imaging modalities such as magnetic resonance (MR) imaging and ultrasonography have become important for diagnosis in early stage and evaluation of therapeutic effects in PsA. They enable the assessment and monitoring of inflammatory changes before structural changes, such as bone erosion and bone proliferation, and early access to biological treatment in PsA patients could delay joint destruction and even avoid structural changes ⁴⁾.

Contrast-enhanced (CE) T1-weighted (T1W) magnetic resonance (MR) imaging allows highly sensitive assessment of inflammatory changes in PsA. Short tau inversion recovery (STIR) image is a fat suppressed water sensitive MR image without contrast injection, which also allows to delineate inflammatory changes. If STIR image could replace CE T1W image in the MR imaging protocol for the assessment of PsA, MR examination would be safer and reduce medical expenditure.

The aim of this research was to evaluate the efficacy of STIR image in the assessment of inflammatory changes, including synovitis, tenosynovitis, periarticular inflammation, and bone edema, of PsA in comparison with CE T1W image.

Materials and methods

The ethics committee of the Jikei University Hospital approved this prospective study.

Patient Selection

The study cohort was recruited from the outpatients of the department of dermatology at the Jikei University Hospital from October 2010 to September 2013. The diagnosis of PsA was made by dermatologists specialized in psoriasis according to the classification criteria described by the classification criteria for psoriatic arthritis (CASPER) study group. Written informed consents for participation in the study and administration of Gadolinium-based contrast agent (GBCA) were obtained from all patients.

MR Image Acquisition

The affected hands were imaged using a 1.5-tesla MR imaging unit (MAGNETOM Avanto, Siemens Healthineers, Erlangen, Germany). STIR images were obtained in the coronal plane (repetition time [TR]/ inversion time [TI]/echo time [TE], 3000/180/27 msec; 3-mm slice thickness; 24-cm field of view [FOV]; matrix, 256 × 256 pixels) and axial plane (TR/TI/TE, 3000/180/27 msec; 3-mm slice thickness; 13-cm FOV; matrix, 256 × 256 pixels). After intravenous administration of Gadodiamide Hydrate (OMNISCAN; Daiichi Sankyo Co., Ltd., Tokyo, Japan) at a standard dose of 0.1 mmol/ kg, T1W fast spin echo (FSE) sequences with frequency-selective fat saturation were obtained in the coronal plane (TR/TE, 550/10 msec; 3-mm slice thickness; 24cm FOV; matrix, 256 × 320; echo train length [ETL], 3) and axial plane (TR/TE, 550/10 msec; 3-mm slice thickness; 13-cm FOV; matrix, 256 × 320; ETL, 3).

MR Image Analysis

Images with poor quality and missed the target joints in both STIR image and CE T1W image were excluded from the analysis.

The images were randomized with anonymization of the patient's name, sex, examination method, and date of examination. They were scored independently by two radiologists (T.Y.: 7 year-



experience in musculoskeletal radiology and Y.T.: one-year experience in musculoskeletal radiology). If there was disagreement, the final score was determined by consensus between the two radiologists.

The scoring was performed according to the OMERACT Psoriatic Arthritis Magnetic Resonance Imaging Scoring System (PsAMRIS)¹⁾. In this scoring system, synovitis is scored 0–3, tenosynovitis is 0–3, bone marrow edema is 0–6, and periarticular inflammation is 0–2 for each metacarpophalangeal (MCP) joint, proximal interphalangeal (PIP) joint and distal interphalangeal (DIP) joint of 2nd to 5th fingers of the affected hand. Bone marrow edema was assessed in proximal and distal part of each joint and periarticular inflammation was assessed in volar and dorsal aspect of the joint. Therefore, both features were assessed two areas of each joint. Structural changes,

such as bone erosion and bone proliferation, were not included for analysis because our aim was to evaluate feasibility of STIR image in the assessment of inflammatory changes.

Statistical Analysis

We used the intra-class correlation coefficient to identify interobserver reliability between the two radiologists. Landis and Koch suggest the following interpretations: below 0.0 Poor, 0.00 – 0.20 Slight, 0.21 – 0.40 Fair, 0.41 – 0.60 Moderate, 0.61 – 0.80 Substantial, 0.81 – 1.00 Almost perfect⁵⁾. It was analyzed by STATA[®] software (StataCorp LP, College Station, Texas, USA).

Sensitivity, specificity, positive predictive value, and negative predictive value were calculated in the following two different methods. In method one, STIR finding was regarded as false negative in case where score by STIR image was lower than that by

Table 1 Patient characteristics

Patient Number	Age	Sex	Biological Agents	Number of MR examination
1	49	F	None	Once
2	75	M	OM, ADA 6M, IFX 4M, IFX 8M	Four times
3	32	M	OM, ADA 6M	Twice
4	39	M	OM, ADA 2Y8M	Twice
5	48	F	OM, IFX 6M	Twice
6	30	F	None	Once
7	33	M	OM, IFX 8M	Twice
8	42	M	None	Once
9	69	M	None	Once
10	52	M	OM, IFX 1M, IFX 6M	Three times
11	45	F	None	Once
12	61	M	OM, ADA 1M	Twice

Note.---OM =before biological agent therapies, ADA = Adalimumab, IFX = Infliximab,

Table 2 Scores of synovitis by STIR image and CE T1W image

	CE T1W imaging				
	Score	0	1	2	3
STIR image	0	156	25	4	0
	1	6	13	4	0
	2	0	0	1	2
	3	0	0	0	0
		162	38	9	2

Note.---STIR imaging = short tau inversion recovery imaging, CE T1W imaging = contrast enhanced T1-weighted imaging

CE T1W image, and as false positive in case where score by STIR was higher than that by CE T1W image. In method two, STIR finding was regarded as false negative in case where score by STIR image was zero while score by CE T1W image showed positive value, and as false positive in case where score by STIR showed positive value while score by CE T1W image was zero.

Results

Twelve consecutive patients (8 men, 4 women, aged 30 to 75 years) with PsA were recruited and underwent MR imaging. Among 12 patients, 7 patients underwent repeated MR examinations during and after biological agent therapies, which resulted in 22 MR examinations of the hands. Patient characteristics are shown in Table 1.

After the exclusion of images which were poor

quality or failed to cover interest area, 211 joints, 212 flexor tendons, 424 periarticular areas, and 424 bone marrow were evaluated for joint synovitis, tenosynovitis, bone marrow edema, and, periarticular inflammation, respectively.

Interobserver Reliability in the Assessment of Scores

Weighted kappa value in the assessment for synovitis and tenosynovitis was 0.43 and 0.58 respectively, which indicates poor to moderate agreement in synovitis and moderate agreement in tenosynovitis. Weighted kappa value in the assessment for bone marrow edema and periarticular inflammation was 0.72 and 0.73 both of which indicate good agreement.

Synovitis

Scores of synovitis by STIR image and CE-T1W

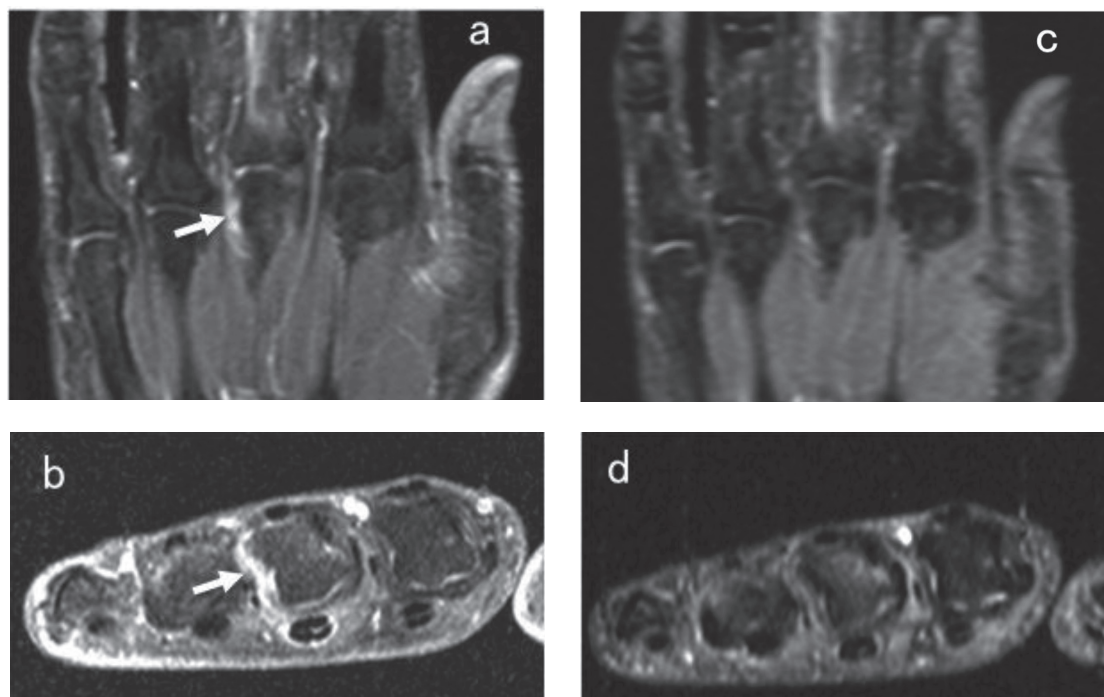


Figure 1 Example of synovitis.

(a), (b) Contrast-enhanced (CE) T1-weighted (T1W) magnetic resonance (MR) images show contrast enhancement (arrows) in the 3rd metacarpophalangeal (MCP) joint.

(c), (d) Short tau inversion recovery (STIR) images show no high signal intensity in the same joint.



image are shown in Table 2. Scores of synovitis by STIR image were identical to those by CE T1W image in 170 joints out of 211 joints (80.6%). Scores by STIR image were lower than those by CE T1W MR image in 35 joints and higher in 6 joints (Fig.1). Sensitivity, specificity, positive predictive value and negative predictive value using method one was 28.6%, 96.3%, 70.0% and 81.7%, and using method two was 40.8%, 96.3%, 76.9 %, and 84.3 %, respectively.

Tenosynovitis

Scores of tenosynovitis by STIR image and CE-T1W image are shown in Table 3. Scores of synovitis by STIR image were identical to those by CE T1W image in 183 flexor tendons out of 211 joints (86.7%). Scores by STIR image were lower than those by CE T1W MR image in 10 tendons and higher in 18 tendons (Fig.2). Sensitivity, specificity, positive predictive value and negative predictive value using method one was 58.3%, 90.4%, 43.8% and 94.4%, and using method two was 70.8%,

Table 3 Scores of tenosynovitis by STIR image and CE T1W image

	CE T1W image					
STIR image	Score	0	1	2	3	
	0	169	7	0	0	176
	1	18	13	3	0	34
	2	0	0	1	0	1
	3	0	0	0	0	0
		187	20	4	0	211

Note.---STIR imaging = short tau inversion recovery imaging, CE T1W imaging = contrast enhanced T1-weighted imaging

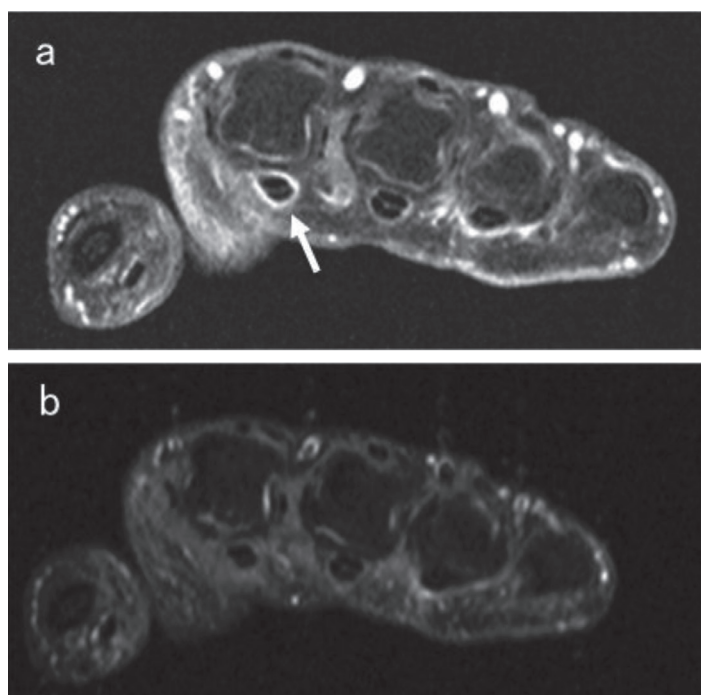


Figure 2 Example of tenosynovitis.

- (a) CE T1W MR image shows contrast enhancement (arrow) in the flexor tendon sheath at the level of 2nd MCP joint.
- (b) STIR image shows no high signal intensity in the same tendon sheath.

90.4%, 48.6 %, and 96.0 % respectively.

Bone marrow edema

Scores of bone marrow edema by STIR image and CE-T1W image are shown in Table 4. Scores of bone marrow edema by STIR image were identical to those by CE T1W image in 414 periarticular areas out of 424 areas (97.6%). Scores by STIR image were lower than those by CE T1W MR image in 5 bone marrows and higher in 5 bone marrows

(Fig.3). Sensitivity, specificity, positive predictive value and negative predictive value using method one was 50%, 98.8%, 50.0% and 98.8%, and using method two was 81.8%, 99.0%, 69.2%, and 99.5 %, respectively.

Periarticular inflammation

Scores of periarticular inflammation by STIR image and CE-T1W image are shown in Table 5. Scores of periarticular inflammation by STIR image

Table 4 Scores of bone marrow edema by STIR image and CE T1W image

	CE T1W image					
STIR image	Score	0	1	2	3	
	0	409	2	0	0	411
	1	4	3	2	0	9
	2	0	1	1	1	3
	3	0	0	0	1	1
		413	6	3	2	424

Note.---STIR imaging = short tau inversion recovery imaging, CE T1W imaging = contrast enhanced T1-weighted imaging

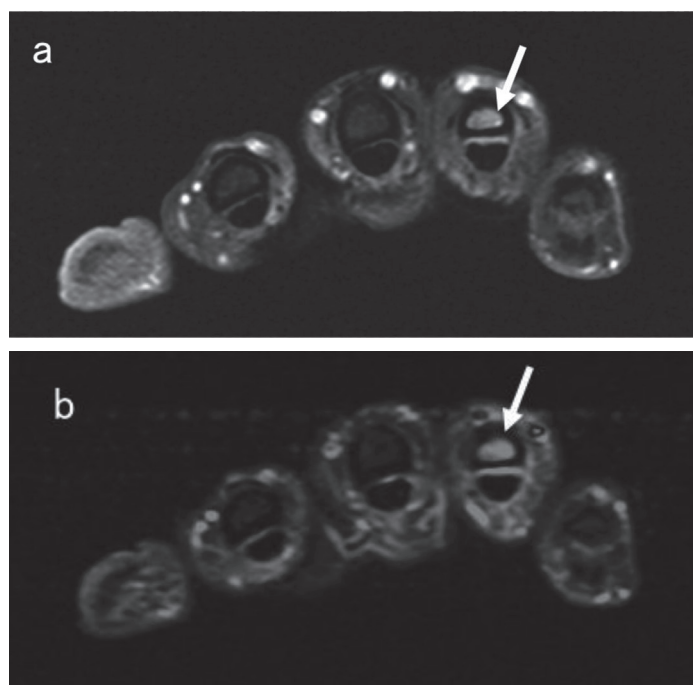


Figure 3 Example of bone marrow edema.

- (a) CE T1W MR image shows contrast enhancement (arrow) in the bone marrow of the proximal part of the 4th proximal interphalangeal joint.
 (b) STIR image also shows high signal intensity (arrow) in the same region.



were identical to those by CE T1W image in 409 periarticular areas out of 424 areas (96.5%). Scores by STIR image were lower than those by CE T1W MR image in 7 tendons and higher in 8 tendons (Fig.4). Sensitivity, specificity, positive predictive value and negative predictive value were 75.9%, 98.0%, 73.3% and 98.2%, respectively, by using both method one and method two.

DISCUSSION

OMERACT recommends MR imaging sequences include non-CE T1W images which are primarily used to assess bone erosions, T2-weighted (T2W) fat saturated (FS) images or STIR images, and CE T1W MR images used in combination with non-CE T1W images¹⁾. However, administration of GBCA has a potential risk of anaphylactoid reaction and

Table 5 Scores of periarticular inflammation by STIR image and CE T1W image

		CE T1W image		
STIR image	Score	0	1	
	0	387	7	394
	1	8	22	30
		395	29	424

Note.---STIR imaging = short tau inversion recovery imaging, CE T1W imaging = contrast enhanced T1-weighted imaging

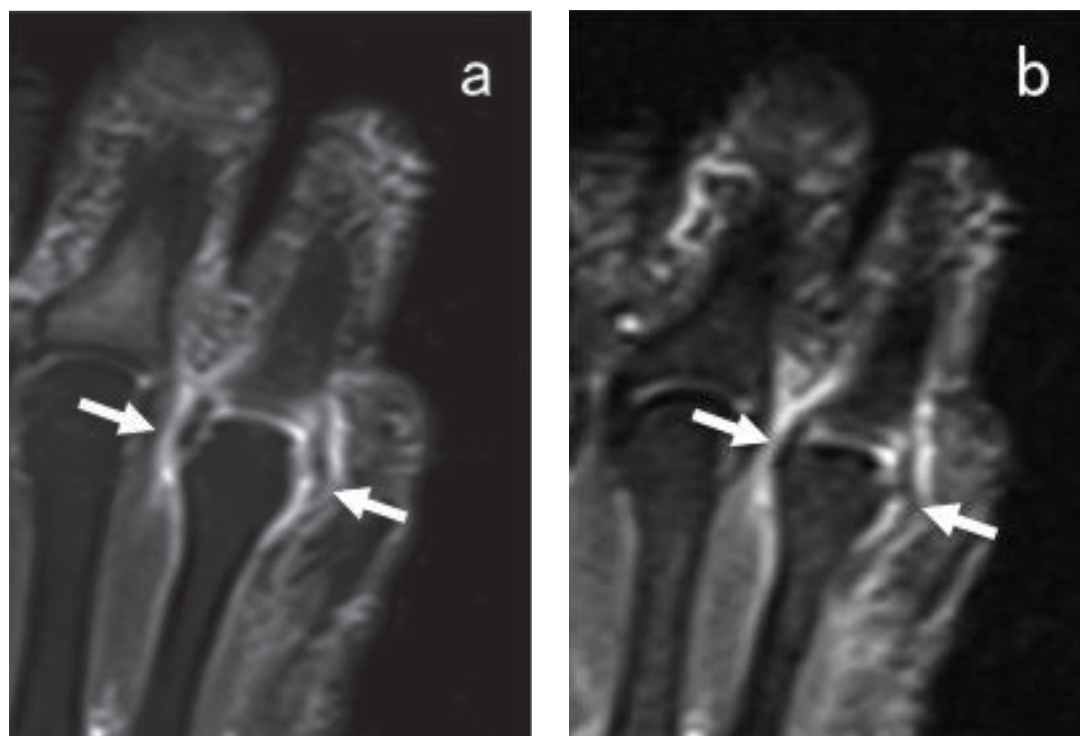


Figure 4 Example of periarticular inflammation.

(a) CE T1W MR image shows swelling and marked contrast enhancement (arrows) in the periarticular area of the 4th MCP joint .
(b) STIR image also shows swelling and high signal intensity (arrows) in the same joint.



even development of nephrogenic systemic fibrosis in patients with severe renal failure. In addition, according to recent article, gadolinium could accumulate in various tissues of patients who do not have renal impairment, including brain and bone ⁶⁾. Furthermore, GBCA is expensive and administration of contrast medium results in prolonged MR image time and increases patient discomfort.

In our study, weighted kappa's for agreement of synovitis and tenosynovitis scores in individual joint between two radiologists was poor to moderate while that of bone marrow edema and periarticular inflammation was good. This results probably reflect the fact that joint cavity and tendon sheath are small anatomical structures compared with bone marrow and periarticular soft tissue because of poor special resolution of MR imaging compared with computed tomography. Slice thickness of MR image of the currently study was 3mm.

According to the consensus based scoring of our study, accordance ratio of synovitis and tenosynovitis between STIR image and CE T1W image was moderately good, but, sensitivity of STIR image was poor in both synovitis and tenosynovitis, positive predictive value was also low in tenosynovitis. In contrast, accordance ratio of bone marrow edema and periarticular inflammation was very good. Sensitivity of STIR image for bone marrow edema was not good using method one but it become good using method two. Sensitivity of STIR image for periarticular inflammation was good. Therefore, contrast enhancement is necessary for evaluation of synovitis and tenosynovitis, and probably for evaluation of bone marrow edema but it is not mandatory for evaluation of periarticular inflammation.

We searched for the similar articles to our study using PubMed and found three relevant articles; Stomp et al. ⁷⁾, Tamai M et al. ⁸⁾, and Ostergaard M et al ⁹⁾.

Stomp et al reported that elimination of contrast administration resulted in low specificity for

synovitis and low sensitivity for tenosynovitis, and concluded that contrast enhancement remains essential for an optimal assessment ⁷⁾. Materials and methods of Stomp et al. were different from our study. Their materials were 92 cases with various types of inflammatory arthritis, including 35 cases of rheumatoid arthritis (RA) and 36 cases of undifferentiated arthritis. Cases with PsA were only seven. Their target joints for analysis were the wrist joints while our target joints were the finger joints, where PsA more likely involve. Usually MR images of the finger joints tend to have more artifacts because of inhomogeneity of static magnetic field and difficult to obtain orthogonal images because of radiating orientation of fingers. Also, Stomp et al used T2 weighted fast spin echo sequence with frequency selective fat saturation while we used STIR sequences. STIR image is very sensitive for fluid, such as joint fluid, soft tissue inflammation, and bone marrow edema. Fat suppression with STIR does not depend on local magnetic field homogeneity. Therefore, more stable fat suppression image can be obtained with STIR sequence compared with frequency-selective fat saturation in the areas of unstable homogeneous magnetic field, such as off-center parts of the body like hands and fingers.

Tamai M et al. analyzed between STIR image and CE T1W MR image in 51 early stage RA ⁸⁾. PsA case was not included. Synovitis judged by STIR image showed high false-positive rate; thus, the specificity, positive predictive value and accuracy of STIR image was low compared with CE T1W MR image. In contrast to synovitis, the false-positivity of bone lesions (bone marrow edema and bone erosion), judged by plain MRI-based findings, was very low compared with Gd-DTPA-enhanced.

Ostergaard M et al. analyzed between T2W fat-saturated MR image/STIR image and CE T1W MR image in 40 patients with RA ⁹⁾. No PsA was included. They also concluded that omitting contrast injection decreased the reliability of synovitis



scores, but did not change scores of bone erosions and bone marrow edema.

As for bone changes in inflammatory arthritis, there were more reports in which contrast enhancement is not necessary for their evaluation. Baraliakos et al. compared the performance of two different MR sequences, CE T1W MR images and STIR images to detect spinal inflammation in patients with ankylosing spondylitis (AS). Both MR techniques can evaluate active spinal lesions in patients with AS¹⁰⁾. In RA, regions of bone where MR image has revealed bone edema have become available for histologic examination following joint replacement surgery^{11, 12)}. Inflammatory osteitis has been detected, and the extent of inflammation parallels the intensity of the bone edema signal. Although this confirmation versus histology has not yet been achieved in PsA, peripheral and axial bone edema in PsA have been responsive to anti-TNF agents^{13, 14)}.

In contrast to previous reports, all our subjects consisted with PsA patients. Periarticular inflammation reflects soft tissue inflammation adjacent to enthesitis. Enthesis is the insertion of ligament, tendon, or joint capsule to bone, and enthesitis is a cardinal feature of the spondyloarthropathies¹⁵⁾. Enthesitis has been viewed as focal insertional inflammation. PsA and RA have been shown to be very similar in terms of synovitis, but a difference has been observed between the two conditions when MR image is used to examine the periarticular tissues. This was first noted by Jevtic et al.¹⁶⁾, who investigated finger joints in patients with inflammatory arthropathy and described as a distinctive feature of PsA. They described periarticular inflammation as “inflamed tissue extended far beyond the joint capsule, involving neighboring structures such as thickened collateral ligaments and surrounding periarticular

soft tissue.” This was reexamined in the knee joint by McGonagle et al.^{17, 18)}, who concluded that these appearances were representative of the soft tissue component of enthesitis, which they postulated to be the initiating lesion of PsA. Therefore, high detectability of periarticular inflammation may be advantage over detection of synovitis and tenosynovitis, which could be induced by enthesitis.

There are several limitations in our study. First, number of patients was relatively small partly because of rareness of psoriasis in Japan compared with Western countries. However, it was a prospective study and there was no patient selection bias. Second, none of our patients has pathological confirmation. All patients were diagnosed by qualified dermatologists who were specialized in psoriasis.

In summary, STIR images without contrast enhancement is sufficient for assessment of bone marrow edema and periarticular inflammation while administration of contrast medium remains essential for optimal assessment of synovitis and tenosynovitis, and probably need for evaluation of bone marrow edema.

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Disclosures of Conflicts of Interest

Authors disclosed no relevant relationship.



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