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Evaluation of Rheumatoid Arthritis Using a Scoring System Devised from Magnetic Resonance Imaging of Rheumatoid Knees

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Abstract

We studied the magnetic resonance imaging (MRI) of 120 knees in 86 rheumatoid arthritis (RA) patients and of 14 unaffected knees in 12 control cases. We also developed a scoring system as a quantitative analysis method. We divided the MRI into 10 items, and classified the severity of the symptoms into 4 grades (score 0 to 3). The average total score increased according to the radiographic grade. Soft tissue lesions were clearly detected, even in the early stages of RA. Items such as synovial proliferation showed a high score even in the early stages, suggesting that it was the initial symptom of RA. The score also showed a correlation with the inflammatory signs. These results suggest that this scoring system is very sensitive and yields a good reflection of RA activity. We demonstrated that this system is simple and convenient for routine diagnostic use. We further demonstrated that it is useful for following the advancement of RA and for evaluating the response to treatment.

KEYWORDS: rheumatoid arthritis, magnetic resonance imaging, scoring system, synovial membrane

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We studied the magnetic resonance imaging (MRI) of 120 knees in 86 rheumatoid arthritis (RA) patients and of 14 unaffected knees in 12 control cases. We also developed a scoring system as a quantitative analysis method. We divided the MRI into 10 items, and classified the severity of the symptoms into 4 grades (score 0 to 3). The average total score increased according to the radiographic grade. Soft tissue lesions were clearly detected, even in the early stages of RA. Items such as synovial proliferation showed a high score even in the early stages, suggesting that it was the initial symptom of RA. The score also showed a correlation with the inflammatory signs. These results suggest that this scoring system is very sensitive and yields a good reflection of RA activity. We demonstrated that this system is simple and convenient for routine diagnostic use. We further demonstrated that it is useful for following the advancement of RA and for evaluating the response to treatment.

Key words: rheumatoid arthritis, magnetic resonance imaging, scoring system, synovial membrane

Rheumatoid arthritis (RA) is a chronic and systemic articular inflammatory disorder. RA can involve any synovial joint, and the lesions can also extend into related tissues (menisci, tendons, ligaments and so on). Although several factors such as the immune system, heredity and gender, have been reported to contribute to RA, the etiology is still unclear. The lesions lack specific histologic features and individually manifest varying degrees of severity. Therefore, RA may represent several heterogeneous groups of disorders, which makes its symptoms variable and complex.

The synovial membrane is the primary site of RA (1). The initial changes may include edema and congestion of the synovial membrane, which are common to many articular diseases. As RA advances, cellular infiltration occurs in the synovial tissues, which then proliferate markedly and create granulation tissue such as a pannus (2). Finally, the inflammatory tissues invade and destroy both cartilage and bone. Although these osseous changes are related to joint deformity and the resultant joint dysfunction is very harmful, soft tissue lesions also affect the daily life of RA patients. Rupture or elongation of the tendons and ligaments have been well-documented in many instances (3). The goal of treatment for RA is to prevent this progression; therefore, evaluation of these symptoms is essential for the treatment of RA.

Many methods have been applied to the study of RA, such as physical examination, laboratory analysis, image analysis and so on (4-7). Radiography is one of the most valuable methods for the evaluation of RA (8, 9), as well as for resultant bony erosion and deformity. Larsen *et al.* classified the course of RA progression in radiographs into 6 grades in order to assess the state of each joint individually (Grade 0: Normal conditions, Grade 1: Slight abnormality, Grade 2: Definite early abnormality, Grade 3: Medium destructive abnormality, Grade 4: Severe destructive abnormality, Grade 5: Mutilating abnormality) (10). The value of this grading system as a guide for therapy has been established. However, radiographs can only detect later bone lesions and cannot assess early soft tissue changes. Therefore, radiography is not adequate as a guide for early therapy.

Magnetic resonance imaging (MRI) is used widely today and has become an essential method for the assessment of articular disease because it is non-invasive and can

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detect soft tissue changes, especially in lesions of the cartilage (11-15), meniscus (16-22), ligament (22) and synovial membrane (16). Although there have been a few reports on the use of MRI for the qualitative assessment of RA (20-28), a quantitative analysis method has not been used except for a single report (29). In this study we evaluated the initial MRI sign in RA patients and compared it to non-RA patients. A quantitative image with a scoring analysis was then established from the previous qualitative analysis. The correlation between this scoring system and the clinical data was also analyzed.

Materials and Methods

One hundred and twenty knees from 86 RA patients ranging in age from 33-84 years (mean age: 59.1 years) were examined by MRI and simultaneous radiographs. This group consisted of 13 men and 73 women. All patients had RA for more than four months. The mean duration of RA was 7.3 years (range four months to 38 years). All patients satisfied the criteria of the American Rheumatism Association for RA (1987) and had variable evidence of active inflammatory disease upon clinical examination. The majority of patients were taking some form of anti-inflammatory and/or anti-rheumatic drugs. As controls, we also studied the MRIs and radiographs of 14 unaffected knees from 12 non-RA patients and volunteers (21-82 years; mean age: 57.6 years). Some patients in the control group complained of slight knee joint pain, but they had no apparent evidence of bony changes on their radiographs.

Radiographs of the knee in two planes (anteroposterior and lateral) were taken before the MRI examination. According to Larsen's radiographic classification system (10), the patients were divided into 6 grades: Grade 0 was present in 23 joints/16 patients; Grade 1 in 38 joints/27 patients; Grade 2 in 38 joints/30 patients; and Grade 3 in 21 joints/15 patients. The cases of Grade 4 and 5 were excluded because we want to study MRI findings in the early stages of RA.

The erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) levels were used for the evaluation of RA activity.

MRI was performed with a 0.5T magnet (YMS,

Table I The criteria of the grade in magnetic resonance imaging (MRI) change

Items of MRI system	Grade 0	Grade I	Grade 2	Grade 3
Sagittal				
Synovial proliferation (suprapatellar pouch)	None	Only swelling	Slight proliferation	Full of proliferation
Synovial proliferation (intercondyle)	None	Limited in intercondyle	Both sites (not continuous)	Full of proliferation
Meniscal degeneration	None	Limited within meniscus	Reaches edges	Not evident
Cartilage degeneration	None	Irregular	Discontinuous	Not evident
Bone deformity (femur)	None	Irregular	Cyst formation	Destroyed
Bone deformity (tibia)	None	Irregular	Cyst formation	Destroyed
Coronal				
Synovial proliferation (suprapatellar pouch)	None	Only swelling	Slight proliferation	Full of proliferation
Cartilage degeneration	None	Irregular	Discontinuous	Not evident
Bone deformity (femur)	None	Irregular	Cyst formation	Destroyed
Bone deformity (tibia)	None	Irregular	Cyst formation	Destroyed

MRI of rheumatoid arthritis (RA) knee was evaluated on ten items and each item was classified into four degrees: Grade 0 = no change (Score 0); Grade I = slight change (Score 1); Grade 2 = moderate change (Score 2); Grade 3 = severe change (Score 3).

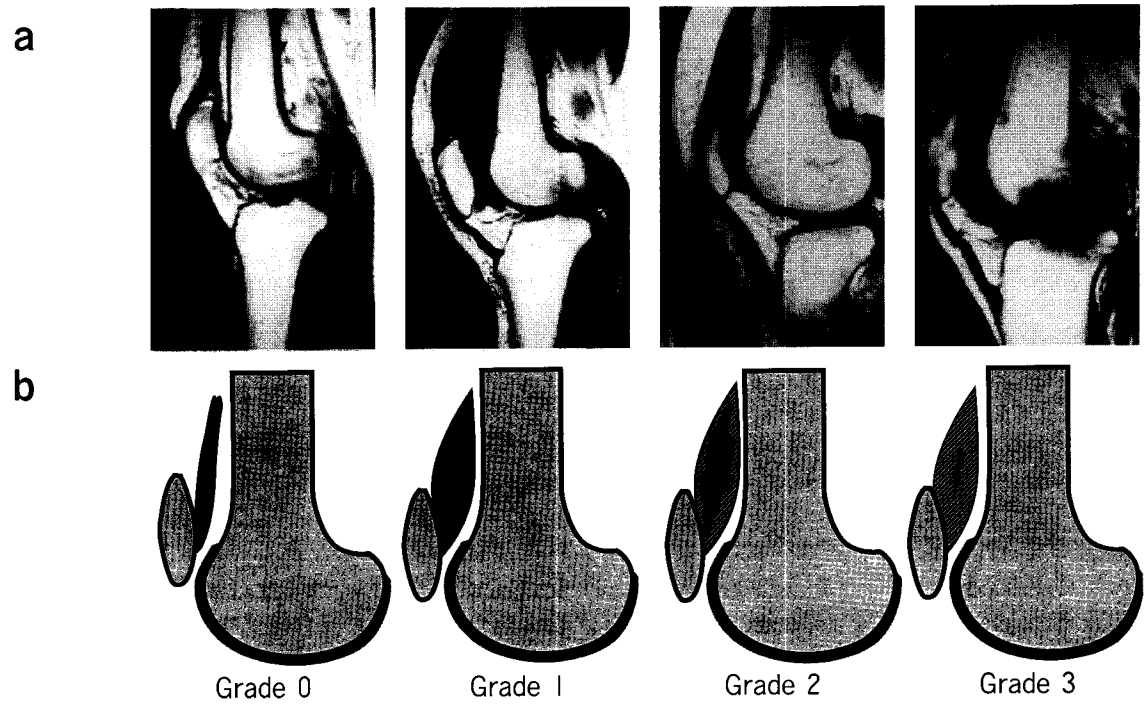

Fig. 1 Grading of synovial proliferation (suprapatellar pouch) by magnetic resonance imaging (MRI) (sagittal view). **a**: MRI; **b**: Schema. See Table I.

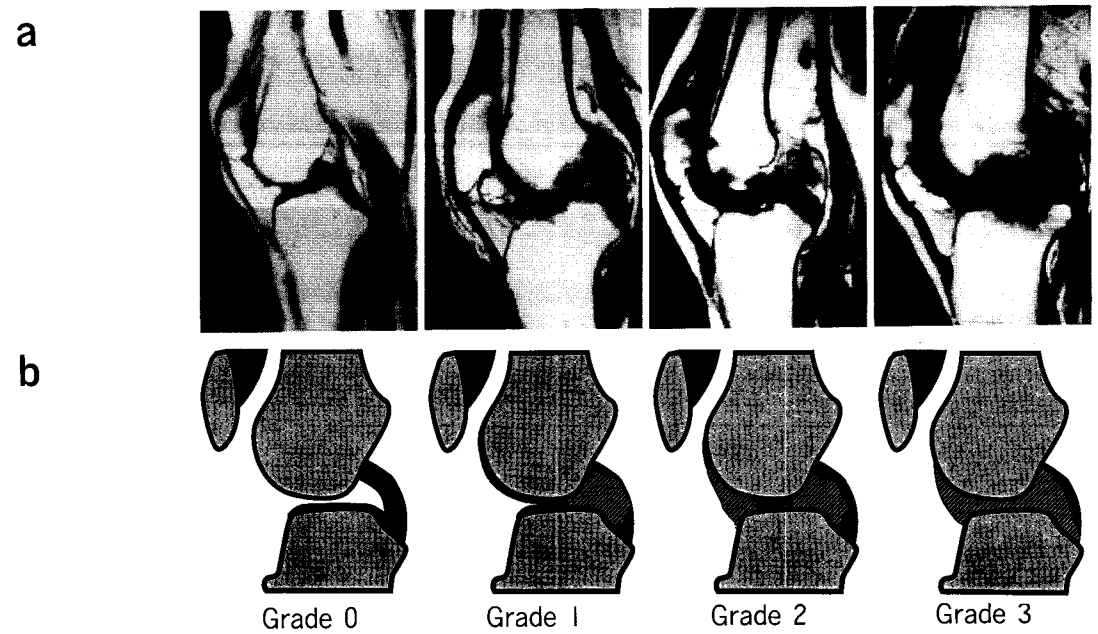

Fig. 2 Grading of synovial proliferation (intercondyle) by MRI (sagittal view). **a**: MRI; **b**: Schema. See Table I.

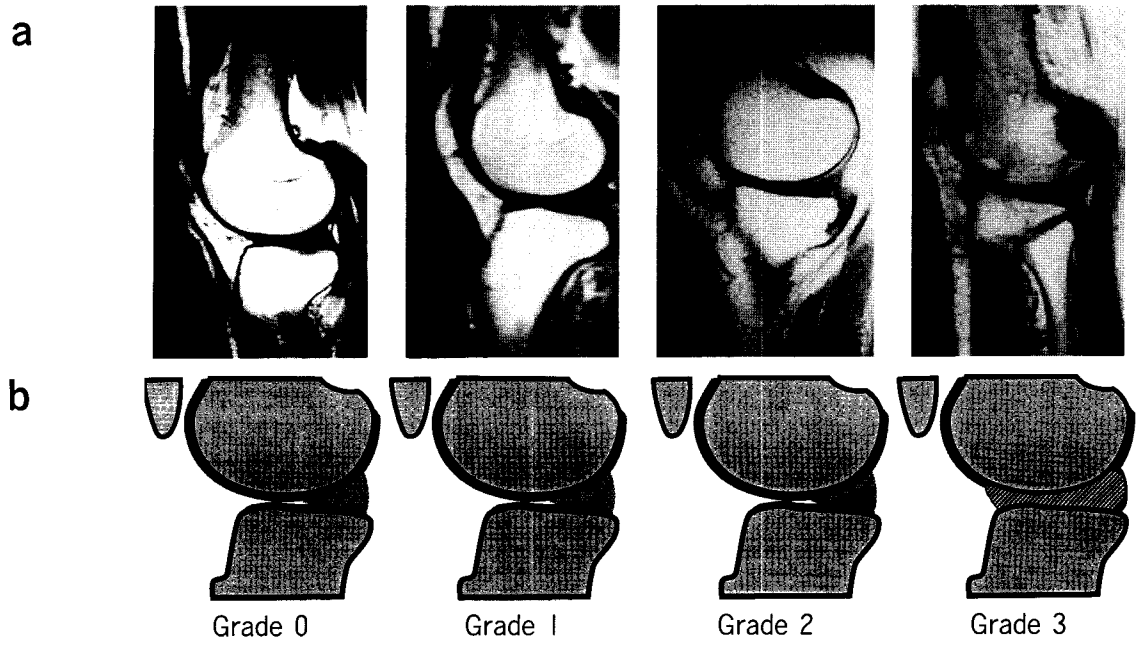

Fig. 3 Grading of meniscal degeneration by MRI (sagittal view). **a**: MRI; **b**: Schema. See Table I.

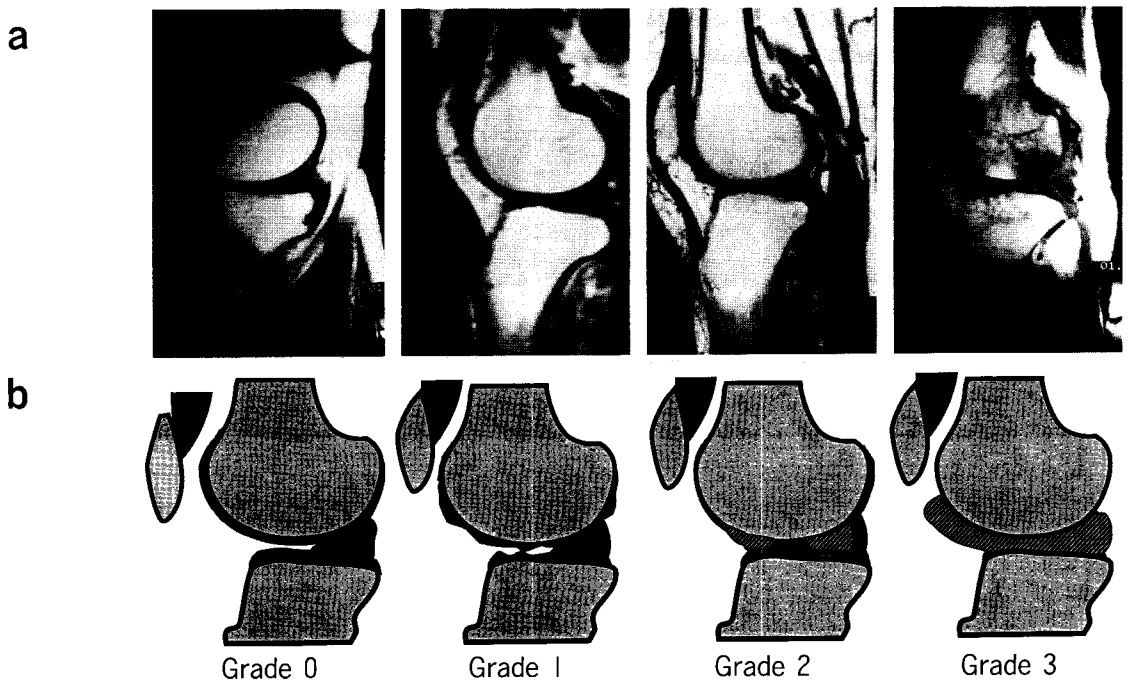

Fig. 4 Grading of cartilage degeneration by MRI (sagittal view). **a**: MRI; **b**: Schema. See Table I.

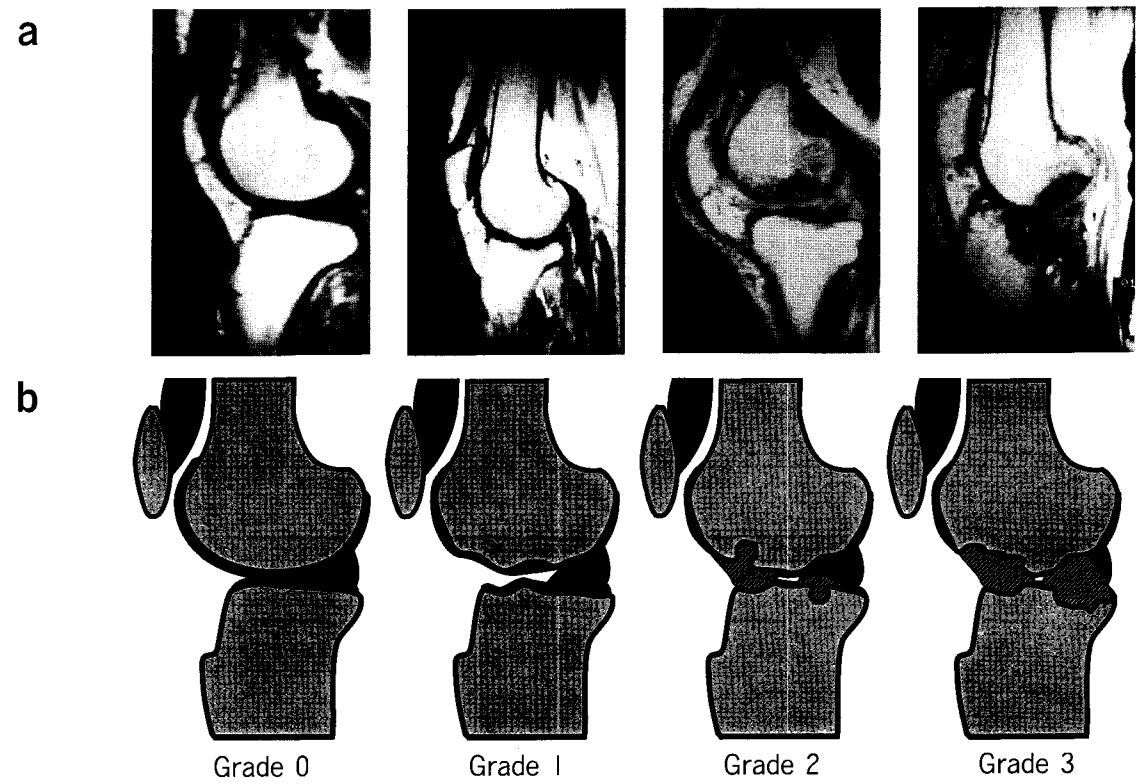

Fig. 5 Grading of bone deformity by MRI (sagittal view). **a**: MRI; **b**: Schema. See Table I.

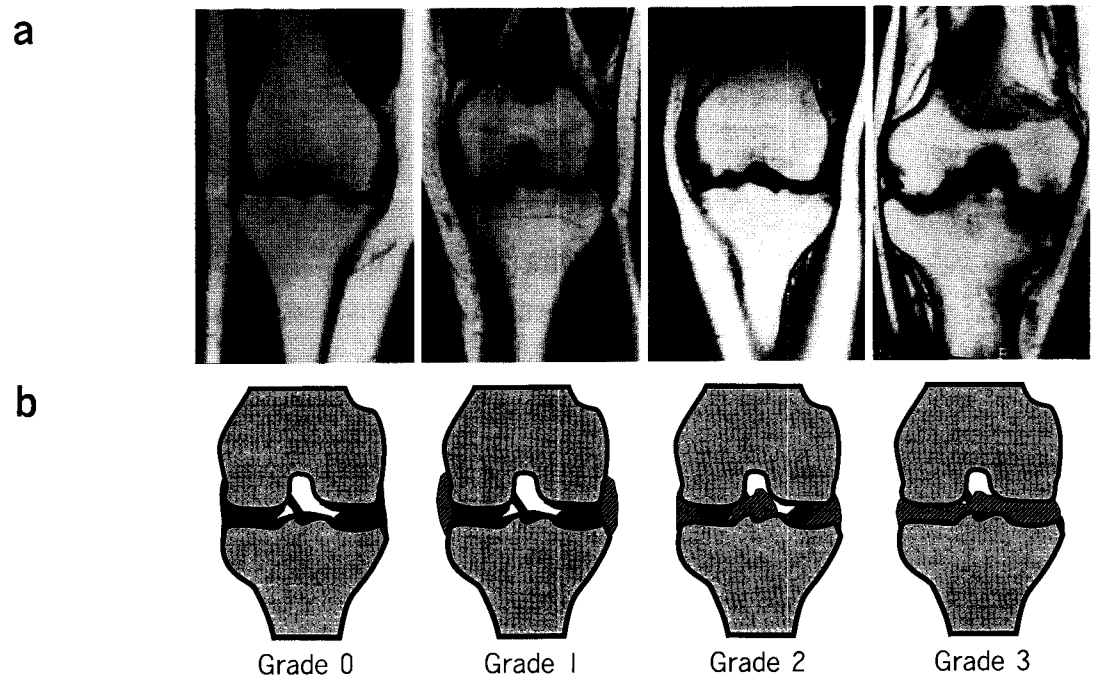

Fig. 6 Grading of synovial proliferation by MRI (coronal view). **a**: MRI; **b**: Schema. See Table I.

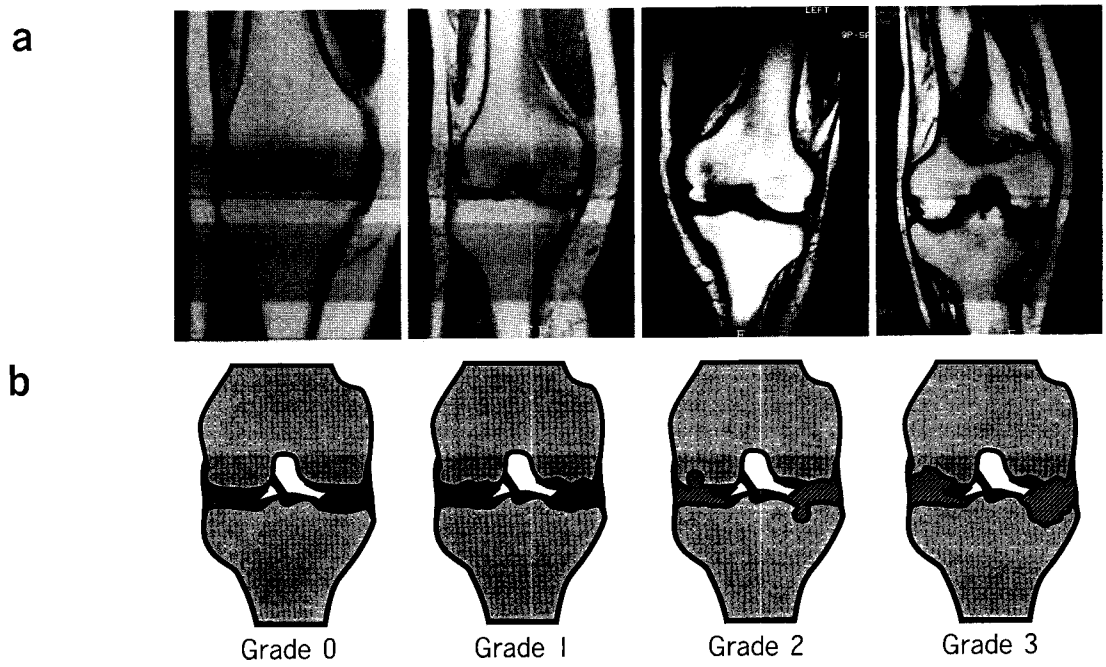

Fig. 7 Grading of bone deformity by MRI (coronal view). **a**: MRI; **b**: Schema. See Table I.

RESONA, JAPAN). All images were obtained with the use of an extremity coil. The knee joints were imaged in the sagittal and coronal planes. The routine study protocol consisted of a T1-weighted spin echo (Reverse time (TR)/Echo time (TE) = 400–550/20–25 ms) and a T2-weighted spin echo (TR/TE = 1800–2500/80–100 ms). The condition was as follows: matrix; 160 or 256 × 256, field of volume (FOV); 20 cm, slice; 5 mm thick with a 0.5 mm gap.

The MR images were interpreted with respect to the following 10 items: In the sagittal plane: 1) proliferation of the synovial membrane (suprapatellar pouch); 2) proliferation of the synovial membrane (intercondyle); 3) meniscal lesions; 4) irregularities of the cartilage; 5) deformities of the bone (femur); and 6) deformities of the bone (tibia). In the coronal plane: 7) proliferation of the synovial membrane; 8) irregularities of the cartilage; 9) deformities of the bone (femur); and 10) deformities of the bone (tibia) were evaluated. Initially, changes in these items on the MRI were evaluated with qualitative image analysis and were compared with the radiographic findings. A detection rate is calculated in each item as number of cases/total × 100. Then, each MR image was quantitatively evaluated with the scoring system. This scoring system was developed from the qualitative image analysis performed previously. An image for each item was classified into 4 grades (Grade 0: No change; Grade 1: Slight change; Grade 2: Moderate change and Grade 3: Severe change), which scores 0–3 were assigned to, respectively (Table 1 and Figs. 1–7). Finally, a statistical analysis was performed to examine the correlation between the MRI scoring system and clinical data, including the age, duration of RA, ESR, CRP levels and the grade of radiographic findings according to Larsen's classification system.

Results

Qualitative image analysis. In the control group knees, components of the knee joint, such as the ligaments and meniscus, were clearly detected with low intensity in the T1-weighted image (T1WI) and the T2-weighted image (T2WI). Intrameniscal signals were seen in two patients, but the signals failed to extend to the margin of the meniscus. The synovial membrane was observed at low intensity on both the T1WI and T2WI. In the case of joint effusion, it was easy to distinguish the ligaments, meniscus and synovial membrane from other tissues because the joint effusion had a very high intensity on the T2WI. The intensity of cartilage was intermediate

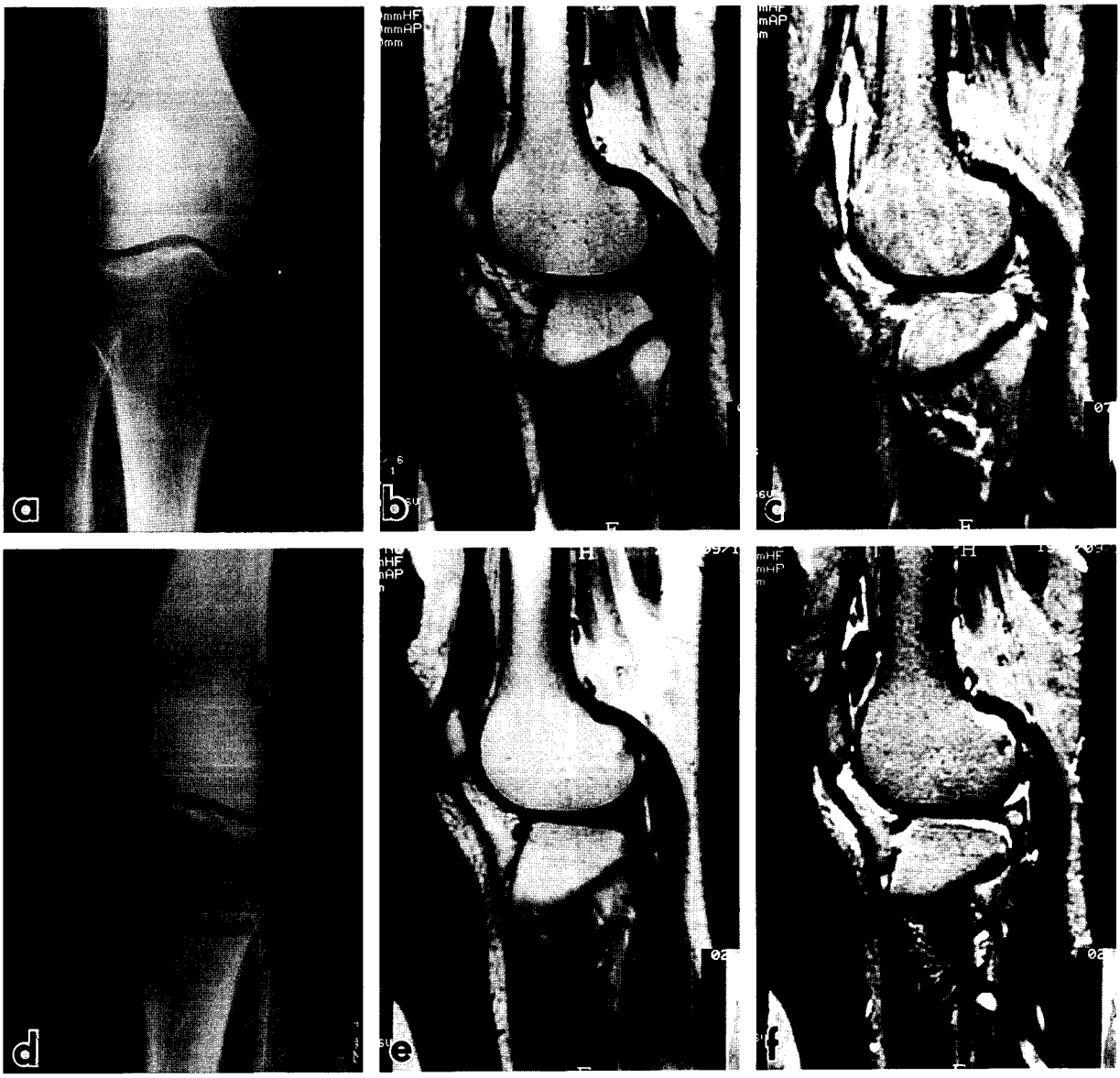

Fig. 8 The case of a 63-year-old woman who has been suffered from RA for one year and seven months.
a, **b**, **c**: Left knee; **d**, **e**, **f**: Right knee; **a**, **d**: Radiograph; **b**, **c**, **e**, **f**: MRI; **b**, **e**: T1-weighted image (T1WI); Reverse time/Echo time (TR/TE) = 500/20 ms; **c**, **f**: T2-weighted image (T2WI); TR/TE = 2300/100 ms.
The swollen suprapatellar pouch was seen on MRI. On the T1WI, two signals were detected; one was a homogeneous low intensity image and the other was a heterogeneous intermediate signal. It was thought to be a complex of effusion and synovium. On the T2WI, synovium was detected as a lower signal intensity. Joint effusion showed as a homogenous high intensity on the T2WI. Therefore, the synovial proliferation was detected more clearly because of the clear contrast.
Though bone change is rarely detected in radiographs, MRI shows severe synovial proliferation precisely. The score (right, 12; left, 9) reflects her active inflammatory state; C-reactive protein (CRP) = 4.2. RA; MRI: See Table I.

on the T1WI. It was difficult to detect the cartilage clearly on the T2WI because the signal intensity of the joint effusion and of the bone marrow fat was high. Changes in the cartilage and bone were clearly detected as compared with normal radiographs. These findings, which may indicate one of the initial signs of osteoarthritis, were observed in some cases, especially in older patients.

In RA patients, most images showed evidence of soft tissue changes: joint effusion, synovial proliferation, cartilage defects, meniscal lesions and osseous changes (irregularity, erosion, cysts). The effusion was detected as a homogeneous low intensity image on the T1WI. The synovial proliferation exhibited an intermediate signal intensity and a heterogeneous pattern image on the T1WI; this sign suggested a complex of effusion and synovial proliferation. The signal intensities for effusion and the synovial membrane were similar, but the synovial membrane image exhibited a slightly higher intensity with an irregular margin. On the T2WI, several images of synovial proliferation were detected as a lower signal intensity when compared to the joint effusion. However, the effusion signal intensity was so high that in some cases these images may be mistaken as homogenous high signal intensity images. Furthermore, the site of synovial proliferation varied substantially within an individual knee joint. Synovial proliferation was clearly detected, even when there were few bony lesions on the radiographs, especially in the suprapatellar pouch and joint space (Fig. 8). The detection rates of these items in early stages of RA were much larger than other items, suggesting these symptoms might be an initial sign of RA (Table 2).

The meniscus was detected as a low signal intensity on the T2WI. Some changes in the signal intensities were found in the meniscus. Intrameniscal high signals reached the margin of the meniscus in some cases, but were limited within the meniscus in other cases. These changes were thought to result from degenerative changes or tears. As the radiographic grade advanced, the detection rate for meniscus lesions increased (26.1 % in Grade 0; 50.0 % in Grade 1; 71.1 % in Grade 2; and 90.5 % in Grade 3) (Table 2).

Cartilage was shown as an intermediate intensity line on the T1WI. Initial changes in the cartilage were detected as irregular images. More severe changes were seen when the cartilage was covered with a synovial membrane and was eroded; this resulted in a discontinuous pattern. Cartilage irregularities were detected even in radiographic Grade 0 (60.9 % in the sagittal plane and 91.3 % in the coronal plane) (Table 2).

Bony lesions were detected as irregular margins, cyst formation or gross destruction. Bony lesions were demonstrated more clearly with MRIs than with radiographs, especially cyst formation. It is not surprising that the detection rate for bone deformities correlates to the radiographic grade (Table 2).

Table 2 The detection rate of change in each part

Items of MRI score	Control	Radiographic grade			
		Grade 0	Grade 1	Grade 2	Grade 3
Sagittal					
Synovial proliferation (suprapatellar pouch)	50.0	91.3	68.4	84.2	100.0
Synovial proliferation (intercondyle)	14.3	78.3	71.1	89.5	95.2
Meniscal degeneration	14.3	26.1	50.0	71.1	90.5
Cartilage degeneration	42.9	60.9	71.1	81.6	100.0
Bone deformity (femur)	21.4	8.7	26.3	42.1	85.7
Bone deformity (tibia)	64.3	43.5	60.5	78.9	100.0
Coronal					
Synovial proliferation	57.1	82.6	81.6	97.4	95.2
Cartilage degeneration	57.1	91.3	76.3	89.5	100.0
Bone deformity (femur)	50.0	30.4	50.0	78.9	85.7
Bone deformity (tibia)	50.0	21.7	39.5	71.1	90.5

A detection rate is calculated in each item as number of cases/total × 100. The detection rates of synoveal proliferation in early stages were much larger than other items, suggesting these symptoms might be initial change of RA. MRI; RA: See Table 1.

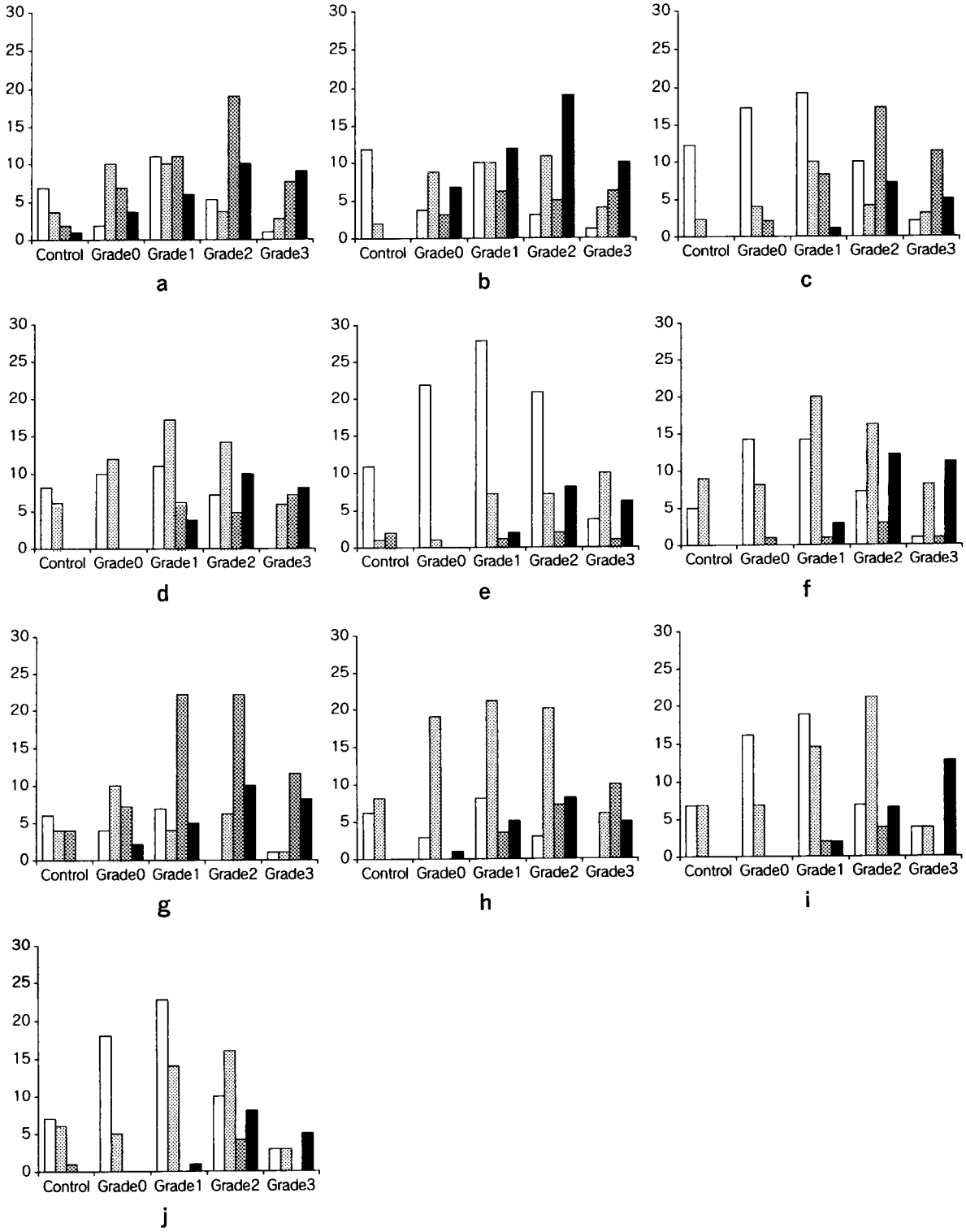

Fig. 9 The correlation between MRI scores of each item and radiographic grade.
Sagittal plane **a**: Synovial proliferation (suprapatellar pouch); **b**: Synovial proliferation (joint surface); **c**: Meniscal degeneration; **d**: Cartilage degeneration; **e**: Bone deformity of femur; **f**: Bone deformity of tibia. Coronal plane; **g**: Synovial proliferation; **h**: Cartilage degeneration; **i**: Bone deformity of femur; **j**: Bone deformity of tibia. MRI scores: ▭, score 0; ▨, score 1; ▩, score 2; ■, score 3. MRI: See Table 1.

Quantitative image analysis. The number of cases in each radiographic grade is shown in Fig. 9, and the mean total scores with the MRI scoring system are presented in Table 3. This scoring system reflected the state of RA more accurately than previous qualitative study (Table 2). In the control group, slight changes of bone destruction and cartilage degeneration were detected. Furthermore, the bone destruction score in the control group was a little higher than in the radiographic Grade 0 in the RA group. On the other hand, other scores in the RA group were much higher than in the non-RA group. The total score of the RA groups was greater than that of the control group and increased according to radiographic grades.

The average score for synovial proliferation was quite high, even in Grade 0 cases as compared with the other items: 1.57 in the suprapatellar pouch; 1.57 in the intercondyle; and 1.30 in the medial and lateral recess (Table 3). The scores for these items were also high in Grade 1 cases. Taken together these data suggest that this scoring system was sensitive enough to detect synovial proliferation in the early stages of RA. The scores for meniscal lesions increased as the radiographic grade advanced. The score for cartilage changes was also fairly high in Grade 0: 0.52 in the sagittal planes and 0.96 in the coronal. It was not surprising that the score of bone deformity increased in every section and site as the radiographic grade advanced.

There were no correlations found among total score and age or duration of RA. However, correlations were found between total score and inflammatory signs; correlation coefficient: 0.56 (*vs* CRP), 0.21 (*vs* ESR) (Fig. 10). Therefore, evaluation with this scoring system was thought to reflect inflammation. The present study consisted of 120 joints in 86 patients; 34 patients were examined bilaterally and 52 patients were examined on one side. When the patient was examined bilaterally, average score was calculated. When we examined the correlation between the averaged score and CRP level, the correlation became stronger (correlation coefficient: 0.61) (data not shown).

Discussion

RA is manifested in various tissues, especially in the synovial joints. Great differences are observed in the

Table 3 The evaluation of MRI with a scoring system

Items of MRI system	Control	Radiographic grade			
		Grade 0	Grade I	Grade 2	Grade 3
Sagittal					
Synovial proliferation (supratellar pouch)	0.79	1.57*	1.32	1.89**	2.19**
Synovial proliferation (intercondyle)	0.14	1.57**	1.53**	2.05**	2.19**
Meniscal degeneration	0.14	0.35	0.76*	1.55**	1.90**
Cartilage degeneration	0.43	0.52	1.08**	1.45**	2.10**
Bone deformity (femur)	0.36	0.04	0.39	0.92	1.43**
Bone deformity (tibia)	0.64	0.43	0.82	1.53**	2.05**
Coronal					
Synovial proliferation	0.86	1.30	1.66**	2.11**	2.24**
Cartilage degeneration	0.57	0.96*	1.16*	1.53**	1.95**
Bone deformity (femur)	0.50	0.30	0.66	1.24**	2.05**
Bone deformity (tibia)	0.57	0.22	0.45	1.26*	2.29**
Total	5.00	7.26*	9.83*	15.53**	20.39**

All figures in table indicate the mean total scores with MRI. Each score of each radiographic grade is compared with that of control. * $P < 0.05$, ** $P < 0.01$ (*vs* control). MRI: See Table 1.

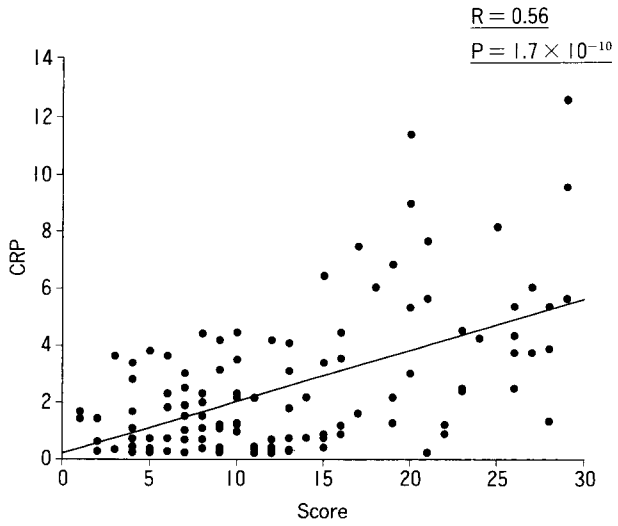

Fig. 10 The correlations between MRI scores and CRP. A correlation was shown in the inflammation state (correlation coefficient; Score & CRP: 0.56). CRP: See legend to Fig. 8.

progression of RA in individual patients. Some patients progress to very severe degrees, whereas others have almost no complaint of joint pain for a long time. The dysfunction accompanying the progression of RA disturbs the quality of life, and the aim of treatment is to prevent this progression. For these reasons, estimating the severity of the symptoms, especially synovial inflammation and bony destruction, is very important in the evaluation of patients with RA. Plain radiographs have been traditionally used for this evaluation (8–10). However, they can only detect late bony changes and cannot visualize early soft tissue lesions of RA such as swelling, proliferative granulation tissues and changes in the cartilage, meniscus and ligaments. Therefore, it is difficult to gauge the early phases of RA with only radiographs. Various imaging methods (computed tomography, ultrasonography, scintigraphy, thermography, etc.) have been applied to evaluate these soft tissue lesions (4–7), but these methods cannot detect soft tissue lesions fully and are not widely used. Recently, MRI has been used and now plays an important role in the assessment of arthritic disorders (23–25). MRI has several great advantages: its non-invasiveness; ability to represent changes in the soft tissues, especially in the synovial membrane, ligament, meniscus and cartilage; and the ability to choose optimal planes without patient position changes.

One of the most important reasons for using MRI in RA patients is the assessment of early synovial proliferation. However, there was a technical difficulty in this assessment because it was hard to discriminate between joint effusion and the synovial membrane in some cases. Certainly, the signal intensities of effusion and the synovial membrane were similar, but images of the synovial membrane exhibited a slightly higher intensity and irregular margins on the T1WI. The rheumatoid synovial membrane can be detected in various ways. Generally, synovial proliferation begins from the edges and grows progressively towards the center. As it progresses, the mass of the synovial membrane becomes thickened and covers the joint surface. In the final stages, the joint space is filled with the synovial tissue. However, substantial variation is still observed within the joints of various regions. Synovial proliferation was detected especially in the suprapatellar pouch and the joint surfaces (Tables 2 and 3). Therefore, it was thought that these regions were the most suitable for observing the initial synovial proliferation, because these spaces are wide and, thus, make it easier to detect small lesions. On the T2WI, several images representing synovial proliferation were detected as a lower signal intensity. Joint effusion showed as a homogenous high intensity on the T2WI. Discriminating between these two was easy because of the clear contrast.

Several studies have demonstrated the effectiveness of gadolinium-containing compounds (for example Gd-DTPA) in the MR imaging of inflammatory soft tissue changes (30–33). We have taken several MR images using Gd-DTPA, and certainly the distinction was easier in some cases because the active synovitis was enhanced. However in other cases, the synovitis was not enhanced. König reported the signal changes with time in knee MR images (31). Østergaard (33) and Björkengren (34) reported a difference following enhancement by gadolinium compounds, which indicated a clear distinction between active and inactive synovitis. They mentioned that early signal enhancement reflects perfusion and capillary permeability. Although the early signal enhancement may represent RA activity, the enhancement on the late images was thought to be dependent on the volume of the extracellular space. Therefore, interpreting MR images is complicated, and the exposure time to gadolinium compounds requires careful consideration. The argument still continues over the leakage of gadolinium compounds and the enhancement of MRI.

The control and treatment of RA almost always extends over long periods of time. Our intention is to

examine the state of RA daily under uniform conditions. Therefore, the diagnosis method should be cost efficient and be well-established. MRI is best suited for this purpose. The aim in using MRI on RA patients is to evaluate the state of the patients, to follow the advancement of this disease and to quantitate the response to treatment during the patients whole life. However there are some difficulties in using Gd-DTPA, because the injection of Gd-DTPA is painful and has some kinds of risks like allergic reaction. Furthermore, the assessment of the enhancement by using Gd-DTPA is still controversial. For these reasons, the assessment of RA should be convenient and suitable for all cases, and therefore, this study utilized MRI without enhancement.

Irregularity in the cartilage and bone were detected more clearly by MRI than by radiographs, and thus, it is not surprising that the detection rate was correlated to the radiographic grade. As the radiographic advancement increased, the detection rate for meniscus lesions also increased. These results were in close agreement with the evaluation using this scoring system; the score increased as the RA advanced. In the control group, the score was a little greater than in the early stage of RA. It was thought that this evaluated score might be due to the initial change of osteoarthritis.

Meniscus lesions were detected as intrameniscal signals. In some cases, the signal reached the margin of the meniscus. The former findings were thought to represent degeneration, whereas the latter suggested a tear of the meniscus. The score for the meniscus lesion increased as the radiographic grade advanced. Although there have been many reports on the accuracy of MRI for the diagnosis of meniscal lesion (13-19, 35-37), further examination will be necessary.

A more definitive analysis is available to us through MRI for examining soft tissue lesions. A few reports have been published regarding synovitis in RA patients, but most of them only refer to image findings using different kinds of methods (25, 30-33). That is to say, they analyzed the images qualitatively and their chief object was to find the best way to detect synovitis.

There have been few reports on the quantitative analysis of MRI in RA patients. Østergaard and coworkers reported a scoring system for membrane hypertrophy and bone erosions in the rheumatoid wrist (29). The wrist was divided into 6 regions, and the synovial lesions were classified into 4 grades. We used this MRI scoring system as a quantitative analysis method in this study. We divided the MRI into 10 items in order to examine the various tissues and their corresponding areas. Each part was classified into four grades, and each grade was scored (Figs. 1-7 and Table 1).

With this scoring system, we could assess the condition of RA patients more clearly (Table 3). Even in the early stages, the score for synovial proliferation was much larger than for the other items. This suggests that synovitis is the initial change seen in RA. Besides this initial sign, we could detect two other patterns in RA patients with this system. It is commonly accepted that synovitis occurs first, and then the cartilage and bone are invaded by the synovitis. However, there is quite a difference between synovitis and bony destruction in individual patients. In some patients, the bony destruction is severe, but the synovitis is slight. In other patients, the bone is barely affected, but the synovitis is severe. The former is known as the " burn out " stage. The presence of this stage may be a good indication for arthroplasty in several cases. The latter case is very important in the early evaluation of RA because this means that there is active synovitis present. Therefore, we should pay more attention to the synovitis in order to prevent the rapid progression of RA by proper early treatment.

Furthermore, we can evaluate each item individually with this scoring system. In this study, a different pattern was shown for synovial proliferation. The number of severe cases increased gradually for every item, except for synovial proliferation as the radiographic grade increased (data not shown). In the synovial proliferation item, the number of cases with slight changes was larger in Grade 0 than in Grade 1 (Fig. 11). These data suggest that the synovial tissue is involved even in the absence of radiographic findings and that whenever slight changes are evident, the synovial proliferation may be severe beyond expectation.

Therefore, we conclude that this system yields more useful information than radiographic grading and is beneficial for long-term follow-up on these patients. The advantages of this system are as follows: (a) It will prove to be very useful for assessing the effects of treatment during a longitudinal follow-up because it is easy to evaluate the patient's state, especially in soft tissue lesions; (b) It can also be divided into several optional parts, for example, when information is required during the early stages of RA, it can be applied to the soft tissues (synovial membrane, cartilage and meniscus); and

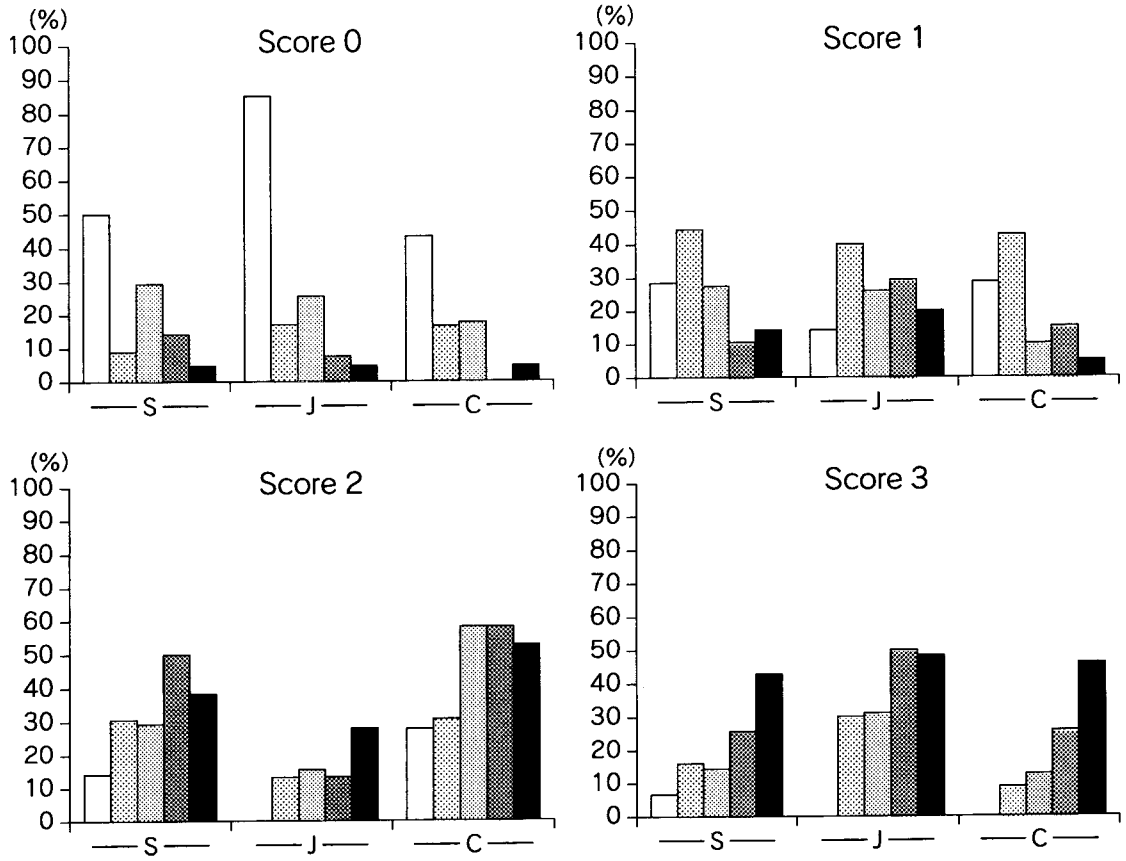

Fig. 11 The correlation between radiographic grades and MRI scores of synovial proliferation. S: Suprapatellar pouch, J: Joint surface, C: Coronal plane. Radiographic grades: ▭, control; ▒, Grade 0; ▒, Grade 1; ▒, Grade 2; ■, Grade 3. MRI: See Table 1.

(c) Scores from this system correlate slightly with inflammatory signs (CRP), and it is believed that this score is a good reflection of disease activity. Although the correlation scores were small, the CRP correlation fell within an acceptable range for validation.

Our goal is to follow the advancement of this disease and to quantitate the response to treatment. MRI is one of the most sensitive diagnostic methods and yields valuable information. It is very important to optimize the use of MRI in monitoring the progress in RA patients. We demonstrated a method of evaluating MRIs of RA patients by scoring the level of severity. We believe that with this system, it is possible to estimate the physical condition of the RA disease. In the future, new methods may be developed and applied to RA patients, for example new imaging techniques and new enhancement methods that have no harmful side effects. Even then, this qualitative image analysis system can still be applied to the sagittal and coronal planes and will be useful for monitoring RA treatment.

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