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# Ultrasonographic evaluation of synovial effusion and synovial proliferation pattern in the knee joints of patients with rheumatoid arthritis

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**Abstract** In the present study, 49 knee joints of 26 patients with rheumatoid arthritis and 17 knee joints of 17 healthy subjects were ultrasonographically examined. Lateral, superior, and medial aspects of the patella were scanned using an ultrasonograph with a 7.5-MHz annular array transducer to evaluate the thickness of synovial effusion and the synovial proliferation pattern. The overall mean thickness of synovial effusion (mean of all three sites) in the knee joints was 4.9 ± 3.4 mm for rheumatoid arthritis patients and 1.4 ± 0.5 mm for healthy subjects. In rheumatoid arthritis patients, the mean thickness of synovial effusion at the superior aspect of the patella (6.5 ± 4.1 mm) was significantly greater than that at the lateral aspect (4.5 ± 4.8 mm) ($P < 0.05$) and the medial aspect (4.0 ± 3.1 mm) ($P < 0.01$). Patients with the villonodular pattern of synovial proliferation had a shorter duration of disease than those with uniform thickening or an overlapping pattern.

**Key words** Knee joint · Rheumatoid arthritis (RA) · Synovial effusion · Synovial proliferation pattern · Ultrasonography

## Introduction

There have been several reports of studies in which ultrasonographic images of synovial effusion and synovial proliferation in the joints of patients with rheumatoid arthritis (RA) were obtained using ultrasonography with high-frequency transducers.[1–8]

Ultrasonographic detection of differences in the thickness of synovial effusion in the knee joints of RA patients by scanning at different sites has not previously been clearly demonstrated. In the present study, we calculated the thickness of the synovial effusion layer at the lateral, superior, and medial aspects of the patella using the measurement scale on the ultrasonograph. We compared the thickness of the synovial effusion at these three sites and assessed the correlation between the thickness of the synovial effusion and clinical data.

Synovial proliferation is one of the characteristic features of rheumatoid arthritis. Several diagnostic techniques have been used to clinically detect synovial proliferation in the knee joints: arthroscopy,[1,6] magnetic resonance imaging (MRI),[9,10] color doppler ultrasonography,[11,12] and conventional ultrasonography.[1,4,6,13] We ultrasonographically evaluated patterns of synovial proliferation in the knee joints of RA patients and compared them with their clinical data and the thickness of their synovial effusion.

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## Materials and methods

### Patients

Twenty-six patients with RA (4 men and 22 women; mean age, 54.3 years; age range, 23–80 years) treated for rheumatic diseases at the outpatient clinic of Ohta Nishinouchi Hospital or admitted to that hospital's Division of Rheumatology were enrolled in the study. Diagnosis of rheumatoid arthritis was made according to the revised American Rheumatism Association (ARA) 1987 criteria.[14] As a control group, 17 healthy staff members (1 man and 16 women; mean age, 43.2 years; age range, 26–65 years) of Ohta Nishinouchi Hospital were also enrolled.

### Laboratory tests

C-reactive protein (CRP) levels and erythrocyte sedimentation rates (ESR) of the patients were assayed.

### Ultrasonography

We used an ultrasonograph (Sonolayer SSA-250 A; Toshiba, Tokyo, Japan) with a 7.5-MHz annular array

transducer or a 12-MHz linear transducer. During scanning, the knees were kept in a slightly bent position by placing a rolled-up towel under the knee of each subject as they lay on the bed in a supine position. Images of the knee ultrasonography could be variable, depending on the place where the transducer was attached and on the pressing tension of the transducer upon the target tissues. We selected scanning sites based on ease of detection of synovial effusion and chose the lateral, superior, and medial aspects of the patella. The lateral and medial aspects were scanned longitudinally and the superior aspect was scanned transversely (Fig. l). For each site, maximum thickness of nonechogenic images, which likely indicated synovial effusion, was calculated using a built-in measurement scale on the ultrasonograph. Positive indication of synovial proliferation was defined as homogeneous, moderately highly echogenic areas in the synovial effusion layer.

Intensity of the synovial proliferation is generally more severe around the synovial capsules than at the femur surface. In the present study, however, the homogeneous, moderately highly echogenic images attached to the very highly echogenic images of the femur surface were evaluated as synovial proliferation because of their easier development on ultrasonography. The patterns of synovial proliferation on the ultrasonogram were classified, according to the system devised by Rubaltelli et al.,[1] as villonodular (VN), uniform thickening (UT), or overlapping (OL).

Figure 2 contains examples of these three patterns. The pattern of synovial proliferation of an individual patient was defined as the pattern that showed overall predominance at six scanning sites (in the 23 patients who underwent bilateral knee scans) or three scanning sites (in the 3 patients who underwent unilateral knee scan). The ultrasonographic images were assessed in an agreement on the observation by two rheumatologists experienced in ultrasonography (R. Kasukawa and I. Takeda). Ultrasonographic images of the knee joints were reproducible whatever the scanning site and scanning direction, and the pressing tension of the transducer was set in an established way and also tested by well-trained examiners using the same transducer and ultrasonograph.

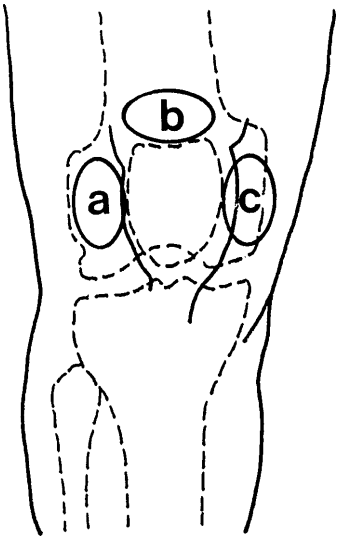


**Fig. 1.** Scanning sites of the right knee: *a*, longitudinal scan at the lateral aspect of the patella; *b*, transverse scan at the superior aspect of the patella; *c*, longitudinal scan at the medial aspect of the patella

### Statistical analysis

Statistical analysis was performed using a Stat View J-5.0 software package for the Apple Macintosh. The chi-square test was used for analysis of correlation between results.

## Results

Ultrasonographic images of the left knee joint of a 58-year-old female RA patient are shown in Fig. 3. Nonechogenic fluid layers above the femur surface were clearly visualized at the lateral (a), superior (b), and medial (c) aspects of the patella. The thickness of the effusion layer at these three sites was 4.7, 10.0, and 5.6 mm, respectively. The thickness

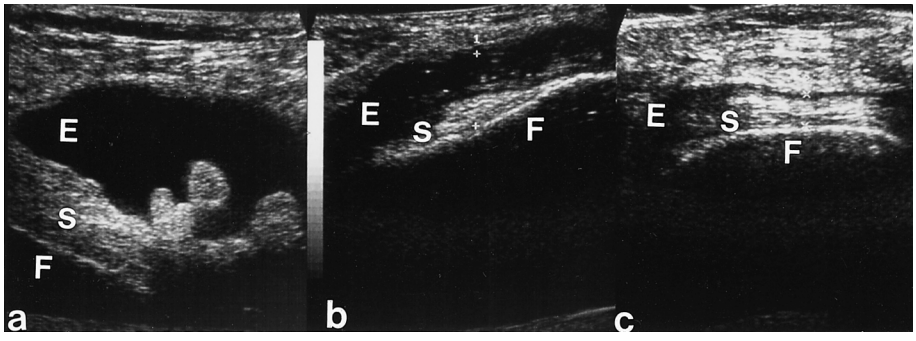


**Fig. 2.** Patterns of synovial proliferation(s) in the knee joints of rheumatoid arthritis (RA) patients. **a** Synovial proliferation with villonodular pattern observed on a longitudinal scan at the lateral aspect of the patella in the right knee of a 35-year-old male patient. **b** Synovial proliferation with uniform thickening pattern observed on a longitudinal scan at the medial aspect of the patella in the left knee of a 52-year-old female patient. **c** Synovial proliferation with overlapping pattern observed on a transverse scan at the superior aspect of the patella in the left knee of a 65-year-old female patient. *E*, synovial effusion; *F*, femur surface

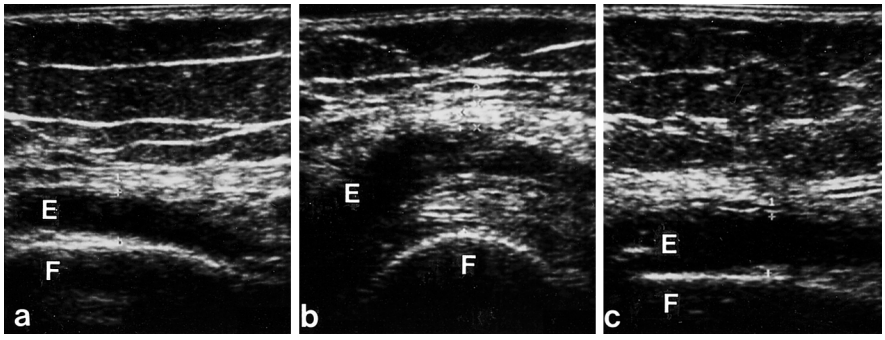


**Fig. 3.** Ultrasonographic images of the left knee joint of a 58-year-old female RA patient scanned at the lateral (longitudinally) (**a**), superior (transversely) (**b**), and medial (longitudinally) (**c**) aspect of the patella. Thickness of the nonechogenic synovial effusion (*E*) layer above the femur (*F*) at sites **a**, **b**, and **c** was 4.7, 10.0, and 5.6 mm, respectively

**Table 1.** Thickness of synovial effusion in knee joints shown by ultrasonographic scans at lateral, superior, and medial aspect of the patella in patients with rheumatoid arthritis (RA) and healthy subjects

| Subjects | No. of joints | No. of patients | Thickness of effusion (mm) | | | |
|---|---|---|---|---|---|---|
| | | | Lateral aspect | Superior aspect | Medial aspect | Mean |
| RA patients | 49 | 26 | 4.5 ± 4.8 | 6.5 ± 4.1 | 4.0 ± 3.3 | 4.9 ± 3.3 |
| | | | * | ** | | |
| Healthy subjects | 17 | 17 | 1.0 ± 0.6 | 1.8 ± 0.9 | 1.4 ± 0.5 | 1.4 ± 0.5 |

Data are mean ± SD
* $P < 0.05$; ** $P < 0.01$

of the nonechogenic fluid layers (mean ± SD) at these three sites in the 49 knee joints of 26 RA patients is presented in Table 1, along with values for 17 joints in 17 healthy subjects. In RA patients, the mean thickness at the superior aspect of the patella (6.5 ± 4.1 mm) was significantly greater than that of the lateral aspect (4.5 ± 4.8 mm) ($P < 0.05$) and the medial aspect (4.0 ± 3.3 mm) ($P < 0.01$). No significant difference in the mean thickness was observed between the lateral and the medial aspect of the patella. All three values were significantly greater than those of healthy subjects ($P < 0.001$). The overall mean thickness of synovial effusion (mean of all three sites) in RA patients (4.9 ± 3.3 mm) was significantly greater than that of healthy subjects (1.4 ± 0.5 mm) ($P < 0.01$). Synovial effusion more than 1.9 mm in thickness (mean + SD value of the healthy subjects) was evaluated as positive accumulation, and its frequency in RA patients was 43 of 49 joints (87.8%). The values of thickness of synovial effusion did not show significant correlation with the duration of the disease or with the values of CRP and ESR (data not shown).

Homogeneous and moderately highly echogenic images, likely indicating proliferation of synovium, were found in 39 of the 49 RA joints (79%). The difference in frequency of the synovial proliferation among the three scanning sites of the knee joints was not precisely evaluated. In general, the synovial proliferation was ultrasonographically found more frequently at the lateral and superior aspect than at the medial aspect of the patella. Representative images of the three patterns of synovial proliferation are shown in Fig. 2: Fig. 2a shows synovial proliferation with a villonodular pattern found in a 35-year-old male patient, Fig. 2b shows synovial proliferation with a uniform thickening pattern found in a 52-year-old female patient, and Fig. 2c shows synovial proliferation with an overlapping pattern found in a 65-year-old female patient. The summarized clinical findings and mean thickness of synovial effusion, classified according to pattern of synovial proliferation, are shown in Table 2. The breakdown of patterns of synovial proliferation was as follows: VN, 3 patients (5 joints); UT, 8 patients (14 joints); OL, 10 patients (20 joints). Patients with VN proliferation had a significantly shorter disease duration (3.2 ± 2.7 years) than patients with UT (10.5 ± 13.1 years) ($P < 0.05$) or OL (13.1 ± 12.8 years) ($P < 0.01$) proliferation. The patterns of synovial proliferation did not show significant correlation with CRP levels, ESR, or the mean thickness of synovial effusion.

## Discussion

Few ultrasonographic studies have included quantitative estimation of synovial effusion in the knee joints. Rubaltelli et al.[1] established four grades of thickness of synovial effusion: 0 (less than 1 mm), 1 (1–4 mm), 2 (5–7 mm), and 3 (8 mm or greater). Hauzeur et al.[8] classified the level of accumulated fluid into three grades: 0 (negative), 1 (moderate), and 2 (large). The precise volume of synovial effusion in the knee joints is difficult to calculate clinically. In the present study, values of thickness of synovial effusion obtained at three scanning sites were compared. We found that synovial effusion in the knee joints of both RA patients and healthy subjects was thickest at the superior aspect of the patella. This finding is consistent with those of previous

**Table 2.** Clinical findings and thickness of synovial effusion in RA patients with villonodular, uniform thickening, or overlapping patterns of synovial proliferation in the knee joints

| | Synovial proliferation patterns | | |
|---|---|---|---|
| | Villonodular | Uniform thickening | Overlapping |
| No. of patients | 3 | 8 | 10 |
| No. of joints | 5 | 14 | 20 |
| Duration of disease (year) | 3.2 ± 2.7 * | 10.5 ± 13.1 | 13.1 ± 12.8 |
| | ** | | |
| CRP (mg/dl) | 3.6 ± 2.1 | 3.1 ± 2.7 | 3.8 ± 3.6 |
| ESR (mm/h) | 50.6 ± 48.0 | 43.6 ± 37.6 | 46.6 ± 31.0 |
| Thickness of synovial effusion (mm) | 9.6 ± 5.9 | 4.9 ± 2.7 | 5.0 ± 2.4 |

Data are mean ± SD
CRP, C-reactive protein; ESR, erythrocyte sedimentation rates
* $P < 0.05$; ** $P < 0.01$

reports, in which investigators found the superior aspect of the patella to be the site at which small amounts of knee joint effusion could be most easily detected.[3,6] Determining the thickest site of the synovial effusion in the knee joints of the RA patients helps to decide the puncture site for the fluids. However, Rubaltelli et al.[1] found no significant difference in thickness of synovial effusion among these three sites. The discrepancy between the results of that study and the present results might be attributable to the difference in bending angle of the knee during scanning and scanning direction (longitudinal or transverse). We believe that quantitative evaluation of synovial effusion in RA patients will likely become a valuable method of estimating the clinical grade of arthritis in the individual joints of patients and monitoring the effects of treatment, despite the fact that thickness of synovial effusion did not correlate significantly with CRP levels or ESR in the present study.

Arthroscopy has greatly contributed to clinician ability to visualize synovial proliferation in knee joints, and arthoscopic images of synovial proliferation in RA patients have been favorably compared with ultrasonograms.[1,6] Recently, color doppler ultrasonography has been used to visualize panni in the knee joints of RA patients.[11,12] We assume that homogeneous, moderately echogenic substances with a clear margin attached to the bone surface indicate synovial proliferation in the knee joints. In the present study, we evaluated patterns of synovial proliferation according to the classification system of Rubaltelli et al.[1] The patients with the VN pattern of synovial proliferation had significantly shorter disease duration. This finding contradicts results reported by Fiocco et al.[4] and Batalov et al.[15]: they found disease duration of patients with VN, UT, and OL proliferation to be roughly equal. Prospective studies with greater numbers of patients are needed to determine whether patients with the VN pattern of synovial proliferation have shorter disease duration.

In the present study, no significant correlation was found between synovial proliferation pattern and thickness of synovial effusion, a finding similar to that of Fiocco et al.[4] Walther et al.[12] recently reported finding no significant correlation between degree of synovial proliferation and degree of synovial effusion. In conclusion, ultrasonography is an easy and effective method of estimating small amounts of synovial effusion and evaluating degree and pattern of synovial proliferation in the knee joints of RA patients.

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