

Ultrasonography Is Superior to Clinical Examination in the Detection and Localization of Knee Joint Effusion in Rheumatoid Arthritis

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ABSTRACT. Objective. Musculoskeletal ultrasonography allows real-time imaging of joint structures and may be used to complement clinical examination in rheumatological practice. We compared ultrasonography (US) with clinical examination (CE) in the detection of effusion, suprapatellar bursitis, and Baker's cyst of the knee in rheumatoid arthritis (RA) in order to determine whether US provided additional clinical information.

Methods. A total of 22 patients with RA (ACR criteria) underwent independent clinical and US examination of both knees for suprapatellar bursitis, knee effusion, and presence of Baker's cyst. US was performed using an ATL HDI 3000 machine with L7-4 MHz and CL10-5 MHz probes. Clinical examination was performed using standard techniques by an experienced rheumatologist. Patients with previous knee surgery were excluded from the study.

Results. A total of 44 knees were examined at a total of 130 sites (one patient was unable to lie prone for US of popliteal fossae). US detected soft tissue abnormality (suprapatellar bursitis, knee effusion, or Baker's cyst) at 54/130 (42%) sites, while CE detected soft tissue abnormality at 36/130 (28%) sites. US detected 17 (39%) cases of suprapatellar bursitis in 44 knees, 7 (16%) of which were detected on CE. US detected 27 (61%) knee joint effusions in 44 knees, 16 (36.36%) of which were detected on CE. US detected 10 (23.81%) Baker's cysts in 42 knees, 2 (4.76%) of which were detected on CE. Taking US of the knee as the gold standard, CE was specific but not sensitive in the detection of soft tissue abnormality of the knee in RA.

Conclusion. US is more sensitive than CE in the detection of suprapatellar bursitis, knee effusion, and Baker's cyst in RA. CE underestimates knee inflammation in RA. This has implications for the use of CE as a component of standardized disease activity scores and in guiding knee joint aspiration. (J Rheumatol 2003;30:966-71)

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RHEUMATOID ARTHRITIS

KNEE

Rheumatoid arthritis (RA) is a chronic, systemic inflammatory disease with a prevalence of 0.8% in Caucasian adults. Joint inflammation is characterized by synovial proliferation and joint effusion with subsequent bony erosion and cartilage damage¹. Early diagnosis of joint inflammation and early institution of immunosuppressive drug treatment — targeted at reducing synovial inflammation — is now being advocated in order to prevent subsequent joint damage and disability². While a number of measures are applied in the diagnosis of joint inflammation in RA, the decision to implement and adjust disease modifying drug therapy is heavily influenced by the presence of synovitis on clinical examination.

The knee joint is commonly involved in RA and the diagnosis of synovial inflammation and joint effusion of the knee is usually made on clinical examination. Current techniques of clinical examination may underestimate significant knee joint inflammation³⁻⁵ and histological evidence of synovial inflammation has been reported in asymptomatic knee joints in RA⁶. This may lead to delayed diagnosis and treatment of joint inflammation or suboptimal suppression of joint inflammation with immunosuppressive therapy.

The application of ultrasonography (US) in musculoskeletal disease is of increasing interest to rheumatologists⁷⁻⁹. US readily reveals soft tissue inflammation of joints and is inexpensive, safe (uses no ionizing radiation), and noninvasive. Routine correlation of US with clinical examination by the rheumatologist may also improve clinical examination skills. US examination of the knee correlates with macroscopic synovial inflammation visualized at arthroscopy¹⁰ and with magnetic resonance imaging (MRI) of synovitis¹¹. Initial studies suggest that it may be superior to clinical examination in the detection of soft tissue inflammation of the knee³⁻⁵. In pauciarticular juvenile idiopathic arthritis, ultrasonography of the knee revealed effusion or

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synovial thickening in 7 of 9 clinically silent knees⁵. The implementation of ultrasonography in routine clinical practice in rheumatology also has been reported to have a significant effect on clinical decision making. In a series of 100 patients attending the rheumatology outpatient clinic, examination of a wide range of joints by US led to alteration of the anatomical diagnosis in 52% of patients. Further, the routine use of US in the rheumatology clinic led to the detection of extensive subclinical synovitis and the initiation of immunosuppressive therapy in 12% of patients¹².

Studies of US of the knee have included a wide range of disease categories or have focused on the detection of Baker's cyst alone in RA^{4,13}. We compared US with clinical examination — performed by 2 blinded observers — in the detection of effusion, suprapatellar bursitis, and Baker's cyst of the knee joint in 22 consecutive patients with RA. Our aim was to determine whether US provided additional clinical information that may influence the management of knee inflammation in RA.

MATERIALS AND METHODS

Patients. Patients satisfying the American College of Rheumatology criteria (1987) for the diagnosis of RA were assessed during consecutive, routine presentations to the rheumatology outpatient clinic. Patients with previous joint surgery of the knee or who had received corticosteroid injection of the knee within the previous 6 weeks were excluded.

Clinical examination. The knee was examined in both lower limbs of each patient with the patient lying supine with the knee in both a neutral position and flexed at 30°. Clinical examination for tenderness and swelling at each site was performed by an experienced rheumatologist (over 6 years clinical rheumatology practice) according to standard techniques¹⁴. Suprapatellar bursitis was diagnosed if swelling (loss of normal suprapatellar contour) was present in the suprapatellar compartment of the knee. A knee effusion was diagnosed if fluctuant fluid was observed in either the medial or lateral compartment of the knee or if a patellar tap was demonstrated. A Baker's cyst was diagnosed if swelling or tenderness on palpation was observed in the popliteal fossa or medial head of the gastrocnemius muscle.

Ultrasound evaluation. The clinical examination and US measurements were performed separately, one immediately after the other, by different investigators, who were blinded to the clinical details of the patient and to each other's findings. Real-time US was performed by an experienced rheumatologist with over 10 years' experience in musculoskeletal ultrasonography, using an ATL (Seattle, WA, USA) HDI 3000 machine with L7-4 MHz and CL10-5 MHz probes. US examination of the suprapatellar, medial, and lateral compartments of the knee was performed with the patient in the supine position with the knee flexed at 30°. The popliteal fossa and the calf musculature were examined with the patient lying prone on the examination table. If the patient was unable to lie prone this area was not examined due to failure to maintain a standardized imaging protocol. The suprapatellar and popliteal sites were examined in both sagittal (longitudinal) and transverse axes and the medial and lateral sites were examined in the transverse axis through the edge of the patella and femur. Representative images are given in Figure 1.

Ultrasonographic assessment of joint effusion or bursitis was recorded at each site. Suprapatellar bursitis was defined as a well circumscribed, localized anechoic or hypoechoic area at the suprapatellar bursa of the knee that was compressible by the transducer. Bursal dimensions were obtained in long and short axis with a normal bursa being < 2 mm in short axis¹⁵. A knee effusion was present if hypoechoic fluid compressible by the transducer was found in either medial or lateral compartments of the knee. A

Baker's cyst was defined as a well circumscribed, localized anechoic or hypoechoic area lying adjacent to the medial head of the gastrocnemius and communicating with the knee joint by a neck lying between the medial head of gastrocnemius and semimembranosus. Bursal dimensions were obtained in long, short, and transverse axis, a normal gastrocnemius-semimembranosus bursa being < 2 mm in short axis. The volume of a Baker's cyst was calculated as follows: long axis × short axis × transverse axis. Sonographic images were stored on magneto-optical disks for offline analysis.

Statistical analysis. Values are given as median except when data are normally distributed and mean value is given. Statistical analysis was performed using Statview software. Sensitivity, specificity, negative and positive predictive value, and false negative and false positive rates of clinical examination were also calculated.

RESULTS

Patients. In total 22 patients (20 female, 2 male) with RA were examined. The mean age was 50.2 years (SD 15.83, range 25–79), mean disease duration 10.5 years (SD 7.8, range 1.5–33); 16 (73%) were seropositive for rheumatoid factor, 19 were taking disease modifying antirheumatic drug therapy. No patient had previous knee surgery or intraarticular injection of the knee in the preceding 6 weeks.

Examination of the knee. Forty-four knees were examined clinically and ultrasonographically for suprapatellar bursitis, knee effusion, and Baker's cyst. One patient was unable to lie prone for US examination of the knees and the results of clinical or ultrasound examination of this patient's popliteal fossae are not included in the final analysis.

Clinical examination of the knee. On clinical examination, suprapatellar bursitis was diagnosed in 10/44 (23%) knees, knee effusion was present in 22/44 (50%) knees, and Baker's cyst was present in 4/42 (10%) knees.

Ultrasonography of the knee. On US examination, suprapatellar bursitis was diagnosed in 17/44 (39%) knees, knee effusion was present in 27/44 (61%) knees, and Baker's cyst was present in 10/42 (24%) knees.

Suprapatellar bursitis. Suprapatellar bursitis was associated with knee joint effusion in 14 (83%) of 17 knees.

Knee effusion. A total of 27 knees were found to have a joint effusion on US examination. The effusion was present in the medial compartment alone in 2/27 (7.41%) knees, in the lateral compartment alone in 5/27 (18.52%) knees, and in both medial and lateral compartments in 20/27 (74.07%) knees.

Baker's cyst. Eight (80%) Baker's cysts were associated with joint effusion. The volumes of the 2 clinically detected Baker's cysts were 8.79 and 6.72 cm³. The median volume of the clinically undetected Baker's cysts was 3.77 cm³ (range 0.96–31.35 cm³). Three clinically undetected Baker's cysts had a greater volume than the clinically detected cysts (Figure 2).

Comparison of clinical and US examination in detection of soft tissue inflammation of the knee. The comparison of clinical examination and US are given in Table 1. Clinical

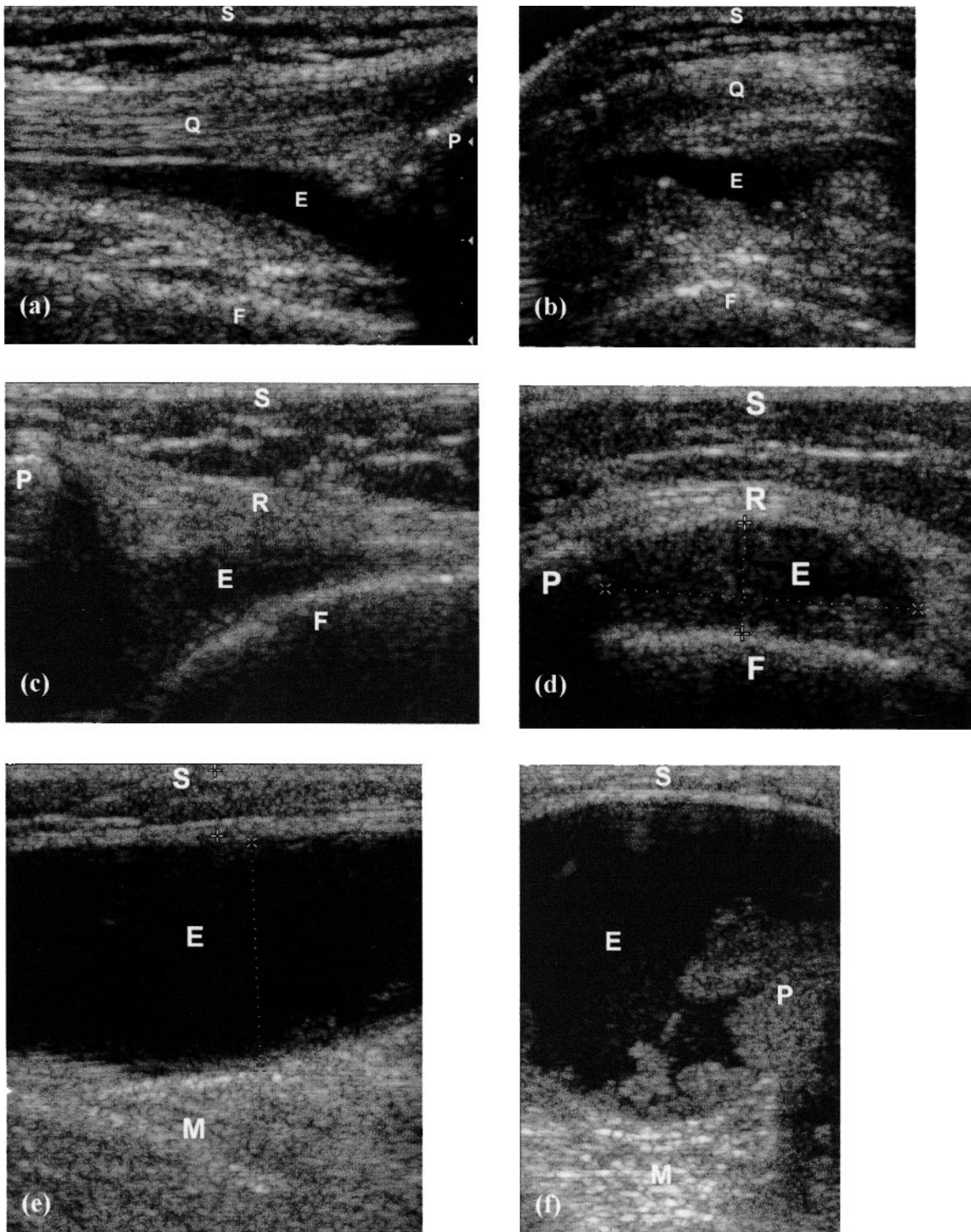


Figure 1. (a) Sagittal (longitudinal) view of suprapatellar bursitis: Effusion (E) is present between skin (S) and quadriceps tendon (Q) inserting into superior pole of the patella (P) above and femur (F). (b) Transverse view of suprapatellar bursitis in the same patient. (c) Transverse view of medial compartment effusion: Effusion (E) surrounded by synovial proliferation is present between skin (S) and medial retinaculum (R) above and is bounded by the patella (P) to the left and the femur (F) to the right. (d) Transverse view of lateral compartment effusion: Effusion (E) is present between skin (S) and lateral retinaculum (R) above and is bounded by the patella (P) to the left and the femur (F) below. (e) Sagittal view of Baker's cyst: Effusion (E) is present between skin (S) above and is bounded by the gastrocnemius muscle (M) below; the irregular inferior border of the cyst is due to synovial proliferation. (f) Transverse view of Baker's cyst: Effusion (E) is present between skin (S) above and is bounded by the gastrocnemius muscle (M) below. There is pannus (P) in the body of the cyst.

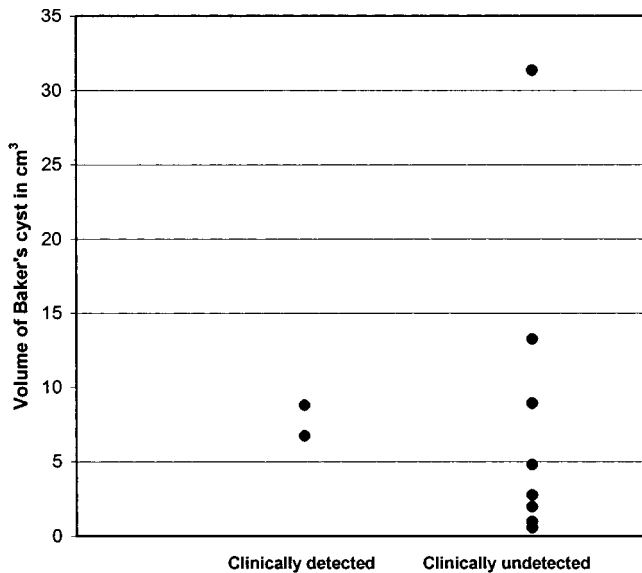


Figure 2. Comparison of US measured volumes of Baker's cysts detected on clinical examination with those not detected at clinical examination.

Table 1A. US and clinical examination in the detection of suprapatellar bursitis of the knee in 22 patients with RA.

Suprapatellar Bursitis	Ultrasound Examination		Total
	Positive	Negative	
Clinical examination			
Positive	7	3	10
Negative	10	24	34
Total	17	27	44

Table 1B. US and clinical examination in the detection of knee effusion in 22 patients with RA.

Knee Effusion	Ultrasound Examination		Total
	Positive	Negative	
Clinical examination			
Positive	16	6	22
Negative	11	11	22
Total	27	17	44

Table 1C. US and clinical examination in the detection of Baker's cyst of the knee in 21 patients with RA.

Baker's Cyst	Ultrasound Examination		Total
	Positive	Negative	
Clinical examination			
Positive	2	2	4
Negative	8	30	38
Total	10	32	42

examination detected 7/17 (41%) cases of suprapatellar bursitis that were detected on US, 16/27 (59%) knee effusions, and 2/10 (20%) Baker's cysts.

Sensitivity and specificity of clinical examination. The sensitivity and specificity of clinical examination compared to US are presented in Table 2. Clinical examination was moderately specific but was not sensitive in the detection of suprapatellar bursitis and Baker's cyst.

DISCUSSION

Musculoskeletal examination is a fundamental clinical skill in rheumatology¹⁴, and the clinical detection of soft tissue inflammation in RA is the cornerstone of clinical diagnosis and management. The application of imaging studies of the joint in rheumatology allows reevaluation of the validity of clinical examination of articular structures. Plain radiography is routinely used to provide additional information on bony tissues, although it is insensitive in the detection of soft tissue inflammation¹⁶. US and MRI allow accurate imaging of articular soft tissues, although MRI is expensive and not widely available for routine musculoskeletal examinations. US can readily detect joint effusions, synovial proliferation, and Baker's cysts^{10,13}, correlates well with MRI in the detection of joint effusion and Baker's cyst¹⁷, and can be performed in the rheumatology outpatient setting. This study compared US with clinical examination for 3 established features of soft tissue inflammation of the knee in RA — joint effusion, suprapatellar bursitis, and Baker's cyst.

A study comparing clinical and US detection of knee effusion performed consecutively by the same observer found that clinical examination detected 50–75% of moderate to large effusions noted on US⁴. Clinical detection of knee effusion was not confirmed by US in 21–43% of cases and the interobserver reproducibility of US in detecting knee effusions was also found to be higher than that of clinical examination [weighted kappa of 0.902 (US) and 0.446 (clinical examination)]. This suggests that US is superior to clinical examination in the diagnosis and monitoring of knee effusion. However, as the same observer performed both clinical and US examinations, the findings were not completely blinded and this may have influenced the results. We compared clinical and US examination by independent blinded observers and found that clinical examination detected 16/27 (59%) knee effusions confirmed on US, but the clinical presence of knee effusion was diagnosed incorrectly in 6/22 (27%). This study confirms that US is more accurate than clinical demonstration of fluctuance or the “patellar tap” sign when diagnosing and monitoring knee joint effusion in RA.

Clinical evaluation of suprapatellar bursitis — effusion of the suprapatellar compartment of the knee — involves assessing a loss of normal suprapatellar contour. This sign may be related to other factors such as obesity, fat pad

Table 2. Sensitivity, specificity, false positive rate (FPR), false negative rate (FNR), positive predictive value (PPV), negative predictive value (NPV) of clinical examination of the knee in RA as compared to ultrasonography.

	Sensitivity	Specificity	FPR	FNR	PPV	NPV
Suprapatellar bursitis	0.41	0.89	0.11	0.59	0.7	0.71
Knee effusion	0.59	0.65	0.35	0.41	0.73	0.5
Baker's cyst	0.2	0.94	0.06	0.8	0.5	0.79

hypertrophy, enthesopathy, or deformity due to degenerative disease, and subsequently may have a poor discriminatory value. We examined the validity of clinically assessing suprapatellar bursitis as compared to the US detection of suprapatellar effusion. The clinical finding of suprapatellar bursitis was only confirmed on 7/17 (41%) cases, while the presence of suprapatellar bursitis on clinical examination was not confirmed on US in 3/10 (30%) cases. Compared to US, the clinical assessment of the suprapatellar contour was not found to be a useful discriminator of suprapatellar bursitis.

Baker's cyst of the knee is the nomenclature used to describe the enlargement of the gastrocnemius-semimembranosus bursa¹⁸. Baker's cysts are a common complication of chronic knee inflammation and joint effusion in a number of rheumatological conditions including RA. They are often asymptomatic and may present following rupture, with a clinical picture similar to that of a deep venous thrombosis. In a series of patients with RA, clinical examination detected 29 of 67 (43%) Baker's cysts found on US¹³. We found that clinical examination detected 2/10 (20%) US-confirmed Baker's cysts. The low rate of clinical detection of fluid in the gastrocnemius-semimembranosus bursa compared to the other knee compartments is probably due to its deeper location within the calf musculature. We examined whether the size of the Baker's cyst influenced the rate of clinical detection. While the majority of the cysts not detected on clinical examination had a smaller volume than the 2 clinically detected cysts, 3 equally large cysts were not detected on clinical examination. This suggests that the clinical detection of Baker's cyst is not influenced by size alone and may reflect the anatomical position of the cyst, intracyst tension, or the development of complications such as rupture. In this series, the prevalence of Baker's cyst in RA knees was 25%, which is comparable to reported rates of between 5 and 32% depending on the means of detection¹⁸. The rate of rupture of Baker's cysts in RA knees is not known and we plan to follow these patients to determine the natural history of the cyst.

Aspiration of fluid from joints allows diagnostic examination of the synovial fluid and confirmation of correct needle placement when performing corticosteroid injection. However, intraarticular aspiration and injection is frequently unsuccessful when performed by a conventional approach

guided by clinical examination, even by an experienced rheumatologist¹⁹. This study confirms the inaccuracy of clinical examination in the detection and localization of fluid in the joint knee, providing one explanation for a "dry tap" when performing conventional joint aspiration. In a small number of cases, the joint effusion was localized to one compartment of the knee only. In these cases, successful aspiration would be dependent on choosing the correct anatomical approach rather than routinely using the same approach in all knees. US allows the discrimination of effusion and synovial proliferation, resulting in accurate detection and localization of joint effusions, which improves the success rate of joint aspiration of the knee²⁰. The use of ultrasonography in routine rheumatology practice will lead to improved aspiration of joint effusions, and is indicated when clinical examination of a symptomatic knee is negative or equivocal for the detection of effusion or when no fluid is obtained by the conventional technique.

Ultrasonography is confirmed as a more sensitive and specific means of detecting knee joint effusion in RA. Loss of contour of the suprapatellar bursa is a poor discriminant of suprapatellar bursitis. Clinical examination for popliteal swelling and/or tenderness is insensitive in the detection of Baker's cyst. These findings confirm significant limitations in the use of clinical examination alone to monitor knee joint inflammation in RA. US was found to be more sensitive and specific in examining all compartments of the knee joint. US has high inter- and intraobserver reproducibility in the detection of soft tissue inflammation^{4,21}. The assessment and management of inflammation of the knee in RA may be improved through the application of US in clinical rheumatology.

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