Power Doppler Ultrasound Assessment of Rheumatoid Hand Synovitis

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ABSTRACT. ***Objective.*** To evaluate power Doppler ultrasound (PD) as a technique in assessing response to treatment with steroids in rheumatoid hand synovitis.

Methods. Twelve patients with rheumatoid hand synovitis were assessed before and after treatment with steroids. Variables used to assess synovitis activity in each patient included patient visual analog scale (VAS) score for pain, physician assessment score (PAS), erythrocyte sedimentation rate (ESR), and PD of the metacarpophalangeal joints.

Results. Nine female and 3 male patients were studied; mean age was 53.3 ± 6.5 yrs and mean disease duration 6.5 ± 4.5 yrs. All patients had a good clinical response to steroid treatment and there was a significant improvement in the synovitis activity assessments. Wilcoxon signed-rank test using the exact method was applied to the change in disease activity variables. For PD signal, $p < 0.002$; VAS, $p < 0.0016$; ESR, $p < 0.031$; PAS, $p < 0.008$.

Conclusion. PD quantifies synovitis and may be a useful adjunct to disease assessment and the response to treatment in RA. (J Rheumatol 2001;28:1979–82)

Key Indexing Terms:
POWER DOPPLER ULTRASONOGRAPHY RHEUMATOID ARTHRITIS SYNOVITIS

Rheumatoid synovitis causes progressive and irreversible joint damage[1] and radiographic studies suggest that this damage occurs early in the disease[2]. Current methods of measuring synovitis have a number of limitations, which lead to difficulties in the true quantitation of synovial inflammation**.** Accurate identification of patients with aggressive synovitis will help to institute an appropriate treatment regimen[3-5].

Conventional radiographic assessment detects only the end result of rheumatoid synovitis. Earlier identification of synovial inflammation and erosion is possible with magnetic resonance imaging (MRI)[6]; however, the dynamics of rheumatoid synovitis are not detected by these technologies. The development of power Doppler ultrasonography (PD) now provides an opportunity to image the synovial inflammation early in the development of rheumatoid arthritis (RA). PD is an imaging technique that encodes an estimate of the integrated Doppler power spectrum in color rather than an estimate of the mean frequency shift, which is the variable typically encoded in color Doppler imaging. This offers greater sensitivity when scanning tissue. PD was initially validated as a means for estimating the fraction of moving blood tissue by Rubin, *et al*[7], and Newman, *et al*[8] showed that PD sonography consistently showed hyperperfusion associated with musculoskeletal inflammatory disease.

Knee synovitis and the response to intraarticular steroid injection have been evaluated by PD, and the changes in synovial inflammation reflected the clinical improvement[9]. We investigated the changes in PD signal of metacarpophalangeal (MCP) joints in RA before and after treatment with steroids.

MATERIALS AND METHODS

Twelve patients with RA who attended the rheumatology clinic were enrolled. Consecutive patients with synovitis of at least 3 MCP joints were identified and selected to participate in this study. All patients fulfilled the 1987 American College of Rheumatology criteria for RA[10].

Assessments were performed on selected joints before and one week after treatment with steroids. Assessments included erythrocyte sedimentation rate (ESR, Westergren method), patient visual analog score (VAS) for pain (0–10 scale), and physician assessment score (PAS), which was a tender joint count score[11] on a 4 point scale where 0 = no pain, 1 = patient complains of pain on applied pressure, 2 = pain and wincing, 3 = withdrawal in response to pain. PAS assessments were performed by the same physician (MS) for all patients. PD assessment was of selected MCP joints (selected by the examining physician if the tender joint score was 1 or more). A maximum of 5 MCP per patient were selected for assessment. Each patient was treated with steroids; 4 received intravenous methylprednisolone (125 mg) for 3 consecutive days and the remainder received 20 mg oral prednisolone. PAS, VAS, and PD assessments of selected joints were performed before and one week after treatment.

The power Doppler scanner used was an Acuson Sequoia 512 ultrasound machine (Mountain View, CA, USA). The same radiologist (DB)

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scanned all patients and was blinded to information regarding the most painful and tender joints. Each patient had the same MCP joints scanned on each occasion. To reduce bias in the selection of sites recorded, the whole joint was scanned and the area showing maximal signal was recorded. Examinations were performed using an Acuson musculoskeletal program, which had fixed settings with low wall filter (persistence 2, gate 2, and edge 1). All joints were imaged at identical parameters. Gain was set just below the disappearance of color noise from cortical bone (this resulted in color Doppler gain of 48–50 db). The mean pulse Doppler frequency used was 5 MHz. A 13 MHz probe was used for all examinations as this has been shown to increase the accuracy of MCP joint evaluation in RA[12]. Dorsal longitudinal and transverse images were obtained of each joint and recorded on magnetic optical disk. Synovial blood flow was graded by power Doppler imaging from grade 0–3. Grade 0: no color pixels were seen in the visualized synovium; Grade 1: joints where color pixels were seen in less than one-third of visualized synovium; Grade 2: joints with color pixels in one-third to two-thirds of visualized synovium; Grade 3: joints where color pixels were seen in more than two-thirds of visible synovium. In equivocal cases and in order to rule out possible artifact the presence of color was confirmed by spectral analysis. PD images were read by 2 radiologists who were not involved in imaging of joints and were blinded to patient symptoms and treatment; agreement was reached by consensus. They were also blinded to the time sequence of the scans. The Doppler grade attributed to a joint was based on the overall assessment of transverse and longitudinal dorsal images of each joint together.

Statistical analysis. Analysis was carried out using the SPSS exact tests. The Wilcoxon rank-sum test was used to compare the pre and post treatment levels for each of the disease assessment variables. A p value < 0.05 was considered significant.

RESULTS

We studied 12 patients, 9 female and 3 male. The mean age was 53.3 ± 6.5 years and mean disease duration was 6.5 ± 4.5 years. All patients were taking nonsteroidal antiinflammatory drugs and 4 patients disease modifying antirheumatic drugs. No patient was taking maintenance steroids. The average number of joints assessed by PD per patient was 3.5.

All patients responded to treatment with steroids. There was a dramatic and statistically significant improvement in measures of disease activity (ESR, VAS, PAS, PD) following treatment (Figure 1).

The Wilcoxon signed-rank test using the exact method was applied to the change in the disease activity variables. For PD, there were 10 negative ranks, and 2 ties ($p < 0.002$). For VAS, there were 7 negative ranks, one tie, and no positive ranks ($p < 0.0016$). ESR showed 6 negative ranks and no ties ($p < 0.031$). Finally, PAS showed 8 negative ranks, no positive ranks, and no ties ($p < 0.008$).

DISCUSSION

This study has shown that a reduction in PD signal in the MCP joints of patients with RA treated with short term steroids reflected a clinical improvement. Deficiencies of current methodologies in assessment of synovitis are overcome by PD[8,13,14]. Radiographs detect cartilage loss and erosions and thus can depict the changes in moderate to advanced disease. In early disease, radiographs only give an indirect assessment of disease activity with soft tissue swelling. MRI with gadolinium enhancement has been investigated in studies of RA synovitis, but it is limited by

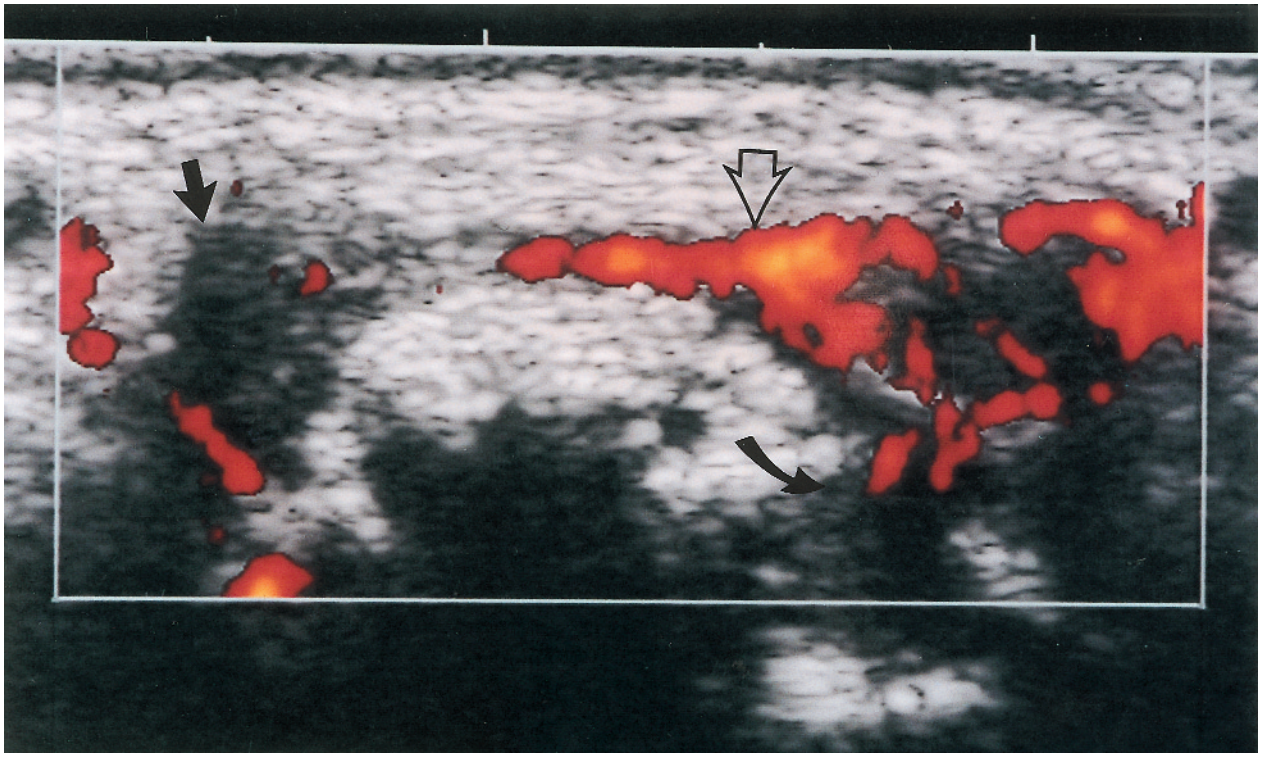

Figure 1A. Transverse image of the 2nd MCP joint of a 43-year-old woman with RA presenting with joint pain and swelling. Thickened irregular synovium (straight arrow) with large bony erosion (curved arrow) is visible along the radial aspect of the joint surface. With power Doppler there is evidence of active synovitis (open arrow); power Doppler grade 2.

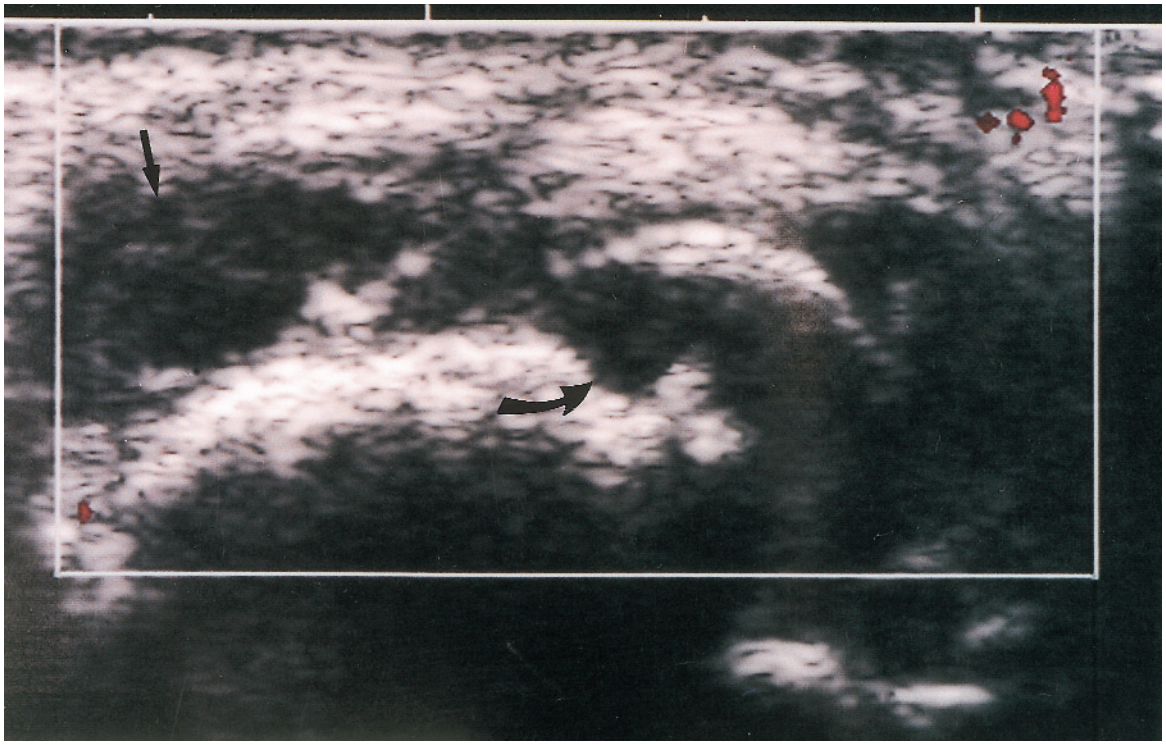

Figure 1B. Followup transverse image of second metacarpophalangeal joint of the same patient 7 days after oral steroid treatment. Once again chronic changes of rheumatoid disease are seen; thickened irregular synovium (straight arrow) and large erosion (curved arrow). With power Doppler there is no evidence of active synovitis; power Doppler grade 0.

expense and restricted access to MRI facilities[15]. There have been several studies of synovial enhancement with dynamic MRI versus histology in RA[2,16,17]. Klarlund, *et al*[16] have suggested that synovial membrane volumes as determined by dynamic MRI in finger joints are related to clinical signs of synovitis. However, such techniques are expensive and may not be readily available. The advent of cross sectional imaging has revolutionized the way we will be able to assess disease activity. Conventional sonography has proved useful in detecting joint effusions and bursal fluid collections[14,18], but does not provide information about disease activity or the dynamics of synovial inflammation. Hau, *et al*[19] used a technique of high resolution ultrasound to evaluate pannus and vascularization in the joints of patients with RA. In a prospective study, Wakefield, *et al* compared conventional radiography, scintigraphy, ultrasound, and contrast enhanced MRI in arthritis of the finger joints[20]. In a cohort of 60 patients they found that MRI and ultrasound are valuable diagnostic methods in patients with arthritis who have normal findings on plain radiological evaluation. PD, however, is more sensitive to low flow states, so is ideally suited to assessing synovium. It can depict areas of hyperemia in the synovium of an inflamed joint[7-9,21].

Clearly, a limitation of our study relates to the relatively small number of patients assessed. However, the changes in PD signal were dramatic, and suggest that the changes shown represent a real change in synovial inflammation. Further study comparing PD to histology and or MRI is needed to validate this hypothesis and to confirm the reliability of this technique. In addition, quantification of the number of color pixels per inflamed joint with a software program would provide a more definite index of synovial inflammation. In this study, the same sonographer (DB), who was a trained radiologist and experienced in the technique of PD, performed all scans. The change in PD signal in individual joints was dramatic after steroid treatment. In addition, joints without evidence of hyperemia (PD score = 0) did not change over the period of observation. This suggests that the changes in PD signal are a true representation of changes in synovial inflammation. However, we do not have sufficient information for analysis of variation (intra or interobserver variation). We would suggest that this data would best be generated by histologic correlation.

We propose that this PD technique is useful in assessing disease activity in rheumatoid hand synovitis, particularly in early disease. Assessment of rheumatoid synovitis and the synovial response to treatment is crucial in determining patient outcome. Given the advent of a number of new biologic treatments we plan to investigate the changes in synovial PD signal with some of the newer agents and follow the progress over a longer period of time.

Arthroscopic biopsy of the knee has been shown to be more accurate than blind synovial biopsy in quantifying inflammation in the infiltrate[22], and with this new technique

we expect PD will play an important role in localizing inflamed synovial tissue for biopsy.

The detection and investigation of MCP joints and the other hand joints most commonly affected by RA is a technically difficult procedure. Ostendorf, *et al* studied the technique of miniarthroscopy as an accurate means of accessing the synovium of the MCP[23]. This method allows access to the medial and lateral recesses of the joint cavity where hypertrophic synovitis is seen most frequently. PD in combination with this technique may be a valuable tool in increasing the yield of this procedure from 80% to 100% and for accessing the other small joints of the hand.

Power Doppler ultrasonography appears to be a promising technique in the quantification of RA hand synovitis and may be useful in longitudinal studies to investigate the factors that are important in the development of erosions, and to monitor disease activity and response to DMARD treatment.

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