Radiologic Outcome and Its Relationship to Functional Disability in Juvenile Rheumatoid Arthritis

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ABSTRACT. ***Objective.*** To determine the radiologic outcome in juvenile rheumatoid arthritis (JRA) and the relationship of radiologically detected joint damage to functional disability using multivariate analyses.

Methods. Selection criteria included a diagnosis of JRA made by 1977 American College of Rheumatology criteria, onset of arthritis ≥ 5 years prior to study, current age ≥ 8 years, a minimum grade 3 reading ability, and the availability of radiographs. Disability was measured by the Childhood Health Assessment Questionnaire (CHAQ) and Steinbrocker classifications. Radiographs taken within 2 years after onset (early) and the most recent radiographs (late) were examined by a single pediatric radiologist blinded to patients' identities, diagnoses, and outcomes. Multiple regression analyses were performed.

Results. On late radiographs the frequencies of joint space narrowing were 38, 14, 43, and 79%, respectively, among patients with systemic, pauciarticular, rheumatoid factor (RF) negative polyarticular, and RF positive polyarticular onset; erosions occurred in 63, 25, 39, and 75%, respectively. Early erosions were most frequent in patients with RF+ polyarticular onset, while both joint space narrowing and erosions occurred early in systemic onset. Radiologic signs of joint damage were most frequent at hips and wrists, while knees and ankles were relatively spared. Based on patients who had radiographs performed within one year of clinical study, 17.7% of the variation in CHAQ score was explained by joint space narrowing, 32.4% by pain, and 5% by a severe rating on physician's global estimate of disease activity. The odds of a Steinbrocker class > I were increased by joint space narrowing, pain, systemic onset, and active joint count.

Conclusion. Differences in the frequencies and patterns of joint damage occur both among JRA onset subtypes and among individual joints. Radiographic damage, especially joint space narrowing, correlates with functional disability. However, pain is the major contributor to variation in CHAQ scores. (J Rheumatol 2003;30:832–40)

Key Indexing Terms:
JUVENILE RHEUMATOID ARTHRITIS RADIOLOGIC OUTCOME DISABILITY

Radiologic changes in juvenile rheumatoid arthritis (JRA) include nondestructive changes such as soft tissue swelling, demineralization, growth disturbances, and periosteal new bone formation. Changes indicative of more specific damage to cartilage, bone, or supporting structures include joint space narrowing, decrease in carpal length, ankylosis, erosions, and subluxation[1-5]. The appearance of radiologic signs of joint damage in relation to disease duration has been described[3,4,6–8], but the correlation of these changes with disability is not clear. Although intuitively one would expect that joint damage correlates with functional disability, other factors such as pain, general well being, muscle strength, limitation of joint mobility resulting from soft tissue contractures, psychosocial and cultural factors, and disease duration may also affect function. Therefore the relation of radiologically detected joint damage to disability needs to be assessed in conjunction with other possible contributors in order to evaluate its relevance to disease outcome.

As part of an assessment of outcome in patients with JRA, radiographs were reviewed retrospectively to detect changes within the first 2 years after disease onset and at last radiographic examination. Our objectives were to assess the radiologic outcome in a cohort of patients with JRA, compare the evolution of radiologic changes among the subtypes of JRA, and determine the relation of radiologic damage to functional disability in multivariate analyses.

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MATERIALS AND METHODS

Patients. Patients were participating in a study of the outcome of JRA. Inclusion criteria were a diagnosis of JRA made or confirmed at a participating center; a period of at least 5 years since the date of onset; and current age of at least 8 years and at least a grade 3 reading level. An added criterion was the availability of radiographs. Exceptions were 2 patients with followup periods < 5 years — 4.8 and 4.9 years, respectively. Patients were diagnosed and classified by onset types into systemic, pauciarticular, and polyarticular according to the 1977 American College of Rheumatology criteria[9]. These criteria rather than the International League Against Rheumatism (ILAR) criteria were utilized as most of the patients who participated had onset prior to publication of the latter[10]. The polyarticular onset group was further divided into rheumatoid factor (RF) positive and RF negative groups. Patients with psoriatic arthritis, juvenile ankylosing spondylitis, seronegative enthesitis and arthritis syndrome[11], or reactive arthritis were excluded.

Participating pediatric rheumatology centers were British Columbia's Children's Hospital and the Mary Pack Arthritis Centre, Vancouver, Royal University Hospital, Saskatoon, and the Children's Hospital, Winnipeg. Patients were identified through existing prospectively collected databases and/or clinic files at the 3 participating centers and were recalled for the clinical followup study described below.

Procedures. The following data were obtained from databases and/or medical charts: date of onset, date of first and last clinic visits, date active arthritis was last recorded, results of RF tests, and medications used. Date of onset was defined as the date of onset of first symptoms of arthritis obtained by history as recorded in medical records or databases. Active disease duration was calculated as the time interval from onset to the date the patient completed the followup evaluation if arthritis was still active at that time or to the date arthritis was last recorded if the disease was in remission. Active disease duration to time of most recent radiographs was calculated as the interval from time of onset to the date the radiograph was performed. For those with intermittent disease activity, the intervals when arthritis was inactive were subtracted.

Participating patients were examined by the authors (DC, PM, RP, AR, KO), who determined active joint counts, Steinbrocker functional class[12], and global assessment of disease activity (0 = inactive, 1 = mild, 2 = moderate, 3 = severe). An active joint was defined as a swollen joint or a joint with limitation of movement with heat, pain on movement, or tenderness[9]. All patients were asked to complete a Child Health Assessment Questionnaire (CHAQ) and a 10 cm visual analog scale (VAS) for pain, independently. CHAQ scores were calculated as the mean score for the 8 categories of activities[13].

Radiographs. Radiographs of participants were retrieved at the 3 centers and were read by a single pediatric radiologist (MR) blinded to the patients' identities, clinical information, and other data collected for the study. Joints imaged were evaluated for joint space narrowing including ankylosis and carpal collapse, erosions, and growth abnormalities. Carpal collapse was defined as a visual decrease in the height of the carpus, without recourse to standardized measurements. Growth abnormalities were classified as overgrowth defined as asymmetry in epiphyseal development, premature closure of an epiphysis, or growth deformity defined as irregular ossification at an epiphysis resulting in bony deformity. Findings were recorded on prepared forms and entered into a database program (Visual Dbase, Borland International, Scotts Valley, CA, USA).

Radiographs performed within the first 2 years after onset (early radiographs) and the most recent films (late radiographs) were examined. Radiographs of involved joints had been performed at the discretion of the patients' physicians at each center. None were performed as part of the present study.

The study was approved by institutional ethics boards at each center and informed consent was obtained from participants and/or their parents.

Analysis. The frequencies of radiographic abnormalities were calculated as a percentage of the total number of patients who had radiographs at each time point, i.e., early and late radiographs. For a given patient an abnormality was entered if it was present in at least one site, i.e., the same abnormality present at multiple joints or severally at the same joint was entered only once. In addition, the frequencies of abnormalities at each joint were calculated as a percentage of the number of patients who had radiographs of the site in question. In this case, an abnormality was entered only once even if present severally at the same joint.

Statistical analyses. Chi-square analyses were used to detect differences in results among subgroups. To determine the correlation of onset subtype, sex, and active disease duration with radiologic outcome, forward conditional logistic regression was performed with erosions and joint space narrowing as dependent variables. Onset subtype and sex were entered as categorical variables, using female sex and pauciarticular onset as reference.

To determine correlations between disability and radiographic changes, only subjects with radiographs performed within one year of clinical study were included. The relative contribution of each variable to the variation in CHAQ scores was determined by stepwise linear regression and estimated by the square of the partial correlation. Possible explanatory variables entered were pain (in cm of VAS), active joint count, physician's global assessment of disease activity, onset subtype, sex, active disease duration to time of clinical followup study, and joint space narrowing and erosions on the most recent radiograph. Dummy variables were entered for sex, global assessment, and JRA onset subtypes using female sex, global assessment score of 0, and pauciarticular onset, respectively, as reference. As the number of subjects in these analyses was only 88, interactions between variables were not included.

Since only 7 patients were in Class III or IV, Steinbrocker classifications were regrouped as Class I or > I and forward conditional logistic regression was performed using Steinbrocker class as the dependent variable. Onset subtype, global assessment, sex, joint space narrowing, and erosions were entered as categorical, and disease duration to time of clinical study, pain, and joint count, as continuous variables.

Data were processed using Dbase and Excel (Microsoft Corp.). Statistical analyses were performed with SPSS (SPSS Inc., Chicago, IL, USA).

RESULTS

Radiologic outcome. Two hundred sixteen patients met the selection criteria; 136 patients had radiographs within 2 years after onset and 187 had later radiographs; 107 had both early and late radiographs (Table 1). Late radiographs were performed 2 to 24 years after onset (Table 1). The majority of patients with systemic and RF negative polyarticular JRA and all with RF positive polyarticular JRA had been treated with disease modifying antirheumatic drugs (Table 1).

The results of radiologic evaluations are shown in Figures 1 to 4. These figures represent cross-sectional studies as not all patients had radiographs at both times. In Figure 1 the frequencies of radiologic abnormalities are shown for each subtype of JRA. As expected, the frequencies of erosions and joint space narrowing differed among the 4 subtypes. Early erosions were most frequent in patients with RF positive polyarticular JRA, but early joint space narrowing occurred most often in patients with both systemic and RF positive polyarticular JRA (Figure 1).

For patients with systemic JRA, erosions were the most frequently detected abnormality, increasing from 35% on early radiographs to 63% on late radiographs (Figure 1). Joint space narrowing was detected in nearly one-third of early radiographs and the frequency was only slightly increased in late radiographs (Figure 1). Growth abnormalities occurred infrequently on early radiographs but more than doubled in frequency on late radiographs (Figure 1).

Radiographic abnormalities in patients with pauciarticular

Table 1. Patients' characteristics.

	Systemic	Pauciarticular	RF Negative Polyarticular	RF Positive Polyarticular
No. in study	30	97	59	30
Female:male	13:17	81:16	45:14	23:7
No. with early radiographs[1]	20	56	39	21
Female:male	11:9	47:9	29:10	15:6
No. with late radiographs[2]	24	81	54	28
Female:male	13:11	67:14	41:13	21:7
No. with early and late radiographs	14	40	34	19
Female:male	11:3	33:7	25:9	13:6
Time from onset to first clinic visit, mo[3], median	1	3	5	10
Range	1–12	1–134	1–125	1–73
Time from onset to last clinic visit, yrs, median	5.4	7.9	8.3	8.6
Range	1.2–17.6	1.9–18.8	1–20.8	1.9–19.2
Age at onset of JRA, yrs, median	6.2	3.2	5.0	10.1
Range	0.3–15.8	0.9–14.9	0.7–15.4	5.2–15.3
Age at late radiographs, yrs, median	14.5	13.4	14.1	17.9
Range	8.3–28.2	4.7–25.5	7.1–26.9	12.0–27.7
Active disease duration to time of late radiograph[4,5], yrs, median	5.3	6.2	6.5	8.7
Range	0.2–21.5	0.6–24.1	2.4–22.6	2.5–17.7
Time from onset to late radiographs, yrs, median	6.4	8.6	8.1	9.1
Range	3.1–21.5	2.3–24.1	3.6–22.6	2.5–17.7
No. (%) treated with DMARD	18 (60)	20 (21)	36 (62)	31 (100)

[1] Radiographs performed within 2 years after onset; [2] most recent radiograph; [3] values of < 1 month were entered as 1 month; [4] periods of disease inactivity were subtracted for those with an intermittent disease course; [5] may be less than time from onset to time of late radiograph.

JRA consisted largely of growth abnormalities, occurring in one-quarter of early and one-quarter of late radiographs. Although the frequency of erosions increased from 9% in early radiographs to 25% in late radiographs, the frequency of joint space narrowing remained low (5 and 14%, respectively) (Figure 1).

For patients with RF negative polyarticular JRA, erosions, joint space narrowing, and growth abnormalities were detected at almost equal frequencies. Each finding was 2 to 3-fold more frequent on late radiographs (16 and 38%; 13 and 39%; and 16 and 43%, respectively, on early and late radiographs) (Figure 1).

Radiologic signs of joint damage were frequently present in early radiographs of patients with RF positive polyarticular JRA. Narrowing was less frequent in early radiographs, 32%, but increased to 79% on late radiographs (Figure 1). Erosions were seen in more than half within the first 2 years and the frequency increased to 75% on late radiographs. A decrease in growth abnormalities on late radiographs may be due to the older age of patients at the time these radiographs were taken. As the median age at this time point was 18 years, epiphyseal advancement or premature closure of epiphyses would not be detectable in many of the radiographs.

The sites at which radiologic abnormalities were found are shown in Figures 2 to 4. All patients were considered together, but the contribution of each subtype to the overall frequency is also indicated on the graphs. Early joint space narrowing was seen most frequently at the wrists (20%) and hips (16%) (Figure 2). On late radiographs, narrowing was noted in at least 30% of radiographs of the cervical spine, hips, wrists, and shoulders (Figure 2). Ankylosis was most frequent on late radiographs of the cervical spine (25% of radiographs) At the wrists, carpal collapse was detected in 14% of early radiographs, but the frequency was only slightly higher on late radiographs (17%).

The frequency of erosions increased at all sites between the 2 time points. Erosions were most often detected on early radiographs of the shoulders and wrists (33 and 24%, respectively), and were found in more than 30% of late radiographs of the hips, feet, wrists, and shoulders (Figure 3).

Growth abnormalities were infrequent in early radiographs, occurring in 9 to 11% of radiographs of the hands, wrists, and knees. They were found most frequently at the hands on the late radiographs (31%) (Figure 4). Overgrowth was the most frequent and the only early growth abnormality at the elbows, hips, knees, and ankles. In contrast, growth deformity was also noted early at the wrists and hands. In late radiographs, growth deformity was frequently detected at multiple sites.

Subluxation was uncommon in this series. It was detected at the hips in 2 of 25 (8%) early, and in 6 of 46 (13%) late radiographs. The next most common sites of subluxation were the metatarsal phalangeal joints of the feet — 3 of 52 (6%) late radiographs. At other sites, subluxation was even less com-

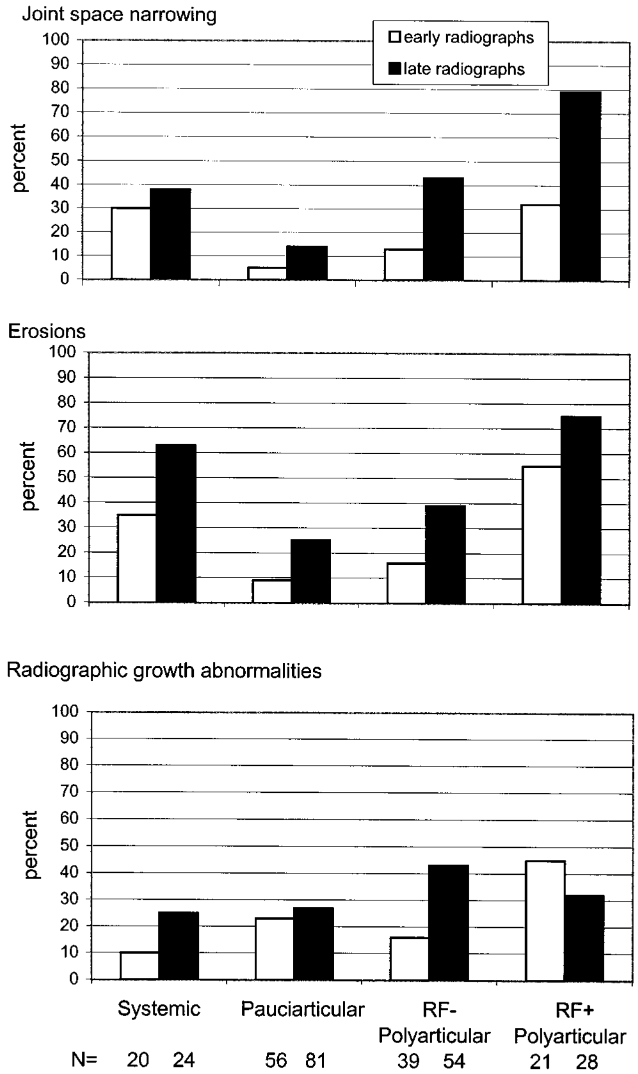

Figure 1. Frequencies of radiographic abnormalities in each subtype of JRA. The frequency of each abnormality is shown as a percentage of the number of patients with radiographs at each time point. Early radiographs were performed within 2 years after onset and late radiographs were the most recent ones available. The frequencies of joint space narrowing and erosions differed among the JRA subtypes ($p < 0.0001$ and $p < 0.0001$, respectively, for early radiographs; and $p < 0.0001$ and $p < 0.0001$, respectively, for late radiographs). The frequencies of growth abnormalities differed on early radiographs only ($p = 0.025$).

mon — 2 of 82 (3%), one of 83 (1%), and one of 17 (6%) radiographs of the wrists, metacarpophalangeal joints of the hand, and shoulders, respectively. Atlantoaxial instability was detected in 2 of 24 late radiographs of the cervical spine.

Correlation of radiologic outcome with onset subtype and disease duration. To assess the relationship between disease duration and onset subtype to the development of radiologic damage on late radiographs, logistic regressions were performed. The odds of joint space narrowing and erosions were both increased by longer active disease duration and systemic and polyarticular onset (regardless of RF status) relative to pauciarticular onset (Table 2). However, RF positive polyarticular onset had a much greater relative effect on the odds of joint space narrowing than on erosions (Table 2).

Relationship of radiologic joint damage to functional disability. Data from 88 patients with radiographs within one year of clinical study were analyzed. Clinical evaluations and CHAQ were completed at a median of 9.4 years (range 4.8–21.7) after onset and after a median of 7.1 years (range 0.6–20.5) of active disease duration. The median age of patients at the time of the clinical studies was 14.2 years (range 7.8–27.7). Twelve had systemic, 14 RF positive polyarticular, 27 RF negative polyarticular, and 35 pauciarticular onset. Erosions on late radiographs were found in 36 and joint space narrowing in 35 of the 88 patients.

Joint space narrowing but not erosions at last radiograph had significant correlations with both higher CHAQ scores and Steinbrocker classifications. By stepwise linear regression, the final model accounted for 48% of the variation in CHAQ scores. Pain, joint space narrowing on late radiograph, and a rating of 3 (severe) by physician's global estimate of disease activity, remained as explanatory variables, with pain accounting for 32% and joint space narrowing for 18% of the variation (Table 3). In contrast, erosions on late radiograph, onset subtype, and active disease duration to time of clinical study were among variables that had no significant effects in this analysis.

By logistic regression, the odds of a Steinbrocker class > I were increased by systemic relative to pauciarticular onset, joint space narrowing on late radiographs, pain, and active joint count. The proportion of variation explained by the final model was nearly 60% (Table 3). Among variables with no significant effects were RF negative and RF positive polyarticular onsets, erosions on late radiographs, and active disease duration to time of clinical study (Table 3).

DISCUSSION

Our study illustrates the differences in frequencies and patterns of radiologic abnormalities among JRA onset subtypes. Abnormalities were most frequent in those with RF positive polyarticular JRA, but considerable frequencies were noted in the other subtypes as well. Growth abnormalities predominated in patients with pauciarticular onset JRA and erosions in patients with systemic JRA. Radiographic joint damage was apparent mainly in late radiographs of patients with pauciarticular and RF negative polyarticular JRA. In contrast, early erosions characterized patients with RF positive polyarticular JRA, and both erosions and joint space narrowing occurred early in patients with systemic JRA.

Differences in the patterns of radiologic changes were also evident among individual joints. Wrists and hips were most vulnerable to early joint space narrowing. Although there were few radiographs of shoulders, the frequency of radiologic damage was relatively high at this joint. Hands and feet were also targets of joint damage, but erosions were more fre-

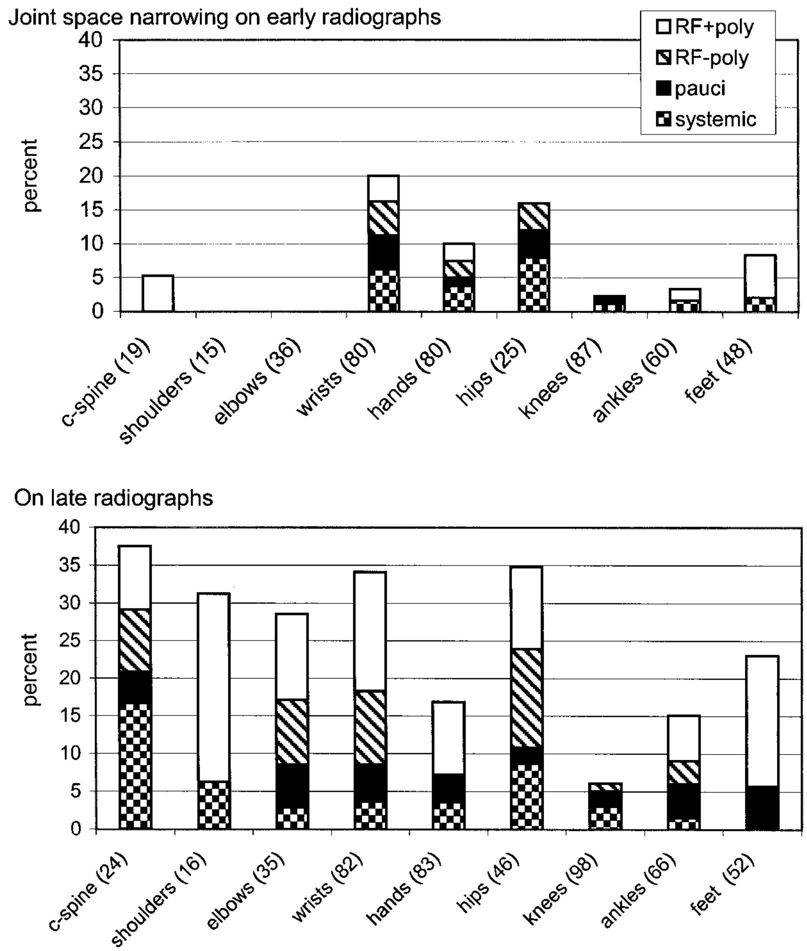

Figure 2. Frequencies of joint space narrowing at each joint. Frequencies are shown as a percentage of the number of radiographs of each joint at early (top) or late (bottom) radiographic examination. Joint space narrowing included decrease in joint space, ankylosis, and carpal collapse. The contribution of each subtype of JRA to the total frequency of joint space narrowing at each joint is shown. Numbers in parentheses indicate the number of radiographs examined.

quent than joint space narrowing at these sites. In contrast, ankles and knees were relatively spared. However, the lack of joint space narrowing at the knees may be partly because radiographs were not uniformly taken in a weight-bearing position.

By multivariate analyses, radiologic changes were found to be much more dependent on onset subtype than on active disease duration. However, joint space narrowing had a more consistent effect on disability than onset subtype in analyses of a smaller subset of patients, while an effect of active disease duration was not detected. These findings suggest that joint space narrowing is clinically meaningful in children with JRA and is one of the better correlates of disability. Pain proved to be the variable that explained the largest proportion of variability in CHAQ scores. The lack of correlations of onset subtype with measures of disability may be due to the smaller numbers of patients with each subtype in these analyses. However, when all patients with late radiographs were included in a separate analysis, both systemic and RF positive polyarticular onset correlated with higher CHAQ scores and Steinbrocker class (data not shown).

These analyses showed differences in the relationships of erosions and joint space narrowing to functional outcome. Although the proportion of patients with erosions and joint space narrowing in the analyses were similar, only joint space narrowing correlated with greater disability, whether determined by CHAQ or Steinbrocker class. These differences may be expected, as joint space narrowing reflects loss of cartilage over the joint surface, whereas erosions are more focal and occur early on in the bare bone areas of the joint not covered by cartilage.

These observations confirm previous reports of early radiologic damage in patients with RF positive polyarticular JRA[4] and systemic JRA[8]. In particular, the wrist has been described as an early target in these patients[4,8]. The timing of radiologic changes has been well documented for patients with systemic

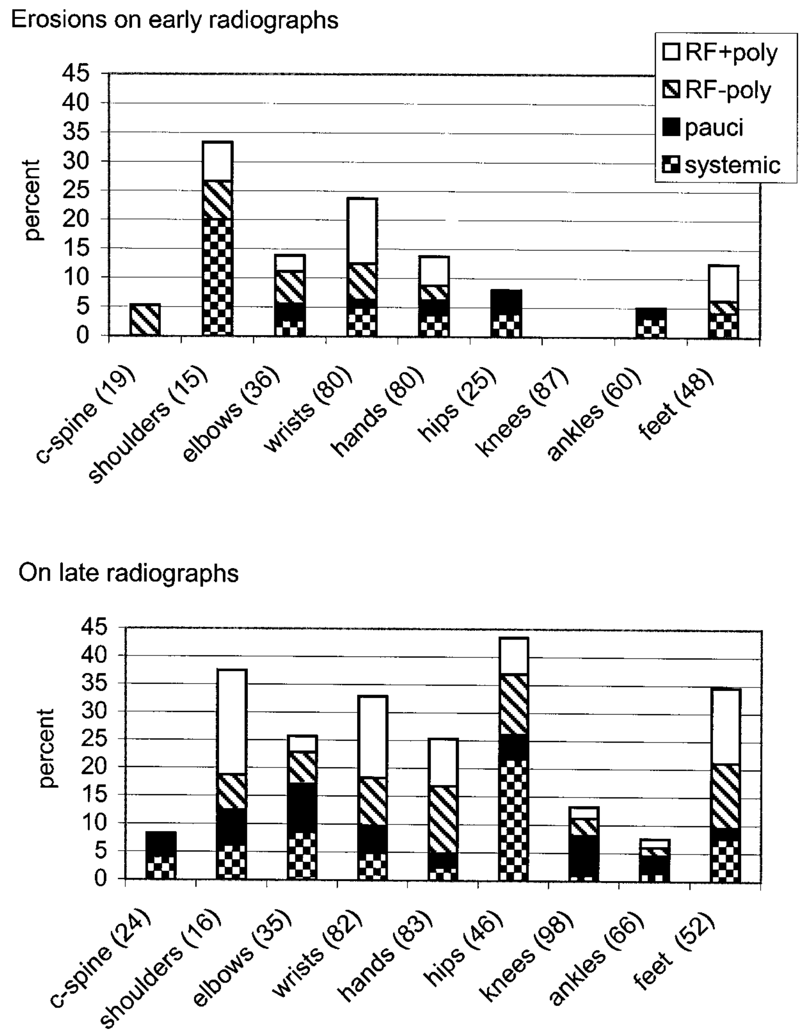

Figure 3. Frequencies of erosions at each joint. See Figure 2 legend for notes.

JRA[8]. In a study of 42 patients, joint ankylosis developed between 3 and 5 years after onset[8]. Joint space narrowing and erosions were detectable within 2 years of onset in about 30% of patients[8]. In another report, erosions or joint space narrowing first appeared at a median of 5.4 years in patients with pauciarticular JRA, 2.4 years in those with polyarticular JRA, and 2.2 years in systemic JRA[7]. In a recent study, destructive changes of the hips were evident in the majority of cases within 5 years[14]. Persistently active disease at 5 years has been reported as the greatest risk factor for joint damage[15].

Few previous studies have systematically examined the association of radiographic joint destruction with disability in patients with JRA. In one report, 94% of patients with erosions or joint space narrowing at the knee were ambulatory, but the percentage decreased to 77% in patients who had additional changes such as pseudocysts, osteophytes, or sclerosis[6]. Similarly, radiologic progression during the first 5 years has been correlated with a worse Steinbrocker functional class in patients with systemic JRA[16]. More recently, a significant positive correlation was found between erosions and the CHAQ disability index[17]. However, both these results were obtained by univariate analyses.

Our results agree with studies of RA in adults that show correlations between Sharp or Larsen scores and the Health Assessment Questionnaires (HAQ) in multivariate analyses, although these radiologic scores are composites of erosions and joint space narrowing and are continuous measurements[18,19]. We chose a categorical measure, presence or absence, because of the greater variability in both joint involvement and frequency of radiologic damage in patients with JRA. The observations that pain is the major determinant of the variation in CHAQ and that it has a greater effect than radiologic damage have also been noted in studies of adult patients (assessed by HAQ)[20,21].

Together with the studies discussed above, our observations attest to the complexity of determinants of physical dis-

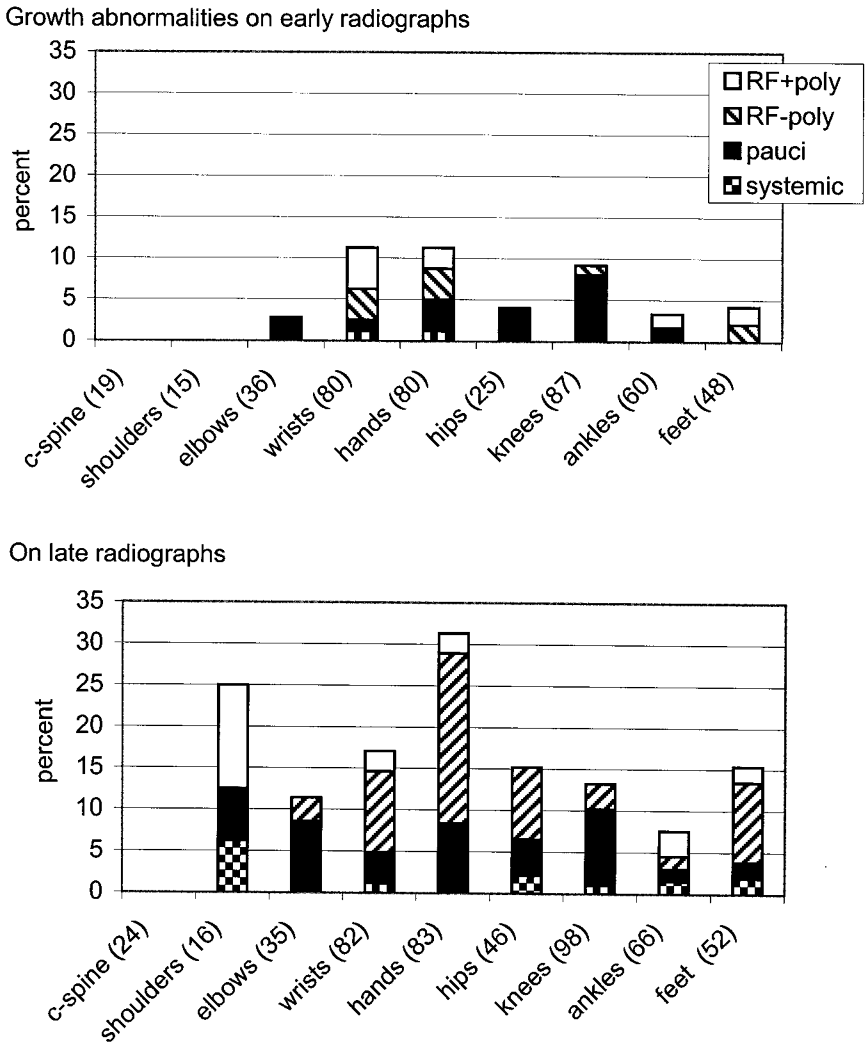

Figure 4. Frequencies of growth abnormalities at each joint. Growth abnormalities were overgrowth, premature epiphyseal fusion, or growth deformity. See Figure 2 legend for notes.

Table 2. Logistic regression analysis for joint space narrowing and erosions.

Dependent Variable	Independent Variable in Model	OR	95% CI	p
Joint space narrowing on late radiograph*	Active disease duration (yrs) to time of late radiograph	1.18	1.08, 1.29	< 0.0001
	Pauciarticular onset	1.00		
	Systemic onset	5.53	1.73, 17.7	0.004
	RF– polyarticular onset	5.10	2.02, 12.83	< 0.0001
	RF+ polyarticular onset	23.43	7.26, 75.60	0.001
	Constant	0.039		< 0.0001
Erosions on late radiograph**	Active disease duration (yrs) to time of late radiograph	1.10	1.02, 1.18	0.016
	Pauciarticular onset	1.00		
	Systemic onset	5.53	2.00, 15.3	0.001
	RF– polyarticular onset	1.74	0.79, 3.83	NS
	RF+ polyarticular onset	8.53	3.08, 23.64	< 0.0001
	Constant	0.159		< 0.0001

* Cox and Snell R^2 for model = 0.279; variable eliminated: sex. **Cox and Snell R^2 for model = 0.171; variable eliminated: sex.

Table 3. Correlations with disability. Analyses were based on 88 subjects who had radiographs performed within one year of clinical study.

Outcome	Independent Variable in Final Model	B[1] or OR[2]	95% CI	p	Percentage of Variation Explained by Variable[3]
CHAQ score[4]	Pain[4] (cm)	0.122	0.084, 0.161	< 0.0001	32.4
	Joint space narrowing on late radiograph	0.509	0.271, 0.747	< 0.0001	17.7
	Physician global assessment of disease activity = 3[5]	0.557	0.045, 1.07	0.033	5.3
	Constant	0.018	–0.156, 0.191	0.841	
Steinbrocker Class > I[6]	Active joint count	1.32	1.11, 1.58	0.002	NA
	Pain (cm)	1.39	1.07, 1.81	0.014	NA
	Joint space narrowing	19.31	3.42, 109.2	0.001	NA
	Pauciarticular onset	1.00			
	Systemic onset	28.81	2.22, 374.1	0.01	NA
	RF– polyarticular onset	4.17	0.55, 31.9	0.17	NA
	RF+ polyarticular onset	19.4	0.831, 453	0.065	NA
	Constant	0.009		< 0.0001	NA

[1] Regression coefficients in linear regression analysis for CHAQ score. [2] Odds ratio for Steinbrocker class > I. [3] Square of partial correlations. [4]Linear regression analysis. R^2 for the final model = 0.484. Variables eliminated were sex, joint count, erosions at late radiograph, onset subtype, active disease duration to time of clinical study, and physician's global assessments of 1, mild, and 2, moderate disease activity. [5] Severe disease activity. [6] Logistic regression analysis. Cox and Snell R^2 for the final model = 0.589. Variables eliminated were sex, erosions on late radiographs, active disease duration to time of clinical study, and physician global assessments. NA: not applicable.

ability. Pain itself is a complex measure and probably incorporates both current disease activity as well as psychosocial and cultural elements. As well, longterm pathologic processes represented by joint space narrowing clearly had a statistical effect on disability measures; however, the variables analyzed together accounted for less than 50% of the variation in CHAQ scores. Further study of other variables such as psychosocial, cultural and genetic factors, functional adaptation, and joint replacement surgery or the lack of it, may help to explain the remaining variability.

As this study was retrospective, it has shortcomings. The number of patients participating in the clinical outcome study was 392; but radiographs were located for only 216 (54%). This is due both to loss of radiographs and to the possibility that not all patients had radiographs. In general, radiographs performed some time ago were not retrievable. Thus there may be an undefined bias that affects our conclusions. Second, radiographs were collected retrospectively and were performed on clinical indications, not as part of this study. Therefore the studies may be biased toward the more severely affected patients. Conversely, not all affected joints were radiographed and abnormalities may have been missed. In the analyses of correlations with disability, only patients with radiographs within one year of study were included, and this may have introduced a bias toward patients with more prolonged active disease duration.

All radiographs were read by a single experienced pediatric radiologist. Although this allowed consistency, other interpretations might have been possible. Objective measurements of carpal height such as that proposed by Poznanski, *et al*[22] might have confirmed visual interpretations but were not applied in this study. Finally, the analyses were based only on the presence of radiographic changes and did not take into account the severity or extent of joint destruction.

With the above reservations in mind, our study supports the conclusion that radiologic damage correlates mainly with onset subtype and to a much lesser extent with duration of active disease. From our analysis, we conclude that joint space narrowing, but not erosions, has an independent correlation with functional disability when other variables are taken into account. However, pain is the major contributor to the variation in CHAQ scores.

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