Comparison of the Rau Method and the Larsen Method in the Evaluation of Radiographic Progression in Early Rheumatoid Arthritis

EIICHI TANAKA, HISASHI YAMANAKA, YUKO MATSUDA, WAKO URANO, HIROSHI NAKAJIMA, ATSUO TANIGUCHI, TERUNOBU SAITO, and NAOYUKI KAMATANI

ABSTRACT. ***Objective.*** To investigate the usefulness of the radiographic scoring method proposed by Rau, *et al* for evaluation of joint damage in patients with early rheumatoid arthritis (RA).

Methods. Radiographs of hands and feet of 30 prospectively observed patients with early RA were assessed by the Rau method, the Larsen method, and count of erosive joints. The standardized response mean (SRM) was used to estimate the sensitivity to change of each method of assessment.

Results. Although the Rau method evaluates only the amount of bony erosion, nearly equivalent radiographic progression was observed with the Rau and the Larsen methods. Radiographic changes in the first year were sensitively identified by all 3 methods (SRM for Rau method 0.83, Larsen method 0.88, and count of erosive joints 0.84). However, in the period from 2 to 6 years after entry into the study, sensitivity to change was maintained with use of the Rau (SRM 1.38) and Larsen (SRM 0.95) methods, but not by count of erosive joints (SRM 0.49). While an apparent ceiling effect was observed after 2 years in count of erosive joints, no ceiling effects were noted for the Rau and Larsen methods.

Conclusion. Our study showed that the usefulness of the Rau method is equivalent to the Larsen method in clinical assessment of radiographic progression in early RA. (J Rheumatol 2002;29:682–7)

Key Indexing Terms:
EARLY RHEUMATOID ARTHRITIS
RADIOGRAPHIC SCORE
RADIOGRAPHIC PROGRESSION
PROSPECTIVE STUDY

Progression of morphological joint damage is a fundamental feature of rheumatoid arthritis (RA), and radiographic evaluation of joint destruction is one of the most useful markers for the outcome of RA[1,2]. There are 2 categories of methodology for assessment of radiographic damage. One is global assessment, which represents the patient's overall radiographic severity, such as the methods of Steinbrocker[3] and Kellgren[4]. The other category is the grading of individual joints or groups of joints, such as the methods of Sharp[5], Larsen[6], van der Heijde modified Sharp[7], and Scott modified Larsen[8]. Of these methods, the Larsen and the Sharp methods are most commonly used by clinical researchers. However, arguments have been raised over details of the original Larsen method. These include the interpretation of soft tissue swelling, periarticular osteoporosis, or slight joint space narrowing in grade I, which can depend on radiographic technique and reader ability.

Recently, Rau, *et al* published a new semiquantitative method for the scoring of joint destruction in RA[9]. Using the Rau method, 38 joints of the hand, wrist, and foot were scored based simply on the amount of joint surface destruction. This method was reported to be reliable and reproducible and to require a shorter time for evaluation than previous scoring methods. We therefore investigated the usefulness of this method for patients with early RA.

MATERIALS AND METHODS

Patients. Thirty patients (24 women, 6 men) with early RA were prospectively observed in our hospital from 1991. At entry, all patients (ages 49.0 ± 11.6 yrs) were within one year of development of chronic arthritis, and fulfilled the American College of Rheumatology criteria for RA[10] during their clinical course. Radiographs of the hands and feet were taken at enrollment and annually thereafter for 6 years. All radiographs were assessed using the Rau method, the Larsen method, and with a count of erosive joints by 3 skilled rheumatologists who were blind to all patient information. All radiographs were simultaneously scored by 3 rheumatologists in chronological order.

Methods. For the Rau method[9], scoring was assessed by the amount of joint surface destruction in the following 38 joints: bilateral interphalangeal (IP) joints of the thumbs, proximal interphalangeal (PIP) joints 2–5, metacarpophalangeal (MCP) joints 1–5, IP joints of big toes and metatarsophalangeal (MTP) joints 2–5, and 4 sites in each wrist (naviculum, lunatum, distal radius, and distal ulna). Joint surface destruction was graded from 1 to 5 according to the percentage of eroded area in the total surface of a joint,

From the Institute of Rheumatology, Tokyo Women's Medical University, Tokyo, Japan.

E. Tanaka, MD, Research Associate; H. Yamanaka, MD, PhD, Associate Professor; Y. Matsuda, MD, PhD, Research Associate; W. Urano, MD, Research Associate; H. Nakajima, MD, Research Associate; A. Taniguchi, MD, PhD, Assistant Professor; T. Saito, MD, PhD, Professor; N. Kamatani, MD, PhD, Director and Professor.

Address reprint requests to Dr. E. Tanaka, Institute of Rheumatology, Tokyo Women's Medical University, 10-22 Kawada-cho, Shinjuku-ku, Tokyo, 162-0054 Japan. E-mail: e-tanaka@tkg.att.ne.jp

Submitted January 16, 2001; revision accepted October 18, 2001.

as described in the original article[9]. With the Larsen method[6], we assessed the following 34 joints: bilateral IP joints of thumbs, PIP joints 2–5, MCP joints 1–5, IP joints of the big toes and MTP joints 1–5, and wrists. Each wrist was considered as a unit and its score multiplied by 5[11]. Count of erosive joints was defined as the number of joints with any evidence of erosion out of 34 joints, as in the Larsen method. The maximum scores obtainable with the Rau method, Larsen method, and count of erosive joints were 190, 210, and 34, respectively.

To compare the sensitivities to change of these 3 methods, the standardized response mean (SRM) was used[12]. SRM was calculated by dividing the mean change of radiographic scores between the baseline and a certain year by the standard deviation (SD) of the score.

RESULTS

In our study, the duration between the onset of joint symptoms and the first radiographs at enrollment was 3.5 ± 2.9 months (median 2.5 mo, range 1–12 mo). The numbers of swollen and tender joints at enrollment were 4.1 ± 3.6 and 8.5 ± 7.6, respectively. Joint damage progression during the 6 years after entry into the study was assessed in 30 patients by all 3 methods (Figure 1), and the means of the radiographic scores are shown in Table 1.

Radiographic change in the first 2 years was compared. Since the maximum scores of the 3 methods differed (Rau method 190, Larsen method 210, count of erosive joints 34), we compared the grading of joint damage for each method as a percentage of the maximum score (Figure 2). All 3 methods yielded a steady increase in scores during the first 2 years of the study period. However, the count of erosive joints increased most rapidly and appeared to be the most sensitive method for detecting change in this early period. The scores obtained with the Larsen increased more sensitively than those obtained with the Rau during the first 2 years.

We then compared the rates of increase in scores assessed by the 3 methods from 2 to 6 years after study entry. However, as shown in Figure 2, joint damage progression diverged widely among patients. We therefore divided patients into 3 groups according to mode of progression: progressive type (n = 15), late-progressive type (n = 8), and less-progressive type (n = 7). The scores in each group were then evaluated by the 3 methods (Figures 3–5).

The percentages of the maximum score (mean ± SD) 2–6 years after entry for the 15 patients with progressive type RA are shown in Figure 6. Joint damage progression was most prominently revealed by the Rau method, and was least obvious by count of erosive joints, which yielded the lowest score increase during the 2–6 year period and exhibited a ceiling effect.

Changes in radiographic scores assessed by each method for the 30 patients 0–1, 0–2, and 2–6 years after study entry are shown in Table 2. The SRM was calculated for each period. Radiographic changes in the first (0–1) and second years (1–2) were sensitively identified by all 3 methods. However, in the 2 to 6 year period, sensitivity to change was still high with the Rau (SRM 1.38) and Larsen (SRM 0.95) methods, but not for the count of erosive joints method (SRM 0.47). Compared with the Rau method, the Larsen method increased more sensitively in the first 2 year period, but in the 2 to 6 year period, the Rau method increased more sensitively than the Larsen method.

DISCUSSION

We found that the Rau and Larsen methods revealed nearly equivalent radiographic progression. Radiographic scores obtained with both the Rau and Larsen methods increased steadily up to 6 years after entry into the study without apparent ceiling effect.

Scores in the count of erosive joints increased most rapidly during the first 2 years (Figure 2); however, SRM

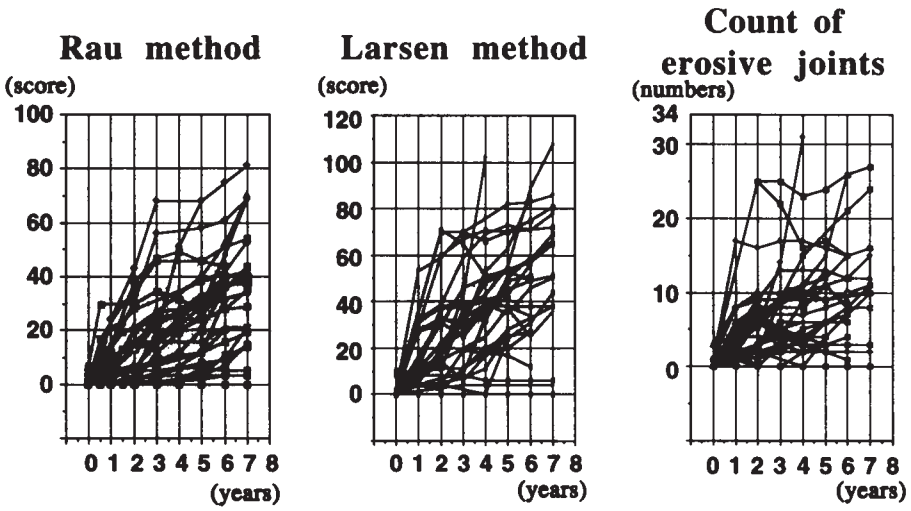

Figure 1. Radiographic scores for each method in 30 patients with RA during 7 year followup. The maximum scores for the Rau method, Larsen method, and count of erosive joints were 190, 210, and 34, respectively.

Table 1. Radiographic scores obtained with 3 radiographic methods in 30 patients with RA during 6 years after study entry.

Radiographic Method	0 Year	1 Year	2 Years	6 Years
Rau method	1.4 ± 2.2 (0–7)*	6.0 ± 6.7 (0–24)	12.7 ± 13.1 (0–43)	32.7 ± 23.4 (0–81)
Larsen method	1.1 ± 2.4 (0–10)	13.0 ± 13.5 (0–53)	24.2 ± 21.2 (0–71)	41.0 ± 27.4 (0–89)
Count of erosive joints	0.34 ± 0.67 (0–3)	3.8 ± 3.7 (0–17)	6.3 ± 6.5 (0–25)	8.9 ± 7.5 (0–26)

* Mean ± SD (range).

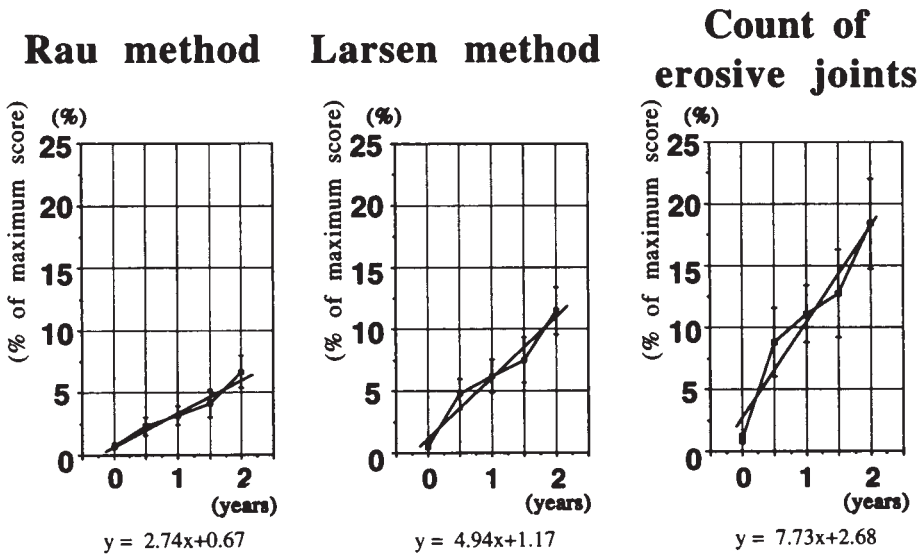

Figure 2. Percentages of the maximum score (mean ± SD) for each method (Rau method, Larsen method, and count of erosive joints) during the first 2 years after entry into the study for 30 RA patients. The count of erosive joints was the most sensitive among the 3 methods during the first 2 years.

scores during this period were not found to be high (Table 2). Probably, a large difference in the count of erosive joints in our cases affected this result.

We scored the Larsen method by multiplying the wrist joint by 5, as others did[13-17], although the original Larsen report did not show this in the original manuscript[6]. In addition, we intended to compare the Larsen method with the Rau method, which weighted the wrist count in the evaluation of joint damage.

The Larsen method increased more sensitively than the Rau method in the first 2 year period, while the Rau method increased more sensitively in the 2 to 6 year period. This can be explained by the scoring procedures of these 2 methods. In situations in which a number of tiny erosions exist in one joint, the grade in the Larsen method would be grade 2 or higher, and assessment using the Larsen method would result in a higher score than that using the Rau method. Thus, compared to the Rau method, the Larsen method tends to result in higher scores in the period directly after the onset of RA, even though it takes account of the score of soft tissue swelling, periarticular osteoporosis, or slight joint space narrowing in Larsen grade 1, but yields smaller increases in score during later periods[9]. The patients in our study were enrolled in the very early period of disease (3.5 ± 2.9 mo), and the number of swollen joints was low (4.1 ± 3.6) at enrollment. This may explain our finding that the Rau method was more sensitive than the Larsen method during the 2–6 year period after study entry in patients with progressive type disease.

The original Larsen method scored joint swelling, osteoporosis, erosion, and joint space narrowing of all limb joints according to written criteria and reference radiographs[6]. In addition, grade I findings using the Larsen method included soft tissue swelling and periarticular osteoporosis. It has been argued that these findings can depend on the observer[8,9], and are often reversible during the course of RA. However, erosive change is a distinct radiographic alteration and is usually stable and irreversible, although healing of erosive change has been reported in RA after successful drug therapy[18]. Based on these arguments, Larsen published a modified scoring system in which soft tissue swelling and periarticular osteoporosis were deleted and the wrist was divided into 4 quadrants[19].

The Larsen grade is determined by comparison with reference radiographs, while the Rau score is based only on the amount of eroded joint. Radiographic joint destruction

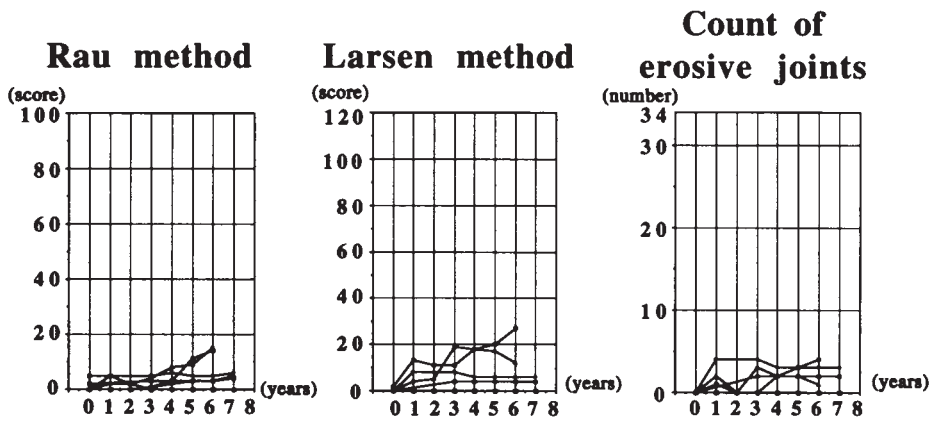

Figure 3. Scores obtained with each method in 7 patients with less-progressive type RA. Scores did not markedly increase during the course of RA.

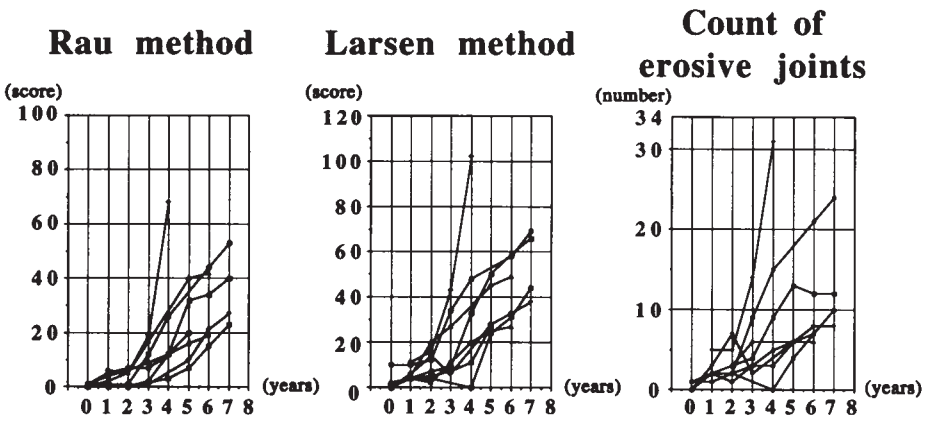

Figure 4. Scores obtained with each method in 8 patients with late-progressive type RA. Scores began to increase 2–3 years after study entry.

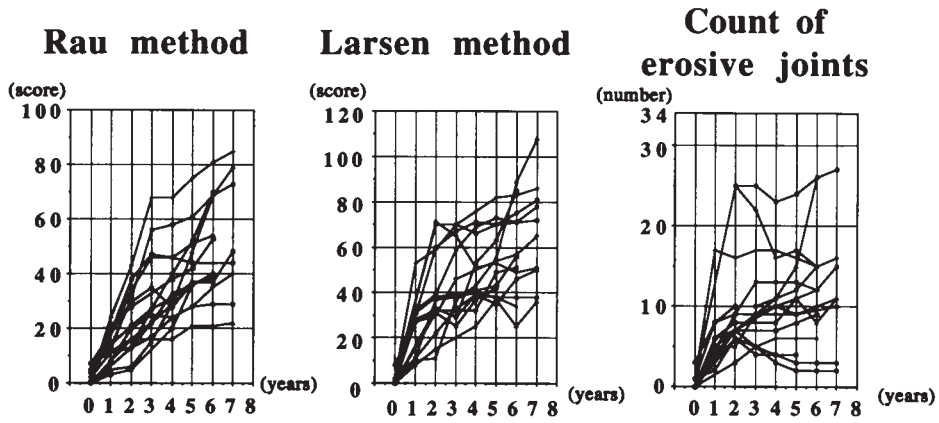

Figure 5. Scores obtained with each method in 15 patients with progressive-type RA. Scores increased in parallel with the course of RA, particularly as assessed by the Rau and Larsen methods.

of RA progresses in 2 ways, i.e., bony erosion and joint space narrowing. The Larsen grade accounts for both modes of progression, while the Rau method evaluates only bony erosion. Since these 2 modes of radiographic change may progress independently[20], the Rau method might be disadvantageous for evaluation of total bony destruction.

The Larsen and Sharp methods are currently the most widely used by clinical researchers. The usefulness of the

Table 2. Changes in radiographic scores with each method in 30 patients with RA during years 0–1, 0–2, and 2–6 of followup.

Radiographic Method	0–1 Year	0–2 Years	2–6 Years
Rau method	5.0 ± 6.0 (0.83)*	11.6 ± 12.5 (0.93)	22.9 ± 16.5 (1.38)
Larsen method	11.8 ± 13.5 (0.88)	23.3 ± 21.4 (1.09)	20.4 ± 21.5 (0.95)
Count of erosive joints	3.4 ± 3.6 (0.94)	5.9 ± 6.4 (0.93)	3.0 ± 6.4 (0.47)

* Mean ± SD (SRM). SRM: standardized response mean (the mean change between the baseline and year x radiographic score/SD of the change score).

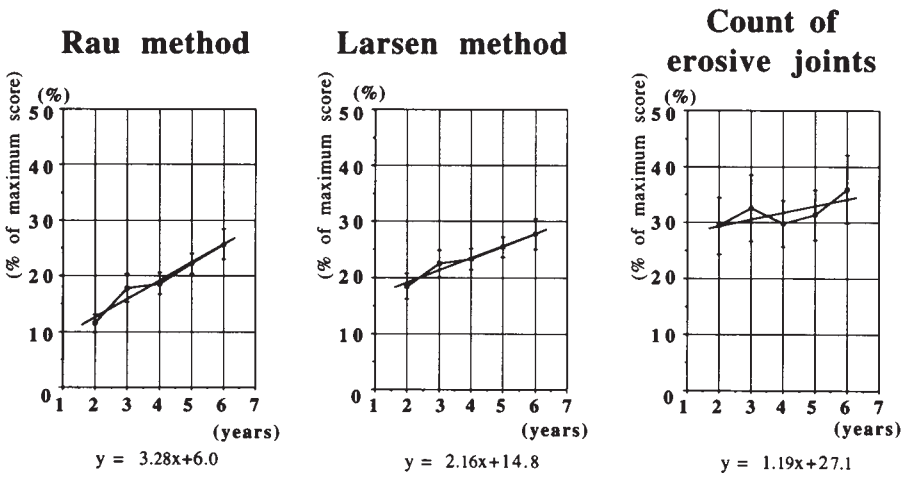

Figure 6. Percentages of the maximum score (mean ± SD) from 2–6 years after entry into the study for 15 patients with progressive type RA. The rate of change was the highest for the Rau method, and the lowest for the count of erosive joints. A ceiling effect was evident in the count of erosive joints.

Larsen and Sharp methods in joint damage evaluation has been compared, but the results have been inconsistent[17,21-24]. The Sharp method is based on scoring of the number of discrete erosions and joint space narrowing[5,25]. Since joint space narrowing is thought to be significant for the assessment of joint damage in RA[26], and is reported to progress independently of the emergence of erosion[15,26], the Sharp method measures damage more accurately but is complicated to perform, and radiographs take longer to read with it than with the Larsen method[9,21,22].

A grading system that is based on a simple methodology, is easy to perform, and has had its usefulness validated is desirable. In the Rau method[9] scoring depends completely on the amount of joint surface destruction in 38 joints. Thus, although theoretically the Rau method might have the handicap of omitting joint space narrowing in evaluation, the steady increase in the Rau scores over many years in patients with progressive RA, coupled with its short reading time, suggests that the Rau method may be useful for radiographic evaluation in clinical trials, especially those that are large-scale.

The Rau method evaluates only the progression of bony erosion, but is as useful as the Larsen method in revealing radiographic progression in patients with early RA. Considering its shorter evaluation time, the Rau method may be useful for clinical assessment, especially in large-scale trials.

REFERENCES

1. Brower AC. Use of the radiograph to measure the course of rheumatoid arthritis. Arthritis Rheum 1990;33:316-24.
2. Boers M. The validity of radiography as outcome measure in rheumatoid arthritis. J Rheumatol 1995;22:1783-6.
3. Steinbrocker O, Traeger CH, Batterman RC. Therapeutic criteria in rheumatoid arthritis. JAMA 1949;140:659-65.
4. Kellgren JH, Bier F. Radiological signs of rheumatoid arthritis. A study of observed differences in the reading of hand films. Ann Rheum Dis 1956;15:55-60.
5. Sharp JT, Lidsky MD, Collins LC, Moreland J. Methods of scoring the progression of radiologic changes in rheumatoid arthritis. Correlation of radiologic, clinical and laboratory abnormalities. Arthritis Rheum 1971;14:706-20.
6. Larsen A, Dale K, Eek M. Radiographic evaluation of rheumatoid arthritis and related conditions by standard reference films. Acta Radiol Diagn (Stockh) 1977;18:481-91.
7. van der Heijde DMFM, van Riel PL, Nuver-Zwart IH, Gribnau FW, van de Putte LBA. Effects of hydroxychloroquine and sulphasalazine on progression of joint damage in rheumatoid arthritis. Lancet 1989;13:1036-8.

8. Scott DL, Houssien DA, Laasonen L. Proposed modification to Larsen's scoring methods for hand and wrist radiographs. Br J Rheumatol 1995;34:56.
9. Rau R, Wassenberg S, Herborn G, Stucki G, Gebler A. A new method of scoring radiographic change in rheumatoid arthritis. J Rheumatol 1998;25:2094-107.
10. Arnett FC, Edworthy SM, Bloch DA, et al. The American Rheumatism Association 1987 revised criteria for the classification of rheumatoid arthritis. Arthritis Rheum 1988;31:315-24.
11. Kirwan JR. Using the Larsen index to assess radiographic progression in rheumatoid arthritis. J Rheumatol 2000;27:264-8.
12. Liang MH, Fossel AH, Larson MG. Comparison of five health status instruments for orthopedic evaluation. Med Care 1990;28:632-42.
13. Luukkainen R, Kaarela K, Isomaki H, et al. The prediction of radiological destruction during the early stage of rheumatoid arthritis. Clin Exp Rheumatol 1983;1:295-8.
14. Plant MJ, Saklatvala J, Borg AA, Jones PW, Dawes PT. Measurement and prediction of radiological progression in early rheumatoid arthritis. J Rheumatol 1994;21:1808-13.
15. Fex E, Jonsson K, Johnson U, Eberhardt K. Development of radiographic damage during the first 5-6 yr of rheumatoid arthritis. A prospective follow-up study of a Swedish cohort. Br J Rheumatol 1996;35:1106-15.
16. Jessop JD, O'Sullivan MM, Lewis PA, et al. A long-term five-year randomized controlled trial of hydroxychloroquine, sodium aurothiomalate, auranofin and penicillamine in the treatment of patients with rheumatoid arthritis. Br J Rheumatol 1998;37:992-1002.
17. Paimela L, Laasonen L, Helve T, Leirisalo-Repo M. Comparison of the original and the modified Larsen methods and the Sharp method in scoring radiographic progression in early rheumatoid arthritis. J Rheumatol 1998;25:1063-6.
18. Rau R, Herborn G. Healing phenomena of erosive changes in rheumatoid arthritis patients undergoing disease-modifying antirheumatic drug therapy. Arthritis Rheum 1996;39:162-8.
19. Larsen A. How to apply Larsen score in evaluating radiographs of rheumatoid arthritis in longterm studies. J Rheumatol 1995;22:1974-5.
20. Kirwan J, Byron M, Watt I. The relationship between soft tissue swelling, joint space narrowing and erosive damage in hand X-rays in patients with rheumatoid arthritis. Rheumatology 2001;40:297-301.
21. Cuchacovich M, Couret M, Peray P, Gatica H, Sany J. Precision of the Larsen and the Sharp methods of assessing radiologic change in patients with rheumatoid arthritis. Arthritis Rheum 1992;35:736-9.
22. Wassenberg S, Herborn G, Fischer S, et al. Comparison of Larsen's and Sharp's method of scoring radiographs in rheumatoid arthritis [abstract]. Arthritis Rheum 1994;37 Suppl:S250.
23. Pincus T, Callahan LF, Fuchs HA, Larsen A, Kaye J. Quantitative analysis of hand radiographs in rheumatoid arthritis: time course of radiographic changes, relation to joint examination measures, and comparison of different scoring methods. J Rheumatol 1995;22:1983-9.
24. Plant MJ, Saklatvala J, Borg AA, Jones PW, Dawes PT. Measurement and prediction of radiological progression in early rheumatoid arthritis. J Rheumatol 1994;21:1808-13.
25. Sharp JT, Young DY, Bluhm GB, et al. How many joints in the hands and wrists should be included in a score of radiologic abnormalities used to assess rheumatoid arthritis? Arthritis Rheum 1985;28:1326-35.
26. Sharp JT. An overview of radiographic analysis of joint damage in rheumatoid arthritis and its use in metaanalysis. J Rheumatol 2000;27:254-60.