CONCISE REPORT

The "X-Ray RheumaCoach" software: a novel tool for enhancing the efficacy and accelerating radiological quantification in rheumatoid arthritis

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Background: Precise diagnosis and follow up treatment of rheumatoid arthritis (RA) requires objective quantification, which is still lacking. For this purpose, radiological analyses are considered to be the most appropriate method.
Objective: To develop computer assisted quantification software that is particularly applicable to joint scoring in rheumatic disorders.
Methods: 3914 radiographs from hands and feet of 190 patients with RA were collected, expertly examined, analysed, and statistically evaluated. Radiographs were quantified using the conventional Larsen score and the "X-Ray RheumaCoach" (XRRC) software. The XRRC is a Java stand alone application which can support and accelerate, but not fully automate, the scoring procedure in RA. The scorer can apply both the Larsen and the Ratingen-Rau scores.
Results: Compared with conventional scoring procedures, the XRRC software accelerated quantification time by ~25%. The program, which is now available on the internet free of charge, ran stably and proved to be a consistently valuable tool.
Conclusions: Compared with conventional scoring methods, the XRRC software offers several advantages: (*a*) structured data analysis and input that minimises variance by standardisation; (*b*) faster and more precise calculation of sum scores and indices; (*c*) permanent data storing and fast access to the software's database; (*d*) the possibility of cross calculation to other scores; (*e*) "user friendly" technology and a dedicated help program; (*f*) fast access and data transfer through the internet if desired; and (*g*) reliable documentation of results in a specially designed printout.

In rheumatoid arthritis (RA), quantitative radiological evaluation of the affected joints is crucial to establishing a diagnosis and planning appropriate therapeutic intervention. Radiographic assessment of RA yields important information beyond that obtained from other variables, such as tender and swollen joint counts.[1] Moreover, radiological evaluation correlate well with functional outcome.[2]

Many attempts have been made to develop efficacious and economic scoring methods that improve on those of Larsen[3 4] and Rau,[5] and their modifications, which currently represent the most widely used and valid scoring systems.

Compared with conventional scoring methods, computer assisted quantification offers several advantages: structured data analysis and input that minimises variance by standardisation, faster and more precise calculation of sum scores and indices, the possibility of cross calculation to other parameters, "user friendly" technology and a dedicated help program, fast access and optional danalysisdanal67T

Figure 1 Data input sheet for assessing radiographs of the hands of a patient with RA.

Figure 2 Data input sheet for assessing radiographs of the feet of a patient with RA.

database decisively facilitate long term follow up studies. The software is programmed to accommodate permanent implementation of new modules.

METHODS

The XRRC software was installed on customary notebooks, and standardised evaluation sheets provided for conventional scoring.

Three thousand nine hundred and fourteen radiographs of the hands and feet of patients with RA were "blinded" and scored in chronological sequence by four experienced radiologists applying the Larsen method.[4 8] Two scorers used the XRRC software, the other two scored conventionally. In each case, 64 joints were scored (hands: 4 proximal carpal, 4 distal carpal, 10 metacarpophalangeal, 8 proximal interphalangeal, 2 thumb interphalangeal, 8 distal interphalangeal joints; feet:

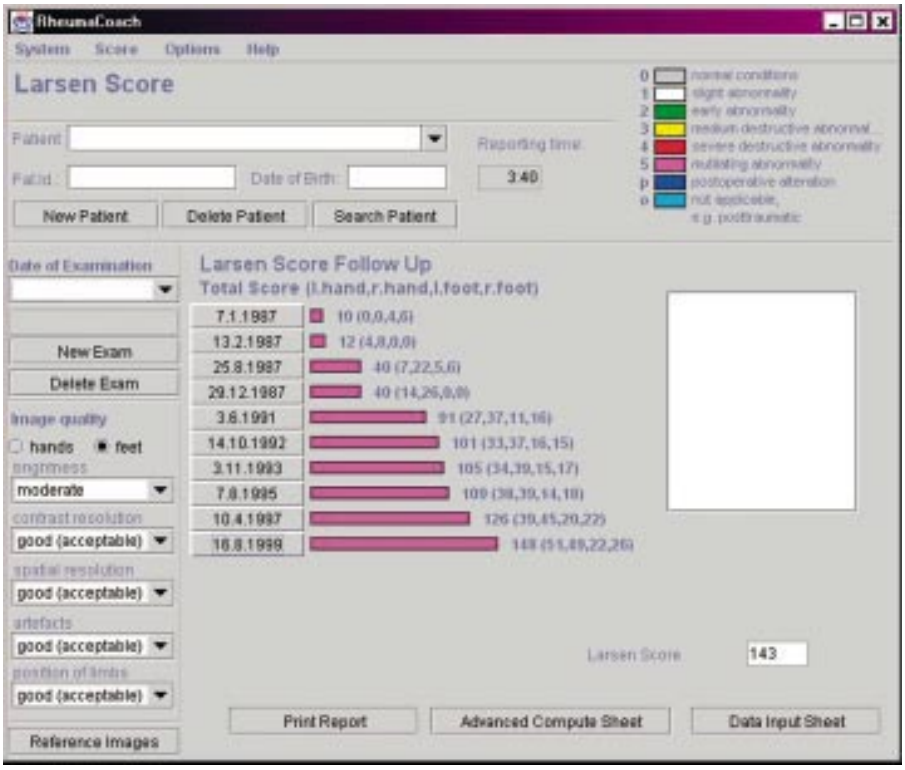

Figure 3 Computer sheet providing detailed information on the Larsen score obtained from patients with RA.

10 metatarsophalangeal, 8 proximal interphalangeal, 2 toe interphalangeal, 8 distal interphalangeal joints).

The exact time for quantification was taken in minutes and seconds. Time needed for intraobserver calculations and documentation was excluded.

All data are given as mean (SEM). Statistical comparisons were performed using analysis of variance following ad hoc Student's *t* test analyses. Differences were considered statistically significant at p values ≤ 0.05. All statistical analyses were performed using Microsoft Excel 97 and SPSS 11.0 for Windows (SPSS Inc Headquarters, Chicago, IL; http://www.spss.com).

RESULTS

Data analyses and input

Significantly decreased reporting times were recorded for all readers who applied the XRRC software ($p<0.05$). The mean time spent by XRRC scorers was 5.7 (0.1) minutes *v* 7.5 (0.5) minutes for those using conventional methods,[9] an improvement in scoring time of about 25%. Radiologist preparation time and semiautomatic calculation and documentation by the software were excluded. No influence on interobserver variability was detectable and no data were lost.

Calculations and transfer of data

Sum scores, scores for individual joints, and a broad range of optional indices were calculated and stored in the software database. Export to statistical software was easy to perform and yielded data compatible with the XRRC software in clinical long term follow up and comparative therapeutic studies (Wick M, *et al*, unpublished data).

Reporting

No systemic errors occurred during more than 3914 scorings. Documentation of results on the department's printout improved interdisciplinary communication and was easy to interpret. The possibility of exportation to other programs and electronic distribution facilitated and accelerated the scientific work.

DISCUSSION

By evaluating radiographs using the XRRC software, the results of our studies in patients with RA describe (*a*) structured data analysis and input that minimises variance by standardisation; (*b*) faster and more precise calculation of sum scores and indices; (*c*) possibility of cross calculation to other scores; (*d*) user friendly technology and a dedicated help program; (*e*) fast access and optional data transfer through the internet; (*f*) reliable documentation of results in a specially designed printout; (*g*) balanced patient joint score card; (*h*) optimised patient tracking; (*i*) quick identification of trends, even within normal ranges; (*j*) reduction of manual transcription time; (*l*) elimination of paperwork; (*m*) optimised access to data; and (*n*) dedicated online support, development, and implementation for those unfamiliar with computer applications.

The XRRC offers total overview of a patient with RA at a glance, providing up to date and complete radiological information in one place.

To our knowledge, this is the first radiological software package to present a balanced patient joint score card in the form of integrated graphs on which doctors can see the direct effect of their prescribed treatments and quickly identify trends, even within normal ranges. Treatment decisions can thus be based on the most current radiological evaluation, ensuring accuracy and completeness as well as saving time. Moreover, all affected joints can be specifically followed as well as being part of the general assessment of radiological progression for long term follow up. Data transfer through intranet or internet reduces manual transcription time and permits transmission of results electronically to healthcare providers, other health centres, or patients. The XRRC does not, however, currently allow fully automated scoring.

This program allows far greater and faster access to all data by exporting the data for multidimensional analysis. Of note, the online tutorial (http://www.univie.ac.at/radio/radio.htm), which is available to all interested parties, offers detailed information on RA, radiological quantification, software

installation, and the correct use of this software, as well as allowing free downloads of the most recent versions.

In contrast with some other electronic modalities and software in radiological and physician settings,[11–13] the XRRC is well established and robust software that facilitates routine and scientific work and saves time. Because the XRRC software was introduced as a routine tool for doctors in rheumatological and radiological settings, it has proved to be an important time and cost saving tool.

In conclusion, we have designed and successfully applied a new computer program that significantly improves clinical and scientific evaluation of radiographs in RA. More precise data analysis and computation of scores are a crucial part of quality control and offer the potential to replace present scoring techniques in RA. This program is currently in extensive use by the authors and several other groups. One of the major aims for the foreseeable future will be the implementation of the XRRC software to fully automated digital radiography.

Note: The authors will make the software program described herein freely available (http://www.univie.ac.at/radio/radio.htm) to those who agree not to (a) copyright; (b) patent; or (c) use the program for commercial purposes. Furthermore, user comments are invited and will be included in a collection of comparative data on conventional