RADIOGRAPHIC EVALUATION OF RHEUMATOID ARTHRITIS AND RELATED CONDITIONS BY STANDARD REFERENCE FILMS

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Radiography is of primary importance in the evaluation of chronic inflammatory conditions with joint manifestations, such as rheumatoid arthritis, ankylosing spondylitis and psoriatic arthropathy. As yet, no system has been presented having proven reproducibility and validity for grading the severity of arthritis in these conditions. The absence of a satisfactory evaluation system has been obvious, especially in therapeutic and epidemiologic investigations on rheumatoid arthritis. In this report, a short review on the radiographic evaluation of arthritis is given and a new system based on standard reference films is introduced.

Previous systems for evaluation of arthritis

The first attempt towards a standardized evaluation of rheumatoid arthritis dates back to 1949 when, through the initiative of the American Rheumatism Association, four stages were introduced (Steinbrocker et coll. 1949), still the most commonly used grading. The radiographic criteria of the four stages are as follows: Stage I: Osteoporosis may exist, no erosions. Stage II: Osteoporosis, slight cartilage or subchondral bone destruction may be present. Stage III: Osteoporosis, cartilage and bone destruction. Stage IV: Same as III, with bony ankylosis.

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Several difficulties are involved when applying this system. The evaluation may be based on any single joint, without the grading providing information about the other joints. An osteoporotic joint may be graded either as first or second stage. The difference between the second and third stages is vague. Bony ankylosis as a criterion of the most severe stage is not acceptable; in actual fact, the new bone formation leading to ankylosis is a reparative process in arthritis (Gardner 1965).

The 'Atlas of standard radiographs of arthritis', which represented a remarkable methodologic advance, was published in 1962, mainly for epidemiologic investigations of arthritis (Kellgren et coll. 1963). This atlas contains paper prints of standard reference films for the hand with the wrist, the forefoot and the cervical spine illustrating the second to fourth stages of rheumatoid arthritis, the zero and first stage remaining verbally described. The atlas presented a new idea in definition: reference to figures instead of words. However, the illustrations are small, implying that it is difficult to observe the erosive and joint space abnormalities characterizing the different stages.

The two systems mentioned are designed to classify patients with rheumatoid arthritis according to the grade of the lesion in one or a few joints. Therapeutic trials in arthritis need more accurate evaluation, a good example being the scoring system used in the Empire Rheumatism Council investigation of gold therapy in 1961. In this system 20 finger joints in the final films were compared with those in the initial films. The new erosions, extensions of old erosions, and narrowed joint spaces were scored. A more detailed scoring system for erosions and joint space narrowing in the hands and wrists was presented by Sharp et coll. (1971).

Development of the present system

The first version of the present system was developed at the Rheumatism Foundation Hospital, Heinola, Finland (Larsen 1974). Films demonstrating 6 stages were produced with Logetronics equipment and the joints illustrated in life size on one sheet of film. The first stage represented the normal condition and the subsequent ones a gradual, progressive deterioration, the criteria being bone destruction and cartilage reduction based on conclusions reached in reviewing the pathology and radiology of rheumatoid arthritis. An interobserver analysis with these standard films demonstrated that 9 out of 10 arthritis films may be staged uniformly by 6 observers. A parallel result was obtained using the system in a radiologic quiz arranged during the XIII Scandinavian Congress of Rheumatology (Larsen 1974).

The first independent testing of the system took place in this department of radiology (Dale & Eek 1975). An inability of the system to record slight abnormalities in arthritis was revealed, which resulted in a modification of the system by referring to a normal joint as zero and to a joint with slight abnormalities as grade I. This modified system was tested on 560 films of several types of arthritis in a variety of joints. The agreement in the evaluation of seropositive and seronegative rheumatoid
Table 1

Agreement of two radiologists in reading films of different types of arthritis using standard films as comparison

<table>
<thead>
<tr>
<th></th>
<th>Seropositive rheumatoid arthritis</th>
<th>Seronegative rheumatoid arthritis</th>
<th>Psoriatic arthropathy</th>
<th>Ankylosing spondylitis</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
<td>No.</td>
</tr>
<tr>
<td>Patients</td>
<td>67</td>
<td>16</td>
<td>6</td>
<td>11</td>
<td>100</td>
</tr>
<tr>
<td>Films with satisfactory agreement</td>
<td>362</td>
<td>89</td>
<td>58</td>
<td>81</td>
<td>36</td>
</tr>
<tr>
<td>Films with poor agreement</td>
<td>43</td>
<td>11</td>
<td>14</td>
<td>19</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>405</td>
<td>100</td>
<td>72</td>
<td>100</td>
<td>38</td>
</tr>
</tbody>
</table>

arthritides, ankylosing spondylitis and psoriatic arthropathy appears in Tables 1 and 2. The agreement was considered satisfactory if both observers graded the film within the same stage or two adjacent stages. It was considered poor if the evaluation differed by more than two stages. About 90 per cent agreement was obtained in seropositive rheumatoid arthritis and in psoriatic arthropathy, whereas poor agreement was more usual in seronegative arthritis and in ankylosing spondylitis. The poor agreement was attributed to the tendency to bony ankylosis or new bone forma-

Table 2

Agreement of two radiologists in reading films of different types of arthritis using standard films as comparison. Distribution of joints examined

<table>
<thead>
<tr>
<th>Joints</th>
<th>Total No.</th>
<th>Satisfactory</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>Seropositive rheumatoid arthritis</td>
<td>Seronegative rheumatoid arthritis</td>
</tr>
<tr>
<td>Wrist</td>
<td>124</td>
<td>103</td>
<td>16</td>
</tr>
<tr>
<td>MCP</td>
<td>102</td>
<td>96</td>
<td>3</td>
</tr>
<tr>
<td>PIP</td>
<td>82</td>
<td>73</td>
<td>3</td>
</tr>
<tr>
<td>DIP</td>
<td>6</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Shoulder</td>
<td>29</td>
<td>26</td>
<td>2</td>
</tr>
<tr>
<td>Elbow</td>
<td>35</td>
<td>33</td>
<td>1</td>
</tr>
<tr>
<td>Hip</td>
<td>35</td>
<td>26</td>
<td>3</td>
</tr>
<tr>
<td>Knee</td>
<td>51</td>
<td>38</td>
<td>7</td>
</tr>
<tr>
<td>Ankle/tarsus</td>
<td>35</td>
<td>30</td>
<td>5</td>
</tr>
<tr>
<td>MTP</td>
<td>44</td>
<td>39</td>
<td>3</td>
</tr>
<tr>
<td>IP</td>
<td>17</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>560</td>
<td>486</td>
<td>43</td>
</tr>
</tbody>
</table>
tion which made the evaluation of the films difficult. It was concluded that the system may be used as a semiquantitative measure of several kinds of arthritis when bony ankylosis or predominant new bone formation are not present.

Following this testing a revision of the first version was considered necessary. This revision as presented below was made by the present authors in close collaboration.

**Standard reference films for evaluation of arthritis**

The present standard reference films for evaluation of arthritis demonstrate the radiographic criteria for the grading of the severity of the lesion. Standard films of the finger joints appear in Fig. 1, of the wrist in Fig. 2 and of the hip in Fig. 3. Films from patients for comparison with standard films are given in Figs 4 and 5.

Conventional equipment and standard projections of the joints were used, but only films of antero-posterior projection were chosen for standards, except for the tarsus, which was exposed in lateral projection. The joints were exposed without weight bearing. The right and left joints were exposed on the same film, except for the tarsus and the shoulder. The focus cassette distance was 100 cm. Grids were used for the shoulder and hip joints and intensifying screens were used for all standard films. The mean exposure values were: for the wrist 42 kV, 100 mA, 1.6 s, and for the hip 60 kV, 100 mA, 4 s. The films were developed by an automated developer for 90 seconds.
The individual films for the standard series were selected according to the following principles: The films originated from adult women with rheumatoid arthritis and a positive or negative rheumatoid factor. The films of the zero and the first stage represented symmetrical joints of the same patient or the same joint at different times, to illustrate the delicate abnormalities of the first stage and to emphasize the value of comparing films of possibly pathologic joints with unaffected joints in a contralateral or previous film. The films demonstrating the outer stages originated from different patients. The radiographic criteria of the separate stages are itemized later.
Fig. 3. Standard films. Stages in the hip.
Fig. 4. Hands from a patient with rheumatoid arthritis. Right wrist: Previous synovectomy, arthritis grade III. Left wrist: Grade IV (cf. Fig. 2).

The standard series demonstrating each joint at different stages were prepared as follows: Films representing the different stages of one joint were glued with the legends on to a transparent plastic sheet. The model sheets were duplicated on a radiographic duplicating film (Kodak RP/D X-Omat 24 cm × 30 cm).

The following joints were included in the standard series: The distal interphalangeal joint (DIP) of the finger, the proximal interphalangeal joint (PIP) of the finger, the metacarpophalangeal joint (MCP), the wrist, the elbow, the shoulder, the hip, the knee, the ankle, the tarsus, the first metatarsophalangeal joint (MTP I), other metatarsophalangeal joints (MTP II–V), and the interphalangeal joint of the great toe (IP).

As a supplement to these illustrations the following descriptions of the stages should be considered when using the system:

Grade 0. Normal conditions. Abnormalities not related to arthritis, such as marginal bone deposition, may be present.

Grade 1. Slight abnormality. One or more of the following lesions are present: periarticular soft tissue swelling, periarticular osteoporosis and slight joint space narrowing. When possible, use for comparison a normal contralateral or a previous film of the joint in the same patient, as demonstrated in the standard series. The standard series illustrates a characteristic osteoporosis and joint space narrowing, whereas no attempt was made to demonstrate the appearance of soft tissue. Soft
tissue swelling and osteoporosis may be reversible. This stage represents an early, uncertain phase of arthritis or a later phase without destruction. Compatible appearances may occur without arthritis in old age, traumatic conditions, Sudeck's atrophy, etc.

*Grade II.* Definite early abnormality. Erosion and joint space narrowing corresponding to the standards. Erosion is obligatory except in the weight-bearing joints.

*Grade III.* Medium destructive abnormality. Erosion and joint space narrowing corresponding to the standards. Erosion is obligatory in all joints.

*Grade IV.* Severe destructive abnormality. Erosion and joint space narrowing corresponding to the standards. Bone deformation is present in the weight-bearing joints.

*Grade V.* Mutilating abnormality. The original articular surfaces have disappeared. Gross bone deformation is present in the weight-bearing joints. Dislocation and bony ankylosis, being late and secondary, should not be considered in the grading; if present, the grading should be made according to the concomitant bone destruction or deformation.

There may sometimes, especially in the erosive phase of arthritis, be some disparity between the degree of erosion and the narrowing of the joint space, because loosening of joint ligaments and the presence of excess joint fluid may cause widening of the joint space. If so, the degree of erosion should be the decisive factor when using the present grading system.

**Discussion**

The present system offers a possibility to reproduce radiographic evaluation of arthritis in the essential joints of the extremities. The reproducibility has been tested
several times, with the general result that different observers uniformly graded 90 per cent of films of rheumatoid arthritis (LARSEN 1973, 1974, DALE & EIK). The validity of the radiographic criteria is based on the joint pathology.

The present system is not specific for rheumatoid arthritis. When new bone formation is not predominant it is possible to evaluate extremity joints in other chronic inflammatory conditions, such as ankylosing spondylitis and psoriatic arthropathy, which are known to present many common features in joint pathology (GARDNER). However, the system is not suited for evaluating juvenile rheumatoid arthritis or arthropathies in childhood with abnormal epiphyseal development. Osteoarthrosis may cause abnormalities comparable with grade I, or even more severe grades, particularly in the interphalangeal joints of the fingers (erosive, osteoarthrosis), in the hips and in the knees. Osteoarthrosis is usually differentiated by the presence of osteophytes and sclerosis, but special difficulties may occur in osteoarthrosis secondary to arthritis. The system should not be used for differential diagnosis without considering the clinical and laboratory data, as well as the result of radiography of the spine and sacroiliac joints.

In addition to the technique described for the present system, special methods for soft tissue examination may be used to establish an early diagnosis of arthritis (SOILA 1957, FISCHER & BRAUN 1973, REICHMANN et coll. 1974, 1975, DEICHER & OLSSON 1975). This matter will not be further discussed here, because joint films of conventional techniques are used in the present system. For this reason films of weight-bearing positions in the lower extremity joints were not used. This technique has proved valuable in detecting narrowing of the joint space in osteoarthrosis (AHLBÄCK 1968) where the cartilage reduction in the early stage is more localised, contrary to the more often general reduction in an arthritic joint. The intention was to examine the lower and the upper extremity joints by conventional technique under uniform conditions. Moreover, the weight-bearing position is often painful for patients with arthritis. If a standing position is preferred when examining the lower extremity joints, the present grading system can be used. The grading of the films of the supine or standing position seems to differ very seldom in arthritis and never more than one grade.

The present system is a purely radiographic evaluation method for arthritis. It should not be considered as a general measure of the severity of the disease. Clinical and functional evaluation are of equal importance for the total evaluation of joints.

In the statistical data processing, it should be considered that the grading in the present system follows ordinal scale. Hence the statistical methods should be operable in this scale.

In rheumatology, it is customary to use such concepts as the stage of arthritis in an individual patient. Such a generalization may in many cases be arbitrary, and even misleading. The human body has about 190 synovial joints, and several extraarticular manifestations occur in rheumatoid arthritis and other inflammatory joint lesions. The joints and other features should be evaluated separately. It should be emphasized
that individual joints in one patient may present different stages in the present
system. The individual joints are, in this system, dissociated from a common time-
table. Progress of arthritis may be found in some joints while other joints are un-
changed. Thus, if the present system is used for classifying the patients, the joint
selection and the stages of these joints should be reported individually.

The present system is recommended for the following purposes:

1. In diagnostic radiology for numerical evaluation of arthritis and for recording of
   spontaneous variations of the disease.
2. In therapeutic connections, for evaluating disease progression. The system is
   applicable both in trials of drugs and in synovectomy.
3. In epidemiology of arthritis for exact recording of lesions in individual joints.

Duplicates and copies of the standard films are available on request.

SUMMARY

A review of radiographic evaluation of rheumatoid arthritis is given. Standard reference
films are introduced for evaluation of rheumatoid arthritis and related conditions in the
extremity joints. In this system, numerical evaluation of arthritis is given for individual
joints in a patient.

ZUSAMMENFASSUNG

Eine Übersicht über die röntgenologische Auswertung der rheumatoiden Arthritis wird
gegeben. Standardreferenzfilme zur Auswertung der rheumatoiden Arthritis und ähnlichen
Bedingungen der Extremitätengelenke werden eingeführt. Bei diesem System wird eine
numerische Auswertung einer Arthritis für die individuellen Gelenke eines Patienten gegeben.

RÉSUMÉ

Les auteurs présentent une méthode d'évaluation radiographique de l'arthrite rhumatis-
male. Ils utilisent des radiographies standard de référence pour évaluer les lésions de l'arthrite
rhumatisme et les affections apparentées sur les articulations des membres. Dans ce
système on établit une évaluation numérique de l'arthrite pour chaque articulation d'un
malade.

REFERENCES

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