



Conventional radiography of the hands and wrists in rheumatoid arthritis. What a rheumatologist should know and how to interpret the radiological findings

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Abstract

Rheumatoid arthritis (RA) is a chronic inflammatory disease affecting the synovial membrane, leading to joint damage and bone destruction. Conventional radiography (CR) of the hands and wrists has been, for many years, the primary imaging modality used to diagnose and monitor RA. On the other hand, many investigators in clinical trials and observational studies used CR of the hands and wrists to demonstrate drug effectiveness and structural damage progression. The purpose of this review is to discuss the evaluation and interpretation of the hands and wrists by CR in RA patients and the radiographic changes occurring in a specific joint. Thus, the literature was reviewed until January 2019 for studies regarding RA radiological evaluation of the hands and wrists, as well as radiological progression using CR. The assessment of joint pathology in RA patients should begin with CR which is the best imaging modality to evaluate any subtle changes occurring at the bone level. Once high-quality radiographs are obtained in appropriate views/projections, then an accurate evaluation can often be made without any further imaging studies. Therefore, CR is a valuable tool for RA screening. It is an easy-to-perform technique and gives important information assisting in differentiating between RA from other arthritides. In contrary CR does not provide good information when early RA changes start to appear, such as synovial inflammation or other soft-tissue structural changes. Nevertheless, it still remains the most commonly used imaging tool in rheumatology and has a number of advantages: it is easily available in most rheumatologists and readily accessible in most patients. It is inexpensive and relatively safe. It provides immediate information and can be interpreted easily by the requested rheumatologist. Finally, the data are reproducible and can be used for serial evaluation and follow-up.

Keywords Rheumatoid arthritis · Radiography · Synovial membrane · Inflammation · Wrist

Introduction

Rheumatoid arthritis (RA) is a chronic inflammatory disease affecting the synovial membrane, which in turn produces swelling, tenderness and pain of the affected joints. If the disease remains untreated it can lead to joint damage and bone destruction. The female to male ratio is 3:1. RA is a symmetrical polyarticular disease affecting mainly the small joints of the hands and wrists, as well as those of the feet. Extra-articular involvement is not infrequent, affecting the

eyes, lungs, heart, skin as well as other organ-systems [1, 2]. Its occurrence ranges between 30 and 50 cases/100,000 inhabitants per year with a prevalence of 0.5–1% in the general population [3]. The diagnosis of RA is mostly clinical, with the application of the American College of Rheumatology (ACR) and European League Against Rheumatism (EULAR) 2010 RA classification criteria [4].

For the evaluation of the articular damage, different imaging modalities are in the hand of a clinician's armamentarium, which have to be used in the most appropriate manner. The most important are conventional radiography (CR) [5–7], musculoskeletal ultrasonography (MSUS) [8, 9], magnetic resonance imaging (MRI) [10, 11] and computed tomography (CT) to a lesser extent. New CT techniques such as dual energy CT and high-resolution CT may have a place for the evaluation of the appendicular skeleton of an RA patient [12, 13]. The assessment of joint pathology

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should begin with CR which is the best imaging modality to evaluate any subtle changes occurring at the bone level. Once high-quality radiographs are obtained in appropriate views/projections, then an accurate evaluation can often be made without any further imaging studies. CR of the joints has for many years been the primary imaging modality used to diagnose and monitor RA. Erosions usually reflect late and often irreversible stage of bone destruction but it could be also an early sign but reflecting a bad prognosis for the evolution of the disease [5–7].

On the other hand, MRI and MSUS can show articular changes earlier than CR without the use of ionizing radiation, and for these reasons, both techniques are considered better tools than CR. However, MRI and MSUS are time-consuming techniques and require highly trained personnel and/or radiologists and rheumatologists. In addition, currently not all departments and clinics are equipped appropriately. Moreover, both techniques are operator-dependent. Therefore, CR is a valuable tool for RA screening. It is an easy-to-perform technique with standard protocols to obtain

X rays of different anatomical parts of the skeletal system and gives important information assisting in differentiating between RA from other arthritides. As far as it concerns the interpretation of the findings, not all radiologists are familiar of how to evaluate and interpret specific findings of RA patients while on the other hand not all rheumatologists have been taught of how to properly interpret hand X rays [14]. In addition, many investigators in clinical trials and observational studies used CR of the hands and wrists to demonstrate structural damage progression using conventional synthetic disease-modifying anti-rheumatic drugs (csDMARDs) of biologic (b)DMARDs [15, 16] Thus, all rheumatologists should be able to know how to evaluate and interpret CR findings, especially of the hands and wrists, which are the most affected joints in RA. To this end, the literature was reviewed until January 2018 for studies regarding the use of CR of the hands and wrists in RA patients [17].

In the current review, we will discuss the evaluation of the hands and wrists by CR in RA patients. We will also deal not only with the radiographic changes that occur in a specific

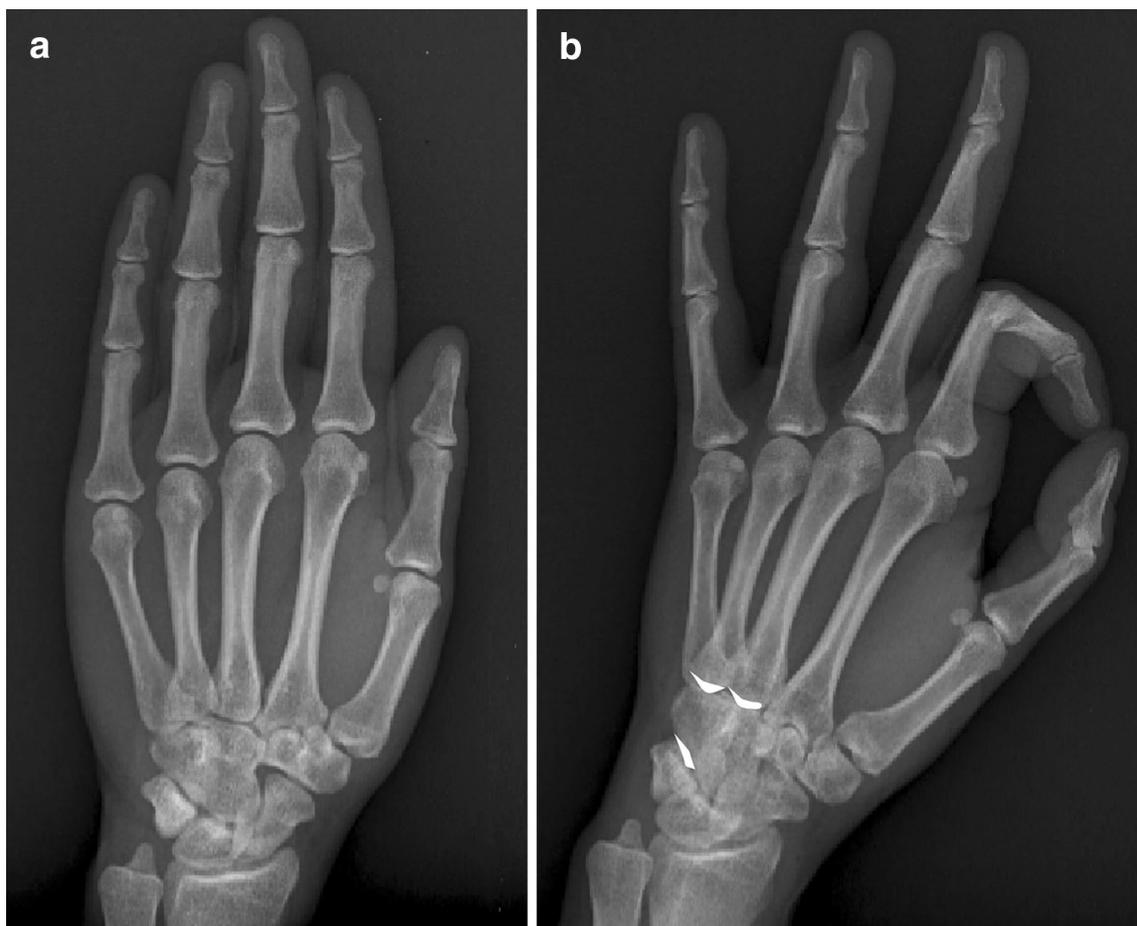


Fig. 1 **a** Posteroanterior and **b** Nørgaard view of a healthy individual. In the latter, the anatomic regions of early erosive changes of an inflammatory arthropathy are marked in white

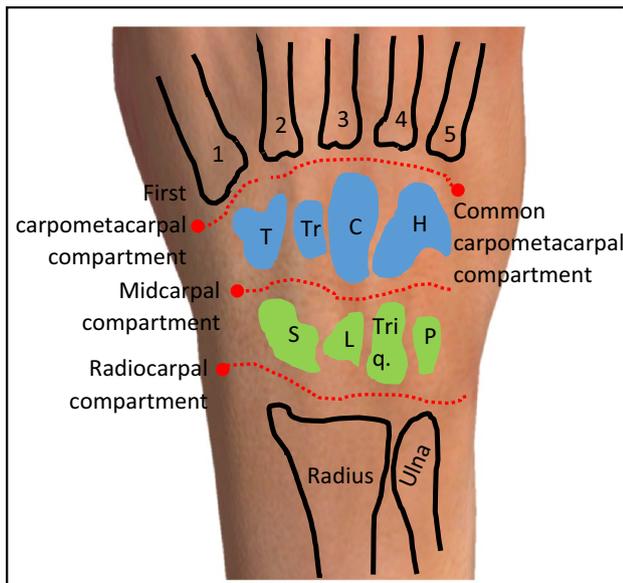


Fig. 2 Anatomical compartments of the wrist (schematic representation). Early erosions in inflammatory arthritides begin in the pisiform and triquetrum bones. 1–5, metacarpal bones; T, trapezium; Tr, trapezoid; C, capitate; H, hamate; S, scaphoid; L, lunate; Triq., triquetrum; P, pisiform



Fig. 3 Soft tissue swelling around the second, third and fourth PIPs in an RA patient

joint but also the distribution of those changes in the hands and wrists, to achieve an accurate diagnosis.

Evaluation of the hands and wrists

CR of the hands and wrists offers important information if used correctly as a screening tool in patients with arthritis. The posteroanterior (PA) and the Nørgaard projections (the latter is also known as the “ball-catcher view”) are used for

a complete radiographic evaluation [7]. The PA view can give information not only for the bony structures but also for any soft tissue changes due to the perpendicular penetration of the X rays to the hand and wrist [18]. For example, soft tissue swelling may be easily detected. On the other hand, the Nørgaard projection, which is an anteroposterior (AP) oblique view, can be used as an additional radiographic view for early erosions in specific areas of the hand and wrist. In this projection, the metacarpophalangeals (MCPs) are better exposed to obtain information for any possible early erosive changes (Fig. 1). In addition, more information can be obtained regarding the triquetrum and pisiform bones in the wrist (Fig. 2). The earliest erosive changes of any inflammatory arthropathy begin in these areas [5, 7, 19]. Both views can give information about any cortical bone changes. The lateral view is mainly used for assessment of fractures and is of limited use in rheumatology. Below, the main changes that can be demonstrated with CR at any diarthrodial joint are presented: soft tissue swelling, calcifications, mineralization, subluxation/dislocation, joint space narrowing, erosions and bone proliferation [20–22].

Soft tissue swelling

Soft tissue swelling is not a pathognomonic finding of RA [7]. Symmetrical soft tissue swelling is seen in early phase of RA but also in other inflammatory arthropathies [23]. In RA soft tissue swelling is evaluated mostly around the proximal interphalangeal joints (PIPs) and wrists (Fig. 3). Asymmetrical swelling around the involved joints is seen in osteoarthritis (OA). Psoriatic arthritis (PsA) is a heterogeneous disease with asymmetrical swelling around the involved joints such as the PIPs and distal interphalangeal joints (DIPs). Diffuse fusiform swelling of the entire digit (dactylitis) may be seen not only in PsA but also in other spondyloarthropathies (SpA) [24].

Calcifications

Soft tissue calcification is not a radiographic feature of RA. In contrary, it is a common radiographic finding in metabolic diseases like gout, calcium pyrophosphate dehydrate deposition disease (CPPD), hydroxyapatite deposition disease and also in systemic autoimmune diseases, such as dermatomyositis and scleroderma [5].

Mineralization

Normal mineralization is typical in every arthropathy except RA. This is an important radiographic sign which may distinguish RA from other inflammatory arthritides such as PsA or metabolic arthritides. Loss of mineralization is seen around the PIPs and wrists and is called juxta-articular

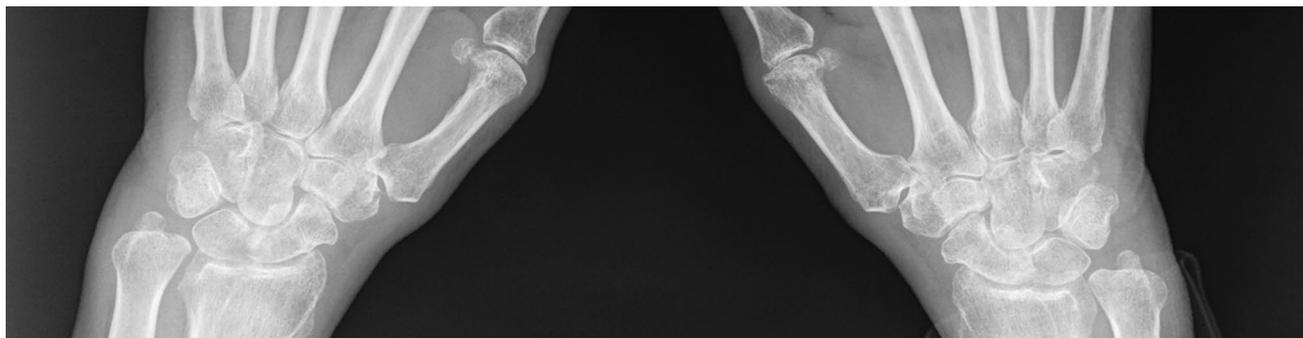


Fig. 4 Periarticular (or juxta-articular) osteoporosis of both wrists in an RA patient with more prominent findings on the right hand

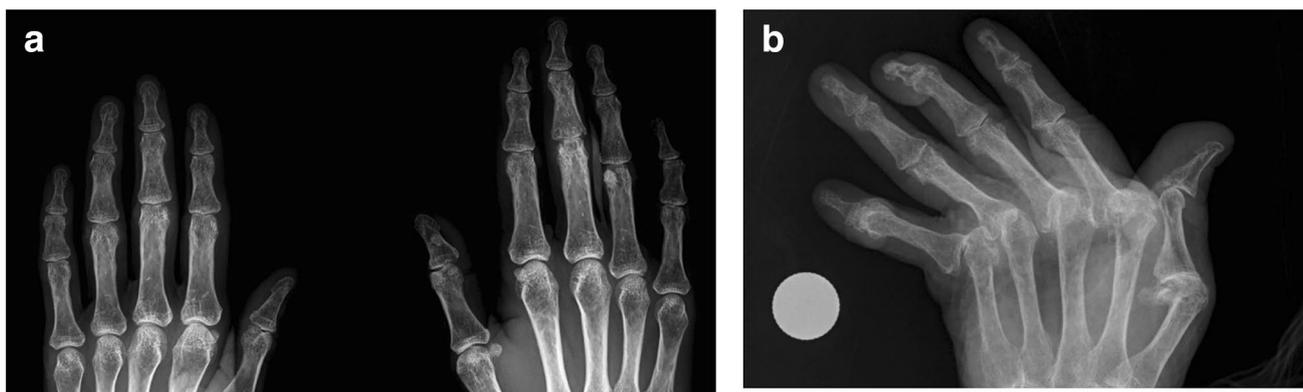


Fig. 5 **a** Early RA patient, uniform joint space narrowing affecting the second–fifth MCP joints bilaterally. **b** Subluxations in an RA patient. Note that proximal phalanges sublux in an ulnar direction in

relation to the adjacent metacarpals. Also, diffuse osteopenia with cortical thinning of the metacarpals and all the phalanges are shown

osteoporosis (Fig. 4). It is seen in RA, but it could be a feature of other conditions including post-traumatic disorders [20, 23, 24].

Joint space narrowing

This is not a characteristic radiographic finding of RA, since all the inflammatory and metabolic arthritides cause uniform joint space narrowing [22]. Usually, in RA patients the MCP and the PIP joints are mostly affected (Fig. 5a). Furthermore, the carpo-carpal joints may be severely affected and fusion of the carpal bones may occur in advanced cases. Non-uniform joint space narrowing is seen mostly in OA patients affecting usually the DIP joints [25].

Subluxations

Subluxations are a prominent feature of RA and lupus arthritis. The proximal phalanges sublux in an ulnar and palmar direction in relation to the adjacent metacarpals (Fig. 5b) [26]. To distinguish RA subluxations from lupus arthritis

one must observe the erosive changes seen in the former, which are not present in the latter. Subluxations do also occur in OA [27]. These subluxations are usually in a lateral deviation, radially or ulnarly affecting mainly the DIPs.

Erosions

In the inflammatory arthritides, early erosive changes are seen in the “bare” areas of the bone, which are located within the joints, between the edge of the articular cartilage and the attachment of the synovium (Fig. 6) [7]. The first radiographic finding is the disruption of the bone cortex, giving a “dot–dash” appearance. These erosive changes are best seen in the metacarpal heads or at the base of the proximal phalanges on the radial aspect when using the Nørgaard projection. As these erosions progress, they involve more and more space and begin to extend occupying the entire joint which may be destroyed (Fig. 7a, b).

The location, the distribution and the type of erosions within a specific joint are important to differentiate one arthropathy from another. In RA, the erosions are seen mainly in the PIP joints, the MCPs as well as the carpal

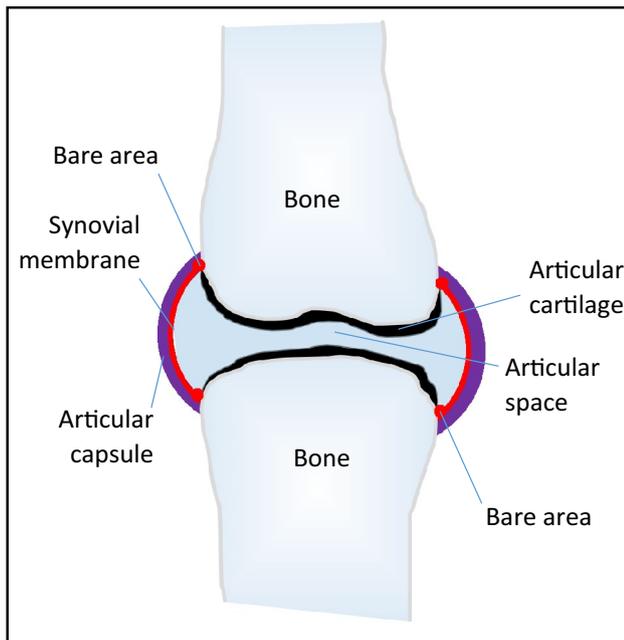


Fig. 6 Schematic representation of a diarthrodial joint in which the bare areas of the joint are shown. These areas are located between the edge of the articular cartilage and the attachment of the synovial membrane. Owing to the direct contact with the synovium, without any protecting layer of the cartilage these areas are very susceptible to inflammation, which leads to erosions and bone destruction



Fig. 7 **a** RA patient. Large erosive changes of the second MCP joint (arrow) are depicted (corresponding to the bare area of the second MCP joint). **b** Extensive erosive changes affecting the second, third, and fifth MCP joints in an RA patient with advanced disease

bones [5, 7, 20]. They have a symmetrical pattern and may allow distinguishing RA from PsA (or other SpAs) and metabolic arthritides, which tend to be asymmetric and have different location and distribution.

Bone proliferation

There are two different kinds of bone production. In the first, new bone is added in the form of periostitis, enthesitis and/or ankylosis. In the second, a reparative response to injury occurs.

The first type of bone formation is seen mainly in PsA and other SpAs. It is a feature that distinguishes SpA from RA [28]. The second type occurs in degenerative conditions or slow loss of cartilage and is a hallmark of OA [20]. Bone proliferation is not seen in RA patients.

Evaluation of carpal bones

The distribution of the radiographic changes in the wrist is very important in distinguishing among different arthropathies. The wrist is divided anatomically into four specific compartments: (a) the radiocarpal compartment, (b) the midcarpal, (c) the common carpometacarpal compartment and (d) the first carpometacarpal compartment (Fig. 2). Each of these compartments is affected by different arthropathies. RA involves all compartments with joint space narrowing and erosions, while OA involves only the first carpometacarpal joint and the trapezioscaphoid joint and CPPD involves mainly the radiocarpal compartment. On the other hand, new bone formation distinguishes SpA from RA [20–22].

Radiographic changes occurring in rheumatoid arthritis

As mentioned above, RA is a symmetrical inflammatory arthritis involving the appendicular skeleton, sparing the axial skeleton except the cervical spine. Clinicians should always have in mind that the dominant hand may be more affected. The commonest radiographic findings seen in RA are as follows: (1) periarticular soft tissue swelling, (2) juxta-articular or periarticular osteoporosis, (3) uniform loss of joint space, (4) marginal erosions progressing to severe erosions of subchondral bone, (5) subchondral cyst formation, (6) subluxations. These radiographic findings have bilateral and symmetrical distribution affecting the hands, feet, knees, hips, cervical spine, shoulders and elbows, in a decreasing order of frequency [20–22]. These features may not be present simultaneously and not all patients will develop the whole spectrum. Also, none of the abnormalities

Table 1 Imaging changes occurring in hands and wrists in RA patients using conventional radiography

Imaging changes	Early RA	Advanced RA
Soft tissue changes	Symmetrical swelling around the PIPs and wrists	Atrophy
Mineralization	Juxta-articular osteoporosis	Diffuse osteoporosis
Subluxation	None	MCPs (proximal phalanges subluxed ulnarly and palmarly)
Joint space narrowing	Maintained	Uniform loss in PIPs, MCPs and carpal bones
Erosions	Mild, sometimes aggressive	Large, aggressive
Joint distribution	PIPs, MCPs, and pancarpal	PIPs, MCPs, and pancarpal

RA rheumatoid arthritis, MCPs metacarpophalangeals, PIPs proximal interphalangeals

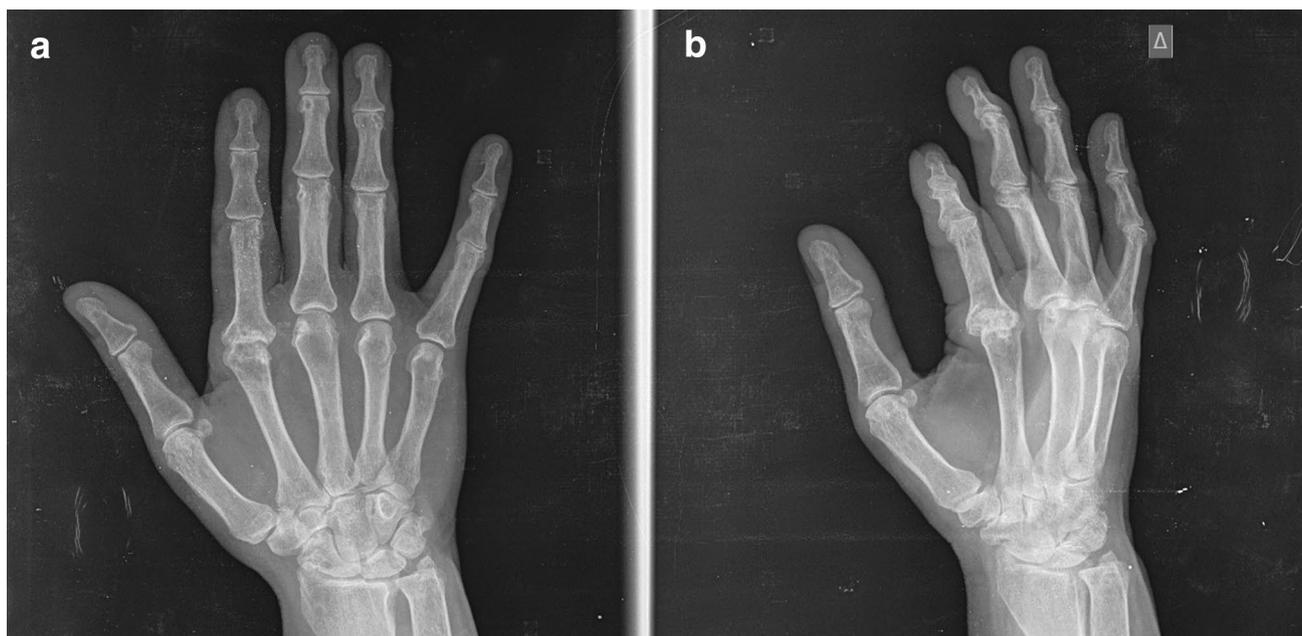


Fig. 8 **a** PA and **b** Nørgaard views in an RA patient. **a** Early aggressive erosive changes are shown in the first and second MCP joints. **b** These changes are best seen in the Nørgaard view, which also reveals

erosions in the third MCP joint, as well as in the triquetrum and pisiform in the wrist

is pathognomonic. However, a combination of these findings should lead to the correct diagnosis of RA [29].

Radiographic changes of the hands and wrists

CR of the hands and wrists is used both in early diagnosis to differentiate RA from other arthropathies but also to assess disease progression. Thus, the radiographic changes can be divided in two separate forms: those observed at an early stage of RA (for diagnostic purposes) and those observed at later stages (to assess disease progression) (Table 1).

Symmetrical soft tissue swelling as well as juxta-articular osteoporosis are the earliest changes that can be noted by

CR in RA patients. Notwithstanding they lack specificity for the disease they can guide the rheumatologist towards the diagnosis of an inflammatory arthropathy. As early erosions are subtle, physicians must be aware of where to focus on a plain film. For example, the “bare” areas of the bone (Fig. 6) that are not covered by articular cartilage may present the first erosions. As discussed earlier, on a complete radiographic evaluation, including a PA and a Nørgaard view, early erosions may be observed. When a Nørgaard projection is obtained, the midshafts of the metacarpals should not be superimposed [20–22, 29] (Fig. 8a, b).

On a PA view radiograph and more specifically of the wrist, early erosions can be noted at the scaphoid bone, the capitate, the level of the first as well as the fifth carpometacarpal articulations, and finally, the radial and the



Fig. 9 Established RA. Joint space narrowing of the second–fifth PIPs bilaterally is shown. Note also severe erosive changes of the MCPs in various degrees bilaterally. In addition, extensive erosions

with fusion of the carpal bones are also shown. Finally, subluxation of the fourth PIP joint of the left hand is demonstrated

ulnar styloid processes. Erosions on the pisiform and the triquetrum are best seen using the Nørgaard projection. If the PIPs are also affected, it could be a sign of established RA as it represents mostly a late radiographic finding of the disease.

With time, as the disease progresses, especially in patients without the appropriate treatment, the carpal bones get equally affected. Cartilage loss and joint space narrowing are more evident with a decrease of soft tissue swelling. At this stage, juxta-articular osteoporosis is also more evident that progresses to diffuse osteoporosis. The subtle marginal erosions continue to progress causing large subchondral erosions (Fig. 9). Subluxations occur at the MCP joints. Ulnar subluxation of the proximal phalanges with also palmar deviation in relationship to the metacarpal heads. Swan-neck and boutonniere deformities may occur in the distal phalanges. In more advanced stages of the disease, soft tissue atrophy of the hands begins. Diffuse osteoporosis is present, joint spaces are difficult to be observed and bone ankylosis may occur (Fig. 10). Despite the extensive involvement of the PIP and MCP joints the DIPs are usually spared. If erosive changes coexist in the DIPs, another

concomitant arthropathy, such as erosive OA or PsA, should be considered [20–22, 29].

Studies have shown a correlation between joint damage seen on CR and disability in longstanding RA. It has also been shown that the presence of radiographic changes is associated with worse outcomes and prognosis. Several factors have been associated with a non-favorable radiological progression [30]. Among those, long-term disease duration, patients without treatment [30], cigarette smoking [31–34], presence of autoantibodies in high titers [35], extra-articular manifestations, and early radiographic changes of the hands and wrists are the most important [36, 37] (Fig. 11) but others have also been identified [38].

Clinical usefulness of conventional radiography

The importance of CR as an imaging modality in RA patients has been supported by many investigators in clinical trials. CR of the hands and wrists has been used to determine the clinical efficacy of a drug by demonstrating structural damage inhibition when using csDMARDs [39–42] or



Fig. 10 Hand X ray of an RA patient in advanced stage. The carpal bones are fused with severe distal radio-ulnar and carpometacarpal erosions. Subchondral cysts are evident. More distally, erosions also

affect the MCPs, which are also subluxed, as well as the PIPs. Diffuse osteoporosis with cortical thinning of the bones is another prominent feature

bDMARDs [43–45]. It is also supported by ACR/EULAR institutions which recommend CR not only as part of the baseline assessment of RA patients, but also for its diagnosis. Furthermore, it can be used as a tool when physicians decide to change into another therapeutic option in those who do not respond to current treatments with csDMARDs or bDMARDs [46, 47].

In this direction, several scoring systems have been developed for the evaluation of radiographic changes in RA. The most widely used systems are the Larsen score and its modifications. Larsen score assigns erosive changes by comparing standard reference radiographs [48]. The Sharp scoring system with its modifications, which are based on detailed separate assessment of joint erosions and joint space narrowing in the hands and wrists [49, 50]. Finally, the van der Heijde modified Sharp score is the most recent modification which is used mainly for research purposes, particularly as an outcome measure for response to therapy with csDMARDs or/and bDMARDs [51, 52]. However, the above scoring systems are not for use in the everyday clinical practice.

Conclusions

CR is a well-established and important method for the evaluation of patients with RA. Initial evaluation often includes X rays of the hands and feet. The hand and wrist radiographs can provide important information, which may help rheumatologists to establish an RA diagnosis and to determine disease extent. Moreover, it is valuable in the prediction of structural damage progression and long-term outcome. Therefore, CR is better when utilized as a serial assessment over time to determine disease progression. CR remains the most commonly used imaging tool in rheumatology and has a number of advantages: (a) it is easily available in most rheumatologists and readily accessible to most patients, (b) it is inexpensive and relatively safe, (c) it provides immediate information and can be interpreted easily by the requested rheumatologist and, (d) the data are reproducible and can be used for serial evaluation and follow-up. On the other hand, CR does have some limitations: (a) it uses ionizing radiation, (b) does not provide good information in early RA patients,



Fig. 11 The same patient as in Fig. 10 is depicted but 18 years earlier. It demonstrates the radiological disease progression. This underlines the unfavourable progression of the disease if there are erosions on diagnosis or if the disease remains untreated

and, (c) does not provide information about synovial inflammation or other soft tissue structures. However, CR remains an important imaging technique for the evaluation of RA patients and those with peripheral arthritis.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest.

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