

Overview of Imaging in Rheumatologic Diseases

T S G Chee,**FAMS, FRCR, DMRD*, F L Thoo,***FRCR*, I Y Y Tsou,****MBBS*

Abstract

The role of radiology in rheumatologic diseases has for many years been confined to conventional radiography alone. The advances in medicine placed great demands on earlier and more accurate evaluation of these diseases. Conventional radiographs have been used as diagnostic aids and radiographic features and measurements are well established. However, the newer technologies, such as ultrasound, computed tomography and magnetic resonance imaging (MRI) have recently influenced accuracy of diagnosis and allowed for earlier detection and a more comprehensive evaluation of the results of therapy. One leading example is the significant role MRI plays in the early detection of avascular necrosis, especially of the hips.

The clinical benefits of the newer modalities in radiology are being increasingly recognised and its full potential realised by both rheumatologists and radiologists.

Ann Acad Med Singapore 1998; 27:67-75

Key words: Computed tomography, Conventional radiography, Magnetic resonance imaging, Ultrasound

Introduction

Since the discovery of X-rays over a century ago, radiology has played a pivotal role in rheumatology and diseases of the joints. The innovations and advances in technology in imaging and interventional radiology today enable more precise and earlier detection, assessment and treatment. Its role has widened with the introduction of magnetic resonance imaging (MRI), which allows for exquisite assessment of soft tissues, particularly in myopathies, tendon disorders, avascular necrosis and infections.

Radiologic imaging procedures provide non invasive information on the gross pathologic processes in the musculoskeletal system. More importantly, radiologic techniques afford detection, evaluation and serial assessment of structural joint abnormalities. Different imaging techniques available for the assessment of rheumatologic diseases are discussed in this article. However, unlike other areas in orthopaedic radiology, the introduction of advanced modalities of imaging such as computed tomography (CT) and MR has not minimised the need and importance of the plain radiograph in evaluation of rheumatologic diseases.

Rheumatic diseases can be categorised into systemic connective tissue disorders, seronegative spondyloarthropathies, degenerative disorders, and crystal depo-

sition diseases. Many of these diseases share similar radiological signs, and diagnosis is usually based on the most prominent indicative features.

Evaluation of the Plain Radiograph

The radiographic presentation of arthritis is dependent on three main factors:

- i) type of disease,
- ii) stage of disease, and
- iii) site within the pathological joint (e.g. synovial membrane in inflammatory arthritis and articular cartilage in osteoarthritis).

Resnick noted that accurate diagnosis of joint diseases is based on two fundamental parameters, the morphology of the articular lesions and the affected joint distribution. The radiographic analysis of the distribution of the articular lesions has been termed the "target area" approach, but this is only a guide and not a rule, as this approach identifies predominant but not exclusive sites of involvement. This article will address the morphology and distribution for each rheumatic disease.

Systemic Connective Tissue Disorders

Rheumatoid Arthritis

Rheumatoid arthritis (RA) involves synovial joints of the body and especially the small joints of the hands,

* Consultant

** Senior Registrar

*** Medical Officer (Trainee)

Department of Diagnostic Imaging

Tan Tock Seng Hospital

Address for Reprints: Dr Thomas Chee, Department of Diagnostic Imaging, Tan Tock Seng Hospital, Moulmein Road, Singapore 308433.

wrists and knees. Axial skeletal involvement in the adult RA is generally limited to the cervical spine or, less commonly, to the sacroiliac joints.

Conventional Radiographic Features

Morphology

Hands: The earliest sign of RA is usually soft tissue swelling in the periarticular region, and a fusiform appearance. This occurs as a result of joint effusion, oedema and tenosynovitis. Later signs include diffuse joint space narrowing from articular cartilage loss, marginal or central erosions due to the direct mechanical action of hypertrophic synovium and granulation tissue, and the absence of osteophyte formation and subchondral sclerosis. Osteoporosis is a prominent feature, which begins in the periarticular areas, and progresses to involve the rest of the adjacent bone.^{1,2}

Fusion or joint ankylosis may also be seen, particularly in the midcarpal joints, in late stages of RA. Complications of therapy may be demonstrated, such as generalised osteoporosis due to steroid usage. Large bony erosions and severe osteoporosis may also result in a pathological fracture.

Cervical spine: The characteristic changes are bony erosions in the anterior aspect of the odontoid peg, erosion and fusion of the apophyseal joints, and subluxation of the atlantoaxial joint, with or without superior migration of the odontoid peg.³

Distribution

Both hands are affected symmetrically, and usually begin in the second and third metacarpophalangeal (MCP), and third proximal interphalangeal (PIP) joints. The disease progresses to involve all the MCP, PIP joints, and the interphalangeal joint of the thumb. Distal interphalangeal (DIP) joint disease without proximal involvement is rare. In the wrist, the distribution is pancompartmental, with initial involvement of the radiocarpal, inferior radioulnar and pisiform-triquetral compartments.

Computed Tomography and Magnetic Resonance Imaging

CT is useful for evaluating the region of the craniocervical junction in RA. CT demonstrates the degree of erosion, subluxation, soft tissue changes and atlantoaxial impaction.

MRI provides excellent delineation of soft tissue changes, cartilaginous defects and osseous erosions associated with RA. The signal intensity of inflammatory soft tissue that penetrates the synovial lining of the joint has been described to vary markedly on T1 and T2 weighted MRI images.⁴ This could reflect the different degrees of inflammation and fibrosis in the proliferative tissue.⁵ The use of intravenous Gadolinium provides better distinction of inflammatory soft-tissue

alterations from joint effusion when compared to unenhanced MRI.⁶⁻⁹

MR imaging is clearly superior to X-rays in the early detection of bone erosions and in monitoring response to therapy.¹⁰ In a study comparing MR imaging with plain radiography of bone destruction in RA, Poleksic et al¹¹ were able to demonstrate 25 marginal erosions and 42 subchondral cysts compared with 3 and 8 respectively on radiographs. Nonetheless, the routine use of MR imaging in assessing arthropathy in RA and the other systemic connective tissue disorders have been limited by the relative high cost, difficulty in positioning disabled patients and inability to simultaneously image several joints.

Systemic Lupus Erythematosus

Systemic lupus erythematosus (SLE) is a chronic disease with musculoskeletal, cardio-respiratory and abdominal manifestations.

Conventional Radiographic Features

Morphology

Joint abnormalities are exhibited in 90% of patients, and the most characteristic radiographic change is pronounced joint deformity without erosive or destructive bone alteration. The synovitis of SLE does not result in erosive disease. Common abnormalities include ulnar deviation and volar subluxation of the metacarpophalangeal joints, hyperextension at the proximal interphalangeal joints and interphalangeal joint of the thumb. Flexion of the distal interphalangeal joints and ulnar drift of the radiocarpal mass can be seen. A characteristic feature of lupus joint disease is the absence of fixed contractures in the presence of severe articular deformities. The deformities may not be apparent on a dorsovolar or anteroposterior radiograph as they may be corrected by the pressure of the hand being placed against the radiographic cassette. Therefore, a lateral or oblique ballcatcher's view is needed for assessment of alignment.¹²

Occasionally, resorption of the tufts of the distal phalanges (acro-osteolysis) or sclerosis of the distal phalanges (acral sclerosis) may be seen. Osteoporosis may be secondary to disuse or corticosteroid treatment.

Soft tissue calcification in the form of subcutaneous linear densities, lumps and plaques, vascular calcification or less commonly, small, punctate calcifications around joints may be found in approximately 5% to 10% of patients with SLE.

Distribution

Radiologic involvement is bilateral and symmetrical, and usually affecting the metacarpophalangeal and interphalangeal joints of all the digits, including the thumb. Osteonecrosis at the metacarpophalangeal joints may be seen.

Ultrasound, Computed Tomography and Magnetic Resonance Imaging

Ultrasound imaging including duplex is useful for the assessment of renal size and complications such as renal vein thrombosis. Ultrasound is an easily available tool for the diagnosis of liver or splenic abscesses.

CT scan of the abdomen is more sensitive for the assessment of gastrointestinal and pancreatic involvement.

Avascular necrosis is seen in approximately 5% of patients with SLE, usually in those consuming corticosteroids. MRI is a sensitive method of identifying avascular necrosis in patients prior to radiographic changes. MRI of the brain is more sensitive than CT scan in the detection of intracranial arterities. Areas of arteritis appear similar to other ischaemic lesions, except that foci of arteritis tend to be more patchy, bilateral and widespread than other ischaemic processes. Arteritis is sometimes reversible and responsive to steroid therapy. As in hypoxic injury, haemorrhage is a common sequelae to arteritis.¹³

Scleroderma

Scleroderma is a generalised disorder of connective tissue characterised by inflammation, fibrosis and degeneration. The clinical manifestations of Raynaud's phenomenon and arthralgia are frequently accompanied by characteristic radiographic changes in about two thirds of these patients. Within six months of onset of scleroderma, radiographic changes may be seen in one third of patients.

Conventional Radiographic Features

Morphology

During the early oedematous phase, soft tissue swelling in the hands is diffuse with some periarticular accentuation. The distal pulp of the fingers is atrophied in 40% of the patients and tapering is a characteristic feature.

Calcinosis, which occurs in 7% to 10% of these patients, is generally a late manifestation and is most common in the palmar aspect of the digital pulp. Other areas of calcification are in the subcutaneous and peri-articular regions.

Bony erosion is noted in 25% to 40% of patients. Typically, resorption of distal phalangeal tufts begins in the palmar aspect. The second form of bone resorption is erosive articular disease which simulates RA in its marginal location but affects the distal more than proximal joints and is a late manifestation of disease.¹⁴

Cardiac involvement can manifest as cardiomegaly and pericardial effusion.

Distribution

The distal interphalangeal, first carpometacarpal and

inferior radioulnar joints are most commonly affected.

Barium studies

Gastrointestinal abnormalities are common. Oesophageal abnormalities include dilatation and gastro-oesophageal reflux. Small bowel can show dilatation, atonia, thickened mucosal folds and pseudo-sacculation.

Computed Tomography

Lung involvement in scleroderma occurs in 10% to 25%. High resolution CT of the chest is of value in the assessment of early interstitial lung disease.

Arteriography

Arteriography study invariably shows partial or complete obliteration of the digital arteries in Raynaud's phenomenon.

Seronegative Spondyloarthropathy

Ankylosing Spondylitis

Ankylosing spondylitis is a progressive inflammatory condition that occurs predominantly in young men. The rheumatoid factor is negative, but a high percentage of patients have the histocompatibility antigen HLA-B27. The axial skeleton is more frequently and most severely involved.

Sacroiliac Joints

Abnormal sacroiliac joints may be seen radiographically even before the onset of focal symptoms. Most patients have radiographic changes at this site within 12 months of clinical onset of the disorder. Early radiographic change in the sacroiliac joint consists of loss of the discrete subchondral cortical line, as a result of focal absorption and erosion and reactive sclerosis in the adjacent cancellous bone. The iliac side of the articulation is affected first because of the thinner cartilage. With progressive erosion, joint widening becomes apparent in association with pronounced patchy sclerosis. The process may be arrested at any phase, but characteristically it progresses to narrowing of the joint and finally, to intracapsular and intra-articular bony ankylosis.^{15,16}

Conventional radiography is frequently limited because of the curved and angled configuration of the SI joint. CT readily displays the SI joint anatomy on each consecutive slice. Early evidence of sacroiliitis can best be detected on CT and differentiated from normal findings or age-related degeneration of the SI joint.¹⁷

In a recent report by Blum et al,¹⁸ they compared MR imaging with conventional radiography and scintigraphy in the detection of active sacroiliitis. Their prospective study revealed MR imaging to be the most sensitive (95%) and superior compared to scintigraphy (48%) or radiography (19%). Regarding specificity, MR fared best

(100%), compared with scintigraphy (97%) and radiography (47%).

Spinal Involvement

In the spine, the changes consist of anterior vertebral squaring, syndesmophytosis, apophyseal joint ankylosis and ligamentous ossification. The changes begin in the lumbar spine and progress to the thoracic and cervical spinal regions. "Squaring" results from a loss of the normal concavity of the anterior surface of the vertebral body. This squaring may be caused by osteitis and erosion of the anterosuperior and inferior vertebral margins and may produce the so called "shiny corners" and the squared appearance.

Syndesmophytes are vertically orientated paravertebral ossifications in the outer fibres of the anulus fibrosus and the adjacent connective tissues along the anterior and lateral aspects of the spine at the level of the interspace. Marginal syndesmophytes appear to rise from the edge of the vertebral body and form a fine vertebral bridge. The nonmarginal syndesmophytes, typical of psoriatic arthritis and Reiter's syndrome, arise in the adjacent connective tissue along the waist or midportion of the vertebral body and are broad and coarse. In ankylosing spondylitis, syndesmophytes are typically marginal and symmetric and eventually result in the classic "bamboo spine" when the apophyseal joints and vertebral bodies fuse.

Peripheral Joints

In the large proximal joints, advanced destructive arthropathy is common. The hips are often involved early in ankylosing spondylitis. Initially, a small focus of new bone forms at the lateral junction of the head and neck. This zone of bone proliferation eventually enlarges to a ridge of exophytic overgrowth that surrounds the perimeter of the femoral inflammation. Loss of cartilage is secondary to synovial inflammation. Mild-to-moderate erosive disease and reactive sclerosis develop, but, unlike osteoarthritis, subchondral cysts do not normally form. Total arthroplasty of the hip is associated with an increased risk of postoperative heterotopic ossification and ankylosis.

In the foot, erosions tend to occur at the tendinous insertions, particularly at the calcaneum at the attachment of the plantar fascia, anterior to the aponeurotic attachment, and above the attachment of the tendon Achilles. A mild periostitis may be present at the inferior aspect of the calcaneum.

Psoriatic Arthropathy

Approximately 7% of the patients with psoriasis develop arthritis. Axial manifestations resemble ankylosing spondylitis whereas the peripheral manifestations may simulate RA. The radiographic changes in the axial

skeleton result from enthesopathy and synovitis.

Sacroilitis is an early, frequent feature, but differs from that of ankylosing spondylitis in that asymmetry is seen in about 50% of patients. The spondylitis of psoriasis is characterised by broad, nonmarginal syndesmophytes in addition to the fine syndesmophytes of ankylosing spondylitis. "Skip" areas are frequent, and advanced cervical spine changes may be seen in the absence of involvement of the thoracic, lumbar or even sacroiliac joints. Atlantoaxial subluxation is frequent, but is generally less dramatic than RA. In advanced instances, psoriatic spondylitis may result in extensive, diffuse, anterior and posterior fusion, although less commonly than in ankylosing spondylitis.¹⁹

Peripheral psoriatic arthritis affects predominantly the small joints of the hand and feet; occasionally destructive changes appear in the larger joints. The spectrum of changes ranges from those characteristic for psoriatic arthropathy to those indistinguishable from RA. Typically, pauciarticular or polyarticular asymmetric arthropathy affects the distal interphalangeal joints and less severely the proximal interphalangeal, metacarpophalangeal, metatarsophalangeal, carpal or tarsal joints. In about one fourth of the patients, diffuse swelling and associated joint destruction of an entire digit ("sausage finger") by tenosynovitis may be present. Characteristic erosions which develop at articular margins and at capsular attachments consist of a combination of focal bone resorption and fluffy new bone formation, often seen with linear periosteal new bone.²⁰ In the calcaneum, this may be associated with broad-based osteophyte formation. In progressive disease, few isolated joints are destroyed whilst other joints may be normal or only mildly affected. The advanced stage is known as arthritis mutilans, which takes its name from mutilating joint disease. This is a destructive arthritis of the hands and feet with resorption of the bone ends and telescoping joints, resulting in almost total disorganisation of the joint. Gross deformities like "pencil-in-cup" appearance and interphalangeal ankylosis of the joints are seen.

Reiter's Syndrome

Reiter's syndrome has a classic constellation of urethritis, circinate balanitis, uveitis, keratoderma, blenorrhagicum and arthritis. When the syndrome is incomplete, the diagnosis may be aided by careful radiographic assessment. Characteristically, the features of arthritis consist of asymmetric, pauciarticular involvement of the feet, ankles and lower spine. The upper extremity is usually spared except for soft-tissue swelling and, rarely, periostitis. One or several joints of the feet, most commonly the first interphalangeal and proximal interphalangeal joints, are sites of pronounced soft tissue swelling, moderate periarticular osteoporosis,

proliferative erosion and periosteal new bone formation. The peripheral manifestations simulate psoriatic arthropathy closely and may be indistinguishable clinically and radiographically. Features that may distinguish Reiter's syndrome from psoriatic arthritis include predominant distribution in the lower extremity, involvement of fewer joints, sparing of the distal interphalangeal joints and greater periarticular osteoporosis.²¹

Asymmetric sacroilitis is common in patients with Reiter's syndrome, whereas additional findings of spondylitis, such as nonmarginal syndesmophytes, are less common than in psoriasis. In the thoracolumbar spine, coarse syndesmophytes may be present.

Degenerative Arthropathies

Osteoarthritis

Osteoarthritis occurs in two major forms, primary and secondary. However, the radiological features are similar in both.

Primary osteoarthritis develops in joints without antecedent history of insult and affects predominantly the distal and proximal interphalangeal joints, the first metacarpophalangeal joints in the hands, spine, and the hips and knees.

Secondary osteoarthritis arises from an underlying condition which predisposes to the development of degenerative joint disease. This could be due to alteration in metabolism or mechanics of the joint such as infection, osteonecrosis, epiphyseal dysplasia, acromegaly, Wilson's disease, pseudogout, neurologic deficit or simple trauma. Alternatively, secondary osteoarthritis may be superimposed late in the course of other common rheumatic conditions such as juvenile RA and gout.

Conventional Radiographic Features

Large joints: The hips and knees are the most common sites affected, because they are weight-bearing joints. Generally, the radiographic manifestations of established osteoarthritis consist of:

- i) irregular narrowing of the joint due to articular cartilage thinning,
- ii) subchondral sclerosis due to remodelling,
- iii) marginal osteophytosis due to remodelling in areas not subjected to stress,
- iv) cyst or pseudocyst formation due to microfractures leading to intrusion of synovial fluid into the damaged spongy bone,
- v) minimal soft tissue swelling (other than joint effusions),
- vi) mild-to-moderate joint deformity, and
- vii) preservation of normal mineralisation.

In the knee, joint deformity is seen as a varus or valgus configuration, depending on whether the medial or lateral compartment is the more affected. Degenerative

change in the third compartment, the patello-femoral compartment, is shown as osteophyte formation at the patella with a reduction in the patello-femoral joint space.

Secondary osteoarthritis in the hip may be related to predisposing conditions that may have previously occurred in childhood such as slipped capital femoral epiphysis, Perthe's disease and congenital hip dislocation.

Small joints: The basic radiological features are the same as above, and they tend to occur in the proximal and distal interphalangeal joints, and the first carpometacarpal joints in the hands. Prominent osteophytes in the distal interphalangeal joints are known as Heberden's nodes, while those at the proximal joints are known as Bouchard's nodes. In the foot, the most commonly affected joint is the metatarsophalangeal joint of the big toe.

Spine: The synovial joints affected include the apophyseal (facet), atlantoaxial and the inferior aspects of the sacroiliac joints. Degenerative changes at the intervertebral discs are seen as the formation of lateral osteophytes at the margins of the adjacent vertebral bodies, disc space narrowing and vacuum phenomenon within the disc.^{22,23}

Complications arising from degeneration include spondylolisthesis and spinal stenosis.

Computed Tomography and Magnetic Resonance Imaging

CT is particularly useful for evaluating subchondral sclerosis and subchondral cyst formation. Osteophytes can be detected by CT even in the absence of radiographic findings.²⁴ Loose bodies can be demonstrated by CT when they are calcified. Cartilaginous loose bodies, however, cannot be delineated by CT.

MR imaging is unique in that it affords direct visualisation of cartilage. Focal thinning of cartilage, irregularity of the cartilage surface, and inhomogeneity of signal intensity are MR imaging signs of cartilage loss in osteoarthritis. Changes in cartilage signal on T2*-weighted gradient-echo sequence reflect degeneration with reduction of water content.²⁵ MR imaging may demonstrate cartilage loss before joint space narrowing is evidenced radiographically.²⁶ MR imaging is unique in evaluating pathologic changes in the menisci that is affected by osteoarthritis.

Overall MR imaging provides better contrast resolution with less spatial resolution than CT.²⁷

Neuroarthropathy

The term *Charcot's joint* was originally used for neuroarthropathy in tabes dorsalis, but now has become synonymous with neuropathic joint, irrespective of the aetiology. It is described as painless, unstable and fre-

quently deformed joints that accompany neurological deficit, and represents the extreme of degenerative joint disease. The most common diseases that caused neuroarthropathy are *tabes dorsalis*, diabetes mellitus, syringomyelia and spinal cord injury or anomaly. The foot and ankle are more commonly affected in diabetes, and the upper limb joints in syringomyelia.

The features of established neuroarthropathy consist of joint effusion, subluxation and dislocation, subarticular sclerosis, fracture and fragmentation, marginal osteophytosis and heterotopic calcification and ossification. There is usually gross disorganisation of the joint. Characteristically, osteoporosis is absent. The common sites of neuropathic involvement are the midfoot, ankle and knee and, less commonly, the hip, spine, shoulder and wrist. The bony resorption is followed by intense sclerosis, prominent osteophytosis and periarticular ossification, which are hypertrophic phases.

Crystal Deposition Disease

Gout

Gout is a form of crystal-induced disease that affects predominantly the feet, hands, wrists, ankles and elbows. The symptoms are due to deposition of monosodium urate monohydrate crystals in the synovial fluid. In severe cases, gouty tophi of sodium urate form within the soft tissues. During the initial acute episode of gout, the only radiographic manifestations are soft-tissue swelling, usually related to capsular distension, and mild focal demineralisation. Even in chronic gout, radiographic evaluation may fail to reveal articular abnormalities.

Tophi are common over the dorsum of the foot, around the calcaneus, and in the bursae, particularly of the elbows. The metatarsophalangeal joint of the big toe is the most common site of involvement, seen in 75% of patients. Erosive disease is frequent in established gout. Characteristically, erosions are sharply demarcated with a fine, sclerotic border and may appear punched out, as opposed to the ill-defined and focally demineralised erosions of RA. A characteristic overhanging margin or lip results from displacement of cortex and apposition of new bone, with remodelling around the tophus. The joint space is generally well preserved in gout because destruction of the cartilage is focal, rather than generalised. Also, osteoporosis is usually absent, and joint involvement is asymmetrical. These characteristic features allow differentiation from RA. Patients with severe gout may have arthritis mutilans simulating psoriatic arthritis or RA.

Calcium Pyrophosphate Dihydrate (CPPD) Crystal Deposition Disease

CPPD crystal deposition disease in the intra-articular space produces symptoms similar to gout, and as such,

the clinical picture of crystal-deposition induced arthritis is termed *pseudogout*. It is also not to be confused with chondrocalcinosis, which is simply the presence of radio-opaque crystals in hyaline cartilage or fibrocartilage, and which may not necessarily produce symptoms.^{28,29}

Radiographical features are similar to osteoarthritis, with joint space narrowing, osteophyte formation and subchondral sclerosis.³⁰ However, the distribution is different in that the wrist, elbow, shoulder and ankle are commonly involved.

Until quite recently, direct imaging and evaluation of soft tissues were difficult and inaccurate. The introduction of CT scan, ultrasonography (US) and MRI revolutionised the way soft tissues could be assessed. Osteoarticular structures and soft tissues are now directly imaged.

Autoimmune Myositis and Other Extra-articular Manifestations

Autoimmune myositis can be grouped together with acquired muscle disorders under the broad classification of inflammatory myopathies.³¹ This group of myositis is associated with autoimmune disorders such as dermatomyositis, RA, SLE and mixed connective tissue disease. Other conditions which can be included under this subtype of autoimmune myositis include idiopathic polymyositis, myositis related with malignancy and myositis in childhood.

Conventional radiography is severely limited in its ability to diagnose this group of conditions. At best, soft tissue swelling and subtle changes in density may be identified. Radioisotope scanning can localise pyomyositis but its specificity and role is limited. Ultrasound can demonstrate intramuscular collections of fluid and disturbance in echogenicity but again its specificity is questionable.

CT is able to depict morphologic abnormalities well and the behaviour with intravascular contrast studies add further information. In polymyositis, hypodensities in atrophied muscles are demonstrated on CT.³²

MRI plays an important role in imaging polymyositis and dermatomyositis or where oedema of the muscle is demonstrated. Characteristically, oedema is shown as an area of high signal intensity on the spin echo T2-weighted and/or short-tau inversion recovery sequence. Fatty infiltration of the muscle can just as easily be shown on MRI, a feature commonly noted in dermatomyositis and chronic polymyositis. It has also been reported that the administration of intravascular contrast is not contributory in myositis.³³ Though there is a propensity to symmetrical and proximal involvement of muscles in autoimmune-mediated myositis which can be illustrated on MRI, the distribution can be extremely

variable. Therefore it has not been possible to identify a pathognomic pattern of involvement for the various myositides.

In studies by Fraser et al,^{34,35} MRI is noted to be more sensitive though not as specific as muscle biopsy. Nonetheless MRI can identify suitable sites for electromyography (EMG) and biopsy thus reducing incidences of sampling error. MRI can also be used to assess response to treatment and successful treatment is reflected in the signal intensities returning to normal.³⁶ This will reduce the need for repeated biopsies.

Other extra-articular manifestations of rheumatologic diseases are varied and they can be seen in the respiratory, gastrointestinal, reticuloendothelial, genitourinary and cardiovascular systems. Examples include rheumatoid lung, complicated by pericarditis, congestive cardiac failure and pulmonary arterial hypertension, scleroderma associated with pulmonary interstitial inflammation and fibrosis, with oesophageal dysmotility and telangiectasia.

One important aspect in imaging rheumatologic diseases is awareness not only of the features of the disease, but also the problems associated with long-term therapy. The immune system function is often affected and imaging reflects these malfunctions such as infection, inflammation and associated neoplasia. Imaging is pertinent to the extra-articular manifestation of rheumatic diseases.

The role that radiology plays today is no longer confined to conventional radiography, or confined to radiography of the chest, abdomen and osteoarticular structures. One example of extra-articular manifestations of connective tissue diseases that is amenable to highly sensitive and accurate radiological assessment is pulmonary involvement in connective tissue diseases. High resolution computed tomographic (HRCT) scanning of the thorax is of value here. Clinical assessment of a patient with diffuse lung disease is difficult and often inconclusive. Conventional radiography and CT scan of the thorax can help but are often limited. Diffuse interstitial lung disease is a very mixed group of lung pathology and over a hundred causes have been described.^{37,38} It is particularly important to note that acute diffuse interstitial lung disease is also increasingly encountered because of longer survival of patients, wider use of immunosuppressives and organ transplantation. HRCT is thus useful to aid diagnosis. It must be remembered that HRCT should not be used in isolation, but rather complement clinical, laboratory, lung function, endoscopic and biopsy data. In all comparative studies so far, HRCT has been shown consistently to be more sensitive than conventional radiography in the detection of diffuse lung disease, in studies on rheumatoid lung disease,³⁹ scleroderma,⁴⁰ drug-induced lung diseases,⁴¹ infections in immuno-compromised patients⁴²

and septic embolism.⁴³ HRCT is also significantly more accurate than conventional radiography in the diagnosis of diffuse lung disease.⁴⁴⁻⁴⁷ Besides detecting diffuse interstitial lung disease, HRCT findings would assist physicians in differential diagnoses or specific diagnosis. Disease activity can be assessed and an optimal site and type of biopsy selected. In some circumstances, the patient can even be spared a biopsy because of characteristic HRCT appearances.

Spiral CT is also beginning to play a significant role in non invasively imaging pulmonary embolism. In a recent study by Remy-Jardin et al,⁴⁸ they compared spiral CT with pulmonary angiography and scintigraphy in the diagnosis of pulmonary embolism. The study showed that prospective sensitivity of CT scan was 91%, specificity was 78%, positive predictive value was 100% and negative predictive value was 89%. They recommended that CT scanning could thus be reasonably interposed between an inconclusive scintigraphic scan and pulmonary angiography in the detection of pulmonary embolism.

One side-effect of long-term high dose steroid therapy is iatrogenic Cushing's syndrome. In children, growth may be retarded. Pathological fractures with osteoporosis can occur. A relatively higher incidence of avascular necrosis and infection, and hypertension is noticeable in this group of patients.

The most sensitive and specific diagnostic test for avascular necrosis has been shown to be MR imaging.⁴⁹

The emergence of radiologically-guided minimally invasive interventional procedures have been shown to benefit the surgically unfit and helped reduce costs and duration of hospitalisation. One example of radiological intervention is in Takayasu's arteritis where percutaneous transluminal angioplasty of the aorta and renal arteries have been found to be a safe and effective means to dilate symptomatic stenosis.⁵⁰

There has also been some controversy lately of the relationship in documenting structural abnormalities on CT and MRI with function or clinical signs and symptoms.^{51,52} To this end, radiologically-guided injections of joints and intervertebral discs help in further elucidating this relationship between structural abnormalities detected and symptoms. In this way, more rational decisions can be made with regards to surgery or conservative management.

An important but often neglected aspect in management is injections into the zygapophyseal (facet) joint and sacro-iliac joint. Injection of facet joints provides important information based on the principle that elimination of pain following local anaesthetic instillation into the structurally abnormal joint implies that the joint is the offending source of pain.⁵³ Corticosteroids can then be added to this intra-articular injections. It has

been found that a few indicators such as older age, prior history of low back pain, normal gait and absence of spasm correlated well with relief after facet injection.⁵⁴ Sacroiliac joint pain is not an uncommon complaint and inflammatory spondyloarthropathies can involve this joint. Ankylosing spondylitis, psoriasis, Reiter's disease and degenerative osteoarthritis are examples of such conditions. A strong indication for sacroiliac joint injection is the provision of pain relief to patients who fail to respond to conventional treatment and rehabilitation.⁵⁵

In sacroiliac joint injection, fluoroscopically-guided intra-articular injection of the sacroiliac joint with an anaesthetic agent and corticosteroid can play a significant role in the overall care of the patient.

Conclusion

The role of radiology in rheumatologic diseases has vastly expanded with newer technologies and techniques. Now, not only are diseases diagnosed earlier but are also done more accurately and painlessly.

Close interaction between rheumatologists and radiologists will ensure the reaping of full clinical potentials of all modalities and interventional techniques in radiology.

REFERENCES

- Martel W. Radiologic manifestations of rheumatoid arthritis with particular reference to the hand, wrist and foot. *Med Clin North Am* 1968; 52:655-65.
- Weissman B N W, Sosman J L. The radiology of rheumatoid arthritis. *Orthop Clin North Am* 1975; 6:653-74.
- Park W M, O'Neil M, McCall I W. The radiology of rheumatoid involvement of the cervical spine. *Skeletal Radiol* 1979; 4:1-7.
- Beltran J, Caudill J L, Herman L A. Rheumatoid arthritis. MRI manifestations. *Radiology* 1987; 65:153-7.
- Senac M, Deutsch D, Bernstein B, Stanley I, Crues J V, Stoller D W, et al. MRI in juvenile rheumatoid arthritis. *AJR Am J Roentgenol* 1988; 150:873-8.
- Adam G, Dammer M, Bohndorf K, Christoph R, Fenke F, Gunther R W. Rheumatoid arthritis of the knee: value of Gadopentetate dimeglumine enhanced MR imaging. *AJR Am J Roentgenol* 1991; 156:125-9.
- König H, Sieper J, Wolf K-J. Rheumatoid arthritis: evaluation of hypervascular and fibrous pannus with dynamic MRI enhanced with Gd-DTPA. *Radiology* 1990; 176:473-7.
- Reiser M F, Bongartz G I, Erlemann R, Schneider, Pauly T, Sittek H, et al. Gadolinium-DTPA in rheumatoid arthritis and related diseases: first results with dynamic MRI. *Skeletal Radiol* 1989; 18:591-7.
- Schormer W, Lang P, Bittner R, Felix R. Gadolinium-DTPA enhanced MRI: applications in body MRI. *Diagnostic Imaging* 1990; 4:114-9.
- Gilkeson G, Polisson R, Sinclair H, Vogler J, Rice J, Caldwell D, et al. Early detection of carpal erosions in patients with rheumatoid arthritis: a pilot study of magnetic resonance imaging. *J Rheumatol* 1988; 15:1361-6.
- Poleksic L, Zdravkovic D, Jablanovic D, Watt I, Bacic G. Magnetic resonance imaging of bone destruction in rheumatoid arthritis: comparison with radiography. *Skeletal Radiol* 1993; 22:577-80.
- Weissman B N, Rappoport A S, Sosman J L, Schur P H. Radiographic findings in the hands in patients with systemic lupus erythematosus. *Radiology* 1978; 126:313-7.
- Scott W. Atlas. Magnetic resonance imaging of the brain and spine. 2nd ed. USA: Lippincott Raven, 1996:701.
- Bassett L W, Blocka K L N, Furst D E, Clements P J, Gold R H. Skeletal findings in progressive systemic sclerosis (scleroderma). *AJR Am J Roentgenol* 1981; 136:1121-6.
- Berens D L. Rotengen features of ankylosing spondylitis. *Clin Orthop* 1971; 74:20-33.
- Resnick D, Dwosh I L, Goergen T G, Shapiro R F, Utsinger P D, Wiesner K B, et al. Clinical and radiographic abnormalities in ankylosing spondylitis. A comparison of men and women. *Radiology* 1976; 119:293-7.
- Fam A G, Rubenstein J D, Chin-Sang H, Leung F Y K. Computed tomography in the early ankylosing spondylitis. *Arthritis Rheum* 1985; 28:930-7.
- Blum U, Buitrago-Tellez C, Munding A, Krause T, Laubenberg J, Vaith P, et al. Magnetic resonance imaging (MRI) for detection of active sacroiliitis-a prospective study comparing conventional radiography, scintigraphy and contrast-enhanced MRI. *J Rheumatol* 1996; 23:2107-15.
- Moll J M H, Wright V. Psoriatic arthritis. A review. *Semin Arthritis Rheum* 1973; 3:55-78.
- Kapasi O A, Ruby L K, Calney K. The psoriatic hand. *J Hand Surg* 1982; 7:492-7.
- Martel W, Braunstein E M, Borlaza G, Good A E, Griffin P E. Radiologic features of Reiter's disease. *Radiology* 1979; 132:1-10.
- Resnick D. Degenerative diseases of the vertebral column. *Radiology* 1985; 156:3-14.
- Knutsson F. The vacuum phenomenon in the intervertebral discs. *Acta Radiol* 1942; 23:173.
- Kindynis I, Haller J, Kang H S, Resnick D, Sartoris D J, Trudell D, et al. Osteophytosis of the knee, anatomic, radiologic and pathologic investigation. *Radiology* 1990; 174:841-6.
- Stoller D W. Magnetic resonance imaging in orthopaedics and sports medicine. USA: JB Lippincott Co, 1989:139-372.
- Chan I, Lang I, Stevens M I, Sack K, Majumdar S, Stoller D W, et al. Osteoarthritis of the knee: Comparison of radiography, CT, and MR imaging to assess extent and severity. *AJR Am J Roentgenol* 1991; 158:799-806.
- Priedler K, Resnick D. Imaging of osteoarthritis. *Radiol Clin North Am* 1996; 34:259-71.
- Dalinka M K, Reginato A J, Golden D A. Calcium deposition diseases. *Semin Roentgenol* 1982; 17:39-48.
- Jensen P S, Putman C E. Current concepts with respect to chondrocalcinosis and the pseudogout syndrome. *AJR Am J Roentgenol* 1975; 123:531-9.
- Adamson T C III, Resnik C S, Guerra J, Vint V C, Weisman M H, Resnick D. Hand and wrist arthropathies of haemochromatosis and calcium pyrophosphate disease: Distinct radiological features. *Radiology* 1983; 147:377-81.
- Fleckenstein J L, Reimers C D. Inflammatory myopathies: Radiologic evaluation. *Radiol Clin North Am* 1996; 34:427-39.
- Konagaya Y, Konagaya M, Mano Y. Quadriceps myositis. *Intern Med* 1992; 31:926-9.
- Reimers C D, Schedel H, Fleckenstein J L, Nägele M, Witt T N, Pongratz D E, et al. Magnetic resonance imaging of skeletal muscles in idiopathic inflammatory myopathies of adults. *J Neurol* 1994; 241:306-14.
- Fraser D D, Frank J A, Dalakas M, Miller F W, Hicks J E, Plotz I. Magnetic resonance imaging in the idiopathic inflammatory myopathies. *J Rheumatol* 1991; 18:1693-700.
- Fraser D D, Frank J A, Dalakas M. Magnetic resonance imaging (MRI) demonstrates muscle inflammation in idiopathic inflammatory myopathies (IIM). *Arthritis Rheum* 1989; 32:S125.
- Hernandez R J, Sullivan D B, Chenevert T L. MR imaging in children with dermatomyositis: Musculoskeletal findings and correlation with clinical and laboratory findings. *AJR Am J Roentgenol* 1993; 161:359-66.
- Coults D B, Zumwalt R E, Black W C, Sobonys R E. The epidemiology of interstitial lung disease. *Am J Respir Crit Care Med* 1994; 150:967-72.
- DeRemee R A. Diffuse interstitial pulmonary disease from the perspective of the clinician. *Chest* 1987; 92:1068-73.
- Fujii M, Adachi S, Shimizu T, Hirota S, Sako M, Kono M. Interstitial lung

- disease in rheumatoid arthritis: Assessment with high resolution computed tomography. *J Thorac Imaging* 1993; 8:54-62.
40. Schurawitzki H, Stiglbauer R, Graninger W, Herold C, Pölzleitner D, Burghuber O C, et al. Interstitial lung disease in progressive systemic sclerosis: High resolution CT versus radiography. *Radiology* 1990; 176:755-9.
 41. Padley S P G, Adler B, Hansell D M, Muller N L. High resolution computed tomography of drug-induced disease. *Clin Radio* 1992; 46:232-6.
 42. Mori M, Galvin J R, Barloon T J, Gingrich R D, Stanford W. Fungal pulmonary infections after bone marrow transplantation: Evaluation with radiography and CT. *Radiology* 1991; 178:721-6.
 43. Huang R M, Naidich D P, Lubat E, Schinella R, Garay S M, McCauley D I. Septic pulmonary emboli: CT-radiographic correlation. *AJR Am J Roentgenol* 1989; 153:41-5.
 44. Primack S L, Muller N L. High resolution computed tomography in acute diffuse lung disease in the immunocompromised patient. *Radio* 1994; 32:731-44.
 45. Nishimura K, Izumi T, Kitaichi M, Nagai S, Itoh H. The diagnostic accuracy of high resolution computed tomography in diffuse infiltrative lung diseases. *Chest* 1993; 104:1149-55.
 46. Primack S L, Hartman T E, Hansell D M, Muller N L. End-stage lung disease: CT findings in 61 patients. *Radiology* 1993; 189:681-6.
 47. Lee K S, Primack S L, Staples C A, Mayo J R, Aldrich J E, Muller N L. Chronic infiltrative lung disease: Comparison of diagnostic accuracies of radiography and low- and conventional-dose thin section CT. *Radiology* 1994; 191:669-73.
 48. Remy-Jardin M, Remy J, Deschildre F, Artaud D, Beregi J P, Hossein-Foucher C, et al. Diagnosis of pulmonary embolism with spiral CT: comparison with pulmonary angiography and scintigraphy. *Radiology* 1996; 200:699-706.
 49. Mitchell D, Kressel H, Arger P, Dalinka M, Spritzer C, Steinberg M. Avascular necrosis of the femoral head: Morphologic assessment by MR imaging with CT correlation. *Radiology* 1986; 161:739-42.
 50. Pariser K M. Takayasu's arteritis. *Curr Opin Cardiol* 1994; 9:575-80.
 51. Boden S D, Davis D O, Dina T S, Patronas N J, Wiesel S W. Abnormal magnetic-resonance scans of the lumbar spine in asymptomatic subjects: A prospective investigation. *J Bone Joint Surg Am* 1990; 72:403-8.
 52. Wiesel S W, Tsourmas N, Feffer H L, Citrin C M, Patronas N. A study of computer-assisted tomography: The incidence of positive CT scans in asymptomatic patients. *Spine* 1984; 9:549-51.
 53. Dreyer S J, Dreyfuss I', Cole A J. Zygapophyseal (facet) joint injections. *Physical Med Rehab Clin North Am* 1995; 6:715-42.
 54. Jackson R I', Jacobs R R, Montesano I' X. Facet joint injection in low back pain: A prospective statistical study. *Spine* 1988; 13:966-71.
 55. Dreyfuss P, Cole A J, Pauza K. Sacroiliac joint injection techniques. *Physical Med Rehab Clin North Am* 1995; 6:785-813.