Postępy Nauk Medycznych, t. XXV, nr 2, 2012

*Małgorzata Wisłowska, Magdalena Matryba

Imaging methods in diagnosis and evaluation of treatment of rheumatoid arthritis patients**

Badania obrazowe w diagnostyce i ocenie leczenia chorych na reumatoidalne zapalenie stawów

Rheumatology and Internal Medicine Clinic of Central Hospital of the Ministry of Internal Affairs
Head of Department: prof. Małgorzata Wisłowska, MD, PhD

S u m m a r y

Conventional radiography is a common imaging method in diagnosis of rheumatoid arthritis. Modified Sharp method and Larsen-Dale method are applied for accurately scoring of joint damages. Intensity of radiological destructive changes are correlated with disease activity and deterioration of joints function. Ultrasonography is the method of evaluation of joints structures, especially soft tissue of movement system. Evaluation of flow in vessels in synovium using Power Doppler enables to estimate angiogenesis in inflammatory joints and is correlated with disease activity. Computed tomography allows to detect destructive changes more early than conventional radiography. Magneting resonance imaging allows accurate evaluation of soft tissues and bones and multilevel imaging of structures localized inside body as atlantooccipital and atlantoaxial joints and extra-articular changes - concerned mainly nervous system, vessels, fascia and muscles.

Key words: conventional radiography, ultrasonography, computed tomography, magneting resonance imaging

S t r e s z c z e n i e

Podstawowym badaniem obrazowym w diagnostyce reumatoidalnego zapalenia stawów jest tradycyjna radiografia. Dla dokładnej oceny progresji zmian stawowych stosowana jest zmodyfikowana metoda Sharpa oraz metoda Larsena-Dale'a. Nasilenie zmian radiologicznych koreluje z aktywnością choroby i upośledzeniem funkcji stawów. Badanie ultrasonograficzne to metoda oceny struktur stawów, w tym tkanek miękkich układu ruchu. Badanie przepływu naczyniowego w błonie maziowej stawów przy użyciu tzw. Dopplera mocy umożliwia ocenę angiogenezy w zapalnie zmienionych stawach i koreluje z aktywnością procesu zapalnego. Tomografia komputerowa pozwala na znacznie wcześniejsze wykrycie zmian niż tradycyjna radiografia. Obrazowanie metodą rezonansu magnetycznego umożliwia dokładną ocenę tkanek miękkich i kości oraz wielopłaszczyznowe obrazowanie struktur zlokalizowanych w głębi ciała, takich jak stawy szczytowo-potyliczne i szczytowo-obrotowe oraz zmian pozastawowych – dotyczących głównie układu nerwowego, naczyń, powięzi i mięśni.

Słowa kluczowe: tradycyjna radiografia, badanie ultrasonograficzne, tomografia komputerowa, rezonans magnetyczny

INTRODUCTION

Imaging used in diagnosis and evaluation of treatment of rheumatoid arthritis (RA) patients includes the following types of examination: radiological, ultrasonographic, scintigraphic, tomographic and magnetic resonance imaging. Imaging allows early diagnosis of RA, even in the symptomless stage, and prompt commencement of treatment. If the treatment begins in the initial phase of the disease, there is a high chance of inhibition of its activity or even, in some cases, of total remission. Moreover, appropriately conducted imaging allows to forecast disease acuteness, to monitor its course and effectiveness of applied treatment.

RADIOLOGICAL EXAMINATION

Traditional radiography is the basic imaging technique used in diagnosis of rhematoid arthritis (RA). In every case of suspected RA, images of hands in AP projection and feet in AP and LL projections should be taken. That should show the tuber calcanei and the head of the fifth metatarsal

**The paper is dedicated to Professor Eugene J. Kucharz on his sixtieth birthday.

b o n e. Another image should include the cervical vertebrae in the lateral projection (neutral position), due to possibility of dangerous complications in a form of a dislocated odontoid process. In cases when the diagnosis is known, additional imaging includes pictures of clinically involved joints (1). Comparative X-ray images, that is pictures of two symmetrical body regions made on the same X-ray film, are of high value.

Radiological examination reflects the course of a disease. However, sometimes in case of patients with acute inflammatory process no essential changes are visible and vice versa. Inhibition or decreased progress of radiological changes means that activity of a disease between subsequent X-ray examinations was low (2).

X-ray examination of patients suffering from RA allows to diagnose swelling of soft tissue in periarticular areas caused by vasculitis of the synovial membrane and adjoining soft structures. That swelling is particularly visible in the surrounding of hand and foot joints. Occurrence of juxta-articular osteoporosis caused by topical congestion of bone and increased inflammatory bone resorption is also visible in X-ray images, as well as narrowing of joint gaps caused by destruction of joint cartilages. Another typical symptom of RA is occurrence of destructive lesions caused by growth of inflammatory granulation tissue (so called pannus) within the synovial membrane and intratrabecular spaces of cancellous bone heads. Initially, those changes occur in the subchondral layer of trabecular bones in a form of inflammatory geodes. Subsequently they cause occurrence of erosion. Those initially occur within the articular capsule, on the surface of bone deprived of joint cartilage as so called border erosion. Due to their gradual expansion, head bones become destroyed. Damage of joint surfaces causes their total consolidation, occurrence of bone and fibrous adhesion (so called ankylosis) with limited mobility of joints. That symptom mainly occurs in phalangeal and carpal articulations. X-ray images also show other types of joint deformations: ulnar deviation in metacarpophalangeal joints and lateral deviation in metatarsophalangeal joints, subluxations, contractures of articulations caused by damage in the ligamento-capsular apparatus and muscle attachments or genu valgum, being a symptom of damage to the lateral part of the joint cartilages. Moreover, RA also causes osteolysis of bone fragments, most frequently affecting phalanges of hands and feet, yet possibly also including the acromial end of the clavicle, the distal end of the radius and the ulna bones and the spinous process of the cervical vertebrae. A lateral image of the calcaneus can demonstrate irregular, fuzzy outline of the posterior part of the tuber calcanei caused by bursitis of the Achilles tendon. In case of subluxation in the atlanto-axial joint, lateral X-ray images of bent head show increased (> 3 mm) distance between the odontoid process (dens) and the arch of the atlas vertebra. Another consequence of such pathological lesions in atlanto-axial joints can be indentation in the base of the skull. To date, two lines have been used to assess such changes: Chamberlain's line (a line drawn from the craniovertebral junction joining the posterior end of the hard palate to the posterior lip of the foramen magnum) and McGregor's line (a line drawn from the posterior edge of the hard palate to the most posterior point of the occiput). Position of the apex of the odontoid process in relation to those lines describes the degree of indentation. In normal conditions, the apex should not reach beyond Chamberlain's line more than 3 mm and McGregor's line more than 5-6 mm. Sakaguchi and Kauppi suggested a much simpler and easier method to assess indentation. Their method traces a line which connects inferior edge of the anterior arch with the inferior outline of the posterior arch of the atlas. Projection of the atlanto-axial joints should be located below that line. Such method does not require any measurements (1).

According to Steinbrocker's criteria, intensification of destructive lesions in articulations is described in four stages (3). Early stage I is a protuberance of soft periarticular parts and periarticular osteoporosis. At moderate stage II, symptoms include narrowing of joint gaps and formation of subchondral geodes, as well as osteoporosis. Advanced changes of stage III include frequent erosion of joint surfaces, osteoporosis and joint deformation in various forms: subluxation, ulnar deviations, hypermobility. In the terminal stage IV, bone or fibrous adhesion occur, accompanied by the same changes as during the stage III.

Assessment of joint changes according to Larsen-Dale (4) **comprises 6 stages:** stage 1 is a normal picture of a joint. Stage 2 describes appearance of minor changes: periarticular edema of soft tissues, juxta-articular osteoporosis, slight narrowing of joint gaps. Stage 2 also means early erosion and narrowing of joint gaps, while stage 3 means average destructive changes such as erosion and narrowing of joint gaps. Stage 4 is described as large destruction to the surface of joints. Stage 5 occurs when significant deformation of articulations can be observed.

Modified Sharp's and Larsen-Dale's methods are used for accurate assessment of progression in joint changes. Sharp's method assesses the number of erosion occurrences and degree of narrowing of the joint gaps in arms, wrists and feet (5). Occurrences of erosion in arm joints are assessed in 0 out of 5 scale, while 0 out of 10 scale is used for foot joints and 1 out of 4 scale is applied to assessment of joint gap narrowing. The maximal score for occurrence of erosion in one patient is 280 (arms – 160, feet – 120), while the maximal score for narrowing is 168 (arms – 120, feet – 48). Hence the total score while using this method is 448. Larsen-Dale's method is based on reference films. The degree of progression is assessed on their basis with use of a 5-stage scale in 32 joints of hands, wrists and feet. The degree of progression corresponds to the number of points scored, while points scored for the wrist are multiplied by 5. The total Larsen Score (LS) is calculated as a sum of points obtained for each joint.

The maximal score (called Larsen-Dale's index) for one patient is 200. Moreover, in case of patients with a diagnosed form of RA, radiological progression expressed with use of one of the above described methods, which assess arm and foot joints, indirectly reflects changes in large articulations. However, those methods cannot be reliably used in patients with early stages of arthritis, as in that case it is possible that other than assessed joints become affected by the disease. The percentage of patients affected with erosion of arm and foot joints, as diagnosed during the first radiological examination, is estimated as low as 15% (2). Another estimation is that probably 70% of patients diagnosed with undifferentiated arthritis, rather than rheumatoid arthritis, do not show symptoms of progression of radiological changes nor occurrence of erosion (6).

Intensification of radiological changes correlates with activity of the disease and impairment of joint functionality. The most rapid development of erosion occurs in the first two years of the disease progress. It was found that frequency of erosion cases increases up to 28% within the first 12 months since the first occurrence of RA symptoms (7). Subsequently, it was calculated that average annual increase of the maximum joint damage, that is the case when the degree of erosion reaches the maximum and the joint gaps become the narrowest, amounts to 1.9%. During the first 2 years, the average value of Larsen's index scores between 8 and 17% of the maximal possible damage. After 5 years, changes assessed with use of Sharp's method gave the maximal score in case of 14% patients, while after 20 years that percentage is as high as 43 (1).

ULTRASONOGRAPHY

Ultrasonography is a method of assessment of joint structures which includes examination of the soft tissues of the locomotor system. That imaging technique uses the reflected ultrasonic wave with frequency over 20 000 Hz (20 kHz), i.e. returning echo, which is then analyzed in terms of location and intensity. Ultrasonographic examination has many advantages: it is non-invasive, harmless and non-intrusive for the patient. Examination can be conducted in virtually any place, for example at the patient's bed. Ultrasonography is widely available and quite inexpensive. Obtained images feature high spatial resolution and contrast, can be recorded in real time, during movement. The examination is possible during passive and active movement of the patient, allows simultaneous puncture and monitoring of treatment response (8, 9).

Ultrasonography allows to diagnose occurrence of erosion earlier than in case of traditional radiography because it enables simultaneous assessment of core layers of joint bones in many planes, also during dynamic examination with their passive bending and straightening. In normal conditions, the bone outlines are smooth, covered with a layer of anechoic cartilage. In case of patients with active inflammatory process, joint surfaces become irregular, uneven and worn. Erosion becomes visible as losses in the bone outline with various sizes and depths, filled during intensified inflammatory state of RA progression with hypoechogenic pannus mass, often with visible vessels penetrating the bone. It was estimated that an ultrasound examination allows to detect from 1.4 to 3.5 times more erosion occurrences than a classic X-ray image of arms (8, 9).

Normal synovial membrane is invisible during an ultrasound examination. However, it allows to detect inflammatory changes in structures which include the synovium (articular capsules and bursae, tendon sheaths). That usually demonstrates various stages of hypertrophy with presence of hypoechogenic tissue foci and effusion). It also allows to assess the state of muscles and ligaments. Research conducted on a larger number of both symptomatic and asymptomatic joints proved ultrasound examination to detect synovitis in 79% cases of edemal, 33% cases of only painful and in 13% of clinically normal articulations (10). In case of RA progression, the earliest visible symptoms include inflammatory changes in the synovial membrane of the metacarpophalangeal, proximal interphalangeal and metatarsophalangeal joints, while in case of children it also affects large joints, frequently knees. In case of the inflammation of tendon sheaths, it is possible not only to see thickening and the degree of vascularization of tendons but also assess their mobility and degree of damage. Due to adhesion with the sheath or inflammation-induced pressure, mobility of the tendon is limited. Changes in tendons demonstrate themselves as dilation or thinning, irregularities and losses in their fibrous structure, occurrence of cysts, strain or tear in their continuity. It may be accompanied by an increased vascular flow related to the ingrowth of the synovial membrane vessels into the tendons. Ultrasound examination also enables differentiation of fluid collection (effusion) from hypertrophy of the synovial membrane. That allows to perform aimed punctures for diagnostic and therapeutic purposes, during which it is possible to evacuate the fluid or administer corticosteroids into the joints. Ultrasound examination also allows for controlled biopsy of pannus and joint erosion (11). Ultrasonic images of inflammatory changes are non-specific in relation to their causes.

Use of so called Power Doppler during examination of vascular flow in the synovial membrane allows to assess angiogenesis in the joints changed by inflammation and is directly related to the activity of the inflammatory process. Use of Power Doppler signal in case of patients suffering from RA allows to detect hypertrophic synovial membrane and, therefore, active inflammation during the stage of clinical remission. It constitutes an unfavorable predictor which increases risk of exacerbation of the disease (12). Sensitivity of the PD method increases even more if an intravenous contrast agent is administered as it intensifies the signal. Despite the fact that results of PD examination are comparable with those obtained with the MRI method, such examination has its limitations

as it cannot show the direction of fluid flows nor their velocities. In case of excessive congestion this means difficult identification of blood vessels. It also requires vast cooperation of the patient as movements of the body largely influence the obtained picture. Therefore, in order to obtain accurate assessment of the vascular flow in the synovial membrane changed by inflammation, the Power Color Doppler (PCD) option is used. It was proven that clinical improvement correlates with decreased count of colorful pixels in a chosen region, as well as with increased vascular resistance index (13).

In clinical practice, an easy, three-stage activity scale is most frequently used to assess inflammation of the synovial membrane:

1. Minor activity – individual vessels present, hardly visible in the thickened synovial membrane of a joint, articular capsule, tendon sheaths and bursae. Minor congestion of the synovial membrane – the PCD signal spreads over less than 25% of the synovium.

2. Average activity – more numerous vessels present, easier and more often visible in the thickened synovial membrane. Average congestion of the synovial membrane – the PCD signal spreads over more than 25% but less than 50% of the synovium.

3. Major activity – numerous vessels present and they form conglomerates, usually aggressively ingrowing into the cartilage and bone, most often visible in largely congested, hypoechogenic synovial membrane – the PCD signal spreads over more than 50% of the synovium.

Ultrasound examination also allows to see structural changes in nerves, such as post-trauma damage, presence of tumors, changes in the course of the compression syndromes, presence of ganglion cysts or lipomas. Segmental nerve swelling is an early change which suggests occurrence of a compression syndrome below the location of edema. Ultrasound examination produces images of segmental thickening with lowered hypoechogenicity and blurring of the structure of the nerve, as well as flattened picture of the nerve due to the compression. In rheumatology diagnostics, assessment of compression syndromes most often relates to the median nerve in the carpal tunnel. Ultrasound examination also play an important role in diagnosis of damages of the ulnar nerve.

Ultrasound examination allows to see and differentiate post-trauma changes (ruptures of muscles, tendons and ligaments), assessment of morphology and tumor exit points in soft tissues, vascular malformations, presence of foreign bodies and fracture gaps, appositional growth of the periosteum, osteochondromas, degenerative and proliferative changes, deformations of bone outlines.

COMPUTER TOMOGRAPHY

Computer tomography (CT) allows for detection of changes earlier than in case of traditional radiography, however its use in diagnosis of arthritis is limited due to low resolution of soft tissues, high dose of X-ray radiation and high costs of research. Intra-joint injections of iodine contrast agent or air (CT arthrography) are used to improve limited contrast resolution of CT in assessment of joint cartilages, synovial membrane and ligaments. That procedure is most frequently used in post-trauma diagnosis as it allows to detect fractures of the meniscus and open damages to cartilages. High quality imaging of bone structures with possibility of their reconstruction in various planes allows to use CT in diagnosis of latent fractures and pre-operative assessment in order to choose adequate surgical methods and suitable joint endoprosthesis. CT is also useful for assessment of joint with complex structure or obscured with other anatomical structures, such as temporomandibular and vertebral joints, particularly in the cervical region. CT examination can also detect large cysts without or with minor cortical discontinuities, which are undetectable in MR examination.

MAGNETIC RESONANCE

Magnetic resonance imaging (MRI) method allows for detailed assessment of soft tissues and bones and multiplanar imaging of structures located deep in the human body, such as atlanto-axial and atlanto-occipital joints and abarticular changes pertaining mainly to the nervous system, vessels, fasciae and muscles. Due to its high safety and lack of harmful radiation, magnetic examination can be subsequently repeated. The only potential harmful effect of MR examination, and therefore contraindication for the procedure, may be due to presence in the body of the patient or in its direct vicinity of metal parts such as, for example: a pacemaker, an irremovable neurostimulator, a micro vascular clip, a metal or electronic ear implant, a subcutaneous hearing aid, a metal shard in the eye or in another part of the body. Devices of at least 1.5 T (Tesla) output are used for examination of the locomotor system because the stronger the magnetic field, the higher is the resultant resolution of images. Low field MRI technique is also used in RA diagnosis. It is limited to assessment of extremities and peripheral joints. The technique can be easily conducted in case of patients with significant deformation of articulations and those suffering from claustrophobia (14).

The most important feature of that type of examination in RA diagnosis is that it allows for early detection of bone marrow edema, synovitis and joint erosion. Additionally, it allows to reveal occurrence of effusions in joints, cysts (especially in the popliteal fossa), tenosynovitis and bursitis, to assess joint cartilages or reveal lesions in the soft tissues, for example tendons. MR examination can detect subchondral hypertrophy of the synovial membrane and initial erosive lesions as early as within the first 4 months of the course of RA (15).

An international group of experts lately reached consensus pertaining to unification of assessment criteria for structural changes diagnosed in MRI

procedures (OMERACT – Outcome Measure in Rheumatoid Arthritis Clinical Trials) (15). In MRI examination, synovitis or inflammation of the synovial membrane occurs an area the size of the synovium with abnormal intensification of the signal obtained after a contrast agent had been administered and thicker than an image obtained from normal synovial membrane. Bone erosions are circumarticular changes with clearly distinguishable outline and typical distortion of the signal. They should be visible in 2 planes and reveal cortical discontinuities in at least one plane. Bone edema is a lesion of a part of a cancellous (trabecular) bone. It is vaguely distinguishable and features signal typical for reduced content of water.

Bone marrow edema is usually visible in MRI examination of patients who suffer from synovitis, however its presence is not only specific to RA. It may also occur in degenerative or post-trauma changes. In the course of RA, bone marrow edema usually precedes occurrence of new erosions. It is considered to be a potentially reversible change.

Administration of a gadolinium contrast (Gd-DTPA) during a MRI examination leads to enhancement of the signal in areas which contain irregular vessels and are affected with inflammatory process. The synovial membrane changed by inflammation has increased volume and enhances the signal after the contrast had been administered. The degree of synovitis revealed in MRI examination proves relation to the progression of destructive lesions in bones and bone edema.

MRI examination reveals erosions in joints of hands in 45% cases during the first 6 months of the course of disease and in 74% patients during the first year. In comparison, X-ray examination conducted after similar periods allowed to diagnose 12% and 29% occurrences of the disease, respectively. It is estimated that MRI examination reveals 9.5 more erosion occurrences in metacarpophalangeal joints than X-ray imaging conducted in the early stage of RA (16). However, a problem with overinterpretation of changes similar to erosions is indicated in the available literature.

In case of patients suffering from RA with affected vertebral joints in the suboccipital area, MRI reveals destructive lesion of bones and ligaments with inflammatory changes of the synovial membrane, sometimes with symptoms of compression of the thecal sac and the medulla oblongata. MRI also proves to be the most useful diagnostic tool of all imaging techniques in the early stages of avascular necrosis of the femur (sensitivity 97%, specificity 98%), which may pertain to patients suffering from RA, especially those on chronic treatment with high doses of corticosteroids. MRI can also be used in diagnosis of the carpal tunnel syndrome, which often accompanies RA, and can yield non-specific clinical symptoms and ambiguous results in electrodiagnostic tests. It is possible that those results remain or recur even after surgical treatment. In such cases, changes in the signal are usually found and the diagnosis is flattening of the median nerve in the carpal tunnel and thickening of the transverse carpal ligament.

SCINTIGRAPHY

Scintigraphy features high sensitivity in detection of inflammatory changes of the osteoarticular system, much higher than in case of X-ray examination. It allows to perform both functional and structural assessment of the locomotor system. In comparison to MRI tests, it is cheaper and enables imaging of the whole bone system. On the other hand, its disadvantages are low specificity, lack of detailed visualization of anatomical structures and exposure of the patient to radiation. (99 m)Tc-methylene diphosphonate (99 mTc-MDP) is most frequently used in scintigraphy of the skeletal system. However, as the complex molecular mechanisms of RA are becoming better known, more kinds of immunoscintigraphy are being made available for its diagnostic purposes. Radioactive tracers uptaken by osteoblasts reveal spots of increased bone remodeling. Negative result of such examination eliminates presence of inflammation, while increased uptake of a radiotracer can also occur in metabolically active areas of a normal skeleton, that is in heads of long bones, costal cartilages, sacroiliac and sternoclavicular joints. Monoclonal antibodies labeled with technetium were used in RA diagnosis against a CD4 molecule present on the surface of TH lymphocytes and macrophages of articulations affected by the disease (17). 99mTc-ciprofloxacin, which deactivates DNA gyrase of gram-negative bacteria, is another new radiopharmaceuticals. Tests conducted with its use are called 'infection-scintigraphy'. Increased uptake of 99mTc-ciprofloxacin has been observed in various inflammatory states of articulations, including the cases of RA.

OTHER IMAGING METHODS

Single Photon Emission Computed Tomography (SPECT) allows to obtain a spatial image of distribution of a tracer, which enables imaging of complex or very small anatomical structures and lets decrease the number of false positive results.

Recently, there have been reports of use of C-11 choline and 18F-2-deoxy-2-fluoro-D-glucose used in PET imaging for assessment of metabolic activity and proliferation of the synovial membrane (18).

A decrease of bone mass, reported in recent years as related to localized osteoporosis induced by inflammatory agents, has focused attention of the researchers on the assessment of usefulness of bone density measurements (Bone Mineral Density – BMD) in diagnosis of early RA conducted with use of the DEXA method. Rapid loss of the cortical bone mass in the carpus causes huge damage to articulations after 5 and 10 years of the course of disease (19). The present state of knowledge allows to consider densitometric tests to be supplementary in examination of patients who suffer from rheumatoid arthritis.

BIBLIOGRAPHY

1. Staniszewska-Varga J, Szymańska-Jagiełło W, Luft S, Korkosz M: Atlas radiologiczny chorób reumatycznych. Medycyna Praktyczna, Kraków 2003; 12-14.
2. Szechiński J, Wiland P: Wczesne reumatoidalne zapalenie stawów. Górnickie Wydawnictwo Medyczne. Wrocław 2004; 17-19.
3. Steinbrocker O, Treger H, Cornelius H: Therapeutic criteria in rheumatoid arthritis. JAMA 1949; 140: 659-662.
4. Larsen A, Dale K, Eek M: Radiographic evaluation of rheumatoid arthritis and related conditions by standard reference films. Acta Radiol Diagn 1977; 18: 481-491.
5. Sharp JT, Lidsky MD, Collins LC et al.: Methods of scoring the progression of radiological changes in rheumatoid arthritis. Arthritis Rheum 1971; 14: 706-720.
6. Landawe R, van der Heijde DM: Is radiographic progression a realistic outcome measure in clinical trials with early inflammatory arthritis? Clin Exp Rheumatol 2003; 21 (Suppl. 31): 37-41.
7. Machold KP, Stamm TA, Eberl GJ et al.: Very recent onset arthritis – clinical, laboratory and radiological findings during the first year of disease. J Rheumatol 2002; 29: 2278-2287.
8. Wakefield RJ, Gibbon WW, Conaghan PG et al.: The value of sonography in the detection of bone erosions in patients with rheumatoid arthritis. Arthritis Rheum 2000; 43: 2762-2770.
9. Weidekamm C, Koller M, Weber M et al.: Diagnostic value of high-resolution B-mode and Doppler sonography for imaging of hand and finger joints. Arthritis Rheum 2003; 48: 325-333.
10. Wakefield RJ, Greek MJ, Marzo-Ortega H et al.: Should oligoarthritis be reclassifield? Ultrasound reveals a high prevalence of subclinical disease. Ann Rheum Dis 2004; 63: 382-385.
11. McGonagle D, Gibbon W, O'Connor P et al.: A preliminary study of ultrasound aspiration of bone erosion in early rheumatoid arthritis. Rheumatology 1999; 38: 329-331.
12. Scire CA, Motecucco C, Codullo V et al.: Ultrasonographic evaluation of joint involvement in early rheumatoid arthritis in clinical remission: power Doppler signal predicts short-term relapse. Rheumatology (Oxford) 2009; 48: 1092-1097.
13. Terslev L, Torp-Pedersen S, Quistgaard E et al.: Effects of treatment with etanercept (Enbrel, TNRF:Fc) on rheumatoid arthritis evaluated by Doppler ultrasonography. Ann Rheum Dis 2003; 62: 178-181.
14. Lindegaard H, Vallo J, Hossslev-Petersen K et al.: Low field dedicated magnetic resonance imaging in untreated rheumatoid arthritis at recent onset. Ann Rheum Dis 2001; 60: 770-776.
15. Ostergaard H, Edmonds J, McQeen F et al.: An introduction to the EULAR OMERACT rheumatoid arthritis MRI reference image atlas Ann Rheum Dis 2005; 64 (Suppl 1): 1-3.
16. McQuenn FM, Benton N, Crabbe J: What is the fate of erosions in early rheumatoid arthritis? Tracking individual lesions using x rays and magnetic resonance imaging over the first two years of disease. Ann Rheum Dis 2001; 60: 859-868.
17. Kinne RW, Becker W, Schwab J et al.: Imaging rheumatoid arthritis joints with technetium-99m labeled specific anti – CD4 and non-specific monoclonal antibodies Eur J Nucl Med 1994; 2: 176-180.
18. Palmer WE, Rosenthal DI, Schoenberg OI et al. Quantification of inflammation in the wrist with gadolinium-enhanced MR imaging and PET with 2-[F-18]-fluoro-2-deoxy-D-glucose. Radiology 1995; 196: 647-655.
19. Hoff M, Haugeberg G, Odegard S et al.: Cortical hand bone loss after 1 year in early rheumatoid arthritis predicts radiographics hand joint damage at 5-yeaar follow-up and 10-year follow-up. Ann Rheum Dis 2009; 68: 324-329.

otrzymano/received: 08.12.2011
zaakceptowano/accepted: 04.01.2012

Adres/address:
*Małgorzata Wisłowska
Department of Internal Medicine and Rheumatology, Central Hospital of the Ministry of Internal Affairs and Administration
ul. Wołoska 137, 02-507 Warszawa
tel.: +48 (22) 508-15-24
e-mail: mwislowska@wp.pl