Development of algorithms for automated detection of inflammation lesions in patients with axial spondyloarthritis.

Axial spondyloarthritis (axSpA) is an inflammatory rheumatic condition, involving primarily an axial skeleton and progressively leading to the sacroiliac, intervertebral and facet joint immobilization. The currently valid Assessment in SpondyloArthritis International Society (ASAS) criteria for classification of axSpA allow for the diagnosis of sacroiliitis with the use of two methods: radiography and magnetic resonance imaging (MRI). However, it is only MRI, which enables to diagnose the disease in the early stage. The inflammation of the sacroiliac joints (sacroiliitis) could have various manifestations in magnetic resonance imaging (MRI) - acute such as bone marrow oedema, as well as chronic, like erosions.

The definition of active sacroiliitis in MRI, fulfilling the ASAS criteria, is a bone marrow oedema visible on T2-weighted or bone marrow enhancement present on T1-weighted sequence after contrast media administration. The lesion should be located periarticularly in a subchondral bone, and must be visible on the two consecutive slices of MRI examination or on only one slice if at least two lesions are noticeable. Nonetheless, the assessment of the active sacroiliitis in MRI is not an easy task, especially when lesions are small. The inter-rater agreement on the presence of 'positive MRI' according to ASAS criteria is substantial (κ=0.73), yet it is still unsatisfactory.

Computer-aided detection (CAD) is one of the fastest developing technologies in Radiology, and the number of clinically available efficient algorithms to semi-automated and automated detection on medical imaging has been constantly growing. CAD has not gained much popularity in rheumatology as yet. Currently, the majority of existing solutions focuses on the evaluation of some features of such diseases as rheumatoid arthritis (RA) and osteoarthritis (OA). Thus far, several methods of automated or semi-automated bone marrow oedema detection were developed, namely: automated RAMRIS (rheumatoid arthritis MRI scoring system) scoring, automated quantification of bone marrow oedema in wrists of patients with RA and semi-automated detection of cartilage-related bone marrow lesions in the group with OA. In the case of axSpA, only one tool was developed, which enables for the semi-automated quantification of active sacroiliitis in MRI. However, the primary drawback of this method is that it requires manual selection of lesions (software only detects their contours) and does not detect lesions missed by the observer. Furthermore, the software enabling automated detection of sacroiliitis on computed tomography scans was recently designed, but this imaging method visualizes only late, irreversible changes within the sacroiliac joints and is not recommended by ASAS to the diagnostics of axSpA, especially in early stage. So far, any software allowing for the detection of bone marrow oedema lesions in MRI, which do not require their manual selection, has not been designed yet, even though the need is large.

The aim of our study is to create an efficient tool for an automated detection of bone marrow oedema lesions in patients with axSpA. Based on ASAS criteria, an effective algorithm for detection of inflammatory changes in axSpA must solve in an automated way the following tasks:

1. Segmentation of the sacral bone and visible parts of left and right iliac bones on T1-weighted sequence images.
2. Fusion of T1- and T2-weighted MR images to find the bone regions in T2-images used for detection of inflammatory changes.
3. Detection of regions of interest (ROIs), where algorithm searches for inflammatory changes.
4. Detection of inflammatory changes.

An MR examination of sacroiliac joints consists typically of no more than 20 slices. The complicated shape of the bones building the joint makes the problem of segmentation especially difficult. Fortunately, only precise segmentation of a part of bones extending by no more than 2cm from the joits is necessary as these are the regions where the inflammatory changes are searched for. Thus the segmentation should start from the detection of the joint which is simpler than segmentation of the whole bones. The bones are much better visualized in T1- than in T2- weighted MR images, used for diagnosing axSpA. Thus, segmentation found in T1-weighted images must be projected to T2-weighted images used techniques of image registration/image fusion. Finally, the inflammatory lesions are defined as bone marrow regions characterized by increased signal. Statistical learning or testing are the tools of the first choice to detect the lesions.