[SY29] MSK Symposium

SY29-01

Bone Marrow: Anatomy and Physiology for MR-imagers

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Along with skeletal muscle, the bone marrow is the most physiologically active and responsive components of the musculoskeletal system. The status of the bone marrow in many respects mirrors the patient well-being. Magnetic resonance imaging (MRI) has allowed, for a first time, a non-invasive means of studying the bone marrow, providing MR imagers with a unique opportunity to learn about the inner workings of this adaptive tissue. Spin echo fat quantification, chemical shift imaging, perfusion imaging, diffusion imaging and blood oxygen level dependent (BOLD) techniques have been applied to further what is known about bone marrow physiology. Understanding normal microstructure of the bone marrow underlies a proper understanding of bone marrow physiology.

This presentation addresses the normal anatomy and physiology of the bone marrow as well as physiological age-related and other adaptive responses.

[SY29] MSK Symposium

SY29-02

Quantitative Imaging of Inflammation in Inflammatory Arthritis

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For the past 25 years, increasingly sophisticated techniques have been applied to quantifying the degree and intensity of inflammation in inflammatory arthritides. This process has gathered pace in the last five years with semi- or fully automated quantification techniques becoming easier to apply and more reliable, particularly those based on MR imaging.

In rheumatoid arthritis, the wrist is the most commonly imaged joint since it is one of the earliest and frequently involved joints. Also the degree of inflammation is the wrist is generally reflective of the degree of inflammation elsewhere. MRI reveals the degree of inflammation present in the wrist to a high level of accuracy. One needs to visualise and quantify the inflammation present in inflammatory arthritides as (a) clinical, serolological and imaging parameters correlate only modestly with each reflecting different aspects of the disease and (b) residual subclinical inflammation leads to progressive structural damage to bones and joints.

There are three main features of inflammation evident on MRI in inflammatory arthritides, namely joint synovitis, tenosynovitis and bone marrow oedema. Other features evident on MRI such as erosions, joint space narrowing and joint incongruity are sequelae of inflammation rather than a direct marker of inflammation per se. Ideally, in RA, one is seeking to quantify (a) the volume joint synovial and tenosynovial proliferation, (b) the activity of this synovial proliferation, (c) the degree and intensity of bone marrow oedema. As the structures in the wrist are anatomically closely apposed, this quantification requires a high level of tissue segmentation. Reliable, accurate tissue segmentation is, without doubt, the overriding problem with automation of quantification systems. For any automated quantification process to be a success, bone, joint synovium, and tenosynovium needs to be accurately segmented.

Currently either (a) manual, (b) semi-automated and (c) fully automated approaches are used. The higher the level of automation, the quicker the evaluation process, though the lower the reliability and accuracy. The complexity and time restraints of manual and semi-automated quantification techniques limit their clinical implementation. Various techniques (thresholding, region growing, graph cut, watershed, deformation models and machine learning) are being tried with encouraging levels of success. Once the different tissues have been segmented, it is then relatively straightforward to measure the activity and intensity of inflammation in these tissues. The MR community is currently on the cusp of making the substantial breakthrough with regard to accurate segment of the different tissue elements. Such a breakthrough will greatly increase the utilization of MR in the evaluation of inflammatory arthritides in clinical practice and clinical research trials.

[SY29] MSK Symposium

SY29-03

Quantitative imaging of bone marrow lesions

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Vertebral bone marrow imaging is important for oncologic patient because spine is one of the most common site for metastasis.As bone marrow infiltrative process tend to replace the normal fatty marrow lowering fat content, fat quantification is an important issue to diagnose bone metastasis in oncologic patient. Single-voxel magnetic resonance (MR) spectroscopy has been the gold standard technique for accurate quantification of fat content in localized regions of the vertebral bodies. However, MR spectroscopy remains largely a research tool because it is technically demanding, time-consuming, subject to sampling errors associated with low spatial resolution, and spatially heterogeneous distribution of bone marrow fat content. In routine clinical practice, conventional MR imaging is usually first used for bone marrow assessment, because malignant bone marrow infiltrative pathology has a lower signal intensity relative to adjacent nondegenerative intervertebral disc on T1-weighted image (T1WI) indicating decreased fat content within the bone marrow. However, difficulty in qualitative interpretation of MR imaging frequently arises when patient has heterogeneous bone marrow signal intensity including focal red marrow hyperplasia, endplate degeneration or benign vertebral fracture. To overcome qualitative assessment of bone marrow fat content, many studies have investigated to quantify the fatty marrow to facilitate distinction between malignant and benign processes. Semiquantitative assessment with chemical shift imaging, which consists of two dimensional dual-echo in-phase and opposed-phase gradient-echo images, allows detection of fat in abnormal marrow lesions and thus may be predictive of whether it is likely caused by neoplastic or nonneoplastic lesions. However, it is well known that there are so many confounding factors in calculation of fat or water signal by chemical shift MR imaging, including main magnetic field inhomogeneity effects, the presence of multiple peaks in the fat spectrum, T2* effects, T1 effects, eddy current effects, and the presence of susceptibility-induced fat resonance shifts. With recent technical achievements, various chemical shift-based water-fat separation methods, e.g. DIXON methods, have been used to provide robust separation of water and fat by correcting such confounding factors. Fat-signal fraction estimated from these methods is expected to improve the diagnostic performance of chemical shift MR imaging in differentiation of benign from malignant lesions. Measurement of the fat-signal fraction (FF) derived from Dixon method with correction of T2* confounding effects could be a powerful noninvasive tool for the quantitative analysis of bone marrow invasion.

Keywords : Vertebral bone marrow imaging, Dixon, Fat fraction