MSK MRI Symposium l & Scientific Session

SY22-1

Advances in MSK Imaging

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The last decade has seen many MR Technology developments in imaging of the musculoskeletal system. Here, we will highlight some of these developments and their potential applications, notably the approaches for imaging of bone, imaging near metal, as well as acceleration techniques for routine clinical contrasts.

With CT being an effective method of choice for imaging bone morphology, the use of Ultrashort TE techniques attempts initially was aimed at directly exciting signal from the free and bound water pools in the bone for studying the tissue composition of the bone and other short T2 tissues. However, not long after, a need for pseudo-CT data emerged in the domains of PET-MRI for attenuation correction (Keereman 2010) and in the domain of radiotherapy for MR-only planning of therapy delivery. In these domains, where bone MRI has a supporting role, a pragmatic choice was soon made for short TE techniques, where bone would be distinguished based on negative contrast, also with respect to short T2 tissues such as tendons. It was then further proposed that this negative contrast could serve to image 3D bone morphology for surgical planning (Breighner 2017) without using ionizing radiation, as long as potential confounding with other low intensity regions could be avoided by using dedicated image processing.

A second area of significant progress has been the imaging near metal implants. While high-bandwidth protocols (Lee 2007) and view-angle-tilting (Cho 1988)already addressed some of the distortions in readout direction, with the introduction of Multi-spectral MRI techniques (Koch, Hargreaves 2008) also the slice and volume selection problems could be usefully reduced. An increasing body of literature has demonstrated the feasibility and utility of MR imaging in patients with (metal-on-metal) total-hip-replacements, spine instrumentation and (partial) knee replacements. The routine availability of these advanced metal artifact reduction techniques, is currently enabling to further build evidence for an increasing number of indications.

Metal artifact reduction techniques, however, come at the expense of increased imaging time. Likewise, the exploration of 3D isotropic imaging protocols to resolve the often curved or oblique structures in joints was based on protocols exceeding five minute scan times, limiting practicability and introducing sensitivity to patient motion. Even routine Multi-Slice protocols typically take a few minutes per contrast and orientation, with room for improvement in terms of imaging times and imaging robustness. Here, fuelled by increased computational possibilities, reconstruction innovations are now making their way into the clinic: compressed sensing was recently introduced on commercial systems allowing for a further reduction of imaging times in addition to that allowed by parallel imaging. Research into reconstruction employing data consistency, e.g. trying to discriminate motion corrupted data from data acquired with the joint immobilized, may help to further improve the robustness of musculoskeletal MRI.

In conclusion, the three above examples demonstrate recent technological and clinical advances of musculoskeletal MR-imaging and give optimism for the future.

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Advanced MR imaging in osteoporosis

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Osteoporosis is now becoming a major health problem in the aging society due to the high risk for fractures. Bone mineral density (BMD) measured by DXA or QCT is widely used for diagnosis, monitoring of osteoporosis. MRI is a no radiation imaging modality, but is under-utilized in the management of osteoporosis.

First, conventional MRI can be very useful in the differentiation of fracture or tumor related fractures, and to rule out infectious conditions. Fat suprressed MRI is the method of choice for showing the bone marrow edema, which is an indicator for vertebraplasty.

The role of bone marrow fat in osteoporosis was unknown, but now this becomes a hot topic for research since studies indicated that bone marrow fat is actively involved in the health of bone. MRI is ideal to determine the bone marrow fat content in the human, and will play an important role in the research of osteoporosis in the future.

MRS is more traditional method to measure the bone marrow fat content, now more advanced and fast MR sequences are developed, such as CSE-MRI measurements of proton density fat fraction (PDFF) with mDixon Quant or Ideal IQ, so that the measurement of several vertebral bodies in a short time becomes possible. With this capacity, combined with the BMD measured with DXA or QCT, will provide a very powerful tool for osteoporosis research. In conclusion, the advanced MRI will play a big in the management and research of osteoporosis