Ultrashort Echo Time Magnetization Transfer (UTE-MT) Imaging as a Tool to Aid in the Diagnosis of Osteoporosis

Published date: Sept. 27, 2018

Technology description

Researchers at UC San Diego invented a better technique for the evaluation of OP. The technique uses ultrashort echo time magnetization transfer (UTE-MT) imaging and signal modeling to quantify the different proton groups, including free water, bound water and macromolecule protons in short T2 tissues such as the menisci, ligaments, tendons and cortical bone. UTE-MT images with a series of MT frequency offsets and MT power are subject to MT modeling to generate maps of T1s, T2s, proton fractions and exchange rates of bound water, free water and macromolecules in short T2 tissues. The techniques allow for the quantification of T1s, T2s, fractions and exchange rates of bound water, free water and collagen protons in cortical bone. Free water fraction can be used to evaluate cortical porosity, while bound water fraction and especially collagen proton fraction can be used to evaluate organic matrix density. Maps of T1s, T2s, exchange rates and fractions are likely to provide much more comprehensive assessment of bone quality and quantity than current gold standard technique, DEXA as well as CT techniques.

Routine clinical evaluation of osteoporosis (OP) has been focused on dual energy X-ray absorptiometry(DEXA) and/or computed tomography (CT), which provides qualitative analysis of bone mineral (~45% of bone by volume). The majority of bone which is the organic matrix and water (~55% of bone by volume) plays an important role in bone viscosity and strength. Bone mineral density (BMD) by itself only predicts fractures with an accuracy of 30-50%. The overall fracture risk increases 13-fold from ages 60 to 80, but BMD alone only predicts a doubling of the fracture risk. A recent study of over 7806 patients found that only 44% of all non-vertebral fractures occurred in women with a T-score below -2.5 (WHO definition of OP). This percentage dropped to 21% in men. There is a clear need for more sensitive risk assessment tools which not only use BMD, but other determinants of risk such as bone microstructure, porosity, organic matrix and bone water. The organic matrix and water are undetectable with any of the current non-invasive imaging and/or quantification techniques. Magnetic resonance imaging (MRI) detects signals from water in tissues, thus potential for detecting the collagen matrix (bound water) and bone porosity (bulk water). However, bone water has very short transverse relaxation time (T2*) and is undetectable using conventional MR sequences on clinical MR systems.

Application area

The potential commercial applications of the UTE-MT imaging and modeling techniques include the evaluation of osteoporosis, osteoarthritis (OA), and tendon diseases. In all cases, the invention allows for the measurement of new biomarkers not available with previous techniques. This is likely to increase the accuracy in predicting bone properties, and improvement of monitoring.

Advantages

The techniques proposed in this invention allow OA evaluation in a more systematic way, i.e., focusing not only on the long T2 component of articular cartilage but the short T2 component of this tissue and other short T2 tissues including their bound and free water components as well as macromolecule protons. Biomarkers such as fractions and exchange rates of bound water, free water and macromolecule protons are magic angle insensitive. The techniques proposed in this invention allow OA evaluation in a more systematic way, i.e., focusing not only on the long T2 component of articular cartilage but the short T2 component of this tissue and other short T2 tissues including their bound and free water components as well as macromolecule protons. Furthermore, biomarkers such as fractions and exchange rates of bound water, free water and macromolecule protons are magic angle insensitive. Therefore, the proposed technique is likely to provide new biomarkers that are more sensitive to early stages of joint degeneration characterized by disruption of collagen, loss of proteoglycans (PG) and increase in water content.

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