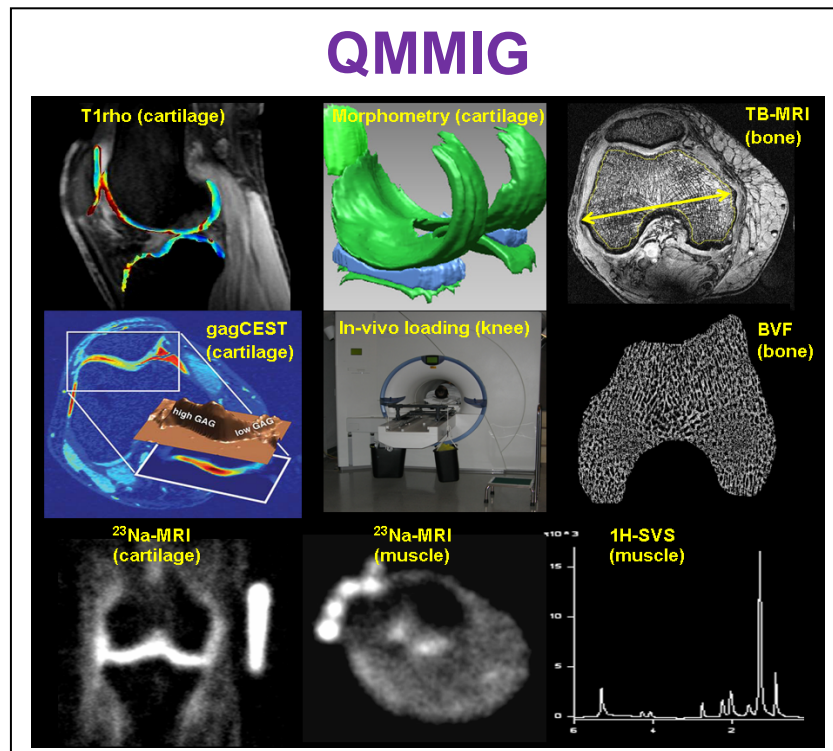


Quantitative Multinuclear Musculoskeletal Imaging Group (QMMIG)

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Research Goals and Directions

The primary goal of the Quantitative Multinuclear Musculoskeletal Imaging Group (QMMIG) is to develop novel, quantitative, non-invasive, multinuclear (^1H , ^{23}Na and ^{31}P) biomedical imaging technologies for early structural, biochemical, and functional assessment of various musculoskeletal disorders using high and ultra high field MRI systems. Specifically, these new technologies will focus on the development of quantitative imaging methods, new radio-frequency pulse sequences, image post-processing and visualization tools to interrogate the functional integrity of musculoskeletal tissues and the underlying biophysical mechanisms of various clinical diseases such as osteoarthritis, osteoporosis, and diabetes. QMMIG also focuses on the rapid clinical translation of new state-of-the-art methodologies into the routine clinical environment. These methodological developments and clinical translations are driven by multi-departmental and multi-institutional collaborations between basic scientists and clinical researchers from around the world. Our research projects are currently supported by National Institutes of Health (NIH), Bi-national Science Foundation (BSF), Radiological Society of North America (RSNA), Bayer Corporation, and intramural NYULMC Musculoskeletal Center of Excellence seed grants.

Research Projects

Osteoarthritis (OA):

OA affects more than half of the population above the age of 65 and is the leading cause of debility in the elderly secondary to the significant negative impact on these individuals' quality of life. Biochemically in OA, cartilage has reduced proteoglycan (PG) concentration, possible changes in the size of collagen fibrils and aggregation of PG, increased water content, and increased synthesis and especially degradation of matrix macromolecules. Conventional imaging techniques have shown promise for the identification of more subtle morphologic alterations as determined by cartilage thickness, volume, or surface fibrillation. However, even the more innovative of these conventional techniques have not been consistent in detecting the earliest stages (biochemical/functional integrity) of cartilage degeneration. The loss of glycosaminoglycan (GAG) is an initiating event in the early stages of OA. QMMIG is specifically focusing on developing new early biochemical markers in cartilage employing novel $T_{1\rho}$ -mapping, T_2 mapping, ^{23}Na -MRI and gagCEST MRI techniques. The currently ongoing projects on OA are:

To develop advanced, three-dimensional (3D), rapid, non-invasive early biochemical markers (T_2 and $T_{1\rho}$) of articular cartilage of the knee joint in early OA at 3T and 7T.

To quantify saturated and unsaturated lipids in subchondral bone of the knee joint in healthy and OA patients at 3T and 7T using MRS methods.

To develop, implement and evaluate new fluid suppressed sodium imaging methods for quantitative assessment of OA at 3T and 7T.

To develop and assess the new chemical exchange saturation transfer based methods (GagCEST) for assessment of early OA at 3T and 7T.

To quantify cartilage, bone and marrow interactions in knee OA patients at 3T and 7T.

Quantification of cartilage degeneration in ACL-tear and cartilage repair patients using advanced ^1H and ^{23}Na MRI.

Osteoporosis (OP):

Currently, 10 million individuals have osteoporosis (OP) and 34 million individuals have osteopenia in the US, resulting in annual estimated health care costs of \$14 billion. Osteoporosis is a metabolic bone disease and ~ 50% of women (~25% of men) have osteoporosis-related fractures over age 50. The pathophysiology of OP is multi-factorial and possibly due to early menopausal calcium and vitamin D deficiency, prior trauma, injury, inadequate peak bone mass, increased bone turnover, decreased bone density, altered bone micro-architecture, and impaired bone quality. Although, Dual-energy X-ray absorptiometry (DXA) is the clinical gold standard for assessment of bone mineral density (BMD) via T-scores, it predicts only 50% of fracture risk. QMMIG is specifically focusing on developing novel new bone quality biomarkers employing high and ultra high field multinuclear MRI (^1H and ^{31}P) of trabecular bone with specialized post-processing and visualization techniques such as fuzzy distance transform (bone volume fraction, trabecular thickness etc), digital topological analysis (surface to curve ratio and erosion index), and structural anisotropy. The specific ongoing projects on OP are:

Development of image-based biomarkers of bone quality using high resolution imaging at 3T and 7T.

Morphological, topological and tensor analysis of trabecular bone in pre and post-menopausal women at 3T and 7T.

Evaluation of bone micro-architectural abnormalities in subjects with disuse osteoporosis at 3T and 7T.

To quantify the degree of mineralization in osteoporosis using ^1H and ^{31}P MRI at 3T and 7T.

Diabetes:

Changes in food habits and lifestyle in developed as well as developing nations over the last century have resulted in a dramatic increase in the incidence of both obesity and diabetes worldwide. Currently 220 million individuals have diabetes globally, representing an ~45% increase over the last decade. This trend of increasing prevalence of diabetes and obesity has already imposed a huge burden on health care systems, and this will continue to increase over the next decade. Type-2 diabetes is multi-factorial disease that shows heterogeneity in many respects and is characterized by impaired glucose tolerance, insulin resistance, hypertension, obesity, hypertriglyceridaemia (low HDL), dyslipidaemia, pro-inflammatory cytokines, mitochondrial dysfunction etc. QMMIG is specifically focusing on an integrative approach using multinuclear MRI and MRS techniques (^1H -MRS-for IMCL/EMCL, ^{31}P -MRS/MRI for bioenergetics and ^{23}Na -MRI ionic changes between pre and post exercise) for assessment of skeletal muscle quality. The ongoing projects are:

Development of multinuclear imaging methods (^1H , ^{31}P and ^{23}Na MRI) for assessment of muscle quality in healthy and diabetic patients.

Evaluation of the physiologic response of muscle before and after exercise via multinuclear imaging methods (^1H , ^{31}P and ^{23}Na MRI).

To quantify the intra and extra-myocellular lipids in healthy and diabetic patients using single voxel MRS methods at 3T and 7T.

Research Highlights/Flash News:

gagCEST:

http://www.rsna.org/Publications/rsnanews/June2008/Noninvasive_Imaging_feature.cfm

http://www.niams.nih.gov/News_and_Events/Spotlight_on_Research/2008/noninvasive_test.asp

Advanced Sodium Imaging:

[http://ryortho.com/largeJoints.php?news=704_Examining-Sodium-Ions-for Knee-OA](http://ryortho.com/largeJoints.php?news=704_Examining-Sodium-Ions-for-Knee-OA)

<http://www.sciencedaily.com/releases/2010/08/100827112942.htm>

<http://www.nature.com/nrrheum/journal/v6/n11/full/nrrheum.2010.165.html>

<http://communications.med.nyu.edu/publications/nyuphysician/fall-2009>

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