

MR MicroImaging at 7 and 9.4 T, on Small Animal Joints With ^1H for *in vivo* Studies in Normal and Pathological States And ^1H Double Quanta Filter

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INTRODUCTION

Polyarthritis is a widespread joint pathology which affects 0.5% of the population. As no treatment is presently available, a better and early characterisation of the disease is necessary to improve the understanding of the pathological mechanism.

MRI studies were performed on rats at 7T for polyarthritis longitudinal follow-up in time [1]. We have defined a NMR strategy with 3D MRI to obtain high resolution anatomical images of the joint. We have optimised the sequences to observe, in particular, the cartilage which reflects the early stage of the disease and to perform longitudinal studies in time compatible with pharmacological protocol. The method was applied on rat joint *in vivo* in normal and arthritic states.

The precocious arthritis initially damages the articular cartilage. Order in hard biological tissues creates dipolar interactions resulting from anisotropic motion [2]. Since the cartilage is composed of oriented collagen fibers, we can use Double Quanta Filtered (DQF) NMR signals of water molecules bound to the collagen. MRI studies were carried out at 9.4T on mice joints.

I - MATERIALS AND METHODS

Polyarthritis was induced with dead Mycobacterium Tuberculosis on 8 rats which were studied during 21 consecutive days.

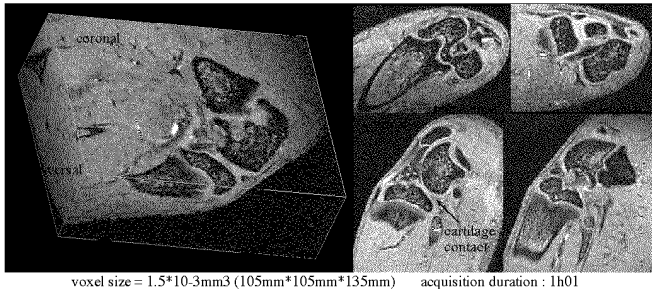
The longitudinal study was carried out at 7 T, on a Varian Inova spectrometer equipped with a horizontal 20 cm bore diameter magnet. A 24 mm diameter surface coil was used for ^1H images. The animal was anaesthetised with a halothane/O₂/N₂O mixture and its temperature was monitored.

II - 3D ^1H SQ Images

Application to polyarthritics Rats

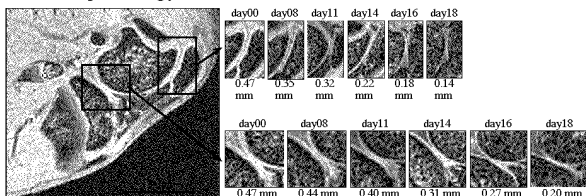
The 3D gradient-echo sequence is the most convenient experiment for the global observation of the joint. The adequate weighting and the reduction of the acquisition time lead to a T1 ρ MRI. This results in a duration of one hour (total anaesthetising time of 1hour20) with a resolution of 0.105*0.105*0.135 mm³, a voxel size of 1.5.10⁻³ mm³.

a) 3D images of a healthy rat joint

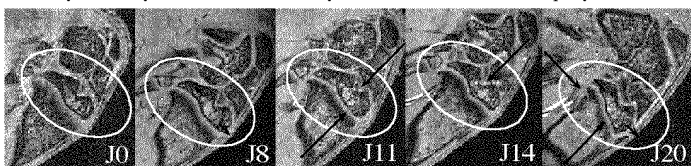


b) 3D images of a pathological rat joint

In cases where evaluation gave weak or high scores, our method showed that the cartilages and trabecular bones strokes were similar, demonstrating the value of high resolution MRI for the study of the time events of the pathology.



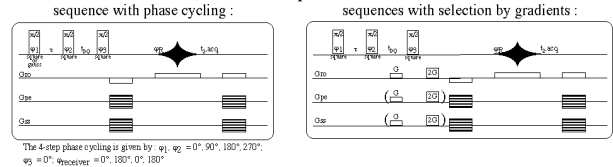
The articular and conjugate cartilages thickness decreased early after 8 days and by half to third 18 days after the induction of polyarthritis.



There is an early erosion of the trabecular bone (8th day, development of geodes) and the cortical line is destroyed in some regions (11th day).

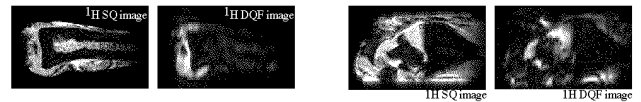
III - MATERIALS AND METHODS

^1H DQF experiments were developed at 9.4T, on a Varian Inova spectrometer equipped with a Vertical 8 cm bore diameter magnet and a microimaging system. 16 mm and 25 mm diameter birdcage coils were used. The ^1H DQF Pulse sequences used were :

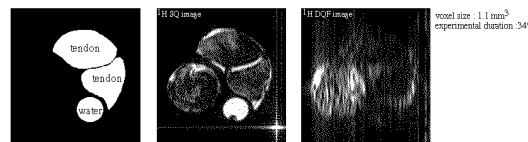


IV - 3D ^1H DQF images

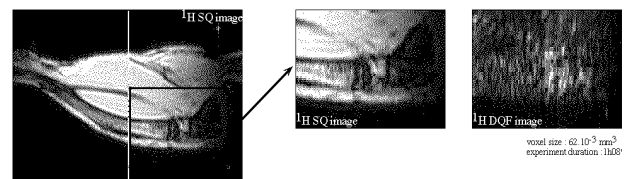
a) chicken samples (sequence with phase cycling)



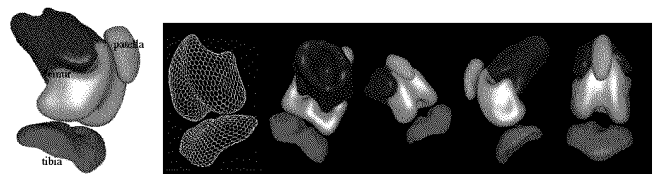
b) cartilage, tendons and water samples (sequence with gradients on Gro axis)



c) mouse hind paw (sequence with gradients on three axis)



V - 3D joint visualization



A software has been developed to delineate semi-automatically the boundaries of the joint by numerical segmentation (yav++, INRIA, Sophia Antipolis) and to obtain an accurate 3D representation of the surface of the femur head and of the tibia plate.

References :

[1] JMR 131 : 8-16 (1998), N Beckmann, K Bruttel, H Schuurman, A Mir
[2] MRM 40 : 720-726 (1998), L Tsoref, H Shinar, Y Seo, U Eliav, G Navon

CONCLUSION

Numerical segmentation reconstruction of the joints gave a 3D view of the cartilage to better observe

3D ^1H DQF MRI at 9.4T gave a new contrast with a relative higher signal intensity for the cartilage compared with other

3D gradient-echo ^1H SQ MRI at 7T provides high resolution images of rat joint (1.5.10⁻³ mm³ within 1 hour) and fine details of the cartilage thickness, the trabecular bone and the bone. These tissues can be studied throughout the evolution of the polyarthritic disease.