UTE acquisitions of rat knee at 9.4T

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Introduction

Diagonal-SPRITE (1) is an ultra-short echo time (UTE) technique (2) which was developed at our institutions to reduce the duty-cycle limitations associated with conventional SPRITE. The method was used to investigate short T2* components in rat knee at 9.4T, with a view to detecting early disease related abnormalities associated with joint structures. Tendons, cortical bone or menisci are usually difficult to detect with conventional imaging. Diagonal-SPRITE was used *ex-vivo* with the patella tendon oriented at the magic angle (about 55deg) (3) and then *in-vivo* with the patella tendon oriented away from the magic angle. The quality and the in-plane resolution of the images were sufficient to assess the T2* of several key components of the knee.

Method

Diagonal-SPRITE was applied on a 9.4T horizontal bore Varian scanner (Palo Alto, CA) equipped with 40 G/cm gradients capable of a 1.44% duty cycle. A home-built 2.5cm diameter solenoid coil was used to acquire 3D images with a matrix of 160x160x30 over a FOV of 30x30x30mm, and a nominal flip angle of 2 degrees.

Post-mortem. The right leg of a Han Wistar rat was imaged with the patella tendon oriented at the magic angle. Three different time phase Tp (which defined the echo time) 250, 1000 and 2000µs were used. Total acquisition time for the 3 echo time was 94min.

In-vivo. A Han Wistar rat was anaesthetized with a 1.5% isoflurane-air mixture, respiration was monitored continuously throughout the experiment and the temperature of the animal was maintained continuously at 37°C by a flow of heated air. The right leg was imaged for a total of 74mins with the tendon oriented away from the magic angle. Two time phase (Tp) of 250, 1000 µs were used.

Results and Discussion

In the post-mortem images, the tendon is significantly brighter than the surrounding tissues for diagonal-SPRITE (Fig.1) and conventional gradient echo (image not shown) because of the magic angle effect on the signal intensity. For diagonal-SPRITE, decreasing the echo time from 1000µs to 250µs resulted in a 50% increase of the signal from cortical bone and meniscus.

In *in-vivo* UTE acquisition, the signal intensity from the patella tendon was greatly reduced once the tendon was positioned away from the magic angle as seen in Fig 2, but is still distinguishable due to the contribution from ultra-short T2 components. Tissues such as bone marrow and meniscus were also clearly identifiable at ultra-short acquisition (<1ms). Muscle did not change greatly in intensity due to its long T2*. The signal intensity from cortical bone increased by over 200% and was visible at Tp=250µs. For cartilage, the signal increase was limited to 30%. In this configuration, the tendon and all other tissues loose a consistent part of signal intensity when gradient echo technique is engaged at TE of 2.6ms (Fig3).

Table 1 Absolute in-vivo diagonal SPRITE signal intensity values and percentage signal changes from 1ms to 250µs Tp.

Tissues	Signal at Tp = 1ms (AU) 10^5	Signal at Tp = 250µs (AU) 10^5	Percentage Increase %
Tendon	1.0	2.0	100
Bone marrow	0.8	1.2	50
Cortical bone	0.1	0.3	200
Cartilage (growth plate)	1.0	1.3	30
Meniscus	0.9	1.5	67
Muscle	1.2	1.4	17
Background noise	0.1	0.1	-

Conclusion

Diagonal-SPRITE 3D images covered the entire rat knee joint where changes of signal intensity associated with a change of Tp for several key components of the knee joint were observed. The signal intensity of tendon, cortical bone, bone marrow and meniscus increased by 100, 200, 50 and 67% respectively when the echo time is reduced from 1ms to 250µs. Diagonal–SPRITE multi-echo UTE images were acquired *in-vivo* for 74mins at 9.4T on a rat knee joint. Although Diagonal-SPRITE is not as fast as radial UTE, we showed in this study that the technique can easily be applied *in-vivo* with good in-plane resolution providing good image quality in an acceptable acquisition time. Future work will compare UTE and T2* map of the knee joint of healthy rat model with disease model, to access T2* related-abnormalities associated with diseases such as arthritis.

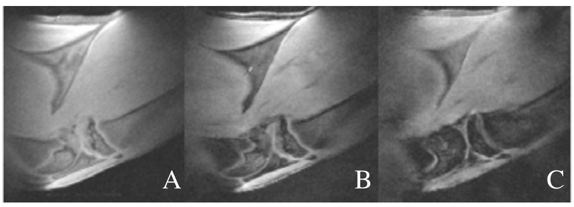

Fig1: post mortem rat knee at 9.4T for 3 different echo times (Tp) 250,1000 and 2000µs acquired with diagonal-SPRITE. The tendon was at the magic angle.

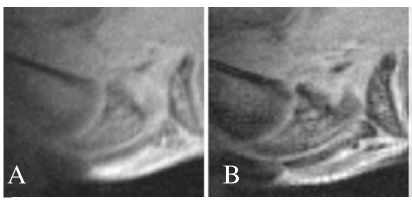

Fig2: knee in a live rat at A) Tp=250us and B) Tp=1000us acquired with diagonal-SPRITE. No magic angle.

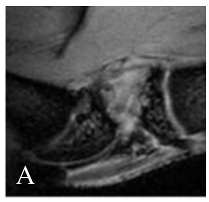

Fig3: A) knee in a live rat gradient echo image.

References

1)Protti A., Herlihy A., Tessier J., and Bell J. (2006), abstract ISMRM
2)P.D. Gatehouse, G.M. Bydder, (2003), Clin. Radiol. 58, 1-19.
3) Peh WC, Chan JH (1998), Br J Radiol 71(841):31–36