# Ultra-short and Zero TE micro-imaging of bone samples at 9.4T

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**Introduction** In conventional MR imaging cortical bone and tendons with high collagen content are generally shown as areas of signal void in the image irrespective of image weighting. Recently there has been increasing interest in the use of Ultra-short[1] and Zero TE[2,3] (UTE and ZTE) sequences which can provide unprecedented high resolution imaging of these bone structures in the presence of severe susceptibility artefact by minimising the time available for T2* signal dephasing. By shortening the TE it is possible to produce positive contrast from cortical bone if necessary. Also in combination, very strong gradients together with custom sized close fitting radiofrequency coils allow acquisition of images with spatial resolution of 10's of microns. This feasibility study investigated the limits of imaging normal bone samples at high resolution and very short echo times.

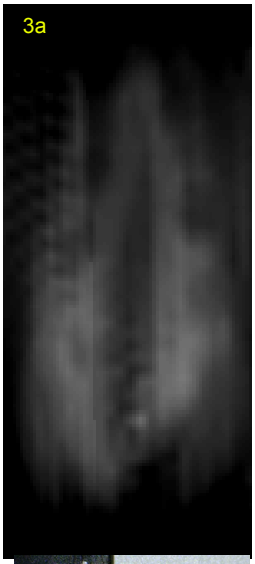
**Methods** A home built 5mm diameter micro-imaging coil was interfaced to a Bruker Avance III 400MHz micro-imaging spectroscopy system with a maximum available gradient strength of 1500mT/m. An excised intact mouse knee was supported in a glass tube and located at the isocentre of the magnet and a single coronal slice UTE image acquired (FA=15deg, TE=0.053ms, TR=500ms, 1 slice, FOV=11.776x11.776mm, 512x512, spatial resolution 23μm) and with a 3D ZTE sequence ( FA=1.4deg, TR=8.0ms, 1 slice, FOV=0.8/0.8/3.0cm, 256x256x256, spatial resolution 31μmx31μmx117μm). In a subsequent experiment a titanium MR compatible syringe needle was introduced alongside the mouse knee to present a susceptibility artefact in the image. A 3D UTE image was acquired (FA=5deg, TE=0.015ms, TR=8.0ms, 1 slice, FOV=0.8/0.8/2.0cm, 256x256x256, spatial resolution 31μmx31μmx78μm). In addition a human milk tooth was placed on top of a support and similarly located at the isocentre of the magnet. A 3D ZTE image of the tooth was then acquired (FA=5deg, TR=10.0ms, 30.0mm isotropic FOV, 100x100x100 acquisition matrix, NA=480).


Figure 1: (a) Single slice UTE image of mouse knee, (b) ZTE 3D image of mouse knee (c) corresponding visual image with 1cm scale.

**Results** Figure 1a shows the coronal image of the mouse knee, observable are the patella and growth plate. Figure 1b shows the intersection of 2 planes from the 3D–ZTE image. Figure 2 shows 3D UTE image with the intersection of 2 planes: the dark stripe on the left hand side of the images marks the location of the needle. The fast relaxing bone in the tooth, figure 3a, can be seen with positive contrast with the zero echo time sequence.


Figure 2: 3D UTE image of mouse knee with needle (left hand side).

**Discussion** The UTE and ZTE images allow bone structures to be clearly visualised at very high resolution. The presence of a metallic object in close proximity to the mouse knee does not cause any significant distortion to the image, and show great promise for developing models of bone pathology in future. Short echo time images of teeth can be developed to observe lesions that are not easily seen in x-ray images[4].



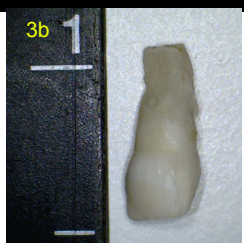




Figure 3: (a) 3D Intersection of coronal and sagittal planes of milk tooth with ZTE sequence showing positive contrast from bone. (b) Visual image of tooth with 1cm scale.

**References**

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