**Introduction:**

Plaque ulceration, thrombosis and intraplaque haemorrhage are the main causes of stroke and clinical symptoms of atherosclerosis [1,2]. In addition to the degree of luminal narrowing, characterisation of the plaque composition and ultrastructure is important for the assessment of stroke risk. *Ex vivo* MR microimaging at very high magnetic field allows for detailed assessment of the plaques components. Furthermore, *in vivo* MR images can easily be correlated to histological analysis based on *ex vivo* high spatial resolution images. In this multimodal study, *ex vivo* plaque contrast and relaxation characteristics were analysed based on high spatial resolution images and compared to in vivo MRI and CT images.

**Material and methods:**

**Patients and samples preparation:** The selected patients (n=8) showed mixed irregular calcified soft plaques with > 70 % stenoses on both CT angiogram and carotid Doppler ultrasound. They underwent an evasion carotid endarterectomy with feathering of the ICA distal plaque. The used plaques were 1.3-5.5 cm long and 0.5-1.4 cm wide. They were fixed in formalin following removal.

**In vivo MRI:** Patients were scanned on a 3T Philips scanner using a 16 channel cardiovascular array coil. For the carotid imaging, the applied sequences were: 3D Time Of Flight angiography (140 slices, Spat.Res.=0.7x1.2x1mm); pre- and post-contrast T1-weighted spin echo (TE/TR=27/604ms, 16 slices, Spat.Res.=1x0.9x3mm); T2-weighted TSE (TE/TR=80/5000ms, 21 slices, Spat.Res.=0.6x0.7x5mm) with fat saturation; and contrast-enhanced MR angiography (150 slices, Spat.Res.=0.6x0.6x1mm).

**Ex vivo MRI:** Data were acquired on a 9.4 T Agilent scanner (Agilent Technologies, Santa Clara, CA, USA) using a transmit/receive volume coil (Ø = 33 mm, made by Rapid Biomedical). Before the scanning, the plaques were immersed in formalin to avoid any susceptibility artefacts. Manual shimming was performed after positioning of the plaques based on low spatial resolution pilot images. The high spatial resolution T1- and T2-weighted images (T1w and T2w) were acquired using 3D fast spin echo sequences. The T1w weighted images (T1w) were acquired using 3D multi gradient echo sequence. The spatial resolution of the acquired images was 100x100x100 μm³ (FOV=51.2x12.8x12.8 mm³, Matrix=512x256x128). The readout encoding was applied along the longest dimension of the plaques. For the comparison with the in vivo images, the ex vivo images were reoriented to be displayed as axial images. The acquisition parameters were: (a) for the T1w images, TE/TEeff/TR = 8.3/8.3/500 ms, ETL=2, NEX=4; (b) for the T2w images, TE/TEeff/TR = 15/15/2000 ms, ETL=2, NEX=1; and (c) for the T1w, TR=100 ms, TE=2.9/9.4/15.9/22.4/28.9 ms, NEX=8. The data were fitted using a Matlab program developed in-house.

**Results:**

Fig 1 is a representative case showing one selected slice of an *ex vivo* plaque image. These images were obtained using 3D multi-GE T1w (Fig 1a), 3D SE T1w (Fig 1b), 3D SE T2w (Fig 1c) sequences. Fig 1d shows the results of the T2* mapping based on multi-GE images. The very restricted lumen is indicated by blue arrows. Fig 2 shows the multimodal matching between the selected slice obtained on patient at 3T and CT scanners and the closest *ex vivo* slice obtained at 9.4T. *Ex vivo* T2* values were lower than 30ms. The range of T2* values within the bright regions on both T1w and T2w images was 20-30 ms. The dark regions (indicated by red arrows on Fig2) on MR images correspond to the calcified regions which are bright on CT images. The areas of T2 hyperintensity (long T2 and T2*) close to the lumen represent fibrous and myxomatous plaque components.

**Discussion:**

Plaque morphology was assessed using complementary in vivo and *ex vivo* imaging approaches, allowing detailed assessment of *ex vivo* plaque haemorrhage (short T1), calcification, dark regions on the MRI due to the very short T2 (red arrows), and fibrous and myxomatous components (bright regions on MR images (long T2 and T2*). Compared to the *in vivo* images, more structure can be distinguished on *ex vivo* high spatial resolution images.

**Conclusion and Perspectives:**

This multimodal imaging study performed on in vivo and *ex vivo* plaques allows a comprehensive assessment of the plaque ultrastructure. *Ex vivo* studies are useful to optimise parameters for in vivo clinical scanning and provide quantitative parameters of plaque components helping the identification of patients with high stroke risk. This preliminary study was designed to compare native contrast imaging between in vivo and *ex vivo* scanning of atherosclerotic plaques. Further studies based on targeted contrast agents [4] might provide increased specificity, and might serve as a basis for translation of these agents into the clinics.