Q-space imaging of abdominal tumor

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Introduction:

One of the current applications is the depiction of pancreatic cancer. Though DWI can be applied here, the full delineation of the tumor remains challenging. Q-space imaging, an alternative diffusion measurement, is currently applied using large diffusion weightings to access non-Gaussian diffusion in the high b-value regime and has so far only been implemented for CNS applications. This non-Gaussian behaviour is attributed to cellular restriction and becomes apparent as non-monoexponential signal decay as a function of b-value [1]. In contrast to these high b-value measurements in the CNS, it has recently been postulated that the diffusion in abdominal organs like the liver [2] and the pancreas [3] deviates significantly from a Gaussian distribution at very low b-values. This behaviour was mainly attributed to microperfusion [4]. Here, we demonstrate the first implementation of q-space imaging of the abdomen and evaluate its potential to improve the delineation of malignancies in comparison to conventional ADC-maps.

Materials and Methods:

Q-space-images of five patients with pancreas carcinoma were acquired at 1.5 Tesla (Magnetom Avanto, Siemens Medical Solutions, Erlangen). Bipolar gradients in three orthogonal directions (1,1,-1/2), (1,-1/2,1) and (-1/2,1,1), separated by two RF pulses, were used for diffusion sensitizing, as seen in figure 1. The acquisition was separated into eleven blocks of equally spaced q-values (q0, q17), (q0, q34)…(q0, q190) and each block was acquired in a single breath-hold (TA = 26 ms) to avoid motion artefacts. A maximum q-value of 190 cm-1 was used corresponding to a maximum b-value of 2800 s/mm² (Gmax = 33 mT/m, Δ/δ = 72 ms/9 ms) and the signal values were mirrored to increase the maximum resolution ΔX (=25.5 µm). The EPI-readout was performed with the following parameters: TR/TE = 1300 ms/90 ms, matrix size = 100x78 with a 3.5 mm pixel resolution, 10 slices, slice thickness = 5 mm, 4 averages, bandwidth = 3000 Hz/pixel and a total measurement time of 13 minutes. Images were post processed using a Fast-Fourier-Transformation yielding the diffusion propagator P(X). The FWHM and the Peak-height P(0) were calculated from the diffusion propagator and were visualized in parametric maps. Conventional DWI was performed using similar parameters, except for TE (= 60 ms) and the b-values (0 and 800 s/mm²). Anatomical scans included a T2-weighted BLADE sequence (TR/TE = 6056 ms/77ms).

Results:

Figure 2 shows the measured signal decay as a function of q and the resultant diffusion propagator P as a function of the displacement X exemplarily for one patient. In comparison to healthy tissue, a decreased signal decay at low q-values is found in pancreatic cancer. Figure 3 shows the obtained images and calculated maps from a patient with pancreas carcinoma. The shown q-space map is of good quality. In comparison to the conventional ADC map, tumor delineation is similar in the FWHM map, but is clearly superior in the P(0) map.

Discussion:

For the first time, q-space imaging of the abdomen was implemented and applied in a reliable fashion. Moreover, the overall image quality of the q-space data was superior to conventional ADC-maps, especially the P(0) map. However this comparison is favouring the q-space method to some extent, since less data points were acquired for the ADC maps. Further research is warranted to evaluate the value of quantitative parameters derived from q-space imaging for tumor monitoring.

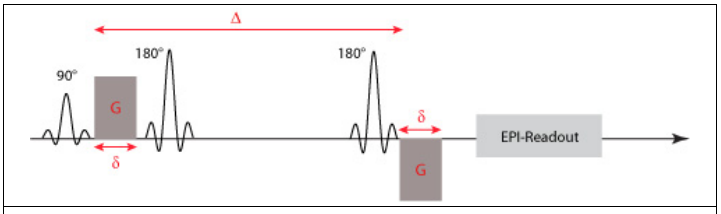

Fig. 1: Schematic illustration of the diffusion pulse sequence used for q-space imaging. G is the gradient amplitude, δ is the duration of the gradient pulses and Δ is the duration between the gradients

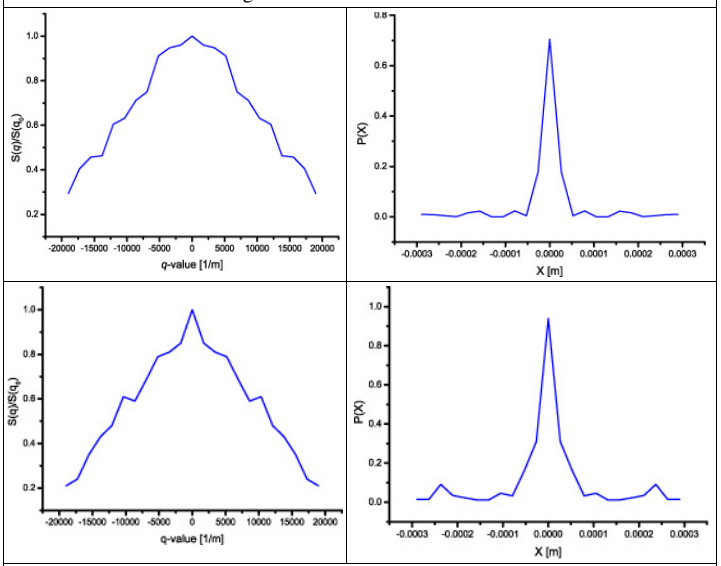

Fig. 2: Signal decay as a function of q (left) and the diffusion propagator P as function of the displacement X (right) in pancreatic tumor (upper row) and healthy pancreatic tissue (lower row)

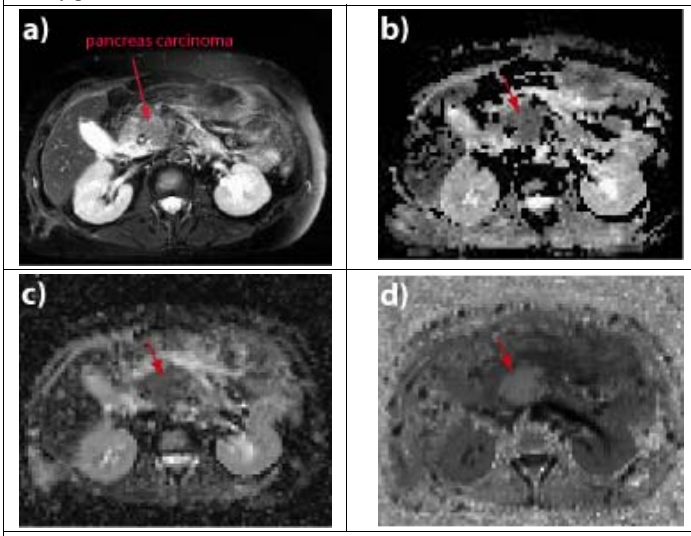

Fig.3: Single slice of a patient with pancreas carcinoma indicated by a red arrow. a) Anatomical T_{2w} image b) ADC-map c) FWHM-map d) peak height P(0). The tumor is clearly delineated on the P(0)-map

References:

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