Feasibility study on reduced FOV Diffusion Imaging of the Pancreas using Navigator Triggering technique

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Purpose:

Diffusion-weighted imaging (DWI) is routinely used in MR imaging of the pancreas. Respiratory motion suppression is critical to achieve images of diagnostic quality and visualizing the fine details. Inhomogeneity artifacts due presence of air in the stomach, transverse colon, and duodenum, or surgical clips from prior pancreatic surgery also often significantly limit pancreatic image quality. Moreover these inhomogeneity artifacts may result in affecting ADC values calculation. Recently, a reduced Field of View (rFOV) methodology has been introduced with the potential to achieve higher resolution DWI in centrally located organs, such as the pancreas and prostate (1-4). We hypothesized that combination of rFOV ss DW EPI with navigator echo respiratory triggering (NT) technique would allow for a more robust and higher quality imaging compared to conventional large FOV ss DW EPI with NT. The aims of this study are:

1) To demonstrate the feasibility of pancreatic high resolution NT rFOV ss-DWI.
2) To compare image quality, presence and grade of artifacts, signal-to-noise-ratio (SNR), and apparent diffusion coefficient (ADC) values in pancreatic tissues between NT full FOV ss-DW EPI and NT rFOV ss-DW EPI.

Method:

This retrospective study was approved by the local IRB committee. 8 consecutive patients who underwent both large FOV and rFOV pancreas DWI with NT over a 4 month period in 2014 were included. MRI examinations were performed with GE 3T systems (MR750, GE Healthcare, USA) using a 32channel Body array coil. Conventional large FOV DWI with adiabatic fat suppression was acquired: FOV: 40cm(LR)x40cm(AP), Matrix: 128x128, TR/TE:12632ms/45.9ms, TI: 110ms, BW:250kHz, Slice thickness: 8mm, number of slices 40, b-value=50s/mm^2(1 nex), 500s/mm^2 (4 nex), diffusion encoding: 3-in-1, ARC acceleration:2, scan time: 1:24min. rFOV DWI was acquired with the following parameters: FOV: 24cm (LR)x12cm(AP), Matrix: 160x80, pFOV = 0.5, TR/TE:3333ms/46.6ms, BW:250kHz, Slice thickness: 6mm, number of slices 15, b-value=50s/mm^2(6 nex), 500s/mm^2 (16 nex), diffusion encoding: ALL, scan time: 3:43min. Small shim volume was placed at the pancreas location for more accurate shimming. Navigator echo respiratory triggering technique was used in both large and rFOV DWI.

Presence of artifacts and overall image quality were subjectively rated for both large and rFOV DWI by 2 radiologists in consensus with a 5 point scale:

Artifacts: 1=no artifact, 2 = minimal artifact that does not interfere with diagnostic quality, 3 = artifacts that reduces diagnostic quality, 4 = only minimal diagnostic information is still present, 5= non diagnostic images.

Overall image quality: rated from 1 to 5, with 1 = excellent image quality, and 5 non-diagnostic images.

SNR and ADC were measured in the head, body, and tail of the pancreas on a dedicated workstation (GE Readyview, GE Healthcare, USA). SNR was calculated as the ratio between the average signal intensity and the standard deviation of the signal intensity within manually placed ROIs at the head, body and tail of the pancreas on the b 500 images. Mean ADC was measured on ADC maps calculated in a monoexponential fashion manually placing ROIs at the head, body and tail of the pancreas in the b 50 DW images and copying and pasting the ROIs in the ADC maps. Statistical analysis was performed using student t-test to compare the ADC and SNR values and Wilcoxon Signed Rank Test to compare the scores on image qualities and artifacts.

Results & Discussion:

Large FOV and rFOV pancreas DWI were obtained from 8 patients. Pancreatic high resolution NT rFOV ss-DWI was feasible in all patients. Average SNR and ADC values are reported in table I. There was no significant difference in the SNR between the two image datasets (figure 1) (all $p > 0.05$, see table I). Average artifact score was 3.3 for large FOV and 2.1 for rFOV (figure 2), with a statistically significant difference between the two image datasets $p = 0.014$. The ADC values in the body of the pancreas were significantly lower when calculated from rFOV images ($p=0.025$). No statistically significant differences were found between ADC values in the head and tail of the pancreas, but a trend was observed, with lower ADC values for rFOV DWI. rFOV images had subjectively higher overall image quality (figure 3): average score for rFOV was 2.0 and for large FOV was 3.3 ($p = 0.015$).

Conclusion:

Our preliminary results show that rFOV DWI is feasible with similar SNR compared to large FOV DWI, and also demonstrates higher overall image quality with reduced artifacts. Furthermore, measurements from ADC maps derived from rFOV DWI show significantly lower ADC values in the body and trends towards lower ADCs in the head and tail, a finding that merits further investigation.

References: [1] Zaharchuk, G, et al. AJNR Am J Neuroradiol 2011; 32:813–820 [2] Ma, C et al. Magn Reson Imaging. 2014; 32:125-131 [3] Korn, N, et al. Magn Reson Imaging. 2014 doi: 10.1016/j.mri.2014.08.040 [4] Thierfelder, KM1, et al. Eur J Radiol. 2014; 83:1709-1714.

Table I: Average SNR and ADC values of the 8 images subjects for the head, body and tail of the pancreas. ADC values are reported are x10^{-3} mm²/s. Student t test p values are reported in the third column

	Full FOV	rFOV	student t-test
SNR head	8.6	9.9	0.73
SNR body	10.5	11.4	0.71
SNR tail	9.6	9.3	0.82
ADC head	2.48	1.75	0.067
ADC body	2.11	1.58	0.025
ADC tail	2.25	1.97	0.223

Fig 1. b 50 NT ss DW EPI rFOV (A) and large FOV (B) show no significant difference in mean SNR distribution. In rFOV image (A) resolution, number of signal averages, and acquisition time are increased compared to large FOV image (B).

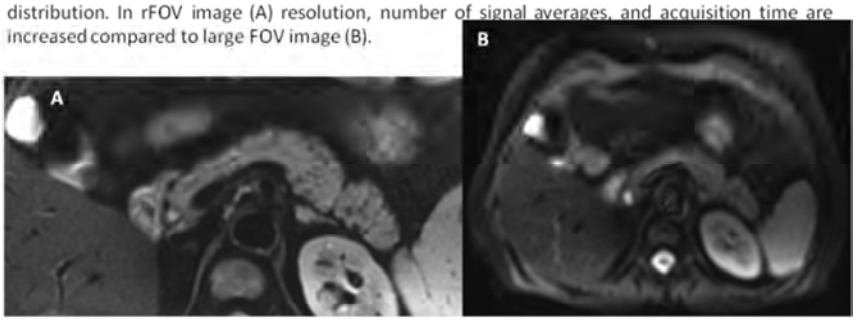

Fig 2. b 50 NT ss DW EPI rFOV (A) and large FOV (B). In B evaluation of the pancreatic body difficult due to susceptibility artifact caused by air in the transverse colon. In rFOV DWI, the reduced echo train length results in reduced distortion by susceptibility artifact.

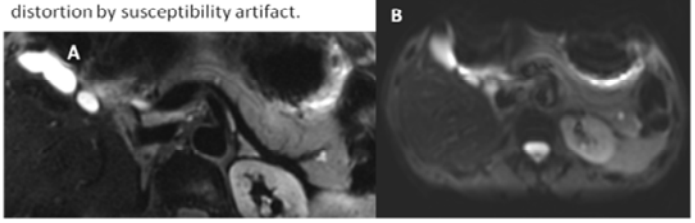

Fig 3. b 50 NT ss DW EPI rFOV (A) and large FOV (B). Higher in-plane resolution allows to identify two small lesions in the pancreatic head (arrows in A), only one lesion (arrow in B) is visible in B.