Zoomed EPI using Parallel Transmission: Impact on Image Quality of Diffusion-Weighted Imaging of the Prostate at 3T

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Target Audience: Radiologists and physicists involved in the optimization of diffusion-weighted imaging (DWI) of the prostate.

Purpose: DWI is a critical sequence for prostate cancer detection and localization, but suffers from distortion and artifacts related to EPI technique and field inhomogeneity; these challenges can be more problematic at 3T. Beyond B1 shimming, two-channel parallel transmission (pTx) enables a zoomed EPI technique that yields focused excitation. Our aim was to assess the impact of zoomed EPI using two-channel pTx on image quality of prostate DWI at 3T.

Methods: Six volunteers (mean age 33±16y) underwent prostate MRI at 3T (MAGNETOM Skyra, Siemens AG, Healthcare Sector) using a 2-channel transmit system and a 18-channel body matrix receive coil. Scans included a single-shot EPI DWI sequence (b-values 50, 500, and 1000 s/mm^2, performed with 4, 8, and 8 averages, respectively; TR 6700 ms; FOV 20x20 cm; matrix 90x90; ST 3 mm; SPAIR; GRAPPA 2; 7:17min), performed with a standard sinc pulse and with a 2D-selective RF pulse using pTx which allows for zoomed EPI[1]. Minimum TE was used (81 ms for standard EPI; 87 ms for zoomed EPI due to longer pulse duration). One radiologist scored b-1,000 images and ADC maps on a 1-5 scale (5=highest image quality) for various image quality measures, blinded to sequence details. A second radiologist placed ROIs to measure peripheral zone (PZ) ADC and estimated signal-to-noise on b-1,000 images (eSNR, determined as mean/SD of PZ). Measures were compared between standard and zoomed EPI using paired t-tests. Coefficient-of-variability (CV) of ADC was calculated as SD/mean of ADC for each sequence.

Table 1: Comparison of standard and zoomed DWI

Feature	Standard EPI	Zoomed EPI	P
b-value 1,000 s/mm^2 images			
Reduced distortion of prostate	3.2±0.4	3.2±0.8	1.0
Absence of Ghosting artifact	3.8±0.4	4.3±0.5	0.076
Absence of Wrap artifact	3.7±0.8	4.7±0.5	0.076
Clarity of transition zone boundary	4.5±0.6	4.8±0.4	0.175
Clarity of prostate capsule	4.0±0.0	4.8±0.4	**0.004**
Clarity of peri-urethral region	3.5±0.5	4.2±1.0	0.102
Overall image quality	3.7±0.5	4.0±0.6	0.175
eSNR	16.6±7.0	17.6±4.5	0.435
ADC maps			
Reduced distortion of prostate	3.5±0.5	3.8±0.4	0.175
Sharpness of prostate	3.2±0.4	3.3±0.5	0.363
Clarity of transition zone boundary	3.2±0.8	3.50.4	0.465
Clarity of prostate capsule	3.2±9.4	3.8±0.4	**0.025**
Clarity of peri-urethral region	2.7±0.5	3.0±0.6	0.363
Overall image quality	3.2±0.4	3.7±0.5	0.076
ADC (x10^{-3}mm^2/s)	1.34±0.3	1.41±0.8	**0.047**

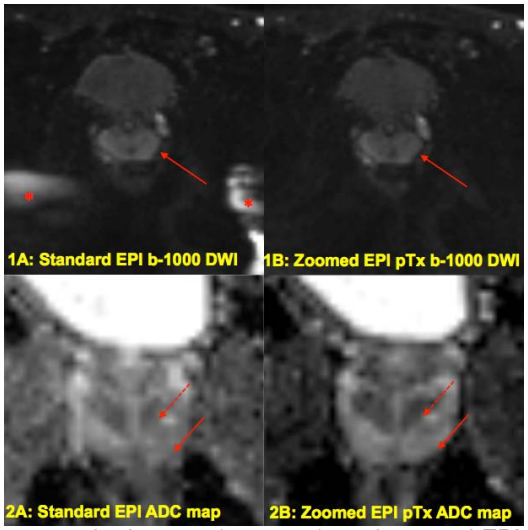

Fig 1 (top): Standard b-1000 image (A) shows wrap artifact (*) not present on zoomed EPI image (B). There is greater clarity of prostate capsule on zoomed EPI (arrow, A and B). **Fig 2 (bot.):** There is greater clarity of prostate capsule (solid arrow) and of transition zone boundary (dotted arrow) on zoomed EPI image (B) than on standard EPI (A).

Results: Compared with standard EPI, zoomed EPI pTx b-1000 images showed significant or nearly significant improvements in ghosting, wrap artifacts, clarity of prostate capsule, and clarity of peri-urethral region (p≤ 0.102), and zoomed EPI ADC maps showed significant or nearly significant improvements in clarity of prostate capsule and overall image quality (p≤0.076). eSNR was nearly identical between standard and zoomed EPI b-1,000 images (p=0.435). The prostate showed a small but significant increase in mean ADC on zoomed EPI images (mean increase=0.07x10^{-3}mm^2/s, p=0.047). However, ADC reproducibility between standard and zoomed EPI DWI remained high [mean CV of ADC=(4.4±4.0)%; CV range=0.3 to 11.0%].

Discussion: In the upper abdomen at 3T, pTx with B1 shimming has been shown to improve image quality and diagnostic accuracy for T2WI[2], as well as to improve image quality for DWI[3]. However, no published study to our knowledge has applied zoomed EPI with pTx for improving DWI of the prostate. In this preliminary assessment in volunteers, numerous measures relating to artifacts and anatomic clarity showed improvements when applying this technique at 3T. While the FOV size was held fixed to ensure comparability between the compared sequences, the use of a smaller FOV is easily possible with zoomed EPI and currently under investigation. Further research in clinical patients is needed to assess whether this benefit translates to improved tumor detection. Also, given the emerging role of ADC values in guiding prognosis for prostate cancer, additional investigation of the possible impact of pTx on ADC value reproducibility is required.

Conclusion: Zoomed DW-EPI using 2-ch pTx has potential to reduce artifacts and improve image quality for DWI of the prostate at 3T.

Ref: *[1]* Schneider R et al. Proc ISMRM 2012 #3459. *[2]* Kukuk GM et al. Radiology 2011;259:421-8. *[3]* Guo L et al. JMRI 2012; Epub ahead of print.