Designing Tissue-specific Variable Flip Angle for Improved 3D Turbo-Spin-Echo Imaging of the Prostate at 3T MRI.

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Introduction: A 3D T2-weighted turbo spin-echo sequence (T2W-TSE) can provide continuous thin slice images and serve as a source data set for multiplanar postprocessing reconstruction of images (MPR images) into any desired plane.   However, it often suffers from blurring and artifacts related to T2 signal decay during large echo train length (ETL); these challenges can be more problematic at pelvic lesion.   Recently, tissue-specific prescribed signal evolutions, achieved by variable refocusing RF-pulse flip angles (tissue-specific VRFA), have been applied to decrease blurring and obtain better contrast for TSE imaging by establishing pseudo-steady state conditions [1-3].   Our aim was to assess the impact of tissue-specific VRFA sequence on clinical 3D T2W-TSE image quality of prostate at 3T by comparing to conventional 3D and 2D sequence.

Materials and Methods: Seventeen patients with biopsy-proven prostate cancer (PCa) (mean age 67±8y) underwent prostate MRI at 3T using a multichannel phased-array coil. Scans included a 2D T2W-TSE sequence in axial and coronal plane (TR/TE 4000/130 ms; acquisition voxel size 0.7×0.7×3mm; SENSE 2; 2:35-40min), a 3D T2W-TSE tissue-specific VRFA, and a conventional 3D T2W-TSE sequence.   For tissue-specific VRFA sequences, values of T1 and T2 relaxation times of prostate tissue was measured for each patient and applied to VRFA setting, whereas a fixed pattern of flip angles modification was applied to a conventional 3D T2W-TSE.   Remaining paremeters were identical in 3D T2W sequences (TR/TE 1500/190 ms; acquisition voxel size 0.6×0.6×1.1mm; SENSE 2; 4:30min).   Coronal MPR images from each 3D images were also evaluated.   One radiologist scored these images on a 1-5 scale (5=highest image quality) for various image quality measures, blinded to sequence details.   Following, ROIs were placed to measure contrast ratio (CR) between cancerous and non-cancerous lesion by referencing histopathological results of the biopsied tissue.   Imaging scores and CRs for each sequence were calculated and compared by using Tukey's HSD test.

Results: Representative case is shown in Figure 1.   Compared with conventional 3D T2W-TSE, 3D T2W-TSE tissue-specific VRFA images showed significant improvements in blurring, clarity of boundary structures (prostate capsule, surgical capsule, anterior fibromuscular stroma), and clarity of internal construction for both PZ and TZ, as well as overall image quality (p<0.05).   Compared with 2D T2W-TSE images, 3D tissue-specific VRFA images showed significant improvements in clarity of surgical capsule, clarity of anterior fibromuscular stroma, clarity of internal construction for PZ and TZ, and conspicuity of lesion (p<0.05).   Highest CR was obtained at 3D tissue-specific VRFA images (p<0.05).   Furthermore, coronal MPR images reconstructed from 3D tissue-specific VRFA images showed significant improvements in clarity of surgical capsule, clarity of internal construction, conspicuity of lesion and overall image quality compared with 2D-coronal images (p<0.05). A conventional 3D T2W-TSE was inferior to 2D TSE in most of image quality measures (Table 1).

Discussion: To our knowledge, no published study has applied tissue-specific VRFA for improving 3D T2W-TSE images of the prostate.   In this assessment in PCa patients, many measures relating to artifacts and anatomic clarity, and CR showed improvements when applying this technique at 3T.   In addition, coronal MPR images from 3D tissue-specific VRFA images showed better image quality than acquired 2D coronal images.   Thus, it is also suggested that 3D tissue-specific VRFA technique can shorten the total examination time with possessing better image quality.   Further research in clinical patients is needed to assess whether this benefit translates to improved tumor detection or localization, as well as staging, especially in assessing the extra-prostatic extension (T3 disease).

Conclusion: Tissue-specific VRFA sequence has potential to reduce artifacts and improve image quality for 3D T2W-TSE images of the prostate at 3T.

Table 1: Comparison of 2D, 3D Tissue-specific VRFA, and conventional 3D for axial and coronal T2W-TSE images

Features	2D-axial	3D-axial tissue-specific VRFA	Conventional 3D-axial
Absence of blurring	4.5±0.5 **, ***	3.9±0.7 ***	2.4±0.7
Clarity of prostate capsule	4.2±0.5 ***	4.2±0.6 ***	2.9±0.9
Clarity of surgical capsule	3.2±0.7	4.2±0.5 *, ***	3.4±0.8
Clarity of anterior fibromuscular stroma	3.8±0.7	4.2±0.9 *, ***	3.2±1.0
Clarity of PZ internal construction	2.8±0.5	4.6±0.6 *, ***	3.6±0.7 *
Clarity of TZ internal construction	3.3±0.9	4.4±0.2 *, ***	3.7±0.7 *
Conspicuity of lesion		4.1±1.1 *	3.4±0.9
Overall image quality	3.9±0.4	4.4±0.6 ***	3.5±0.7
Contrast ratio between cancerous and non-cancerous lesion	0.4±0.2 ***	0.5±0.2 ***	0.3±0.2
Features	**2D-coronal**	**3D-coronal MPR tissue-specific VRFA**	**Conventional 3D-coronal MPR**
Absence of blurring	4.3±0.7 **, ***	3.9±0.4 ***	2.6±0.5
Clarity of prostate capsule	4.0±0.6 ***	4.4±0.5 ***	2.9±0.8
Clarity of surgical capsule	3.2±0.6	4.2±0.5 *, ***	3.4±0.7
Clarity of anterior fibromuscular stroma	3.6±0.7	4.2±0.9 ***	3.1±0.9
Clarity of PZ internal construction	3.1±0.7	4.3±0.8 *, ***	3.6±0.6 *
Clarity of TZ internal construction	3.6±0.7	4.1±0.8 *	3.1±0.9
Conspicuity of lesion	3.2±0.8	4.2±1.0 *	3.5±0.9
Overall image quality	3.9±0.4	4.5±0.6 *, ***	3.5±0.7

*Significantly higher than 2D, **Significantly higher than 3D tissue-specific VRFA, ***Significantly higher than conventional 3D

Figure 1: 69-year-old PCa patient, initial PSA of 8.4ng/ml. Conspicuity of lesion on 3D tissue-specific VRFA images (B,E) is better than that on conventional 3D (C,F) and 2D images (A,D). (arrow, arrowheads)   Blurring is reduced on 3D tissue-specific VRFA images (B,E) compared with conventional 3D images (C,F).
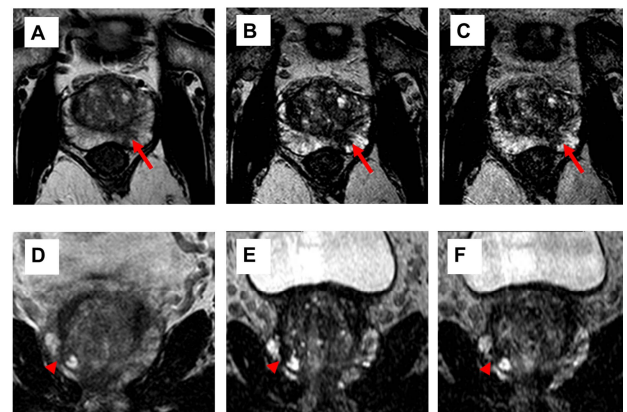
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