

Comparison of an inflatable single loop and rigid dual channel endorectal coil for prostate imaging at 3T.

Thiele Kobus^{1,2}, Andriy Fedorov¹, Vera Kimbrell¹, Tina Kapur¹, Robert Mulkern³, and Clare Tempany¹

¹Radiology, Brigham and Women's Hospital, Boston, MA, United States, ²Radiology, Radboud University Nijmegen Medical Centre, Nijmegen, Netherlands,

³Radiology, Children's Hospital, Boston, MA, United States

Target audience: Clinicians and scientist involved with MR imaging of the prostate

Purpose: In a clinical prostate MR exam external phased array coils can be combined with an endorectal receive coil (ERC) to improve the signal-to-noise-ratio (SNR). There are rigid and inflatable ERCs available. An inflatable ERC can be filled with air or perfluorocarbons and thus be fixed in the rectum, which limits motion artifacts¹. However, the inflatable coil leads to significantly more deformation of the prostate than the rigid coil². Recently, a new rigid ERC (Sentinelle, Hologic, MA) has become available, which has two receive channels, compared to one element in the widely used inflatable coil (Prostate eCoil, Medrad, PA). To minimize motion artifacts, this rigid ERC is fixed to the MR table after coil insertion. The potential increase in SNR and parallel imaging opportunities of the dual element ERC could be used to improve resolution or decrease acquisition time³. In this study, the usability of the new rigid ERC was investigated for clinical prostate MR exams at 3 T.

Methods: In this IRB approved study, 22 patients were included who all received a staging exam on a 3T MR system (Verio, Siemens, Germany). For all patients, external phased array coils were used and these were combined in 11 patients with the rigid ERC and in 11 patients with the inflatable ERC. Two readers evaluated independently the axial T2-weighted images (TE 96-128 ms, TR 4000-5810 ms, voxel size: 0.23-0.55 mm, slice thickness 3mm) and the apparent diffusion coefficient (ADC) maps from DWI (TE 54 ms, TR 2500-4000 ms, voxel size: 2 mm, slice thickness: 4mm, b-values: 0 & 500 s/mm²). The readers scored the images on a scale from 1 (poor) to 5 (excellent) for the criteria listed in Table 1. The data were compared with a Wilcoxon signed-rank test. The pre-contrast T1-weighted MRI (TE 4.92 ms, TR 350-421 ms, voxel size: 0.29 mm, slice thickness 3 mm) was used for a quantitative SNR analysis. For each patient the signal intensity along the dorsoventral axis in the middle of the prostate on one transversal slice was determined and bleeding artifacts were avoided (Fig 2 – black line). For the noise estimate, the standard deviation of two regions in the left and right pectineus muscle was taken (Fig 2 - red circles). The SNR profiles of prostate tissue were corrected for differences in TR.

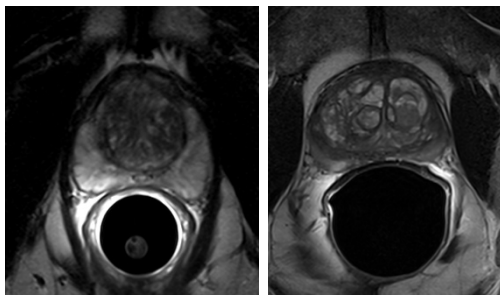


Fig. 1 Axial T2w image of the prostate measured with the rigid ERC (left) and the inflatable ERC (right).

	Axial T2-weighted images			Axial ADC images		
	Rigid	Inflatable	p-value	Rigid	Inflatable	p-value
Conspicuity of peripheral zone	3.6	4.1	0.05	N/A	N/A	N/A
Conspicuity of transition zone	3.2	3.9	0.03	N/A	N/A	N/A
Conspicuity of capsule	3.5	3.7	0.21	N/A	N/A	N/A
Absence of motion artifacts	4.1	4.1	0.59	N/A	N/A	N/A
Penetration depth of the coil	3.5	4.0	0.03	3.9	4.1	0.44
Coverage from apex to base	4.5	4.8	0.38	4.5	4.8	0.38
Overall image quality	3.4	4.0	0.02	3.7	3.8	0.68

Table 1 Average qualitative assessment for axial T2-weighted (average voxel size rigid ERC: 0.27 mm and inflatable ERC: 0.42 mm) and ADC images (voxel size: 2 mm).

Results: The results of the qualitative assessment are given in Table 1 and statistically significant differences are indicated in grey. These parameters lose significance when Bonferroni correction is applied for multiple comparisons. Two patients were excluded from the SNR analysis of the inflatable ERC (rotated coil and no artifact-free profile available). The SNR profiles of the two coils are shown in Fig. 2. The average SNR between 1.5 and 4 cm from the coil was determined. The area of the SNR profile above this average was determined between 0.25 and 1.5 cm from the coil (Fig 2 – red area). The area over average SNR ratio was 2.7 times higher for the rigid ERC compared to the inflatable ERC.

Discussion and conclusion: There is an apparent contradiction in our results as the inflatable coil appears to perform better in the qualitative analysis and the rigid coil in the quantitative analysis. The data were acquired early on in our experience with the rigid coil, as part of an optimization process, thus the parameters for T2w-imaging were not consistent. The average voxel size for the T2-weighted images obtained with the rigid coil was 0.27 mm compared to 0.42 mm for the inflatable coil. The profiles in Fig 2 show that there is no SNR gain at larger distances from the coil. The difference in-plane spatial resolution can explain the better performance of the inflatable ERC when assessing the conspicuity of the transition zone, penetration depth and overall image quality (Table 1). As the rigid coil is not inflated and therefore does not compress or deform the prostate, the distance between the rigid coil and the prostate was in general larger (mean: 0.43 cm) compared to the distance between the inflatable balloon and the prostate (mean: 0.19 cm). As the gain in SNR is mainly obtained close to the coil, this might affect the clinical benefit. In contrast to an earlier study¹, no differences in motion artifacts between the ERCs were observed (Table 1), suggesting that fixation of the rigid coil to the table minimizes these artifacts. The clinical usability of the rigid coil is reduced by the cleaning process. Despite this cleaning inconvenience, the rigid coil ultimately will be cost saving compared to the disposable inflatable coil. Furthermore the rigid ERC is insensitive to mal-positioning or rotation of the coil, while this will lead to an asymmetric coil profile for the inflatable ERC. In addition, the rigid design, with no compression or deformation of the prostate, offers possibilities to make the coil suitable for MR guided prostate interventions. This is particularly relevant for radiation therapy, as the lack of deformation by the coil should facilitate more accurate tracking of the prostate capsule in treatment planning. The use of parallel imaging (PI) was not assessed in this study, but should be explored. PI could be used to shorten the echo train length in DWI to reduce distortion. To conclude, further protocol optimization (e.g. PI, voxel size) is needed to fully exploit the SNR-gain and cost-efficacy of the dual channel rigid coil.

References: [1] Noworolski et al. J Magn Reson Imaging. 2008 [2] Kim et al. Med Phys. 2005 [3] Vos et al. Invest Radiol 2013.

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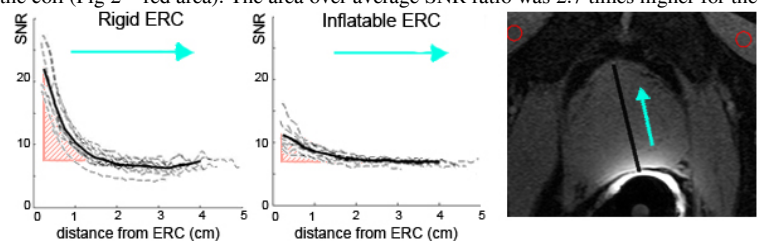


Fig. 2 Left & middle: Patient SNR profiles (dashed) and average SNR profiles (solid). The arrows indicate the direction of the profile as shown on the T1w image (right).