

## **High resolution sagittal T2 in the study of the female pelvis by MRI: comparative study of motion-artifact reduction techniques**

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## Aims and objectives

The high contrast resolution, possibility of tissue characterization, multiplanar imaging, lack of ionizing radiation and the increasing availability of scanners, made MRI an important tool in female pelvis diagnostic, specifically in ovarian and uterine pathology. (1-5)

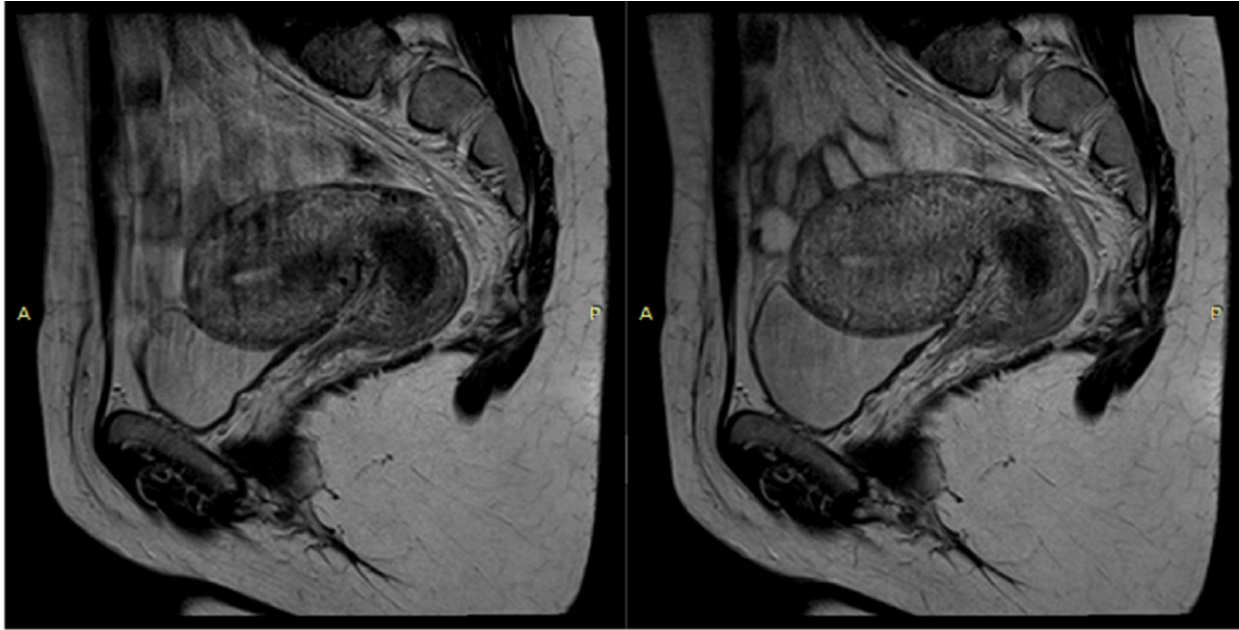
Fasting, empty bladder and compression by a pelvic band, reduce the movement and phase artifacts caused by peristaltic movements of the intestine and other organs (fig.1), as well as pelvic respiratory artifacts.

However, other resources, such as the intravenous administration of anti-spasmodic drugs (glucagon or hyoscine butyl-bromide) are often required to increase imaging quality, and its routine application is often recommended (6). These drugs have few contraindications, such as glaucoma and myasthenia gravis, and low incidence of allergic reactions. The most common side effect is blurred vision, which occurs in about 10 % of the patients and is reversible in 30-45 minutes (7, 8).

The majority of modern MRI scanners include advances in image acquisition, such as the sequences PROPELLER / BLADE (General Electric and Siemens terms, respectively). These sequences have a radial k-space sampling concept with parallel data lines rotating around the k-space center, which allows spatial inconsistencies. Data indicating through-plane motion based on correlation measurement are rejected. Motion artifacts are further reduced through averaging in low spatial frequencies (9).

Thus, considering the side effects that antispasmodic drugs can provoke, and the existence of modern scanners with advanced acquisition techniques that minimize movement artifacts, the aim of our study was to compare image quality, anatomic detail and presence of artifacts on high resolution sagittal T2-turbo-spin-echo (TSE), T2-TSE-BLADE and on T2-TSE after intravenous administration of an antispasmodic drug, hereby referred as T2-TSE-iv, in the female pelvic MRI study.

Images for this section:



**Figure 1.** T2-TSE sagittal view of the pelvis. The image on the left shows blurred contours of the uterus and urinary bladder due to artifacts from peristaltic movements of the bowel, while the image on the right, acquired after intravenous administration of an antispasmodic drug, show significantly less artifacts.

**Fig. 1**

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# Methods and materials

## Study population

Thirty female patients clinically referred for a pelvic MRI scanner were included in the study. No fasting or specific preparation was required prior to the MR exam.

## Image acquisition

Image was acquired in a 1.5T whole body MR scanner (Magnetom Avanto Siemens Healthcare, Erlangen, Germany) using a six-channel phased array body coil, with the patient in the supine position. The protocol included a high resolution sagittal T2-TSE (TR/TE 4800/86ms, FOV 200mm, voxel size 0.8x0.8x3mm, Flip Angle 139° and a factor 2 of Parallel Imaging), sagittal T2-TSE with BLADE technique (TR/TE 5170/87ms, FOV 200mm, voxel size 0.8x0.8x3mm, Flip Angle 139° and a factor 2 of Parallel Imaging) and a repetition of sagittal T2-TSE after intravenous administration of 20 mg of hyoscine butylbromide dilute in 20 ml of NaCl (Buscopan® 20 mg/1ml).

## Image analysis

Quantitative evaluation was performed by drawing ROIs (with a maximum size of 0.5 cm<sup>2</sup>) on the myometrium, on the rectus abdominal muscle and on the air anterior to the rectus abdominal muscle to obtain the mean and standard deviation (SD) of the signal intensity for those regions (fig. 2). With these measurements, we were able to calculate the signal-to-noise ratio (SNR) and the contrast-to-noise ratio (CNR) for those respective regions. These ROIs were placed in the most homogeneous area of these regions, avoiding any artifact (10). SD of the air was considered to represent the background noise (N) of the image.

The SNR and CNR were calculated by the following mathematical expressions:

$$\text{SNR} = \text{SI} / \text{N} \quad \text{CNR} = (\text{SI}_a - \text{SI}_b) / \text{N}$$

Qualitative evaluation was performed by two experienced radiologists who evaluate the MR images by assessing overall image quality, presence of artifacts and detail of uterine anatomy using a 5 -point scale. The evaluators were also asked to select the preferred sequence for diagnostic use for each individual patient.

## Statistical methods

The Friedman test was used to compare the data of the 3 evaluated acquisitions, the qualitative scores differences between the three sequences for each radiologist and the pulse sequence differences for SNRs and CNRs of the myometrium and muscle. A p value of less than 0.05 was considered indicative of a significant difference. Statistical analyses were performed using SPSS software (IBM SPSS Statistics for Windows, Version 25.0, Armonk, NY, IBM Corp for Windows).

Inter-observer agreement for the qualitative rating was calculated using  $\kappa$ -statistics. Kappa scores ( $\kappa$ ) of 0.41- 0.60, 0.61-0.80, and  $\geq$ 0.80 were regarded to be indicative of moderate, good, and excellent agreement, respectively.

Images for this section:



**Figure 2.** Example of placement of the ROIs for image analysis: the more anterior ROI is positioned in the air, the ROI in the middle is positioned in the rectus abdominal muscle and the most posterior ROI in the myometrium.

**Fig. 2**

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## Results

The mean age of patients in this study was 37.8 years. Three (10%) patients reported transitory blurred vision, which is in concordance with previously published studies (11).

In the quantitative analysis, the T2-TSE-BLADE had the higher CNR ( $47.89 \pm 35.81$ ) and higher SNR ( $71.74 \pm 49.11$ , mean $\pm$ SD) of the myometrium as compared to the other 2 sequences ( $p=0.004$ ), followed by the sagittal T2-TSE-iv, with CNR ( $29.36 \pm 15.80$ ) and SNR ( $41.42 \pm 16.97$ , mean $\pm$ SD), as shown in table 1.

SD in was higher in T2-TSE-Blade in all measures, with a mean of SD in air of 6.08 compared to 5.25 for the T2 TSE and 4.78 for the T2-TSE-iv, revealing a higher basis noise.

**Table 1:** CNR and SNR of the myometrium and rectus abdominal muscle for each sequence.

	N	Minimum	Maximum	Mean	SD	p-value
SAG T2-TSE <b>CNR</b> Myometrium	30	1.54	52.52	27.05	14.39	0.004
SAG T2-TSE-BLADE <b>CNR</b> Myometrium	30	1.50	170.03	47.89	35.81	0.004
SAG T2-TSE-iv <b>CNR</b> Myometrium	30	1.28	67.81	29.36	15.80	0.004
SAG T2-TSE <b>SNR</b> Myometrium	30	5.09	70.12	37.86	15.70	0.001
SAG T2-TSE-BLADE <b>SNR</b> Myometrium	30	4.46	224.23	71.74	49.11	0.001
SAG T2-TSE-	30	5.70	80.81	41.42	16.97	0.001

iv <b>SNR</b> Myometrium						
SAG T2-TSE <b>SNR</b> Muscle	30	3.54	27.70	10.81	4.57	<0.001
SAG T2-TSE- BLADE <b>SNR</b> Muscle	30	2.96	58.47	23.85	16.85	<0.001
SAG T2-TSE- iv <b>SNR</b> Muscle	30	4.41	25.07	12.06	4.19	<0.001

Qualitatively, T2-TSE-BLADE was the acquisition with fewer visible artifacts, scoring above 4 (mean 4.17 with  $p = 0.003$  for observer 1 and 4.13 with  $p = 0.001$  for observer 2), followed by the T2-TSE-iv with a score close to 4 (Table 2). Figure 3 illustrates ghosting artifacts seen with T2-TSE and T2-TSE-iv, which are absent in the T2-TSE-BLADE acquisition.

**Table 2:** Qualitative scoring per observer for each sequence with mean values of scoring.

	Reader 1				Reader 2			
	TSE	TSE-Blade	TSE-iv	<i>p</i> -value	TSE	TSE-Blade	TSE-iv	<i>p</i> -value
Overall image quality	3.77	3.77	4.23	0.002	3.70	3.77	3.97	0.274
Presence of artifacts	3.60	4.17	3.97	0.003	3.60	4.13	3.70	0.001
Detail of uterine anatomy	3.90	3.83	4.20	0.114	3.97	3.87	4.23	0.098
Preferred sequence	17%	23%	70%	0.001	20%	17%	63%	0.002

Uterine anatomy was best characterized with the T2-TSE-iv (inter-observer agreement of 0.436 with  $p = 0.001$ ), with the T2-TSE-BLADE sequence having the lowest score. This factor is assumed as the core for the superiority attributed to T2-TSE-iv in the parameter "overall image quality" (Fig. 4), being the T2-TSE-is also the preferred sequence for both observers (70% with  $p = 0.001$  for observer 1 and 63% with  $p = 0.002$  for observer 2).

## Images for this section:

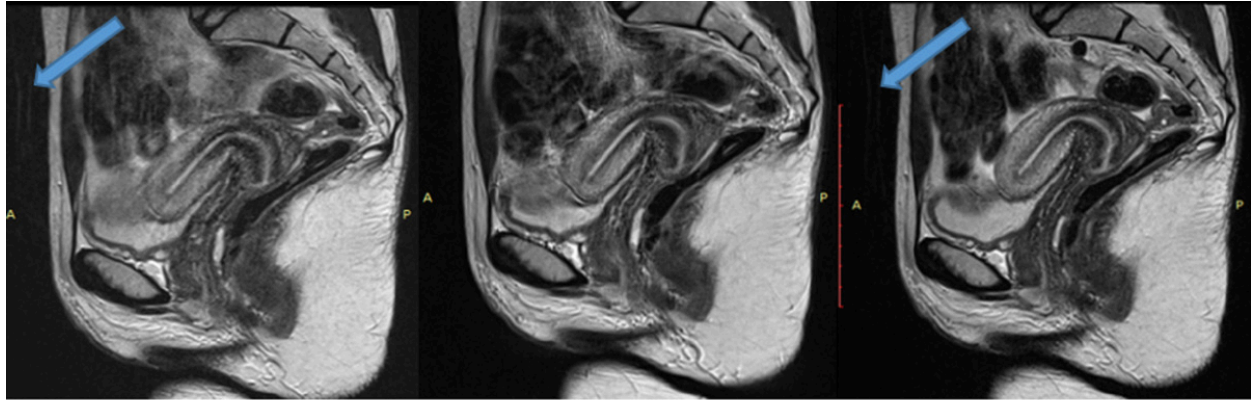


Figure 3. Sagittal T2-TSE (left), T2-TSE-BLADE (center) and T2-TSE-iv (right), showing ghosting artifact with the T2-TSE and T2-TSE-iv acquisitions (arrows). These artefacts are not seen in the T2-TSE-BLADE sequence because phase- and frequency-encoding directions change continuously as the trajectory sweeps or rotates around the center of k-space (12, 13).

## Fig. 3

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Figure 4. Sagittal T2-TSE (left), T2-TSE-BLADE (center) and T2-TSE-iv (right) sequences. Note the blurred definition of the uterine fundus contours in the T2-TSE as well as in the T2-TSE-BLADE sequence, as compared with the excellent definition of the uterus contours and excellent layer differentiation of the uterus in the T2-TSE-iv sequence.

## Fig. 4

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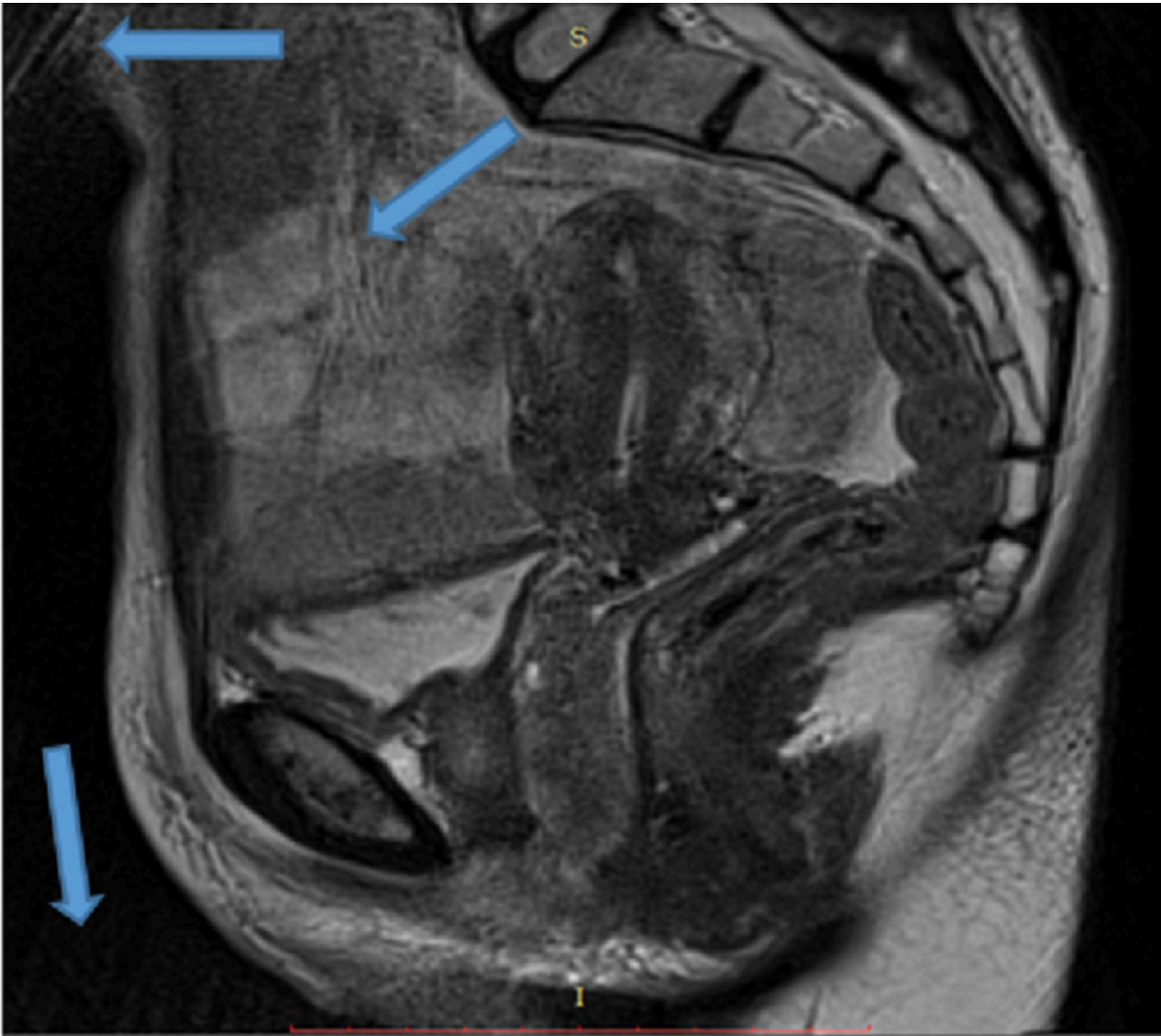
## Conclusion

This study demonstrates a significant positive effect on pelvic MRI image quality of the intravenous administration of antispasmodic drug, suggesting that its use is still the best technique to reduce motion artifacts and improve image quality, with an obvious preference as the sequence of choice for the radiologists. Despite the fact that the T2-TSE-BLADE sequence shows fewer artifacts, caused by the elimination of the ghosting artifacts (fig. 5), the uterine layer differentiation and global quality was approximately equal to a standard T2-TSE.

In summary, BLADE technique cannot replace the overall superior quality of a T2-TSE sequence after the intravenous administration of an antispasmodic drug, but can be possibly used as an alternative to patients with some contra-indications to the use of these drugs.

This study could possibly be improved with the inclusion of a larger number of cases in order to give increase its statistical power. The inter-observer agreement is moderated, and good on uterine anatomy differentiation and preferred sequence. Other techniques can eventually be used in future projects, such as the pelvic band compression, other phase-encoding directions and a spatial saturation pulse (useful to eliminate the ghosting artifact).

Images for this section:



**Figure 5:** Multiple fine lines artifacts from Blade acquisition.

**Fig. 5**

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