

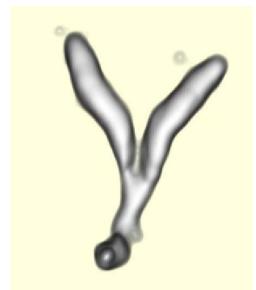
# Diffusion-weighted MR hysteroscopy: initial evaluation and determination of optimal imaging timing during the menstruation cycle

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## Introduction

Infertility, recurrent pregnancy loss, and abnormal vaginal bleeding are commonly evaluated by invasive diagnostic methods, such as hysteroscopy, SIS-ultrasonography (saline infusion sonohysterography), and hysterosalpingography [1]. The downsides of these methods call for a non-invasive, painless, operator-independent imaging modality that can be used in all phases of the menstrual cycle and is safe in case of possible pregnancy. Magnetic resonance imaging (MRI) could overcome these limitations [2]. However, the interpretation of the shape of the uterine cavity is often difficult using conventional MRI [2]. Diffusion-weighted imaging (DWI) highlights the endometrium as high intensity area. The recently established concept of Diffusion weighted Whole body Imaging with Background body signal Suppression (DWIBS) [3] allows volumetric DWI, and may clearly depict the shape of the uterine cavity; DW MR hysteroscopy (Fig.1). However, the signal intensity of the endometrium can change during the menstruation cycle, which may affect the visualization of the shape of the uterine cavity. The purpose of this study is to determine which phase in the menstruation cycle is most suitable for visualization of uterine cavity.



**Fig.1.** Volume-rendered MR hysterosraphic image in a patient with bicornuate uterus

## Methods

This study was approved by the local ethical committee and written informed consent was obtained from all subjects.

Four volunteers of twenty years or older with a normal menstrual cycle and not using any hormonal contraception were included. A total of three examinations were repeated in each subject during menstruation (day 2-4), in the follicular (day 8-10) and luteal phase (day 21-28) of their menstrual cycle. MRI was performed at a 1.5 T system, using a 5-element surface coil. The scan protocol consisted of axial, coronal and sagittal T2-weighted images and DWIBS. The sequence parameter for DW MR hysteroscopy were as follows: SE-EPI-DWI, fat suppression with SPIR (Spectral Presaturation with Inversion Recovery), acquired voxel size of  $2.5 \times 2.5$  mm, slice thickness/gap of 4/0mm, repetition time of 5046 ms, echo time of 74ms, b-values of 0, 150 and 1000 s/mm<sup>2</sup>, number of excitations of 4, SENSE factor of 2, image acquisition under free breathing, total examination time of 4min 32s. Each DW MR hysterosraphic image was reconstructed in the oblique sagittal plane through the main axis of the uterus, to minimize partial volume effects on the measurements. Signal intensity (SI) of the uterine cavity (endometrium, including the cavity) was measured using a free shaped region of interest. Standard deviation of the SI of the adjacent fat tissue was also measured. Apparent signal-to-noise ratio (SNR) was calculated as  $SI_{cavity}/SD_{fat}$ . Relative SNRs at the three different time points of the menstrual cycle (compared to the SNR of the menstruation phase) and apparent diffusion coefficients (ADCs) of the uterine cavity were also calculated.

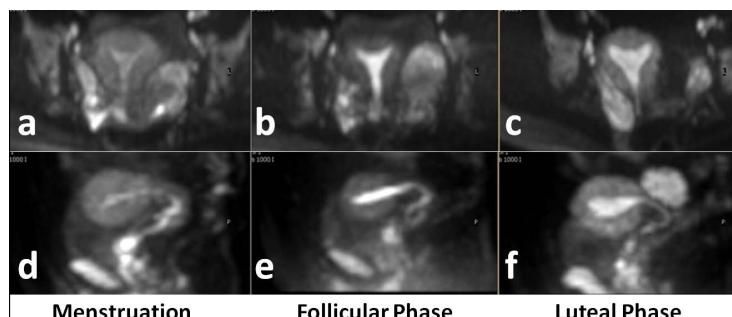
## Results

Typical examples of DW MR hysteroscopy in axial and sagittal views are shown in Fig.2. Paired t-tests revealed that both SNR and relative SNR in the follicular phase were significantly higher than in the menstruation phase ( $P=0.0056$  and  $P=0.0305$ ). There was a trend toward a higher SNR in the luteal phase than in the menstruation phase ( $P=0.0582$ ), whereas relative SNR was significantly higher in the luteal phase ( $P=0.02211$ ). SNR and relative SNR between the follicular and luteal phases were not significantly different ( $P=0.1551$  and  $P=0.2130$ ) (Table 1). ADC of the uterine cavity during the menstruation, follicular, and luteal phases were  $1.07 \pm 0.08$ ,  $1.21 \pm 0.09$ , and  $1.25 \pm 0.12$ , respectively. ADCs of the endometrium in the menstruation phase tended to be lower than those in the follicular and luteal phases, although this difference was not statistically significant ( $P=0.081$ , one-way ANOVA).

**Table 1.** Comparison of ADCs and relative SNRs among the three different time point of the menstruation cycle

**Fig.2.** Comparison of axial (a-c) and sagittal (d-f) MR hysterosraphic images at three phases of the menstruation cycle. Note that the highest contrast between the uterine cavity and the surrounding structures is seen in the he follicular phase.

	Menstruation (day 2-4)	Follicular phase (day 8-10)	Luteal phase (day 21-28)
SNR	$42.8 \pm 17.0$	$80.8 \pm 22.9$	$67.5 \pm 30.8$
rSNR	1.00	$1.99 \pm 0.51$	$1.58 \pm 0.11$
ADC	$1.07 \pm 0.08$	$1.21 \pm 0.09$	$1.25 \pm 0.12$



## Conclusion

Visualization of the uterine cavity using DW MR hysteroscopy is best in the follicular phase, followed by the luteal phase and the menstruation phase. ADC of the endometrium in the menstruation phase tended to be lower than those in the follicular and luteal phases, although sample size of this study was probably too low to show a significant difference.

**References** 1. Brown SE, et al. Evaluation of outpatient hysteroscopy, saline infusion hysterosonography, and hysterosalpingography in infertile women: a prospective, randomized study. *Fertil Steril* 2000;74:1029-1034. 2. Takeuchi M, et al. Pathologies of the uterine endometrial cavity: usual and unusual manifestations and pitfalls on magnetic resonance imaging. *Eur Radiol* 2005;15:2244-2255. 3. Takahara T, et al. Diffusion weighted whole body imaging with background body signal suppression (DWIBS): technical improvement using free breathing, STIR and high resolution 3D display. *Radiat Med* 2004;22:275-282.