# Functional MR imaging of the uterus

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# Topics

- Cine MR in reproductive medicine
- Diffusion Weighted Imaging (DWI) and Apparend Diffusion coefficient (ADC) in oncology
- Perfusion in oncology

# MR imaging in Gynecology

- Excellent modality to evaluate female pelvis because of its noninvasive nature.
- A variety of uterine diseases are easily diagnosed on MR.
- MR has had a great impact on patient management .

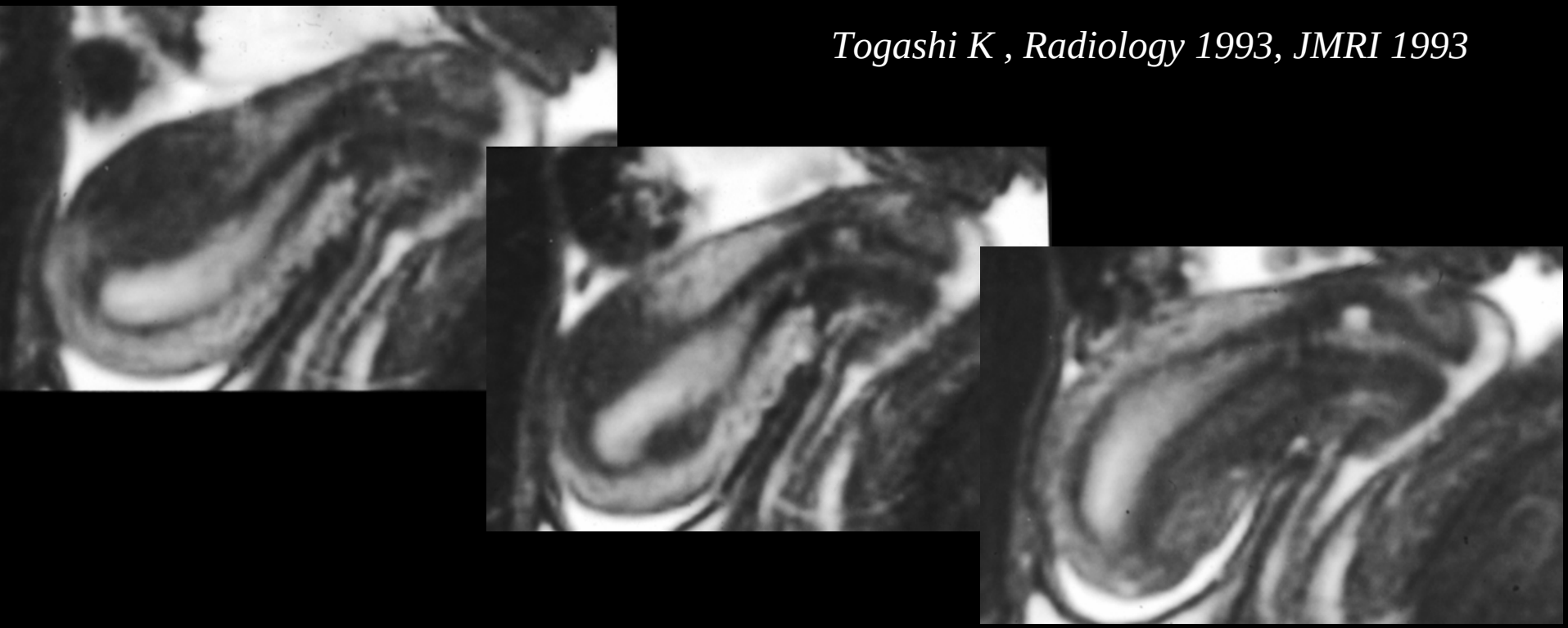
# Typical uterine leiomyomas

Sharply marginated mass of distinct low SI

# Pseudolesions

- **An area of Low SI that bulges into the cavity**
- **Normally considered to represent leiomyoma or adenomyosis**
- **Actually represent Uterine contractions**
  - *Contraction squeezes out blood from the contracted area*

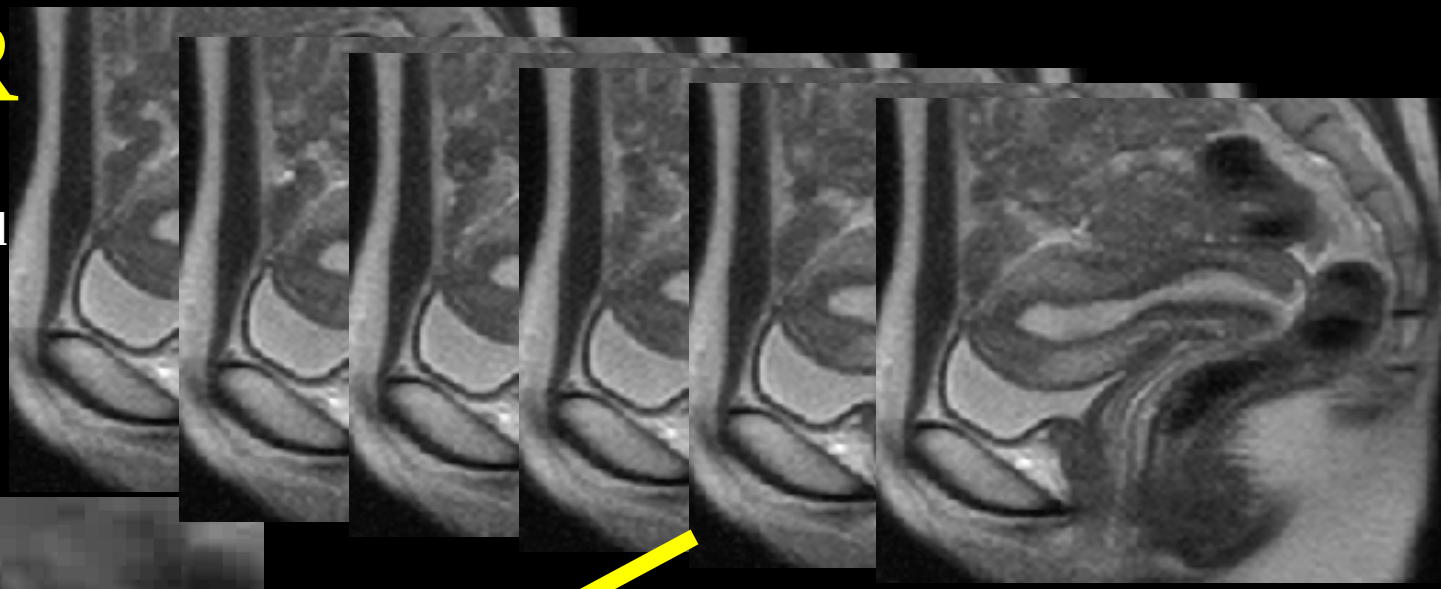
*Togashi K , Radiology 1993, JMRI 1993*



Midsagittal images sequentially obtained with static FSE

# Cine MR

**Sequentially obtained HASTE images/2-3s under breathing**

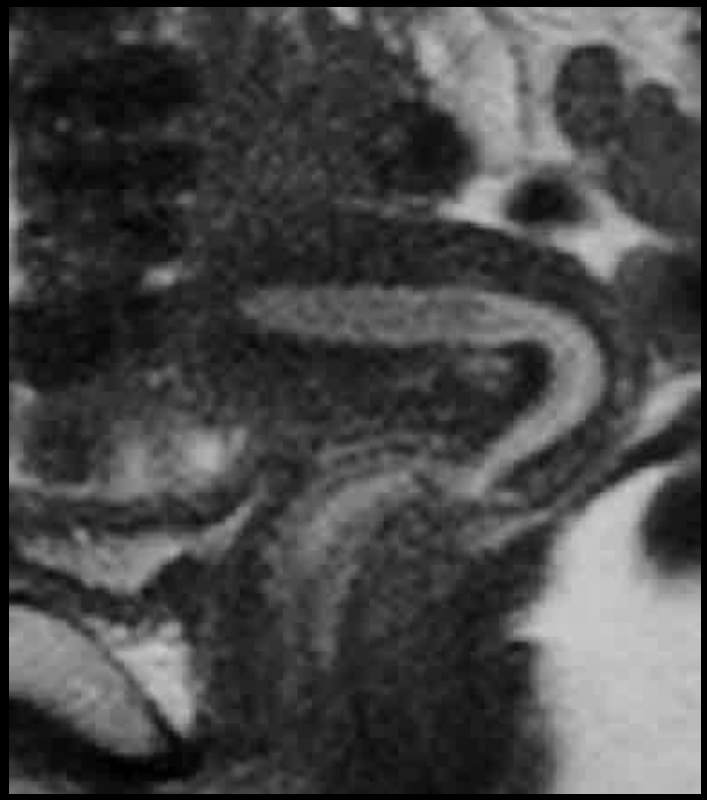


**These 60-300 images (1slice/0.4-1sec) into cine mode** (12x real speed)

Corresponding T2WI

*Nakai A, JMRI 2003, 2004*

# Dysmenorrhea evaluated on cine MR



**CD1 with severe pain**

Wide area of Low SI, E Distortion

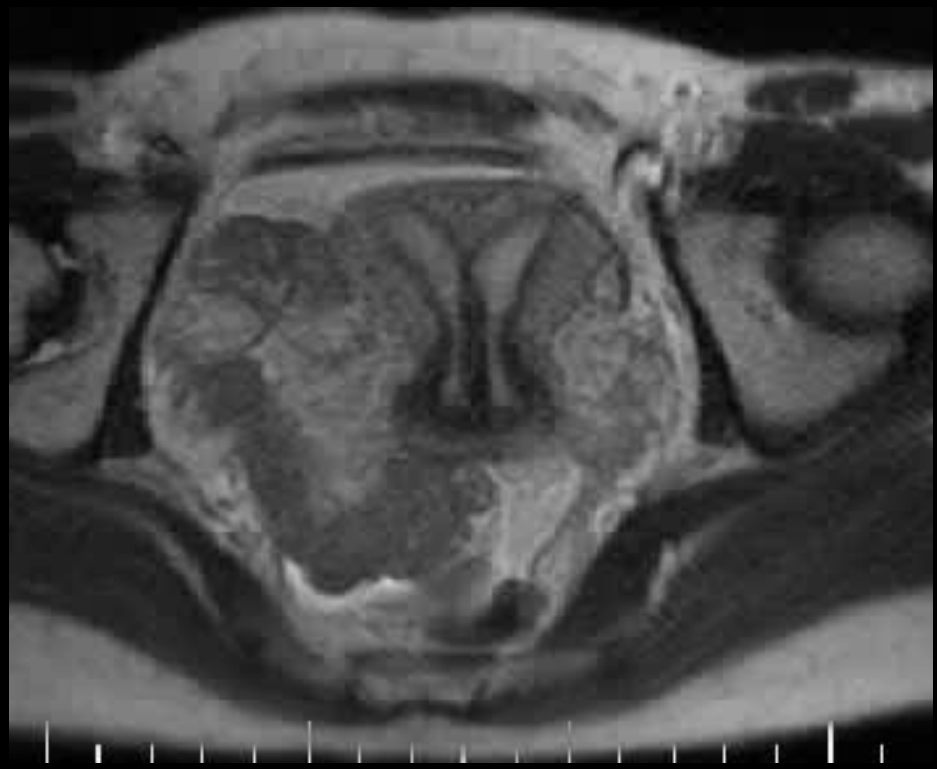
**CD3 without pain**

Narrow low SI, No E Distortion

*Kataoka M, Togashi K et al Radiology 2005*

# Uterine Peristalsis on cine MR

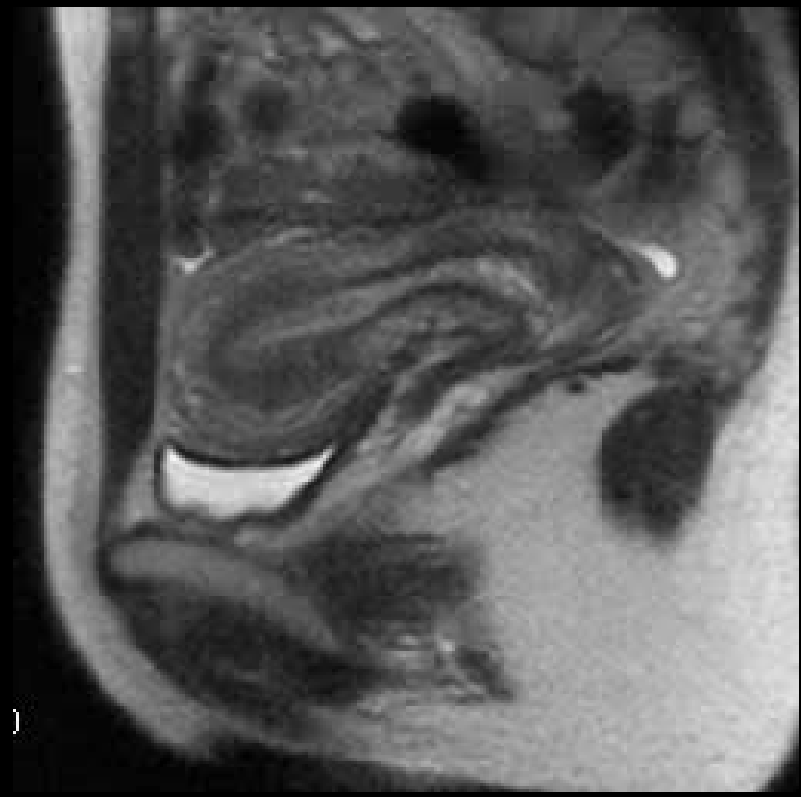
**Subtle & Rythmic contractions**
**Surging Waves at EM Junction**



**31y.o. periovulatory phase, Cervicofundal waves**

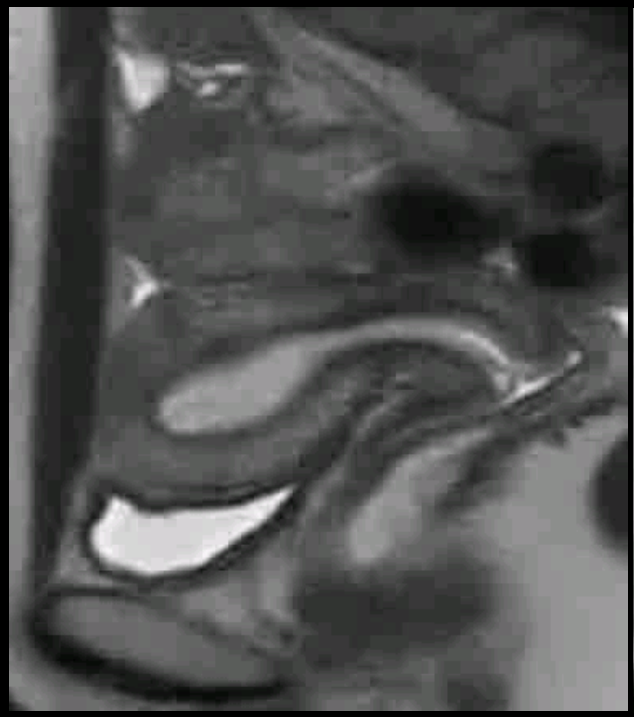
# Differences are observed among cycles

Periovulatory phase



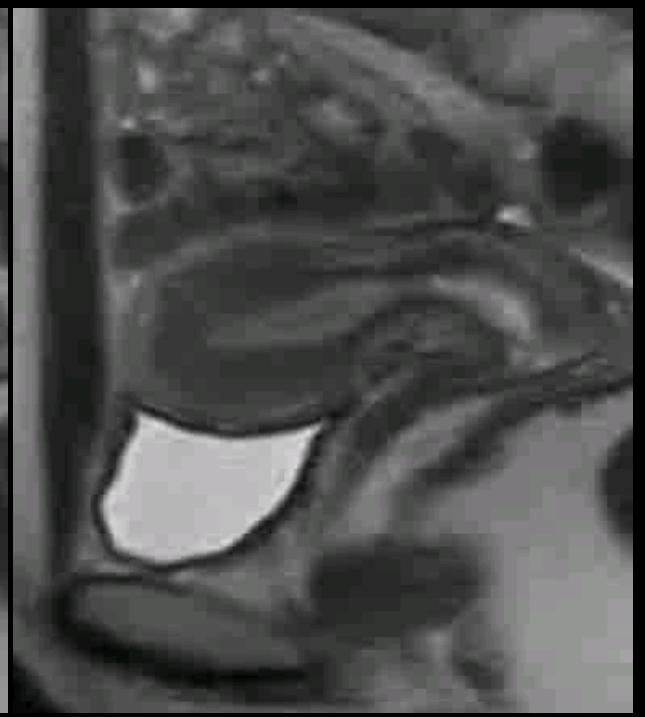
Menstrual period

# Direction, Frequency, and Strength of Uterine Peristalsis varies throughout menstrual cycle



Periovulatory phase

Luteal phase



Menstrual phase

# Contractility and peristalsis seem to be closely related with important uterine functions:
# Fertility problems and Effects of drugs

- **Pill User** (Kido A, et al. JMRI 2005; Kido A, et al. Hum Reprod 2007)
- **IUD user** (Kido A, et al. Magn Reson Imaging. 2008)
- **Submucosal Leiomyomas**
  (Nishino M, et al. Eur J Radiol. 2005)
- **Effect of drugs, anticholinergic etc.**
  (Kido A, et al. Magn Reson Imaging. 2006;
  Nakai A, et al. Radiology 2008)
- **Endometriosis** (Kido A, et al. Eur Radiol. 2007)
- **Recurrent IVF failure**

# Uterine contractility is markedly reduced in OC users.

Menstrual phase,
pre OC use

Withdrawal bleeding,
3Month afterOC usage

*Kido A, Togashi et al. Human Reproduction, 2007.*

# IUD-bearing uterus shows reversed waves and increased contractility

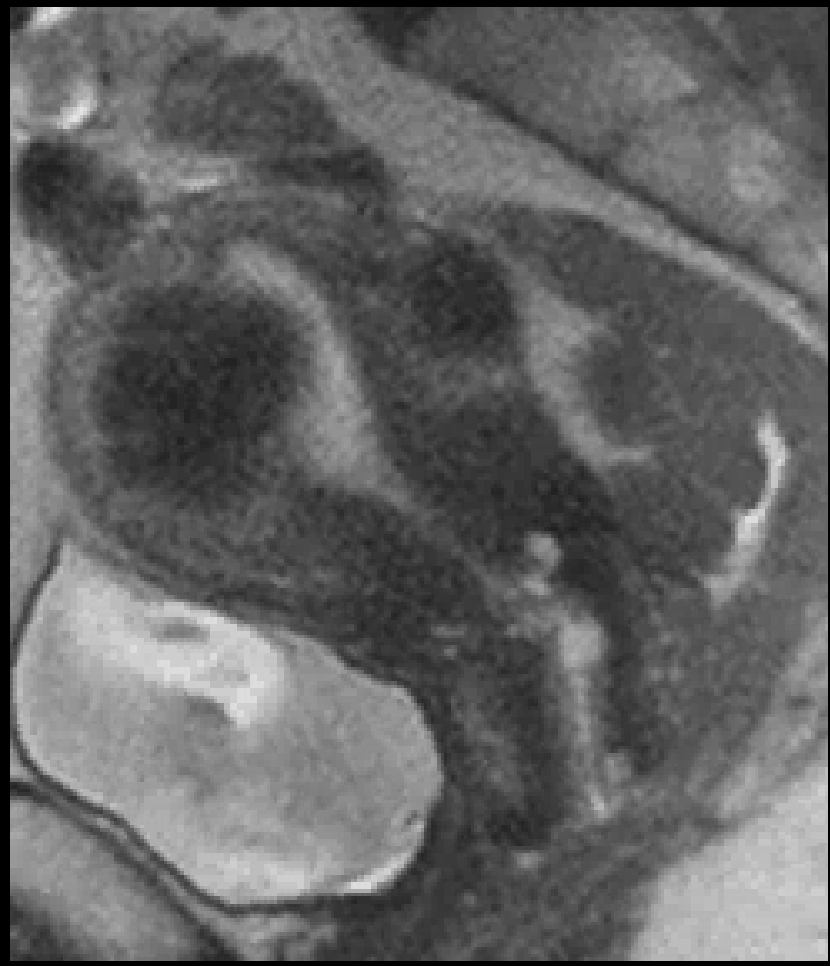
41y.o. IUD 6years

30y.o. IUD 3years,OC 1 year

*Kido A, Togashi K, et al. Magn Reson Imaging. 2008*

# Leiomyoma

**Subserosal M: no wave**



**Submucosal M: uncoordinated contractions**

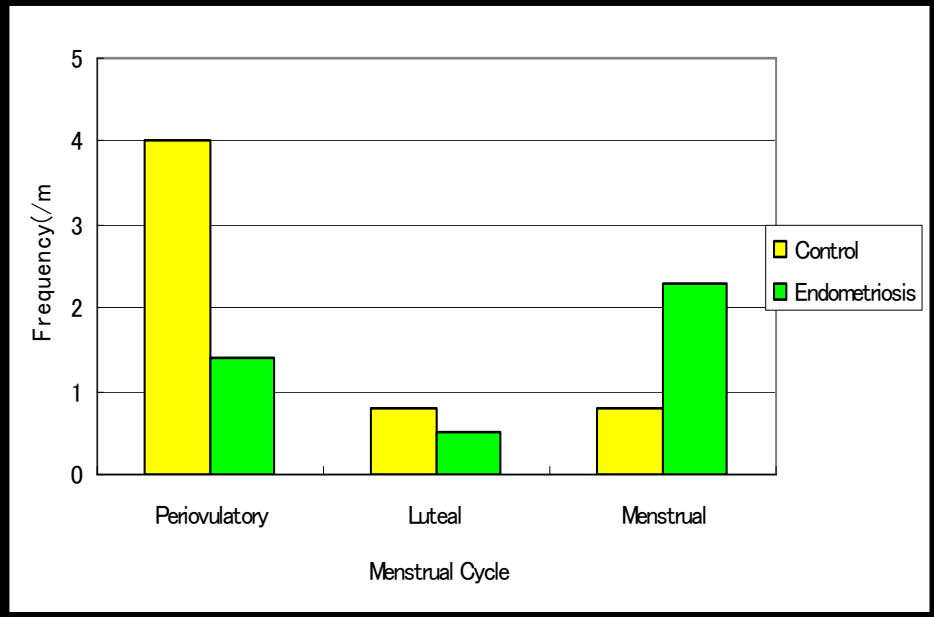
*Nishino M,Togashi K, et al EJR 2005*

# Endometriosis & Peristalsis

## Presence of Peristalsis

| | Endometriosis | Controls |
|---|---|---|
| Periovulatory phase | 6/13 | 87/96 |
| Luteal phase | 4/15 | 29/96 |
| Menstrual phase | 3/3 | 50/96 |

## Incidence of Peristalsis




*Kido A, Togashi K, et al Eur Radiol. 2007.*

# Infertility: Evaluation from a different point of view

34 y.o. Primary infertility
5 times failure of IVF
Abnormal waves

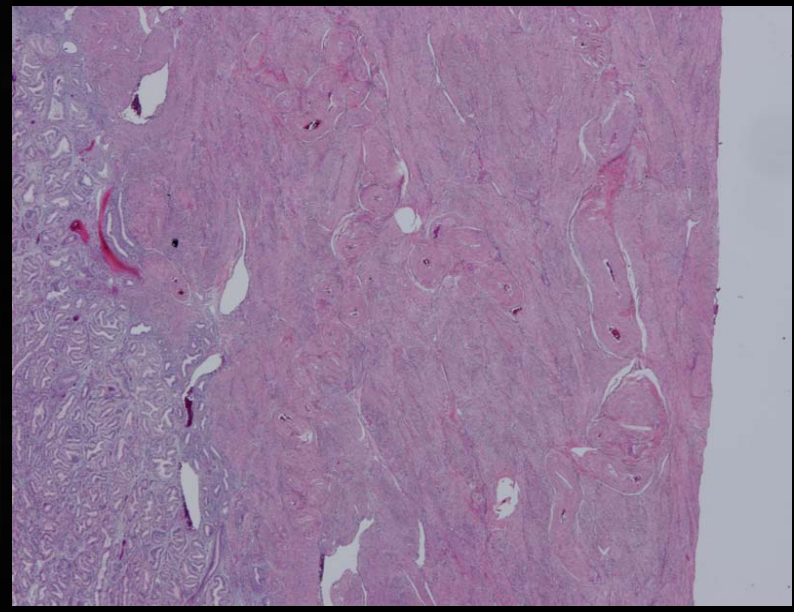
With wave suppression,

Successuful IVF

Kido A, Togashi K, et al.
Uterine peristalsis in women with repeated IVF failures: possible therapeuticeffect of hyoscine bromide. J Obstet Gynaecol Can. 2009;31:732-5

# Mysterious Myometrium

**27y.o. pre Menstrual phase**



Rich vasculature

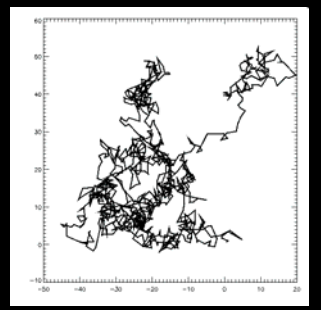
extracellular component such as collagen or elastin increases from the cervix to the fundus

Estrogen ?? Contractile elements

# Diffusion Weighted Imaging

**Originally used to identify acute Cerebral infarction**
**Now attracting attention in Oncology**

- **Represents Brownian motion of molecules**
- **Provides different tissue contrast**
  - Viscosity of fluid
  - Cellularity
- **Enables quantitative measurement of ADC**
  - Decreased ADC values in malignant tumor



*Tamai K, et al J Magn Reson Imaging. 2007;26(3):682-687*

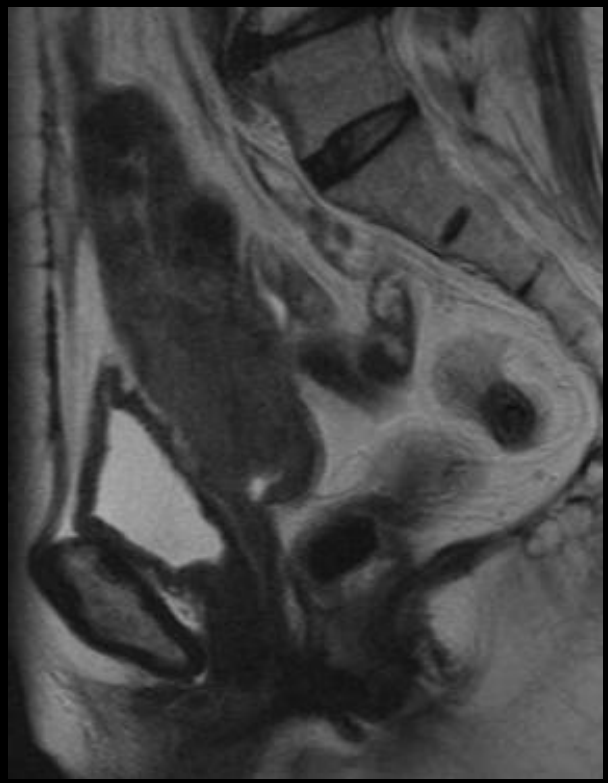
*Liu Y et al. J Comput Assist Tomogr. 2009;33:858-62*

# Cervical Cancer diffusely invading into posterior myometrium

T2WI DWI (b = 1000) ADC map

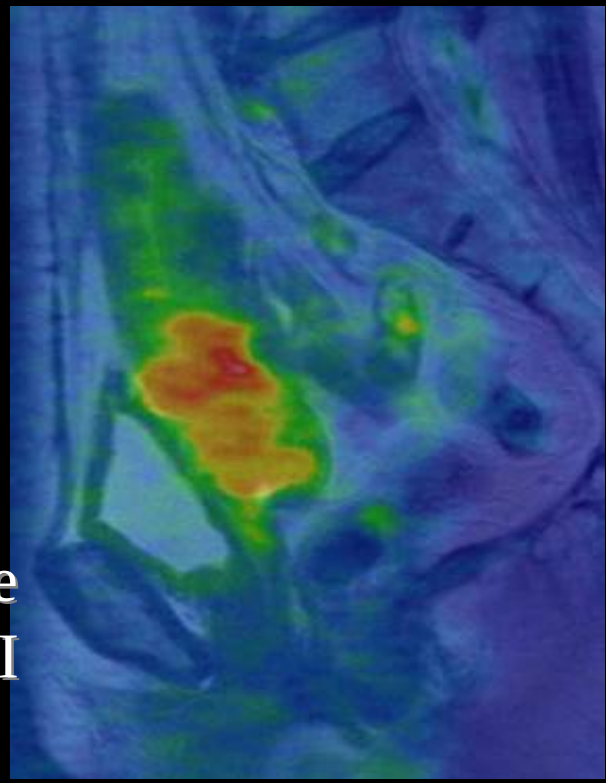
# Malignant uterine tumors on DWI

- Malignant uterine lesions show high SI on DWI
- Fusion image enables to evaluate both anatomic and additional information obtained from DWI.



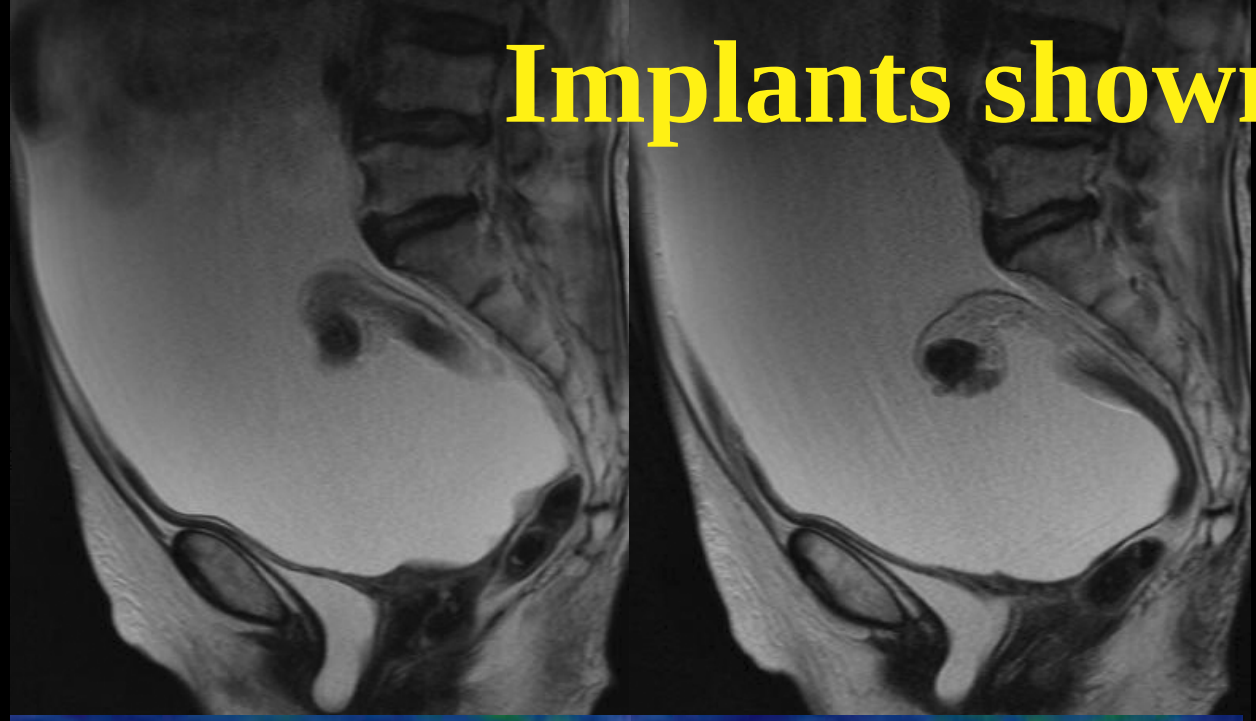
Cervical cancer

T2WI



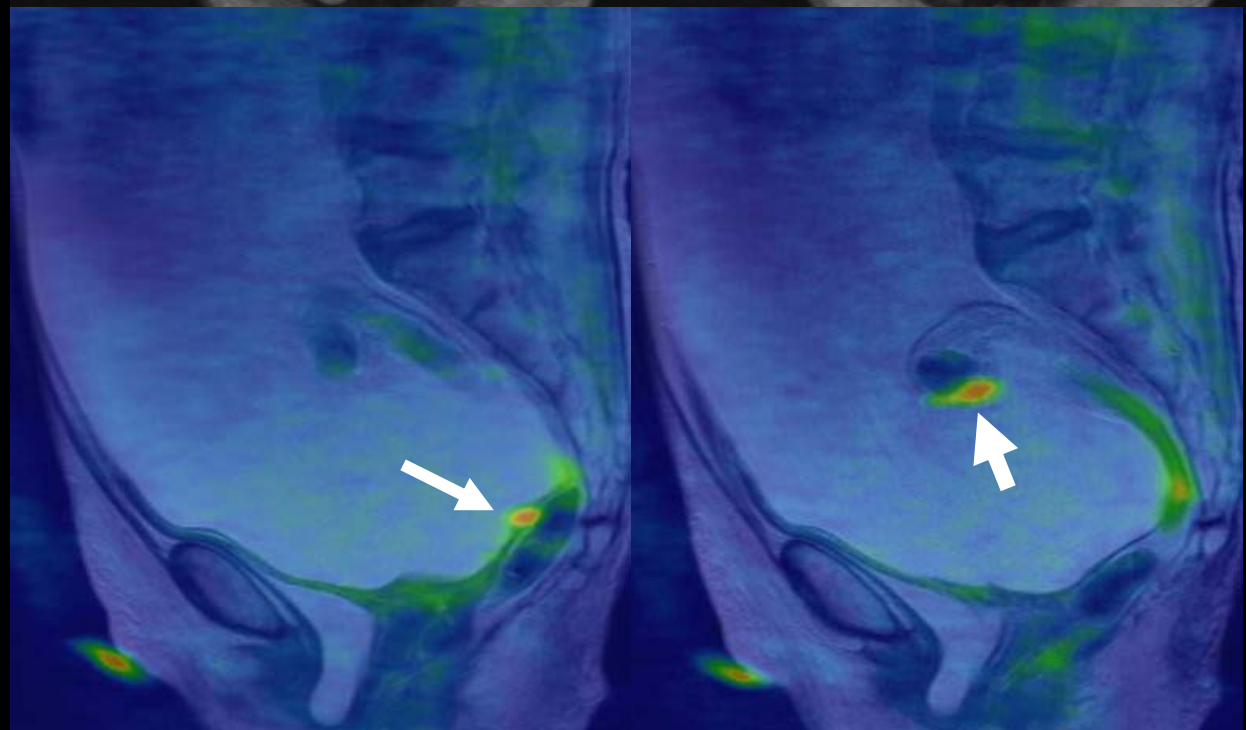
Fusion image
DWI + T2WI

# Implants shown on DWI



MRT2WI

S/O rec. Ovarian CA with ascites and elevated serum marker.



DWI onto T2

# ADC and Tumor Grading

**DWI allows quantitative measurement of the ADC**
**Decreased ADC in malignant tumor have been reported**

- Endometrium & cancer show high SI on DWI. However, Cancer has low ADC values ($mm^2/s$)
  - Ca. ($0.88 \pm 0.16$) < normal ($1.53 \pm 0.10$)
- High grade cancer (G3) tends to show low ADC

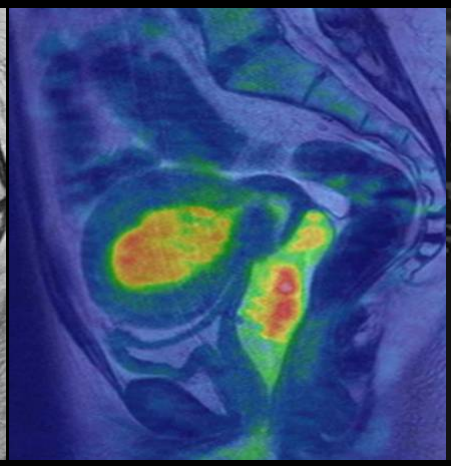
*Tamai K, et al J Magn Reson Imaging. 2007;26(3):682-687*

The ADC value provides a new tool for evaluating the pathologic grading of cervical cancer

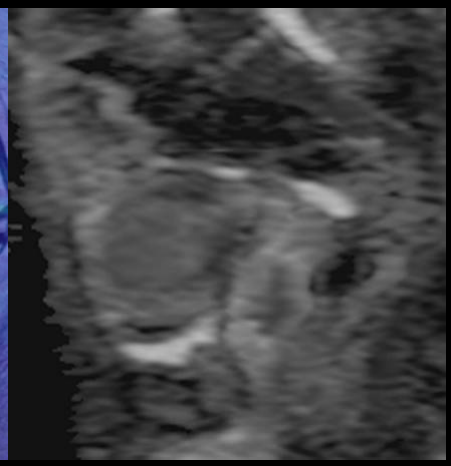
*Liu Y et al. J Comput Assist Tomogr. 2009;33:858-62*

# Well-differentiated endometrial cancer (G1, pT1b) 35 y.o.

T2WI



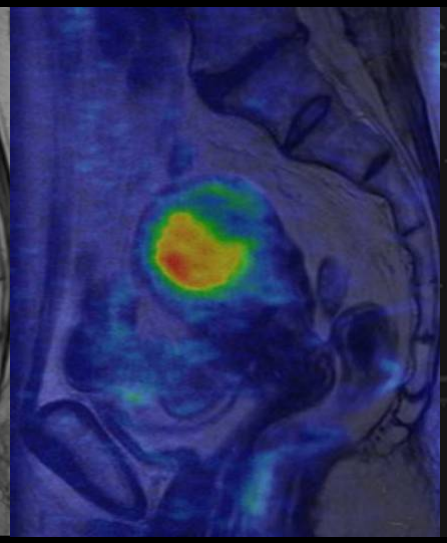
fusion image

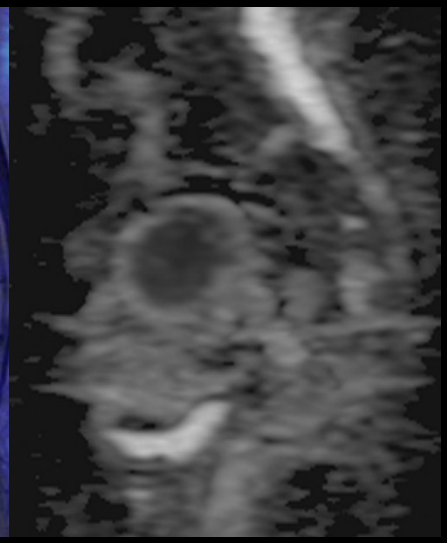


ADC map

Low grade tumor shows relatively low SI on ADC map. The ADC value was 1.13 x $10^{-3}$ $mm^2/s$

## Poorly-differentiated endometrial cancer (G3, pT3a) 69 y.o.





High grade tumor shows prominent low SI on ADC map. The ADC value was 0.62 x $10^{-3}$ $mm^2/s$, extremely low

*Tamai K, et al J Magn Reson Imaging. 2007;26(3):682-687*

# ADC is a potential caner biomarker However there are several problems

- ADC may be dependent on the scanners as well as parameters
  - due to different b values used
  - Cutoff values proposed in papers  are not directly applicable to other sites
- Comparison of ADC and cutoff values in different institutions are difficult.
- Protocol standardization is mandatory

NEOPLASIA
www.neoplasia.com
Volume 11 Number 2 February 2009 pp. 102–125 102

Meeting Report

**Diffusion-Weighted Magnetic Resonance Imaging as a Cancer Biomarker: Consensus and Recommendations**

Anwar R. Padhani[*], Guoying Liu[†], Dow Mu-Koh[‡], Thomas L. Chenevert[§], Harriet C. Thoeny[¶], Taro Takahara[#], Andrew Dzik-Jurasz[**], Brian D. Ross[§], Marc Van Cauteren[††], David Collins[‡], Dima A. Hammoud[‡‡], Gordon J.S. Rustin[*], Bachir Taouli[§§] and Peter L. Choyke[†]

# Dynamic contrast-enhanced MRI

- Technique that can reflect tumor vascularity
  - The contrast between the lesion and myometrium is greater on DCFMR imaging

Sagittal T2WI

Dynamic pre

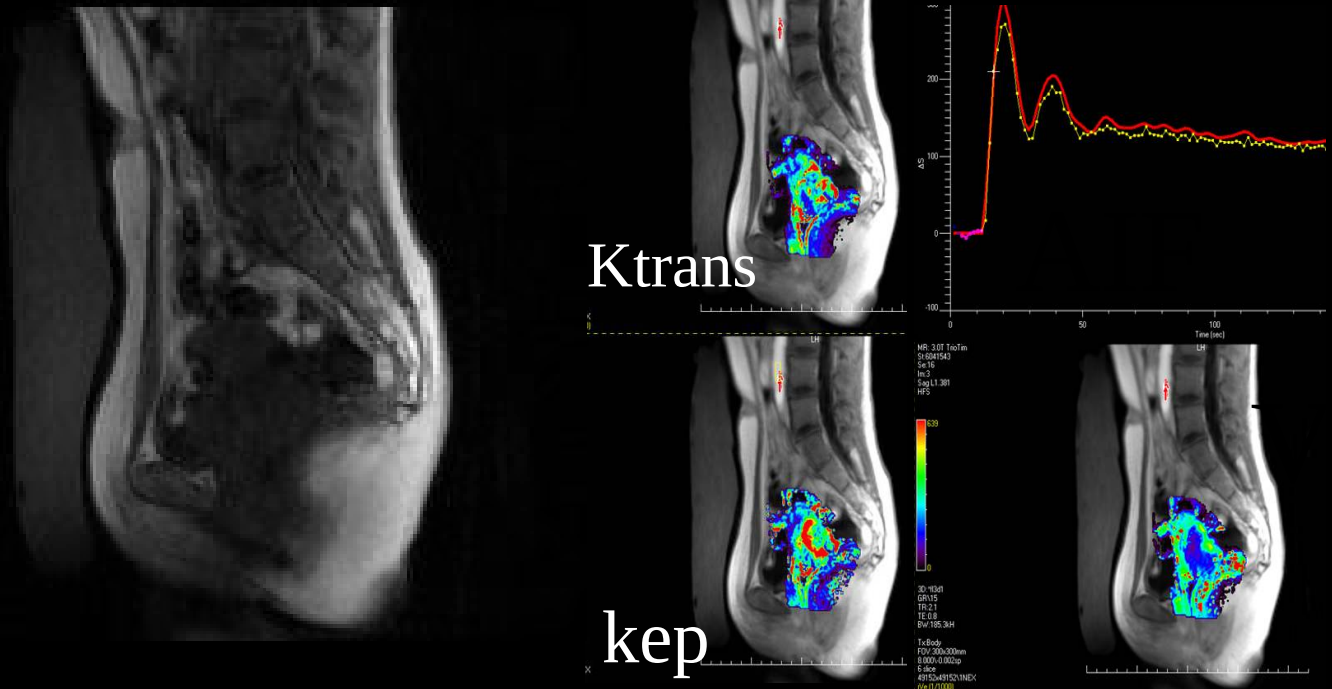
40sec

120sec

180sec

# Perfusion MRI using DCE-MR

- Focuses on hemodynamics of cancer rather than morphology
  - Increasing temporal resolution allows to analyze detailed time-course of SI of cancer
  - DCE offers many analytic values: Ktrans, Kep and Ve represent characteristics of vascular permeability, its reverse speed constant and extracellular space volume, respectively



# Take home messages

- Recent MR techniques have enabled us to evaluate the functional assessment of the uterus.
- Cine MR offers direct visualization of uterine contractility, which closely related with uterine functions, fertility problems and menstrual symptoms .
- DWI and ADC provide tissue contrast based on molecular diffusion phenomenon, and might be a promising tool in oncology as a possible cancer biomarker.
- DCE and perfusion analysis help evaluate hemodynamics of lesions.


*Thank you*
*for your attention*