

Pelvic MRI with a Surgeon`s Eye

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MRI machine

- Hollow cylindrical structure.
- Patient position—
 - usually Lying down.

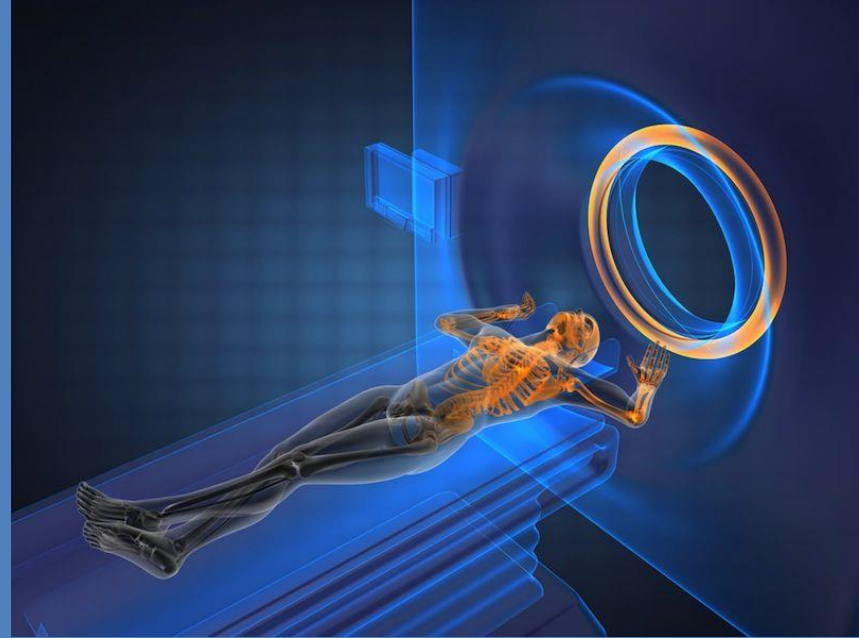


Principle

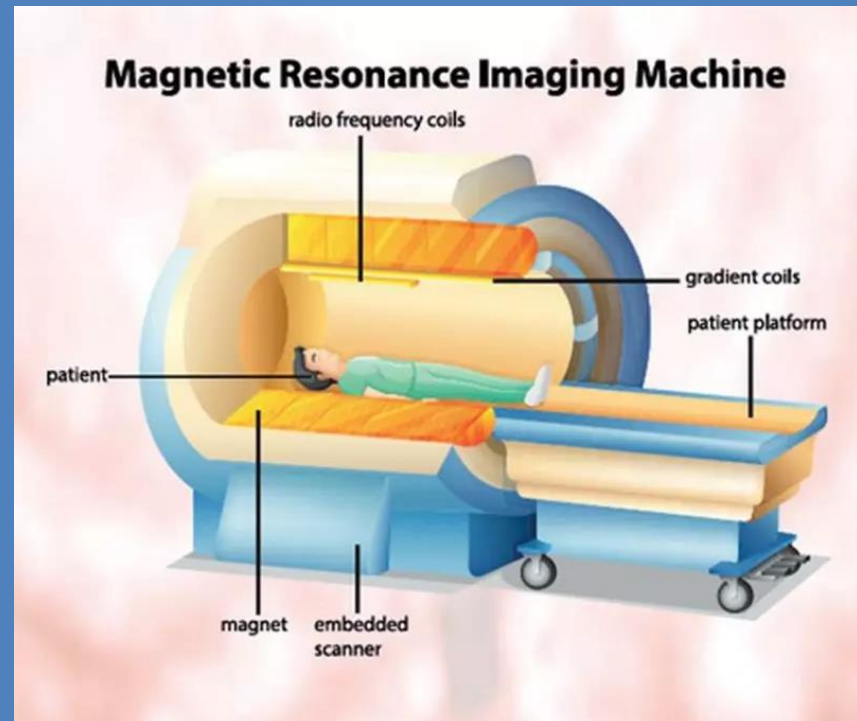
- Based on principles of NMR.
- Uses-
 - Magnetism.
 - Radio waves.
 - Computer to produce images.



Main components

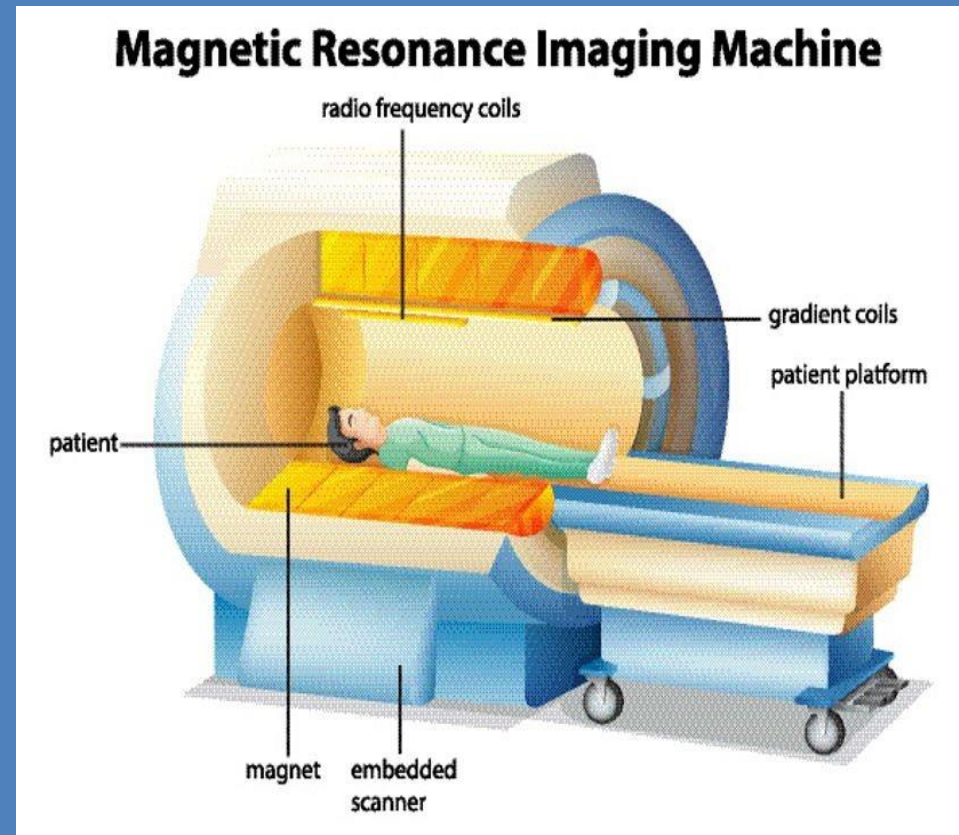


- Scanner.
- Computer.
- Recording hardware.



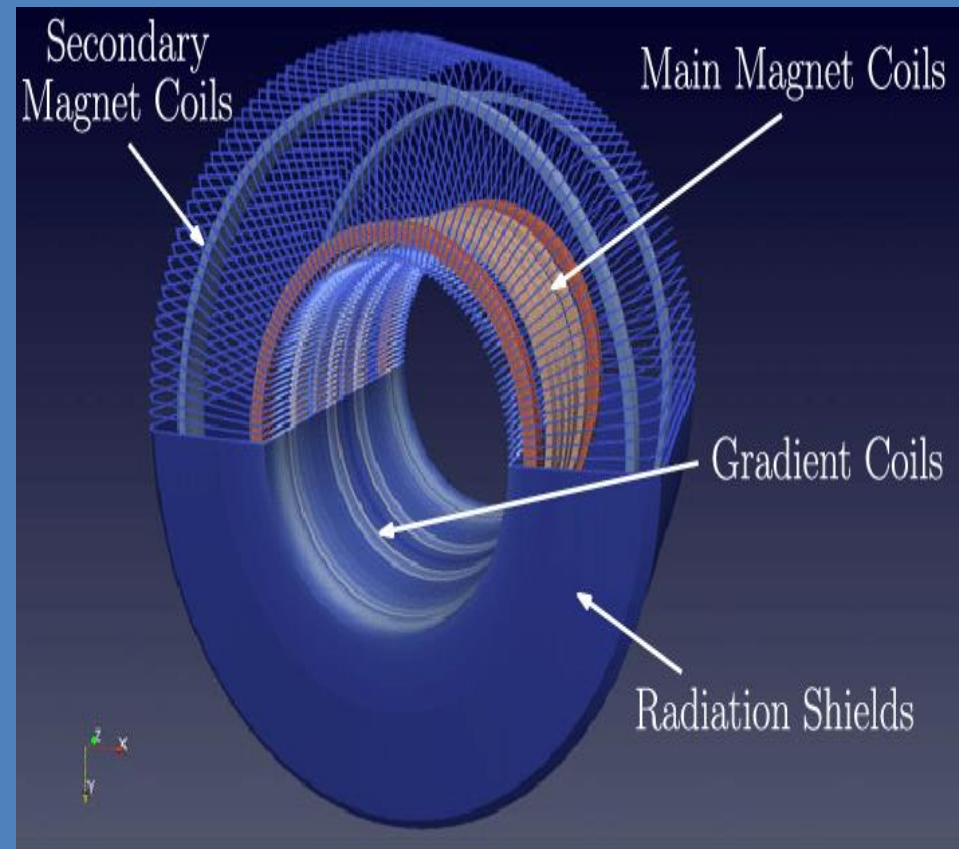
Components of MRI scanner

- Main magnet (superconducting magnet).
- Gradient coils.
- RF (radiofrequency) coils.



Main magnet

- Upto 30000 times stronger than the earths magnetic field.
- Strength of the magnet is rated by using the unit Telsa.
- Magnetic strength-- 0.2-3 Tesla.



Historical background

Niranjan Ultrasound India pvt.Ltd



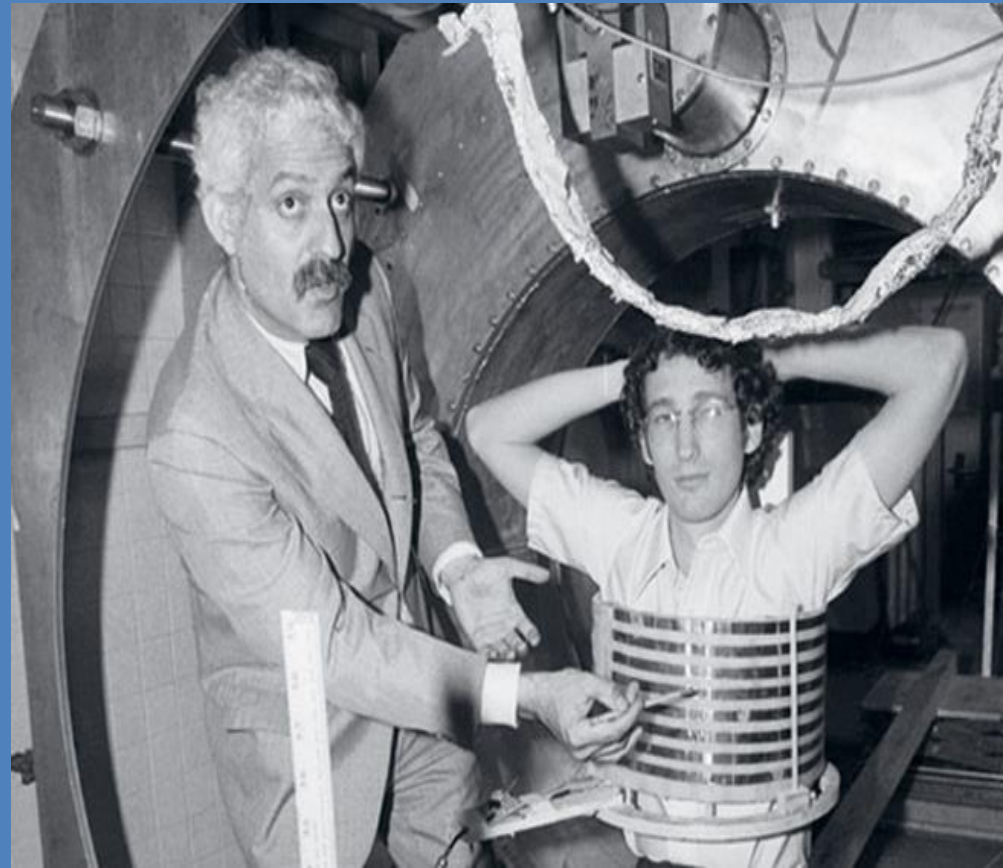
FATHER OF MRI

- Magnetic resonance imaging inventor



RAYMOND VAHAN DAMADIAN

- 1st MRI performed on human being in 1997.
- Took 5 hours to produce 1 image.



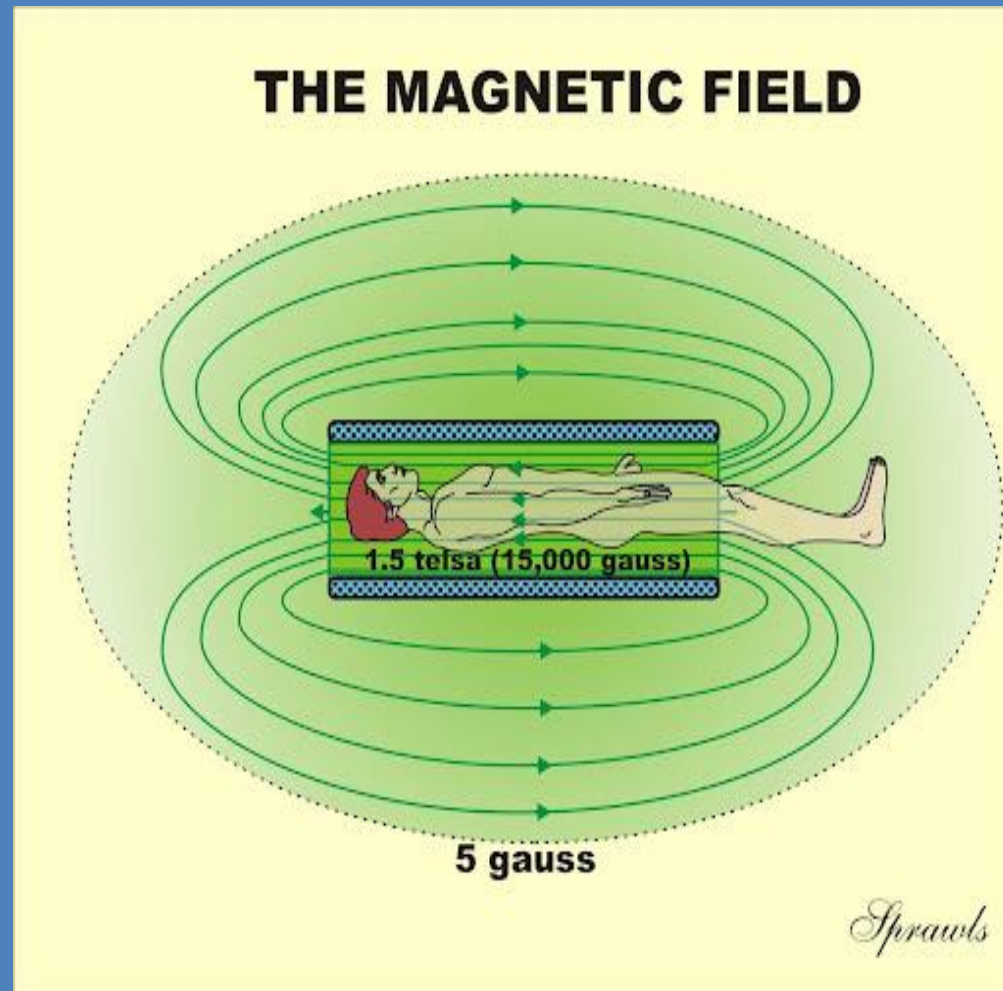
Historical background

- Raymond V. Damadian, an Armenian-- inventor of MRI.
- 1st MRI scan provided a clear image of --
 - heart,
 - lungs and
 - chest wall.
- Today, MRI can analyze any part of the body in minute.



MRI principles

- Based on principles of NMR.
- Utilizes magnetic spin property of protons of H^+ .
- Why H^+ ?
 - Positive charged.
 - Magnetic spin property.

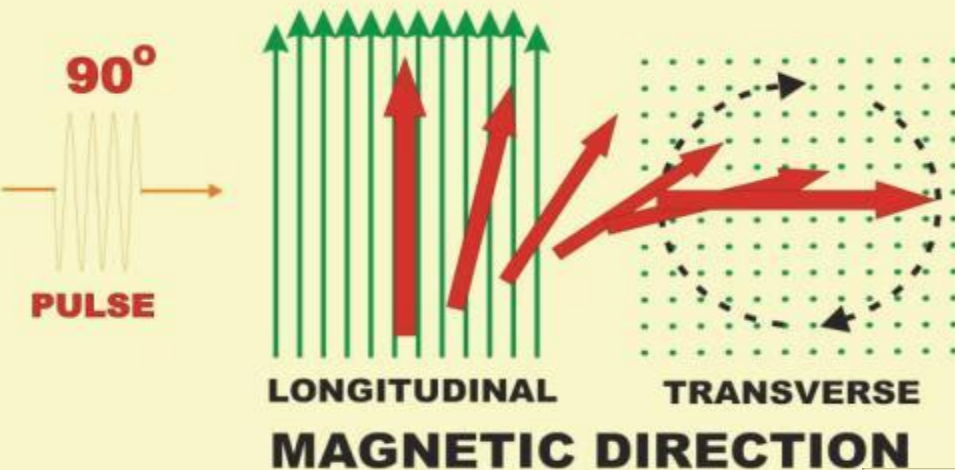


Procedure

- Patient is put in a magnetic field.
- RF signal is sent.
- RF signal is switched off.
- Patient emits a signal-used for reconstruction of image.



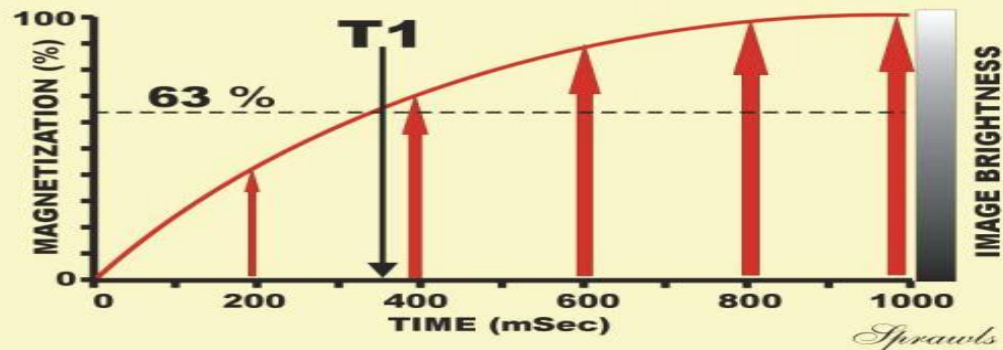
EXCITATION



What is T1 & T2?

- **T1-Relaxation: Recovery**
 - Recovery of longitudinal orientation.
 - 'T1 time' refers to interval where 63% of longitudinal magnetization is recovered.
- **T2-Relaxation: Dephasing**
 - Loss of transverse magnetization.
 - 'T2 time' refers to interval where only 37% of original transverse magnetization is present.

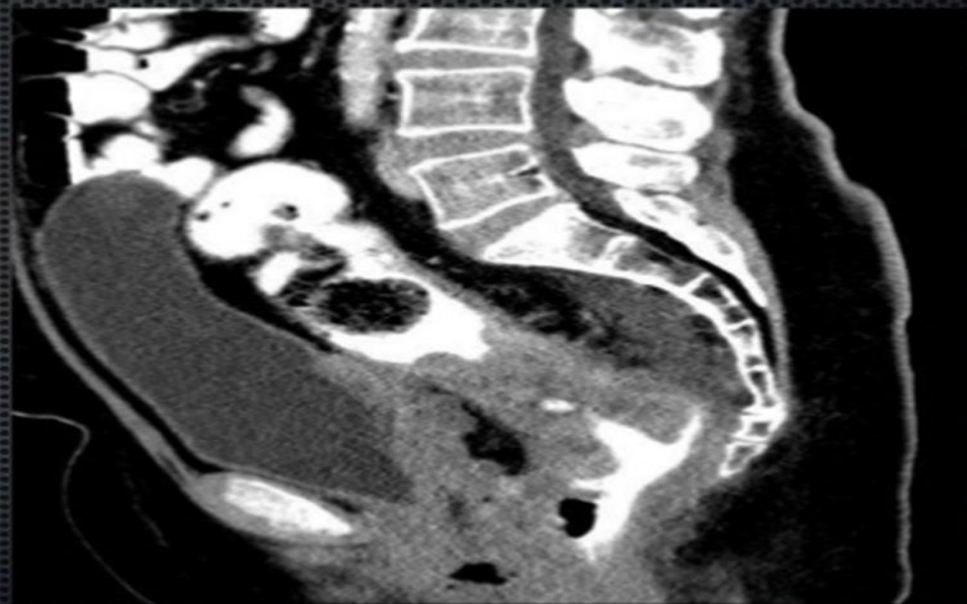
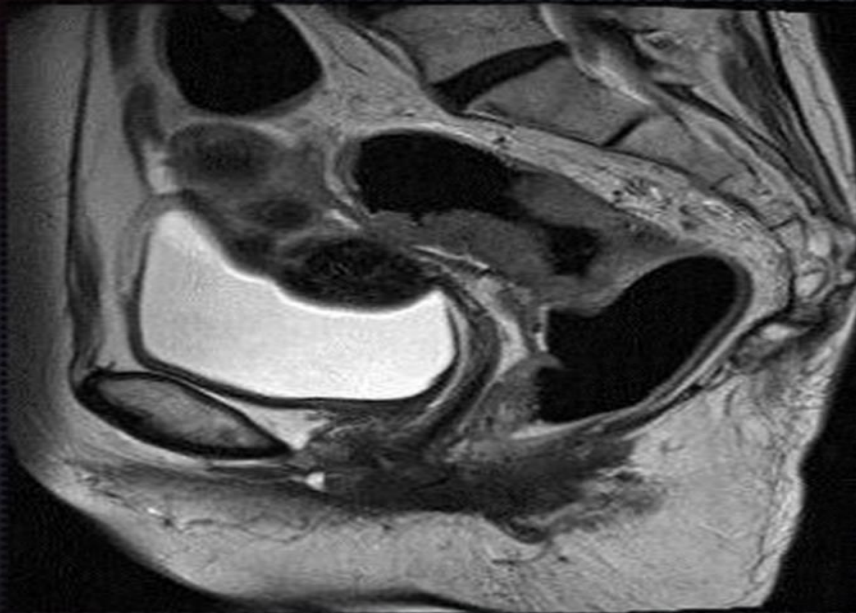
LONGITUDINAL MAGNETIZATION RELAXATION (GROWTH)



TRANSVERSE MAGNETIZATION DECAY



MRI versus CT



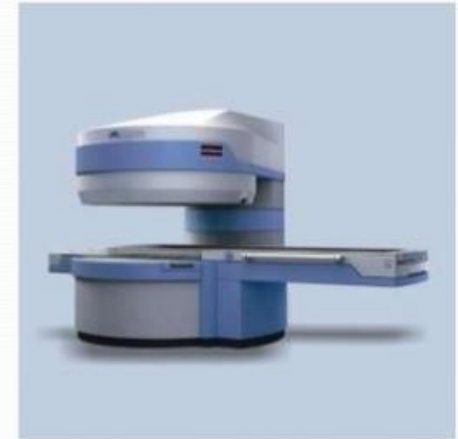
	MRI	X-ray or CT scan
Principle	NMR phenomena.	Absorption of X-ray.
Radiation exposure	NO.	Yes(400 CXR).
Tissue resolution	Excellent	Good
Dynamic image	Easy	Difficult
Examination noise	Large	Comparatively quiet
Time	Long (15-30min).	Short (5-10 min).

**Types of MRI:
Based on Construction:**

SHAPE OF MRI MACHINE

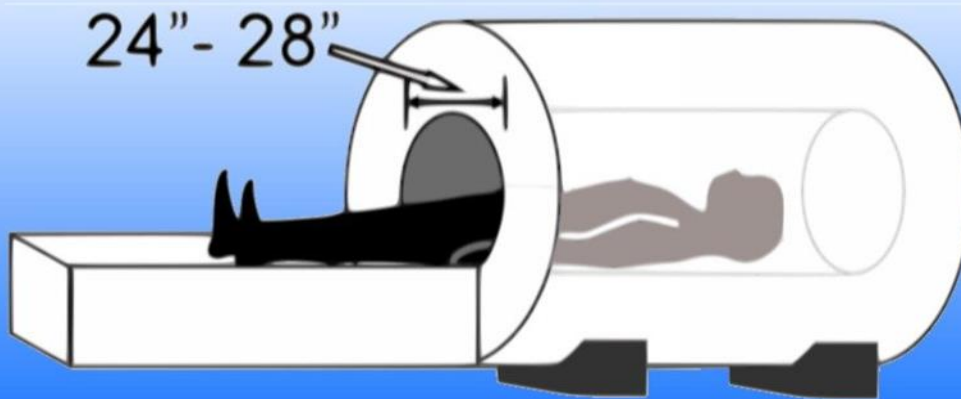


CLOSED MRI



OPEN MRI

38



Closed "Tunnel-style" MRI



Our Open MRI System

Open MRI

- wider diameter (> 60 cm).
- open on the sides.
- more comfortable.

Disadvantage-

- images less clear because contain $<$ magnetic field as desired.





	Closed MRI	Open MRI
Magnetic field	Typically 1.5-3 T	0.2-0.4 T.
Image quality	High.	Low.
Imaging speed	Fast.	Slow.
Patient anxiety	More.	Less.
Acoustic noise	High.	Low.
Claustrophobics	Difficult.	Easy.

Extremity MRI –

- Smaller scanner.
- Minimal restriction on movements.
- No claustrophobia.

3 Tesla MRI –

- Magnetic field double the conventional value.
- Less time.
- Micro vessels (200-300) micron can be easily visualized.
- Better sound control.



Based on Properties & Applications:

Functional MRI (fMRI):

- Looks how blood flows within the nervous system.
 - Stroke.
 - Degenerative diseases like Alzheimer's.

Interventional MRI:



- Used in
 - Biopsies.
 - Thermal ablation.
 - Various heart procedures.
 - Neurosurgical procedures.

Cardiac MRI:



Cardiovascular magnetic resonance (CMR).

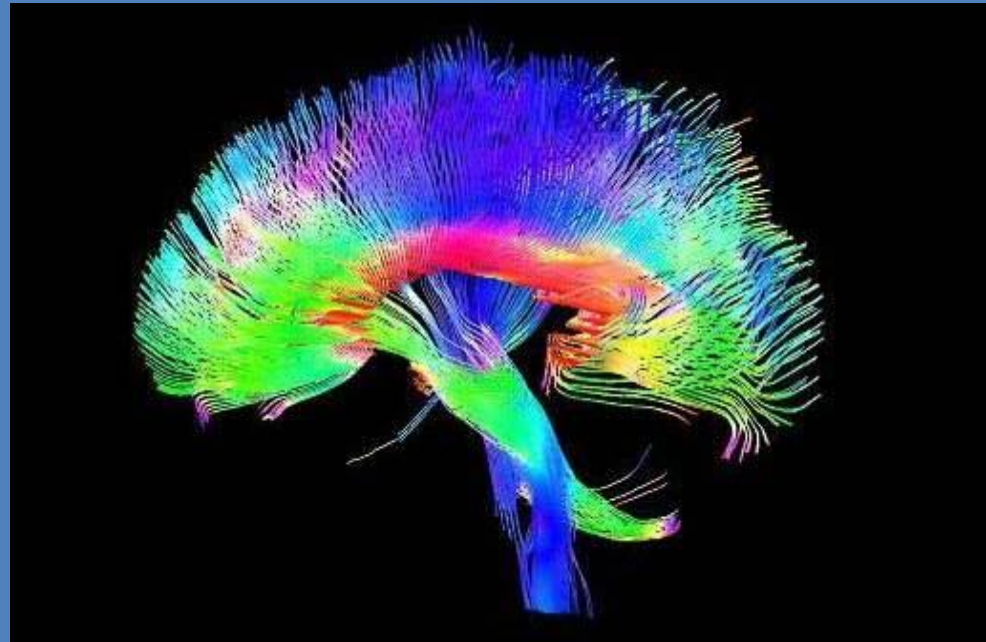
Magnetic Resonance Angiography (MRA):



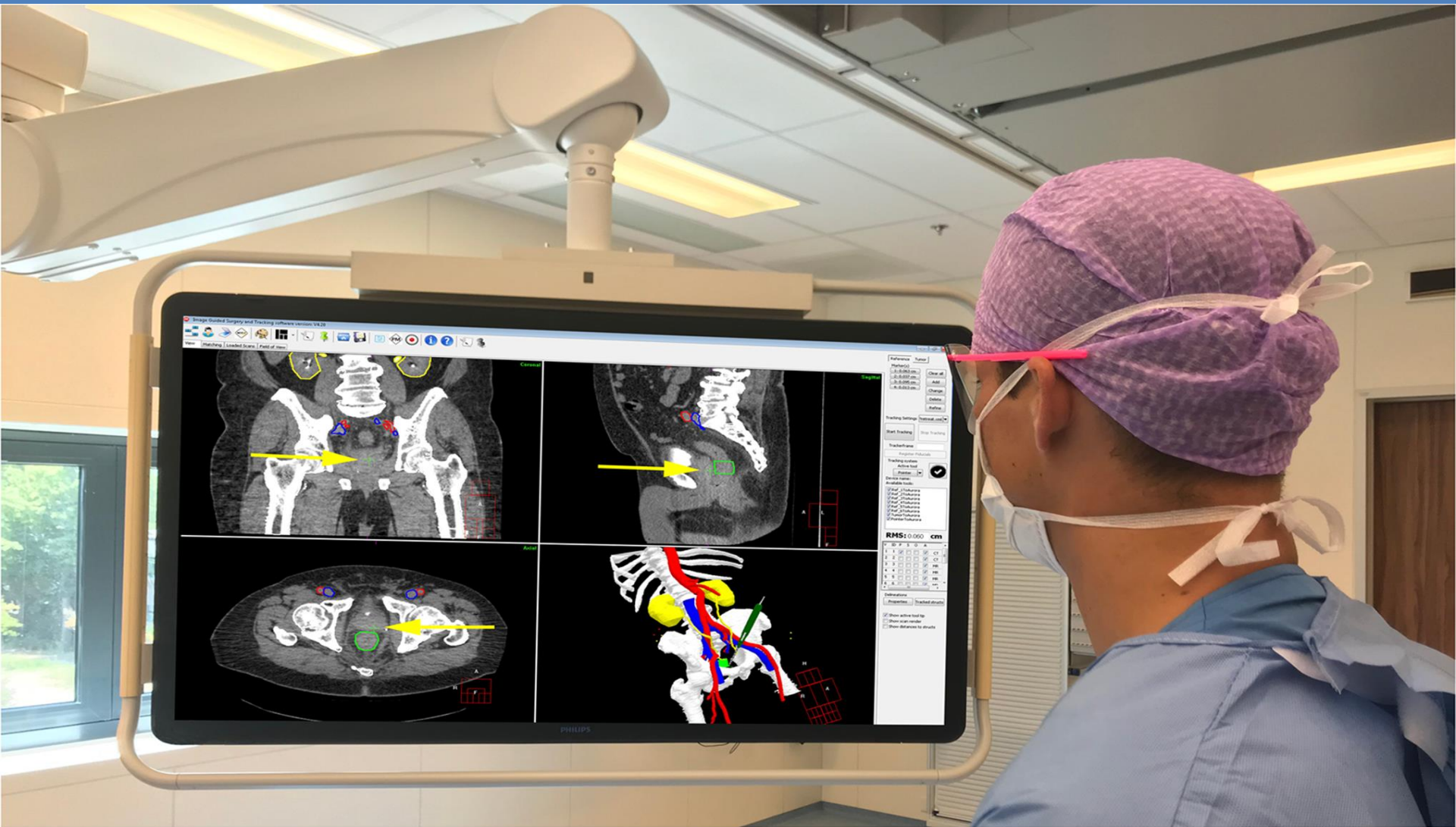
2D and 3D images are made possible.

Diffusion MRI:

- Diffusion- movement of molecules from a region of high concentration to a lower one.
- Uses diffusion of water molecules to generate contrast in MR images.
- Used to -
 - See Direction of nerve fibres in the brain.
 - Create a brain map.
 - Stroke.
 - Pelvic LN.

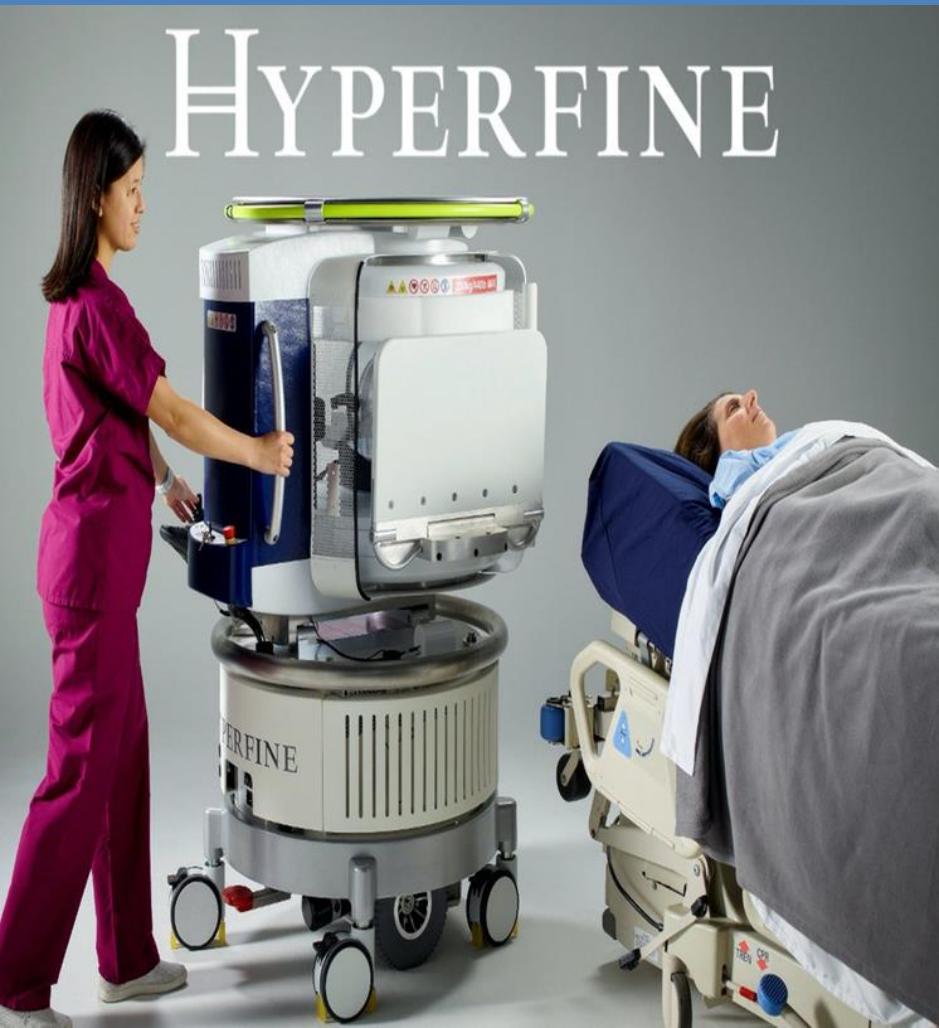


Real Time MRI:

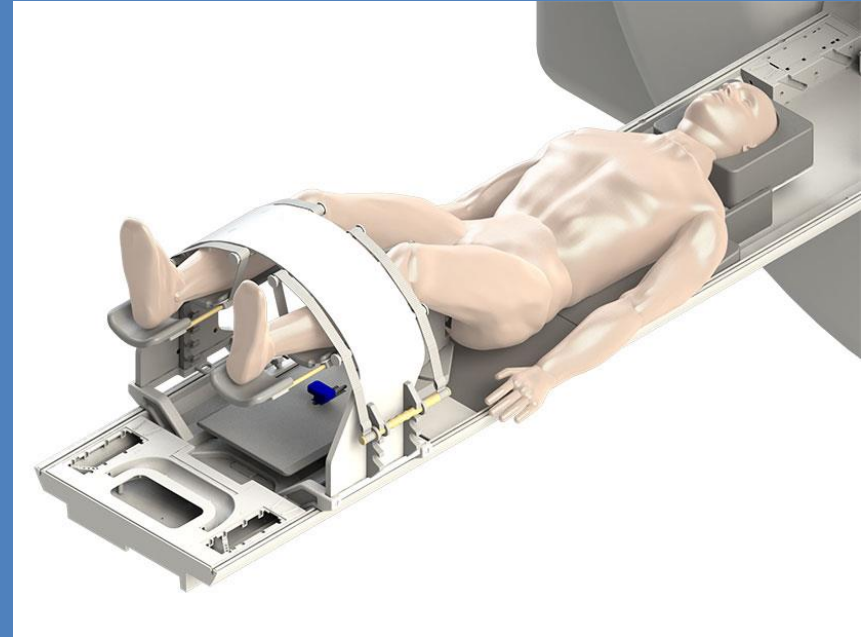
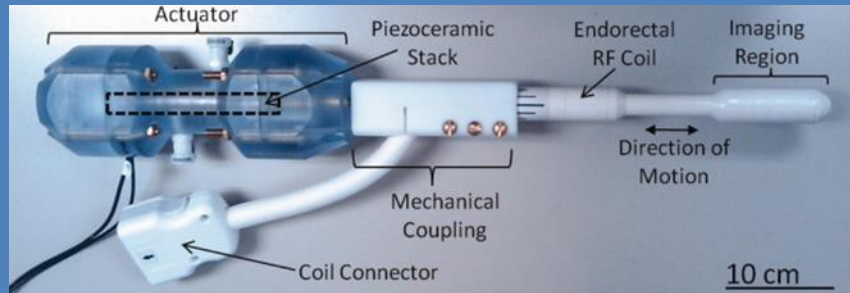


Creates a 'live' imaging.

Portable MRI



Endo Coil MRI



MRI preparation

- Complete history.
- Removal of all metallic objects-
 - Jewellery.
 - Drug delivery patches.
- Acoustic noise protection- ear plugs, pads or head phones.





What about dye?

Side effects?

Side Effects of Gadolinium-Based Contrast Dyes

Common



Headache



Cold sensation
when injected



Nausea



Dizziness

Rare



Itchy skin



Nephrogenic
systemic fibrosis



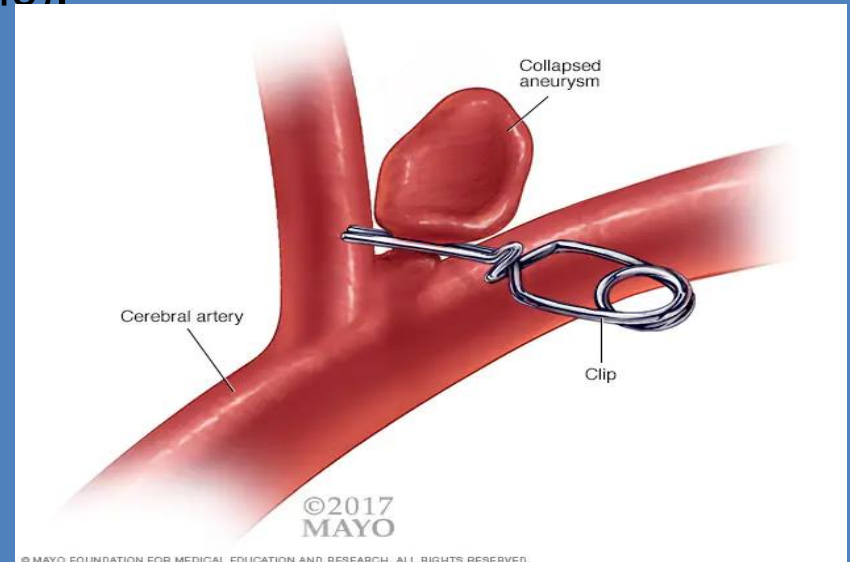
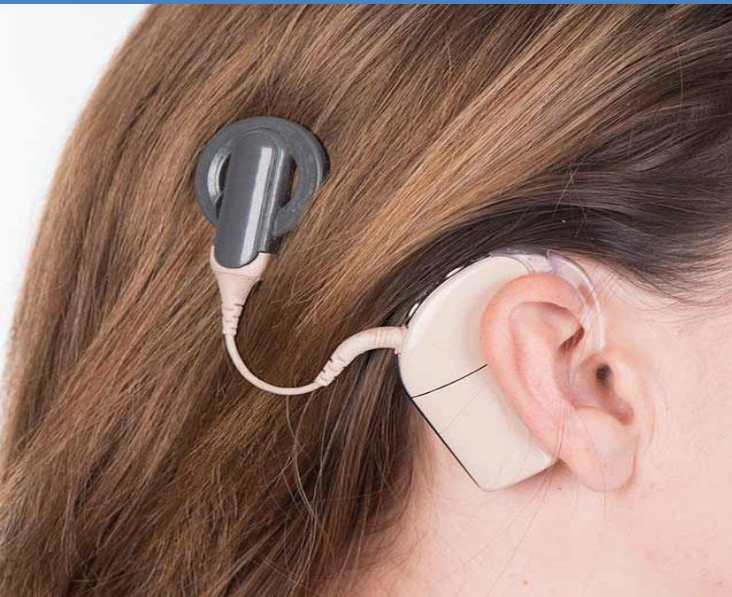
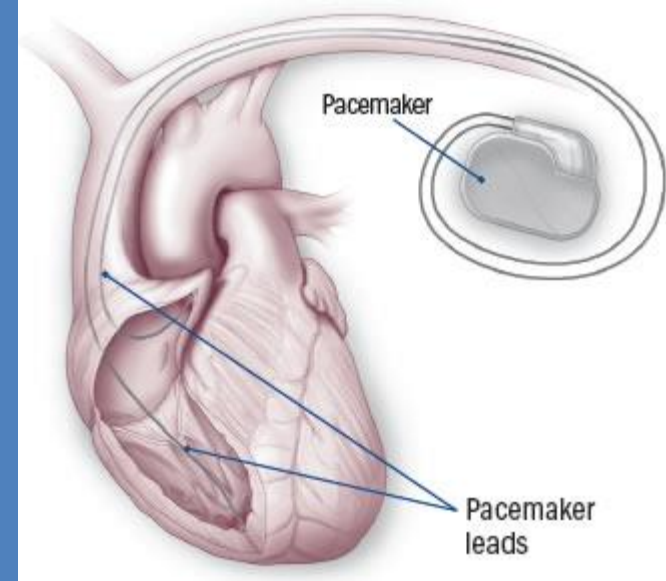
MRI Protocols-

- Field strength-- 1.5- 3 Tesla.
- High resolution T2-weighted imaging in-
 - axial,
 - sagittal,
 - coronal and
 - oblique orientation.
- Slice thickness: 3–4 mm.
- Dye-
 - Gadolinium.
 - Sonographic gel- vagina & rectum.
 - Hydrogen peroxide- fistula.

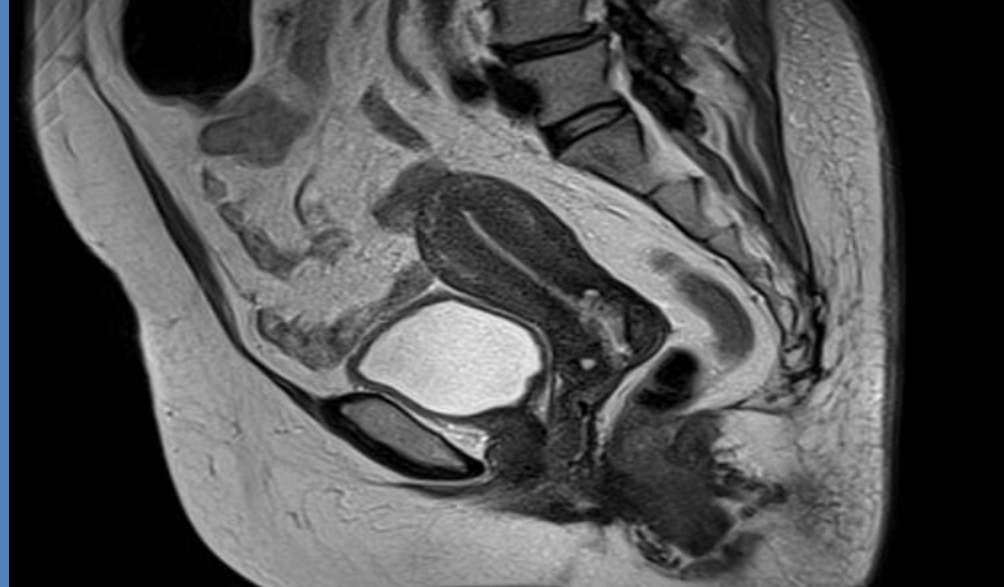
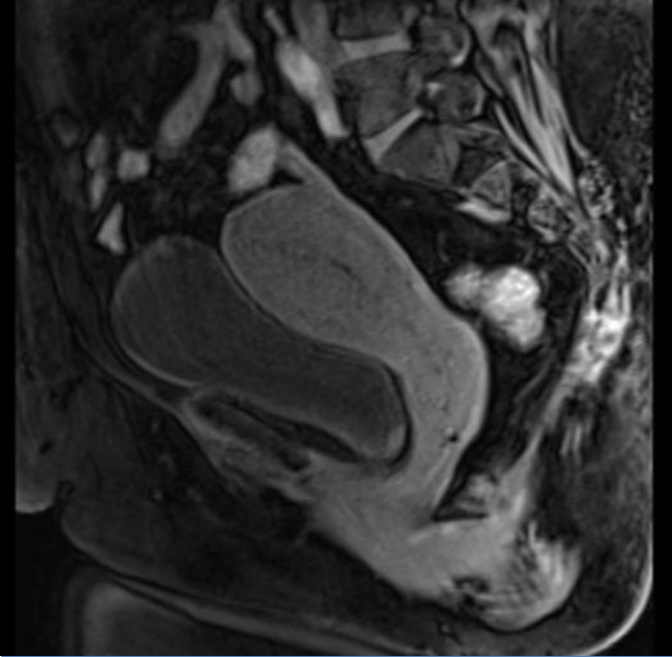


Contraindications

- Cardiac pacemaker (exception- cardiac friendly).
- Brain operation with certain clips.
- Cochlear implants.
- Metallic foreign body in eye.
- Surgery within last 8 weeks.
- Pregnancy- gadolinium (teratogenic).

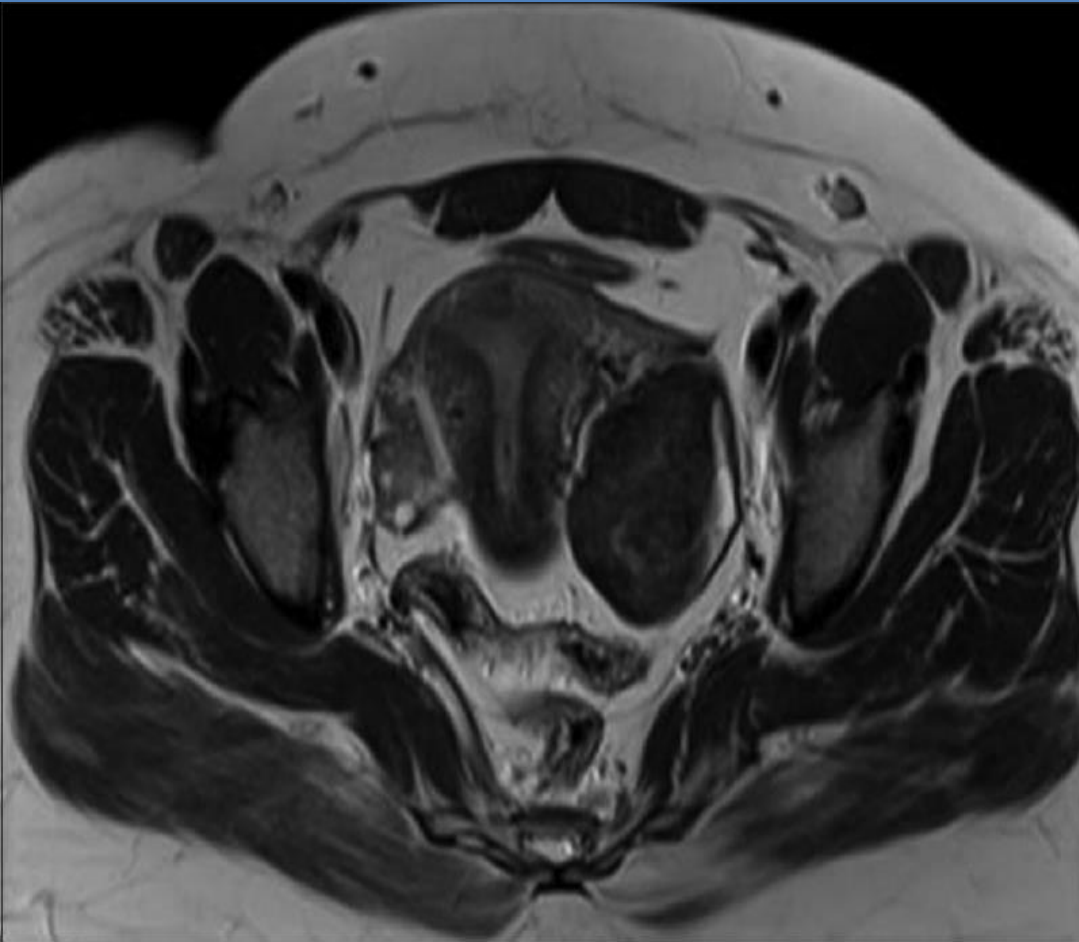


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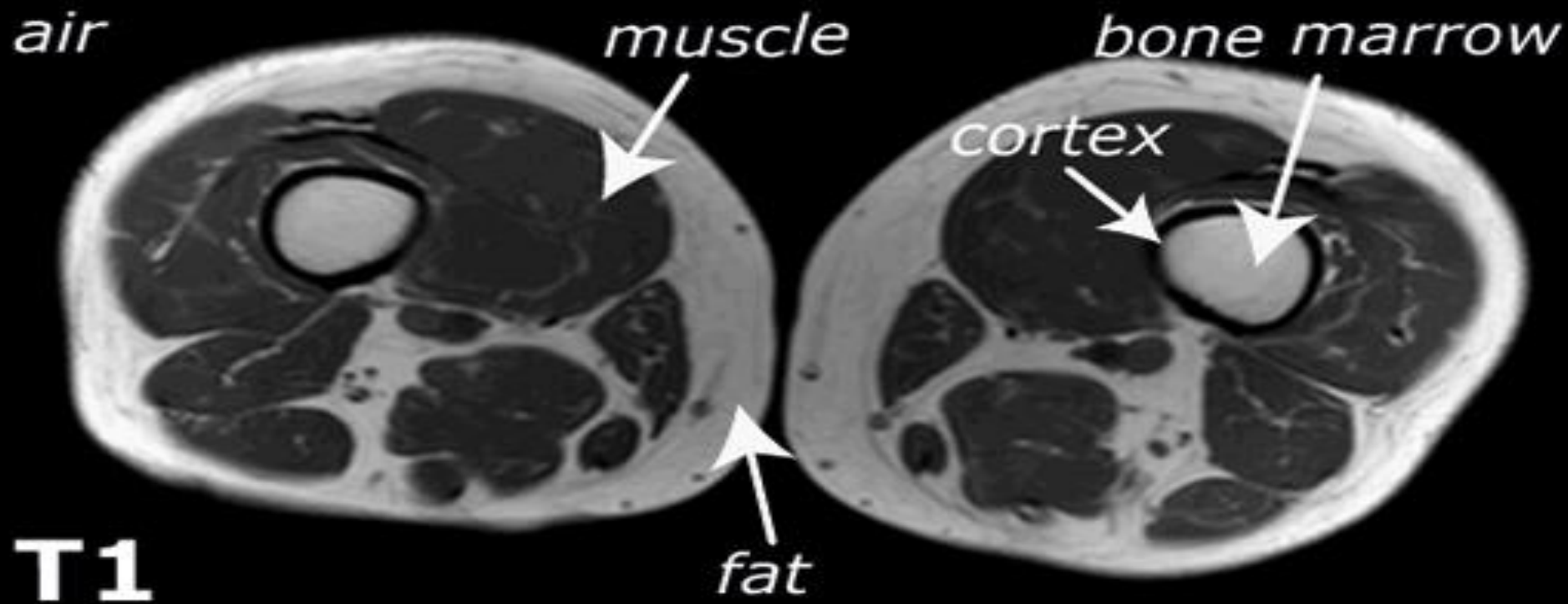
	T1	T2
Tissue with high water content- • Fat. • Oedema. • Infection. • Haemorrhage, Cyst. • Gadolinium.	Darker (grey)	White (brighter). Water is white on T2.
Tissue with low water content	White (brighter)	Darker (grey)
Most pathologies • Solid mass. • Cyst. • Subacute blood. • Exception-acute & chr. blood.	Dark.	White.

Signal intensity



Weighted- one type of protocol.

- Low- Signal intensity < muscle.
- High- Higher than fat.
- Intermediate- in between muscle & fat.



T1 weighted sequence

(black)



*air, calcium,
cortical bone,
rapidly flowing
blood*

low SI



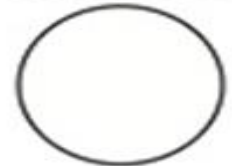
*fluid, ligaments/
muscles/tendons,
abdominal organs,
cartilage*

intermediate SI

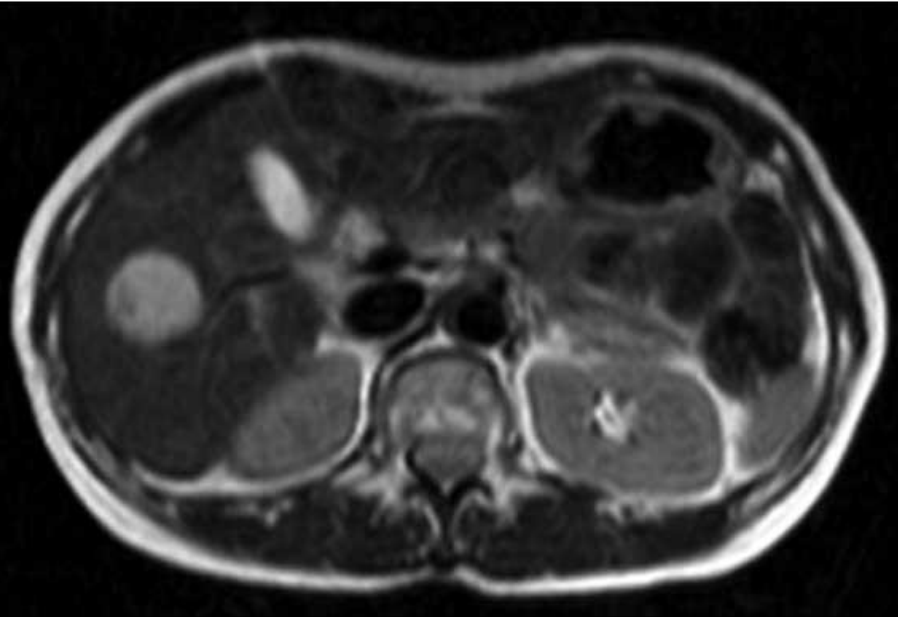
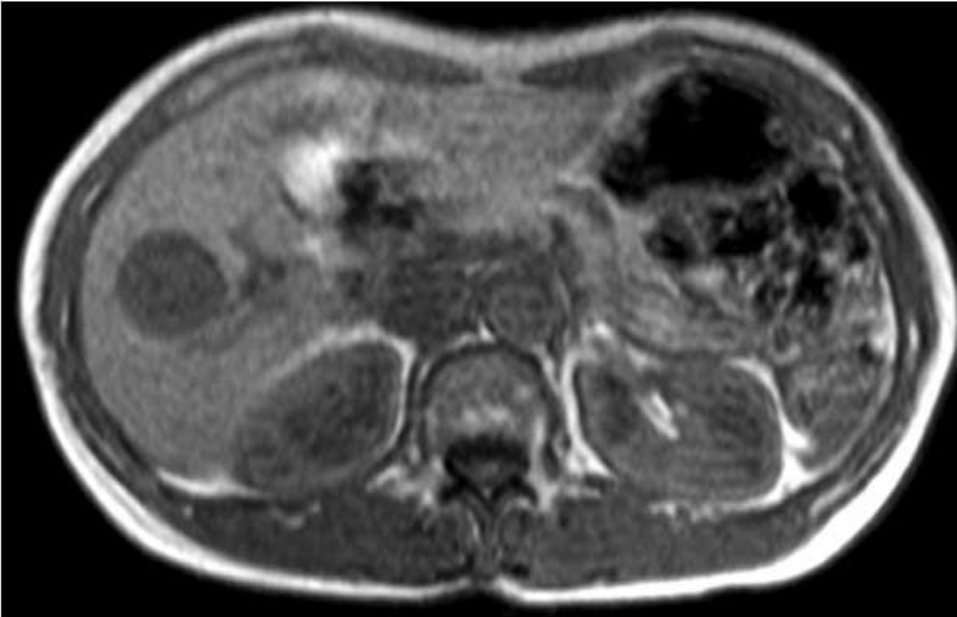


*high-protein tissue
(abscess,
complex cysts,
synovial fluid)*

high SI



*fat, blood,
gadolinium
(= contrast),
melanin, protein*



T1-W

T2-W

T2 weighted image

(black)



*air, calcium,
cortical bone,
rapidly flowing
blood*

low SI



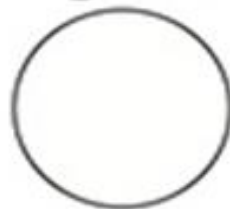
*ligaments,
tendons, liver,
pancreas,
adrenals, cartilage*

intermediate SI



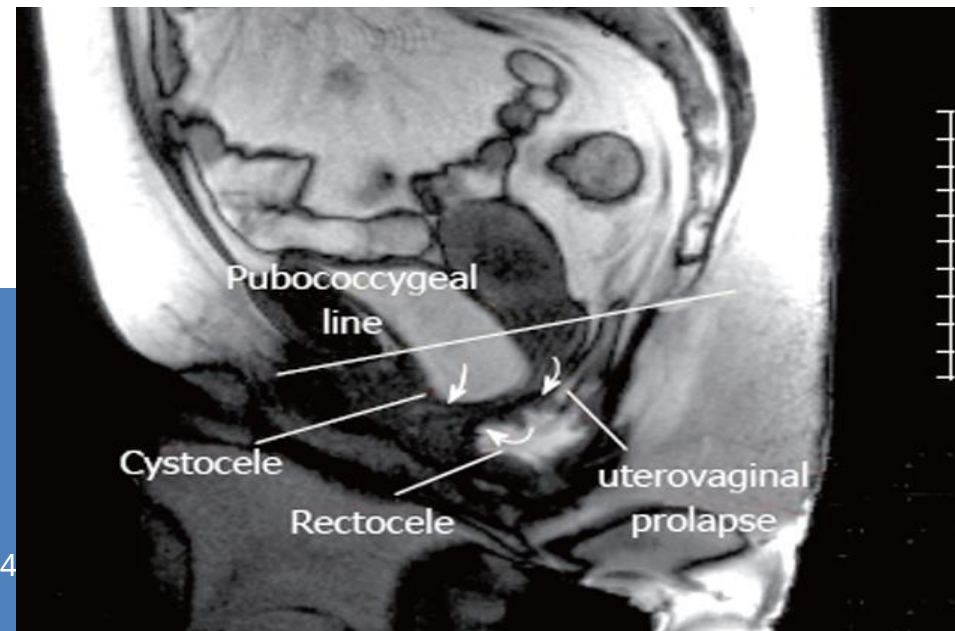
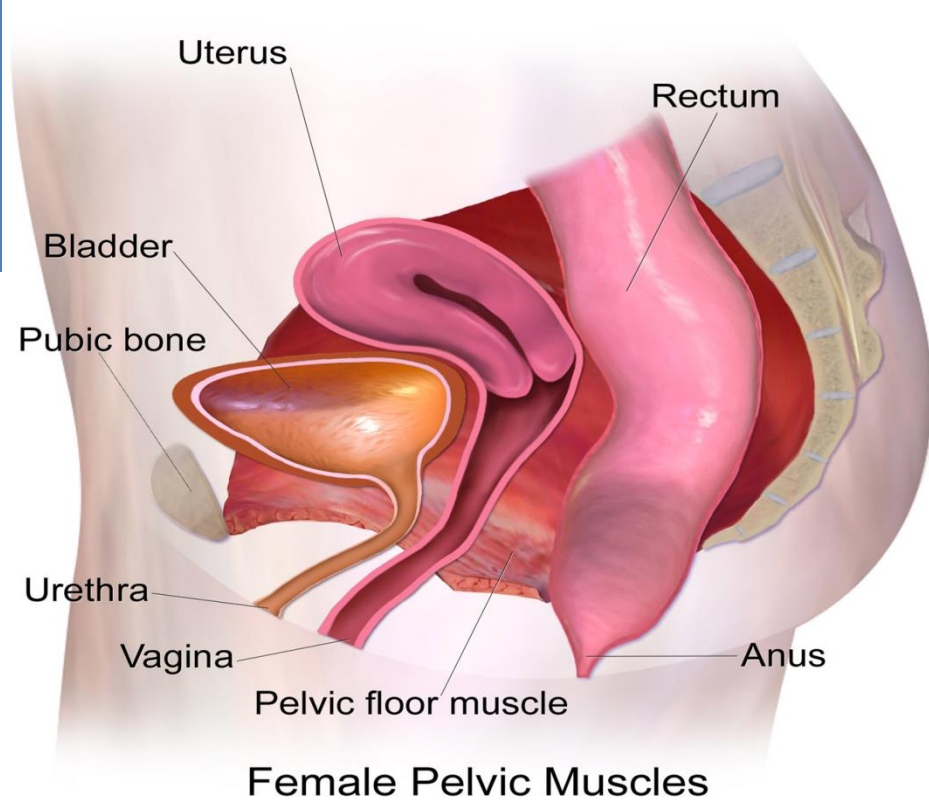
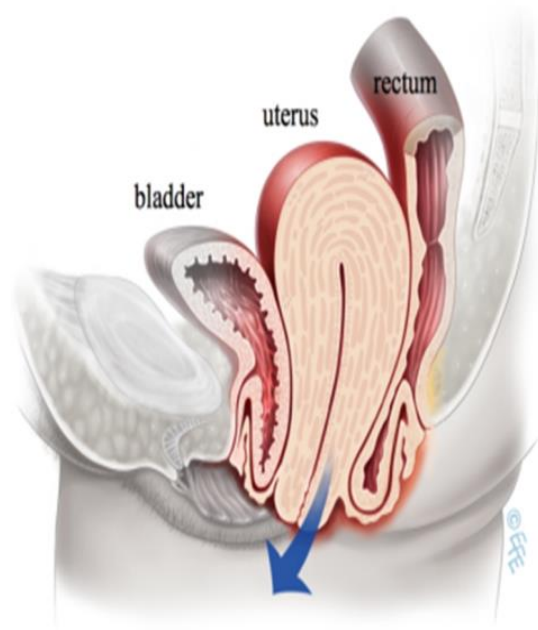
*fat, liver,
pancreas,
adrenals, muscles,
cartilage*

high SI



*fluid, CSF,
bladder, bile/
gallbladder,
kidneys*

Pelvic compartment pathology



Investigation:

- Dynamic cystoproctography or
- Cystodefecography.

Reference lines

PCL-

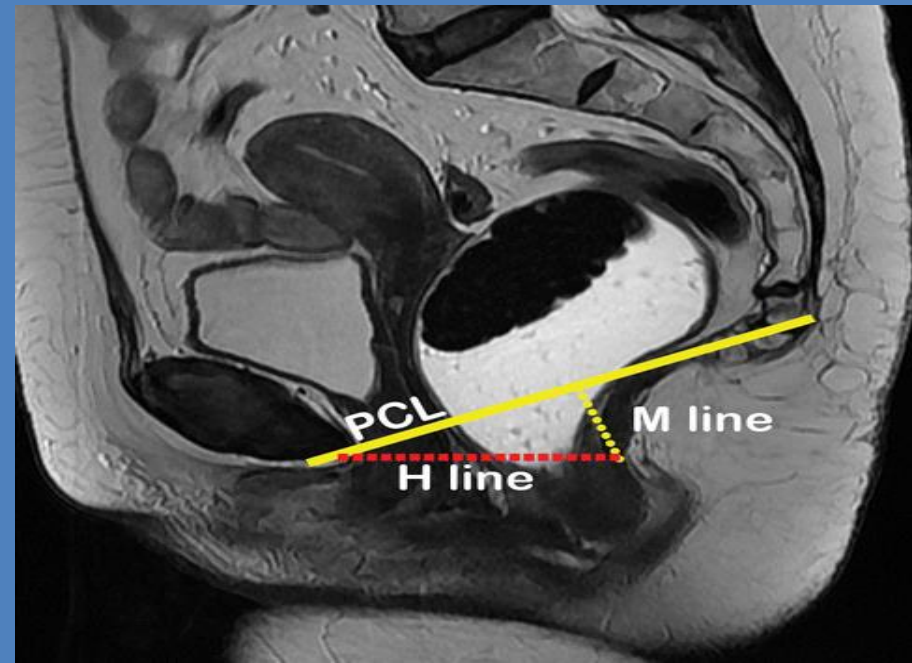
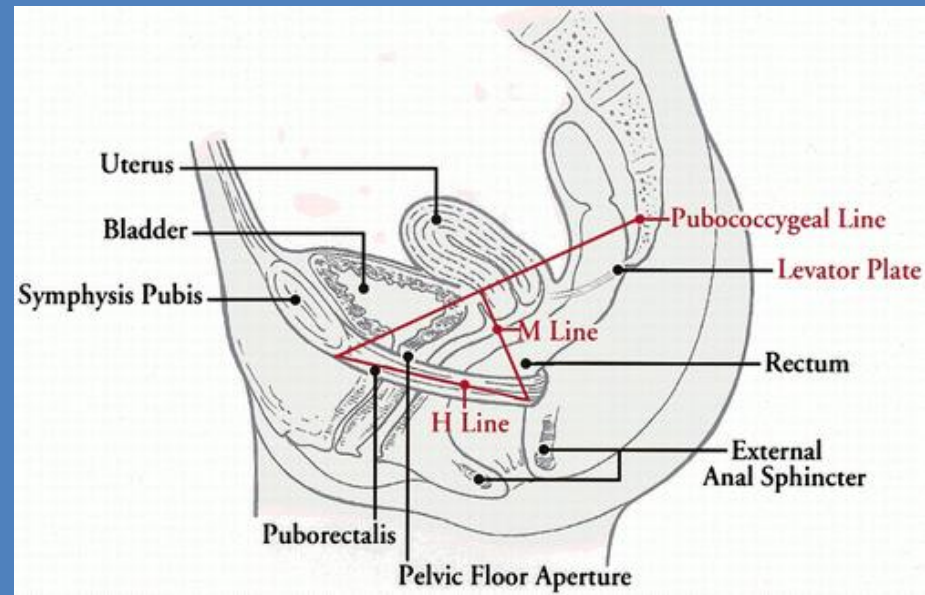
- Inferior border of pubic symphysis to last coccygeal joint.
- Level of pelvic floor.

H line-

- Inferior border of pubic symphysis to posterior wall of rectum at the level of anorectal junction.
- Ant- post width of levator hiatus.
- Max. 5 cm.

M line-

- Perpendicular from PCL to most post. Aspect of H line.
- Max. 2 cm.
- Vertical descent of levator hiatus.



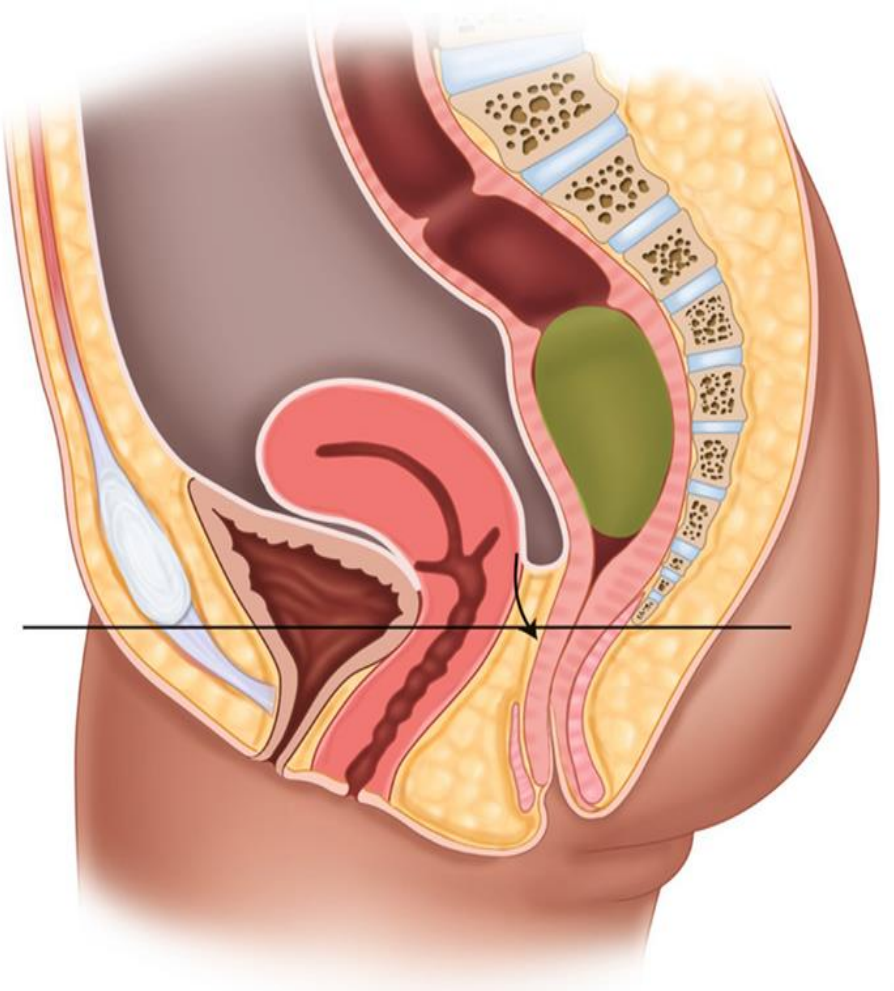
Rectocele

- <2 cm- insignificant.
- >3 cm in depth- abnormal.

Pelvic organ prolapse
quantification(POPQ)



Perineal descent



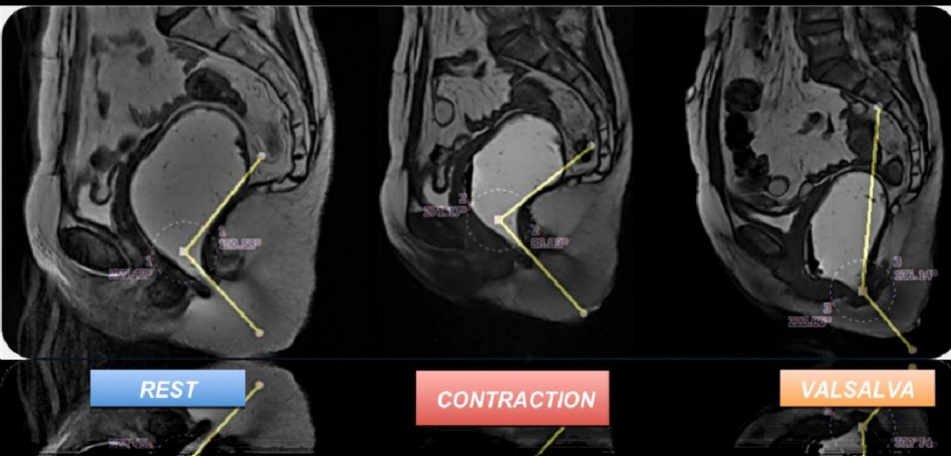
- The anorectal angle lies on a PCL.
- Descends by 2 ± 0.3 cm on straining.
 - In DPS----descends 5-6 cm from PCL.



Anorectal angle

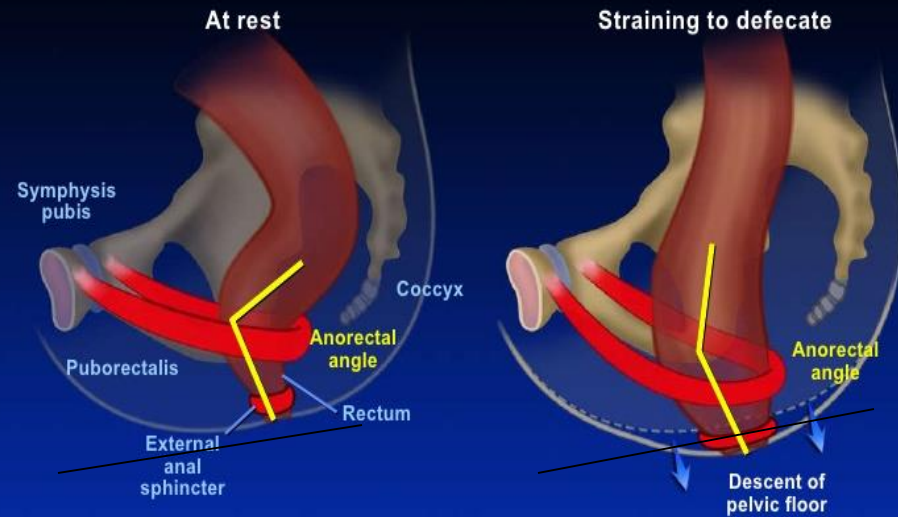
- 108-127.

Measuring the anorectal angle in the dynamic phases



Constipation

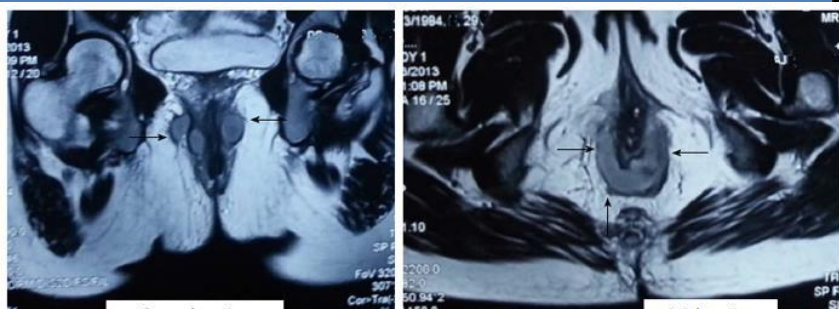
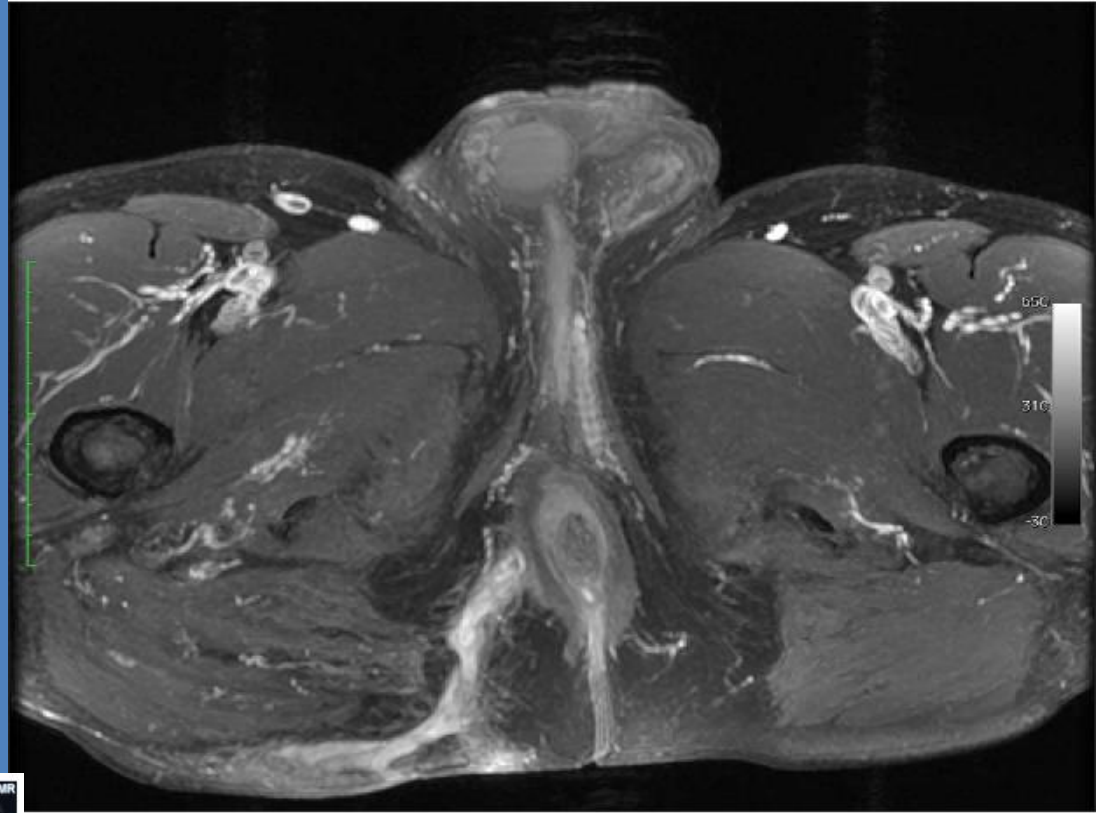
Pelvic Floor Musculature



IV-9

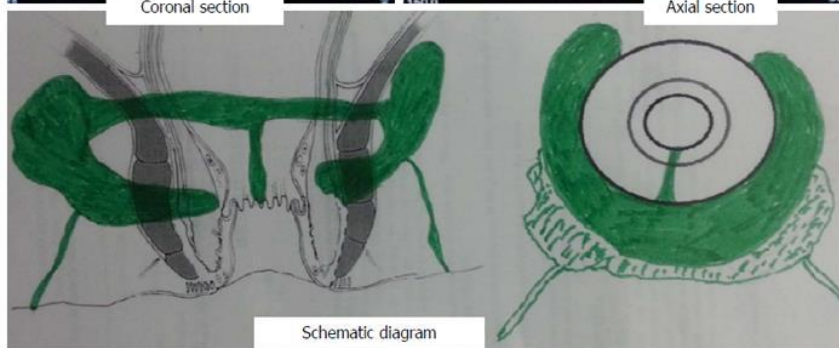
Pelvic floor dyssynergia.

MR fistulogram



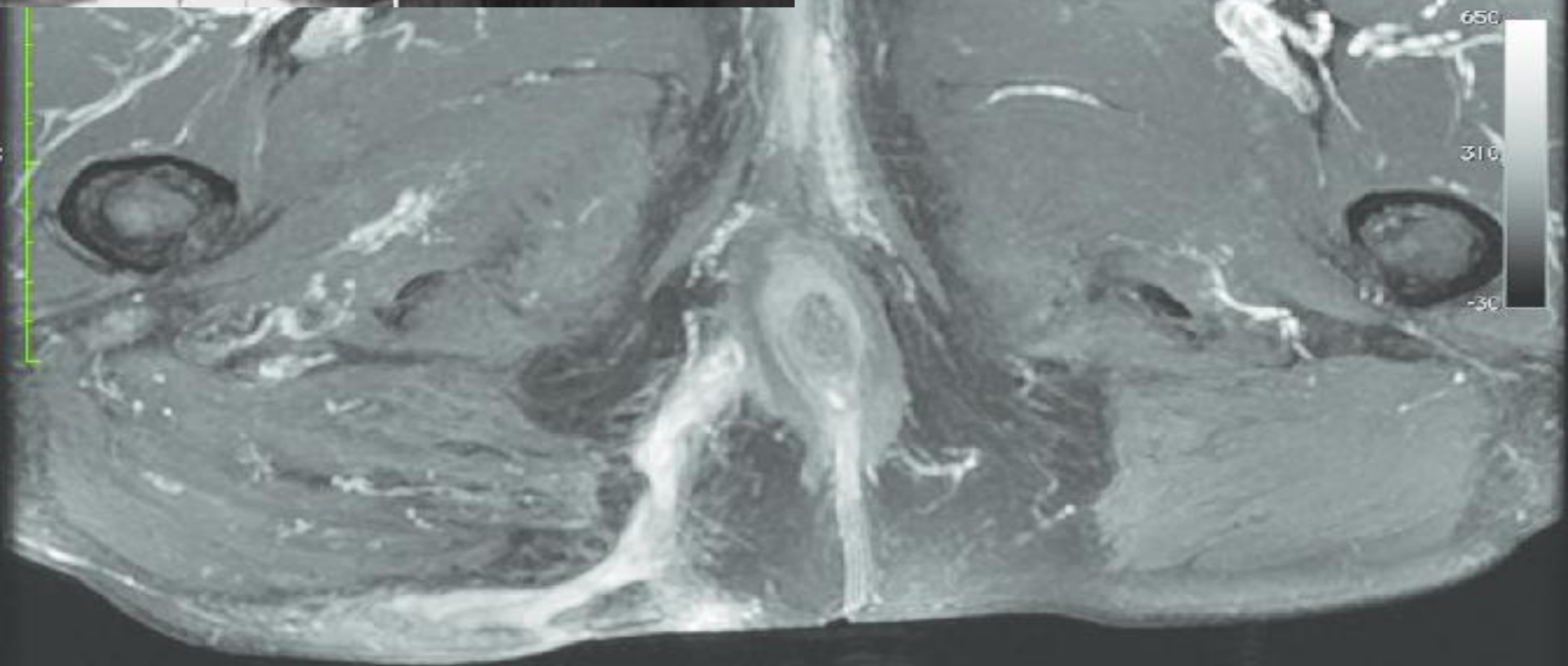
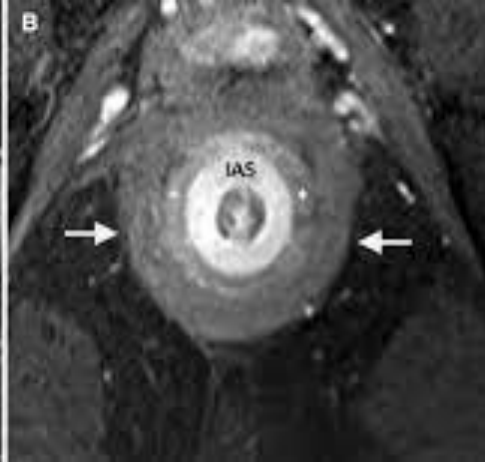
Coronal section

Axial section



Schematic diagram

- Dye- gadolinium in to the tract, covered with plaster dressing with gauze.
- High sensitivity.
 - Primary tract- 86%.
 - 2ndary tract- 91%.
 - Horseshoe extension- 97%.



EAU / MR fistulogram + EUA = 100% accuracy

Rectal anatomy

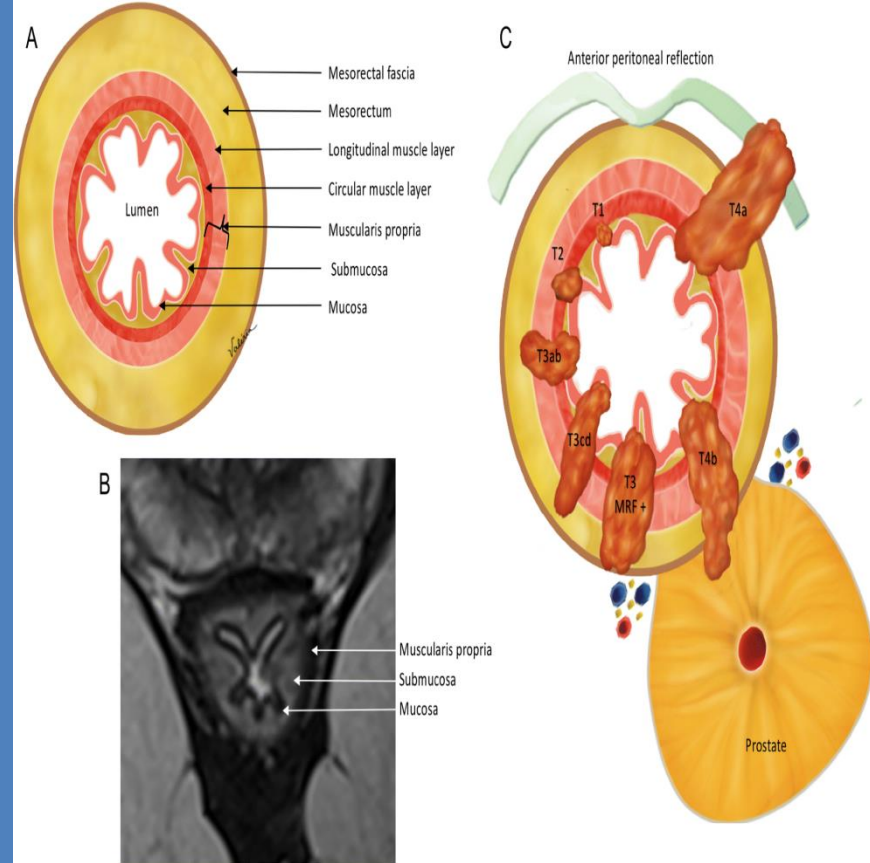
Mucosa- A fine low-signal line.

Submucosa- High signal layers.

Muscularis propria-
2 low signal layers.

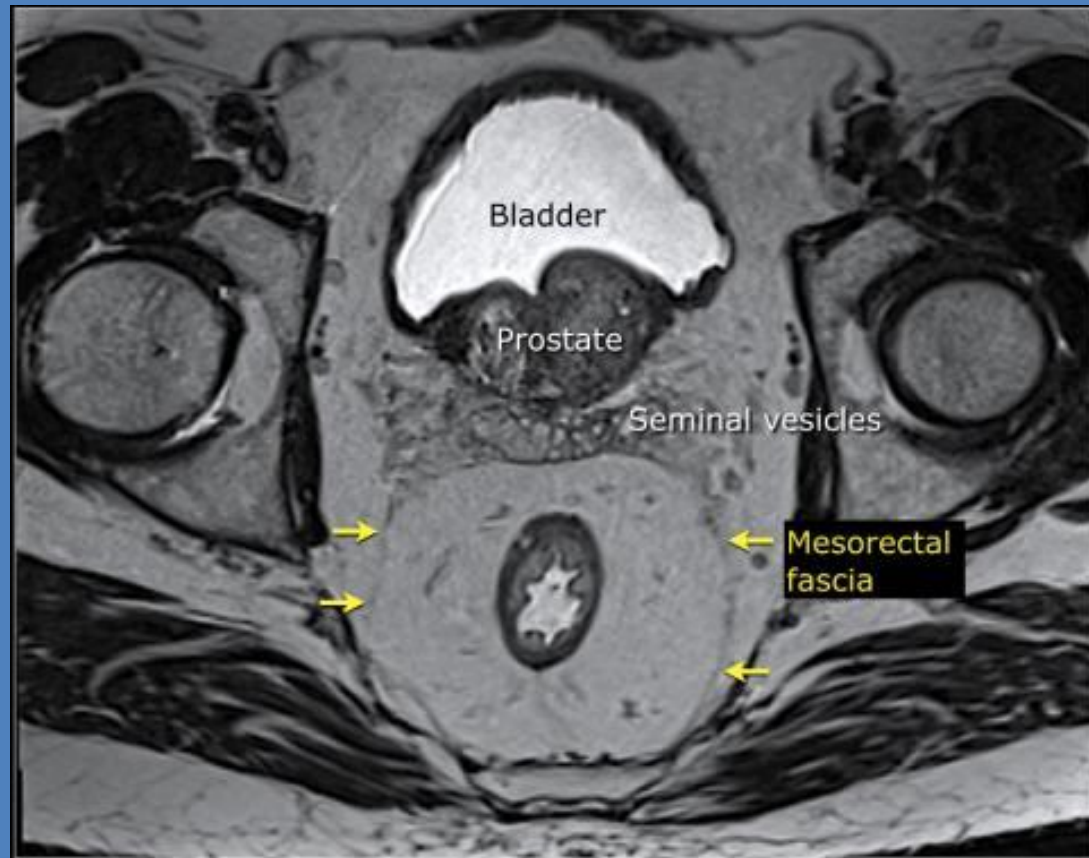
- Outer longitudinal.
- Inner circular.

Muscle- low signal intensity.



MR pelvis

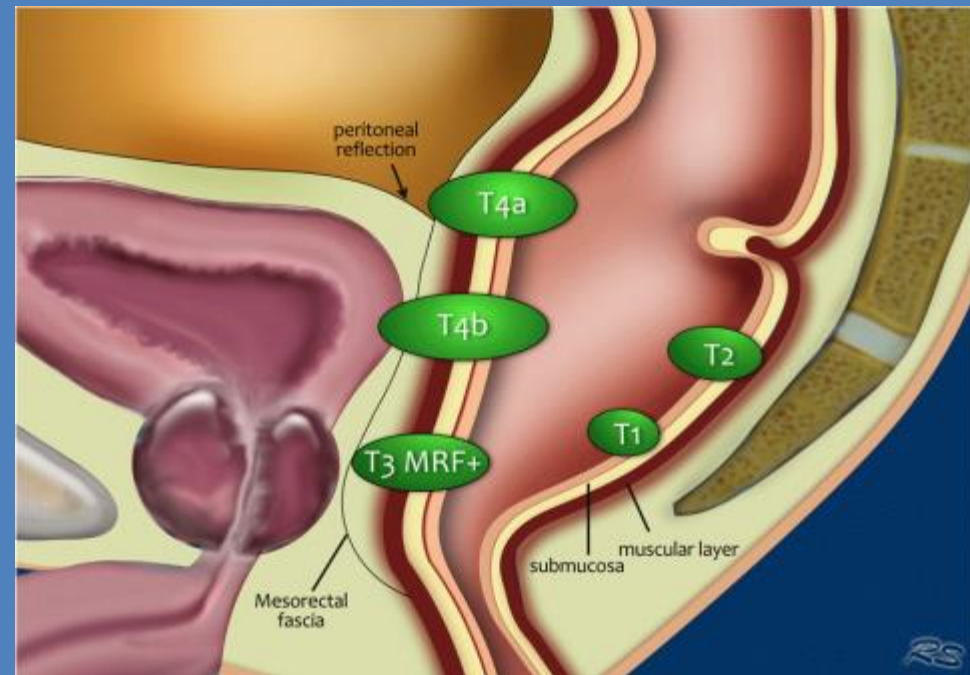
- **Mesorectal fat**- high signal intensity on both T1- and T2-weighted images.
- **Mesorectal fascia**- fine line of low signal intensity (arrows).
- **High resolution T2-images** are needed to clearly identify the MRF.



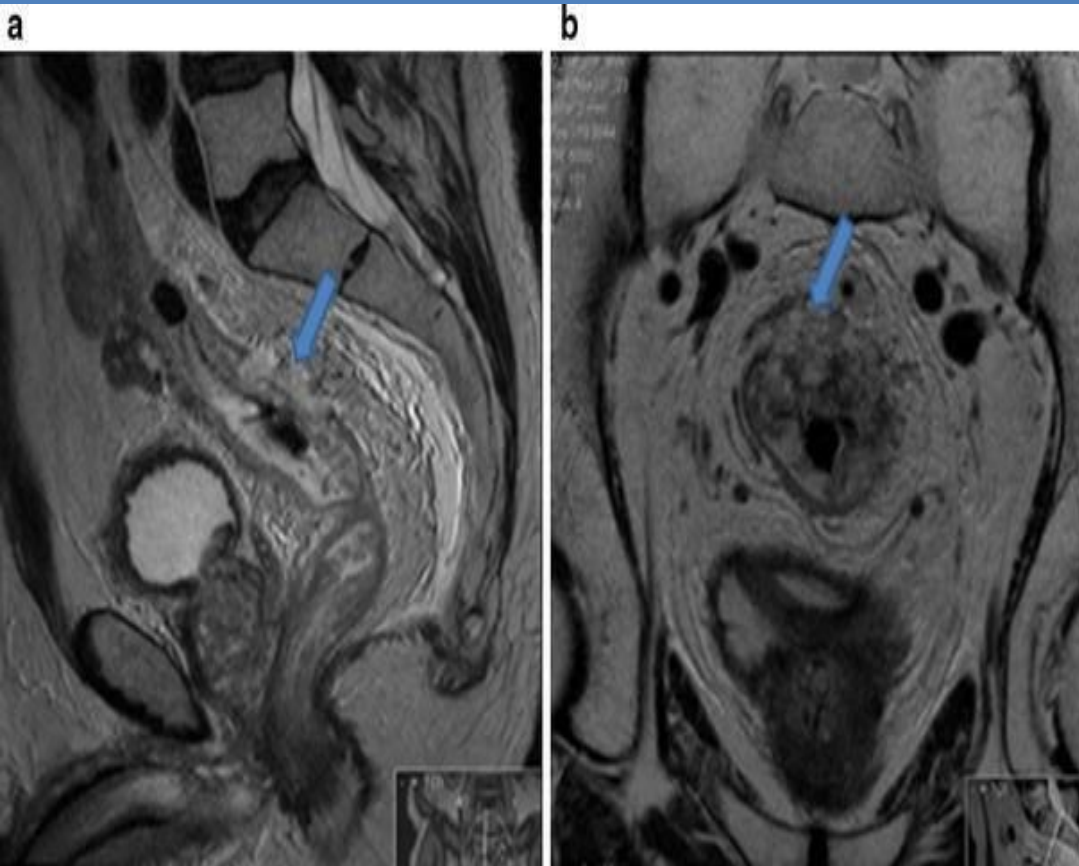
T2- fluid- white.

TNM-stage

- **T-staging**
- T1 and T2 - limited to the bowel wall.
- T3 infiltrate the mesorectal fat.
- T3a
< 1mm extension beyond muscularis propria
- T3b
1-5 mm extension beyond muscularis propria
- T3c
5 - 15 mm extension beyond muscularis propria
- T3d: > 15 mm
- T3 MRF+ tumor within 1mm of MRF
- MRF- no tumor within 1 mm of MRF
- The N-stage is based on the number of suspicious lymph nodes:
- N0 no suspicious nodes
- N1 1-3 suspicious nodes
- N2 $\geq$ 4 suspicious nodes
- [Ref: Colon and Rectum Cancer Staging- quick reference \(AJCC\)](#)

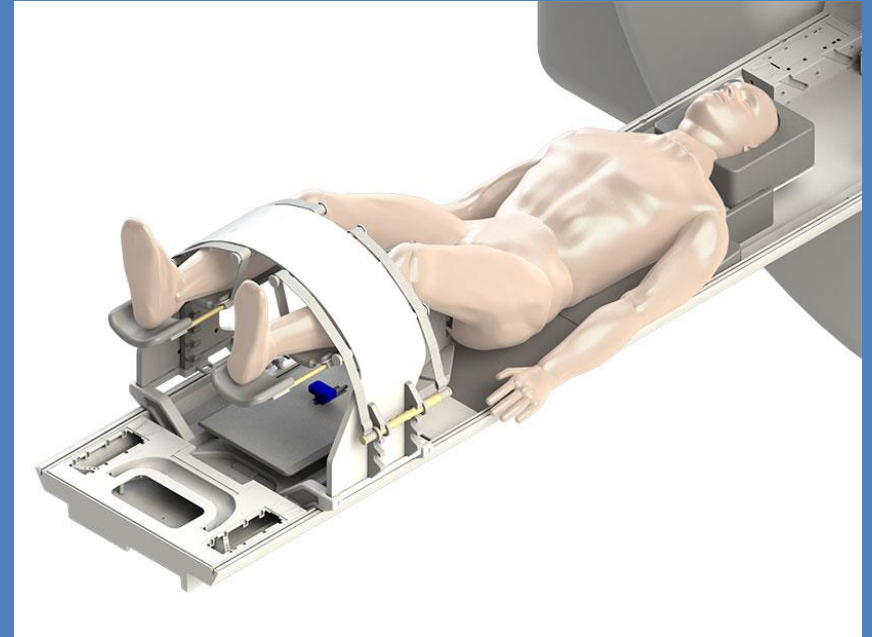
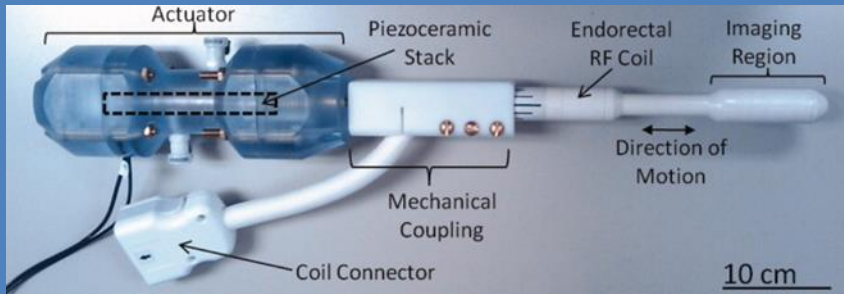


MRI in carcinoma rectum



- High resolution T2 weighted image- key.
- 3 mm axial image-
 - Stage.
 - Depth of invasion.
 - MRF, fascia,.
 - Sphincter.
 - Pelvic side wall.

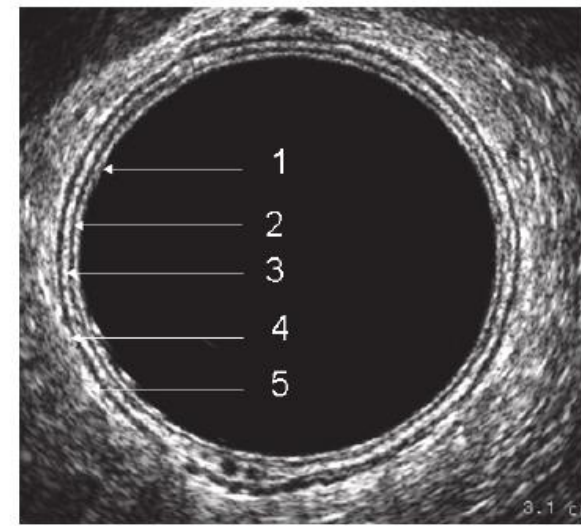
Endo Coil MRI



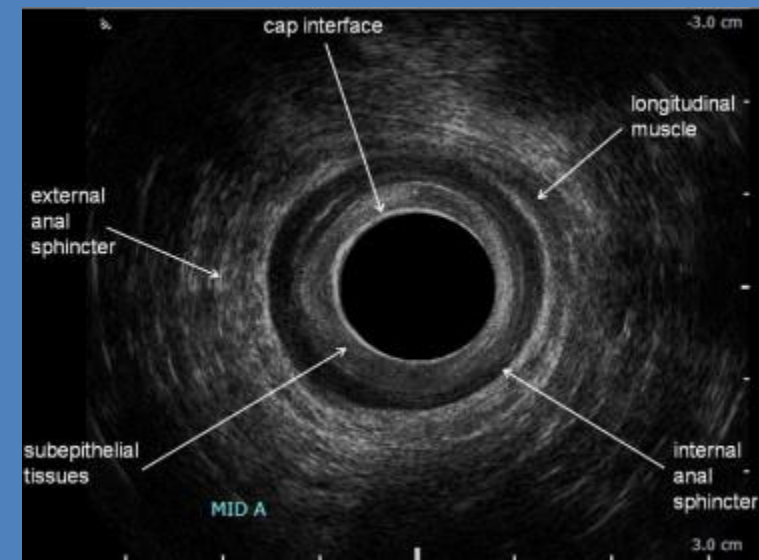
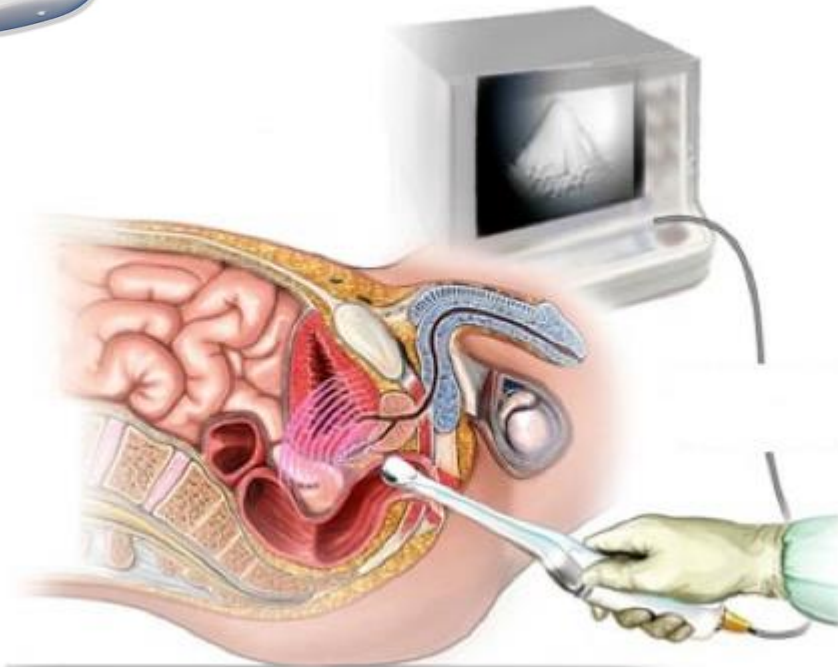
Local staging-
Early cancer



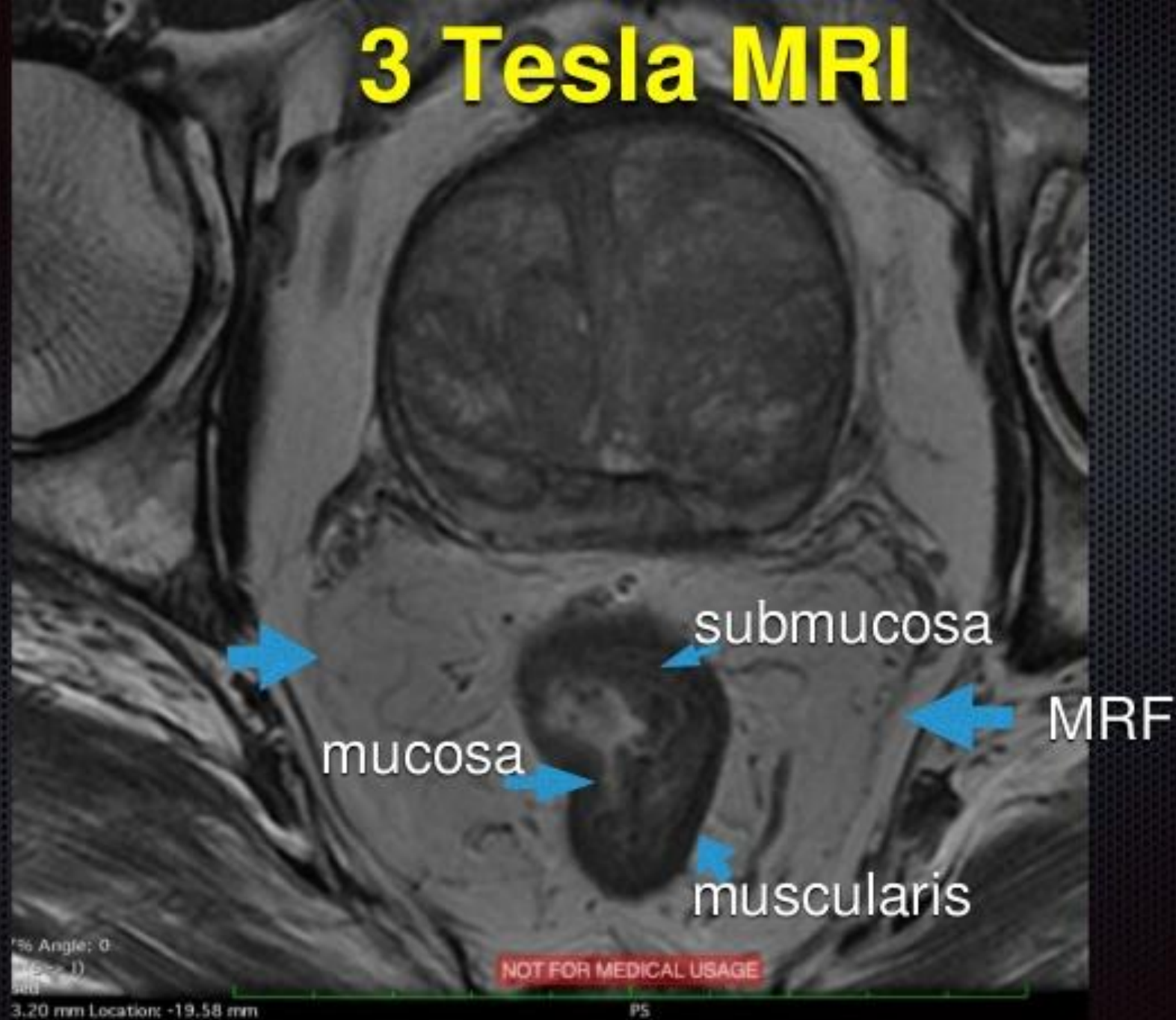
ERUS / EAUS

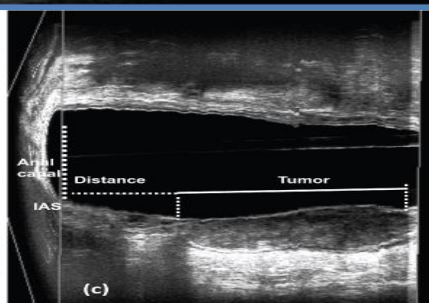
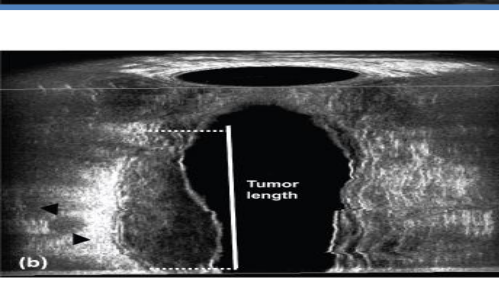
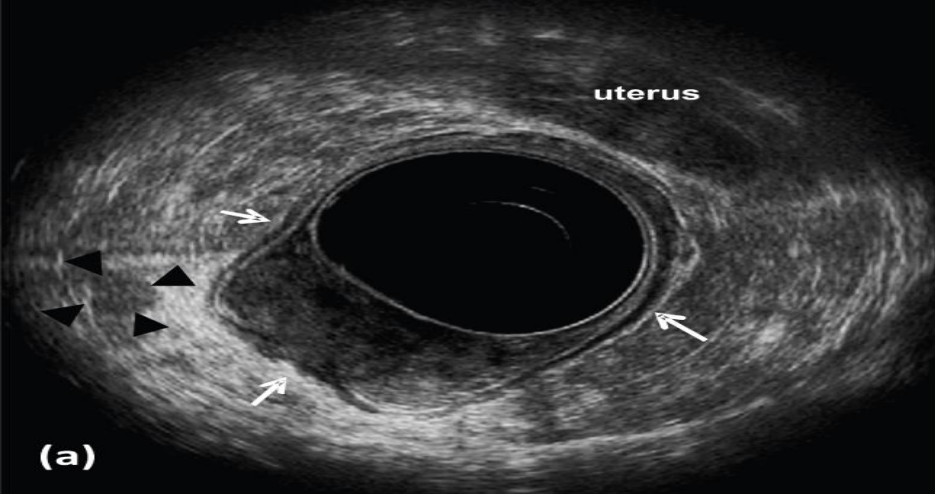


- 1: Interface, hyperechoic;
- 2: Mucosa/Muscularis M., hypoechoic
- 3: Submucosa, hyperechoic;
- 4: Muscularis propria, hypoechoic
- 5: Perirectal Fat/ Serosa, hyperechoic



3 Tesla MRI





	ERUS	MRI
T stage	71-90%	54-81%
N stage(perirectal LN)	61-80%	41-55%

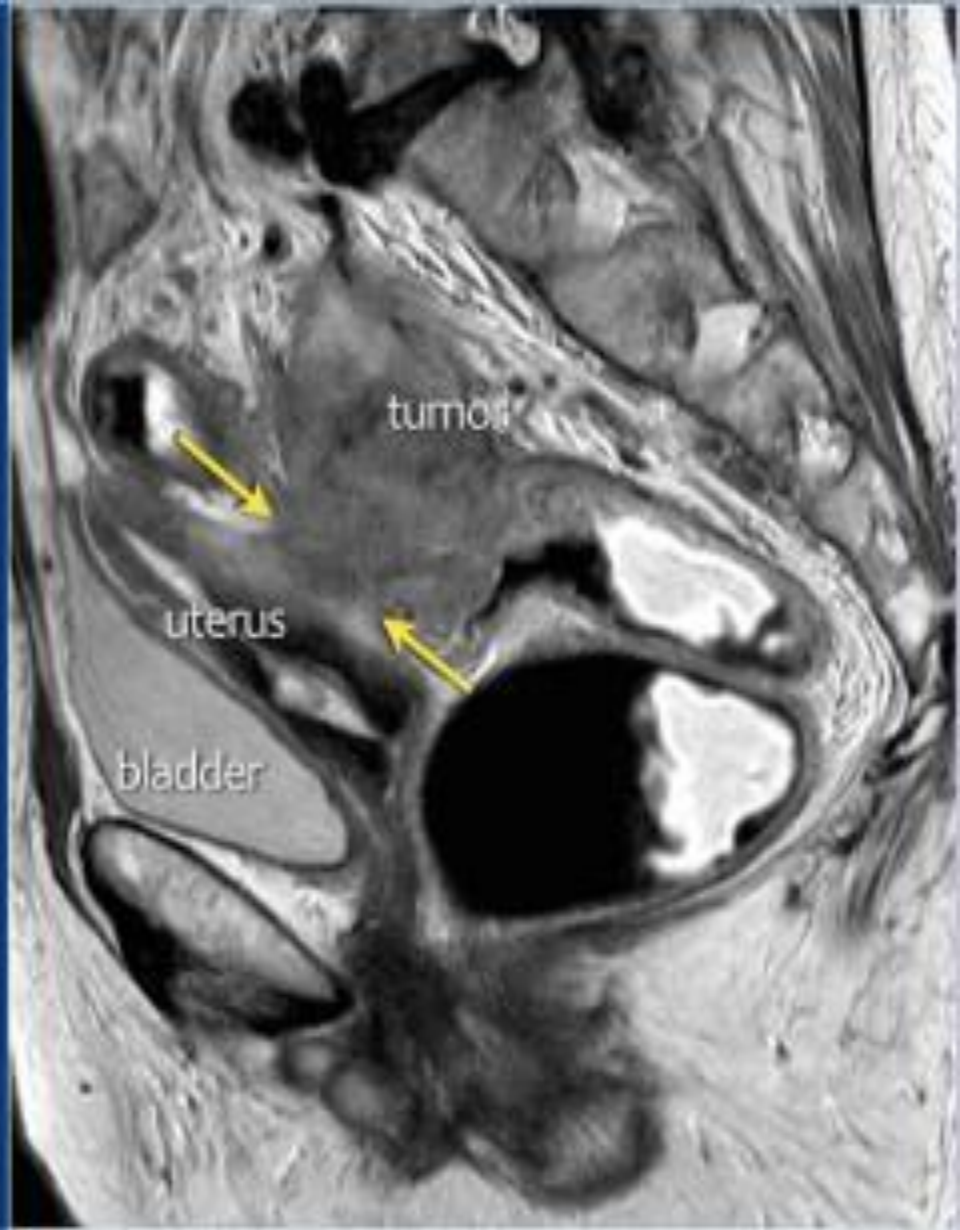
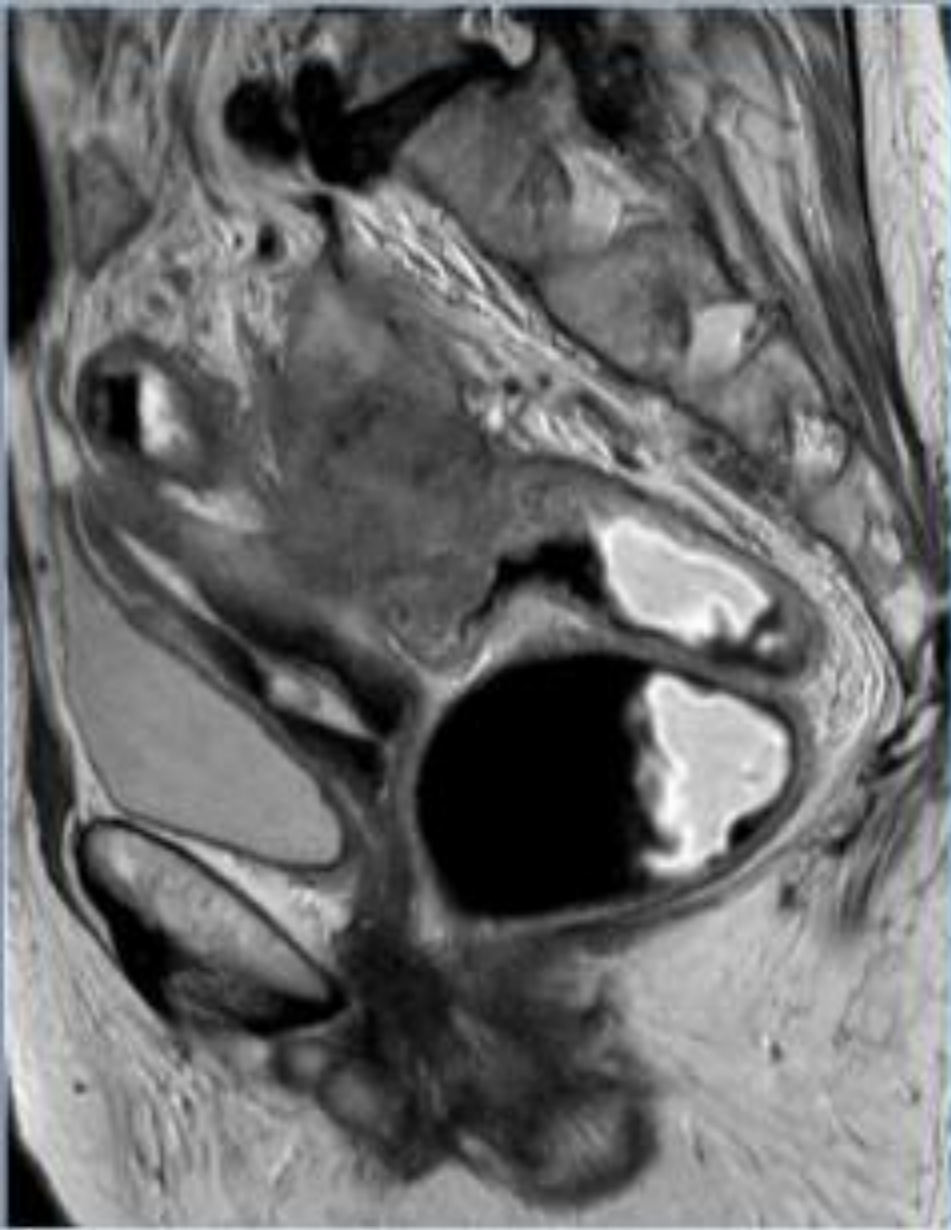
MRI is as accurate as ERUS in diff. T1 & T2 lesion.

ERUS- unable to ascertain pelvic or groin LN.

Metastatic LN-

- T1- 5-10%
- T2- 10-20%
- T3--30-50%.

Stage shift phenomena.



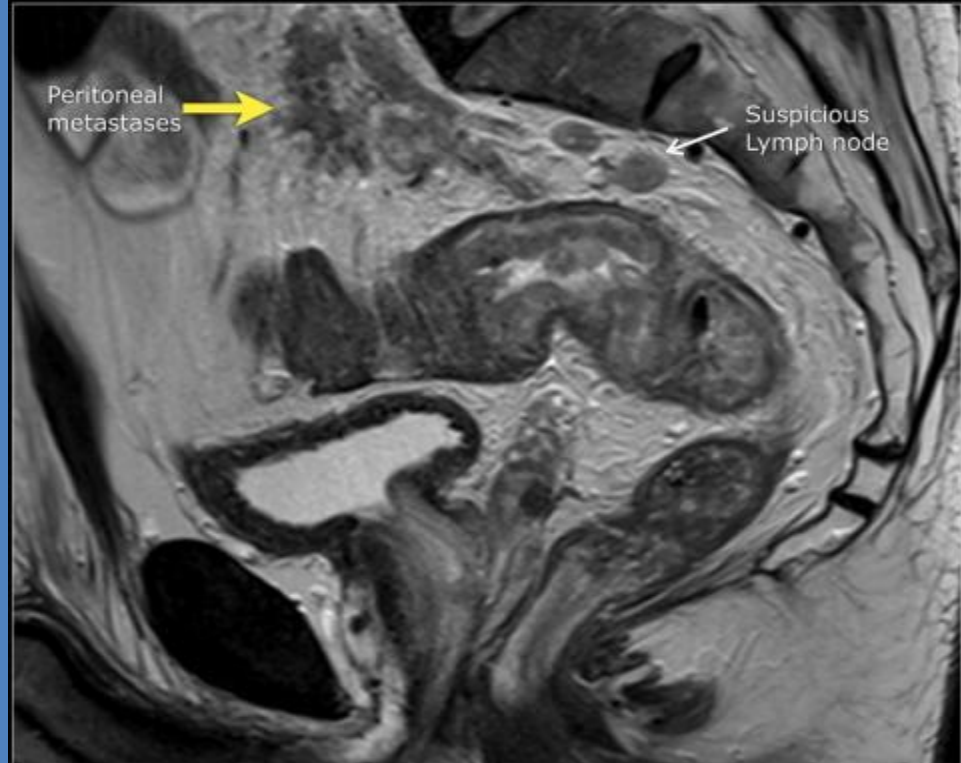
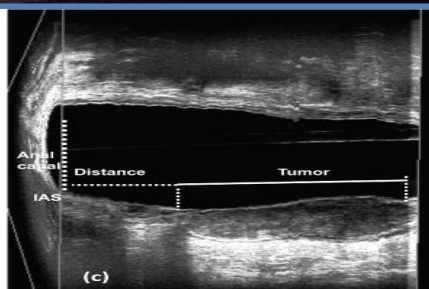
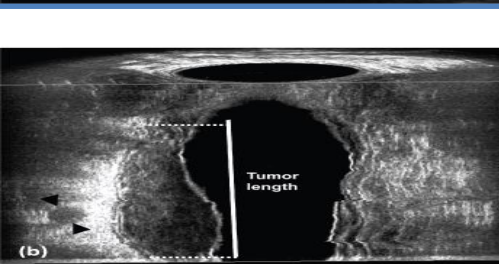
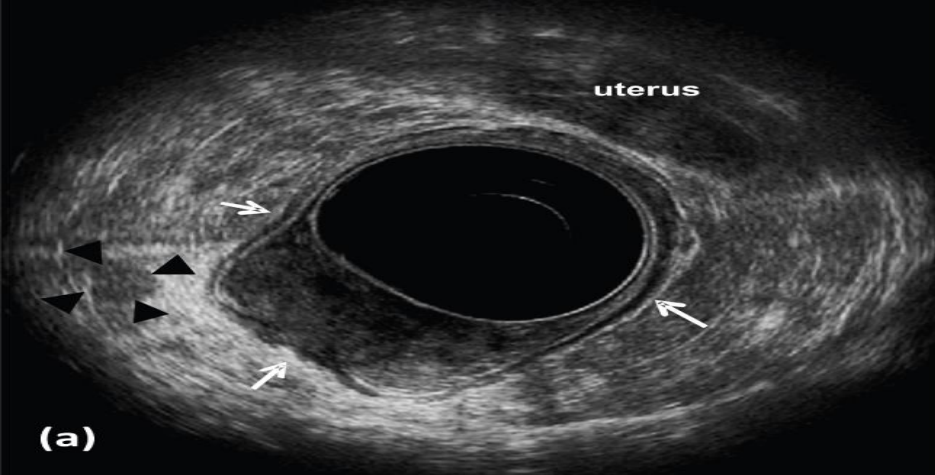
Tumor extending into the posterior wall of the uterus.

LN stage

Depends upon-

- Size of LN.
- Border contour.
- Signal intensity.

N-stage - suspicious nodes			
	Indistinct	Heterogeneous	Round
Malignant characteristics			
Short axis	- < 5mm : needs 3 malignant characteristics - 5 -9mm : needs 2 malignant characteristic - > 9mm : always suspicious		
cN-stage	- N0 : no suspicious lymph nodes - N1 : 1-3 suspicious lymph nodes - N2 : $\geq$ 4 suspicious lymph nodes		



ERUS	MRI
Hypoechoeic.	Hypointense.
>5 mm.	>5 mm.
Usually round.	Usually round.
Same echogenicity with tumor.	Same intensity with tumor.
At same quadrant of malignancy.	At same quadrant of malignancy.

CRM better delineated by MRI.

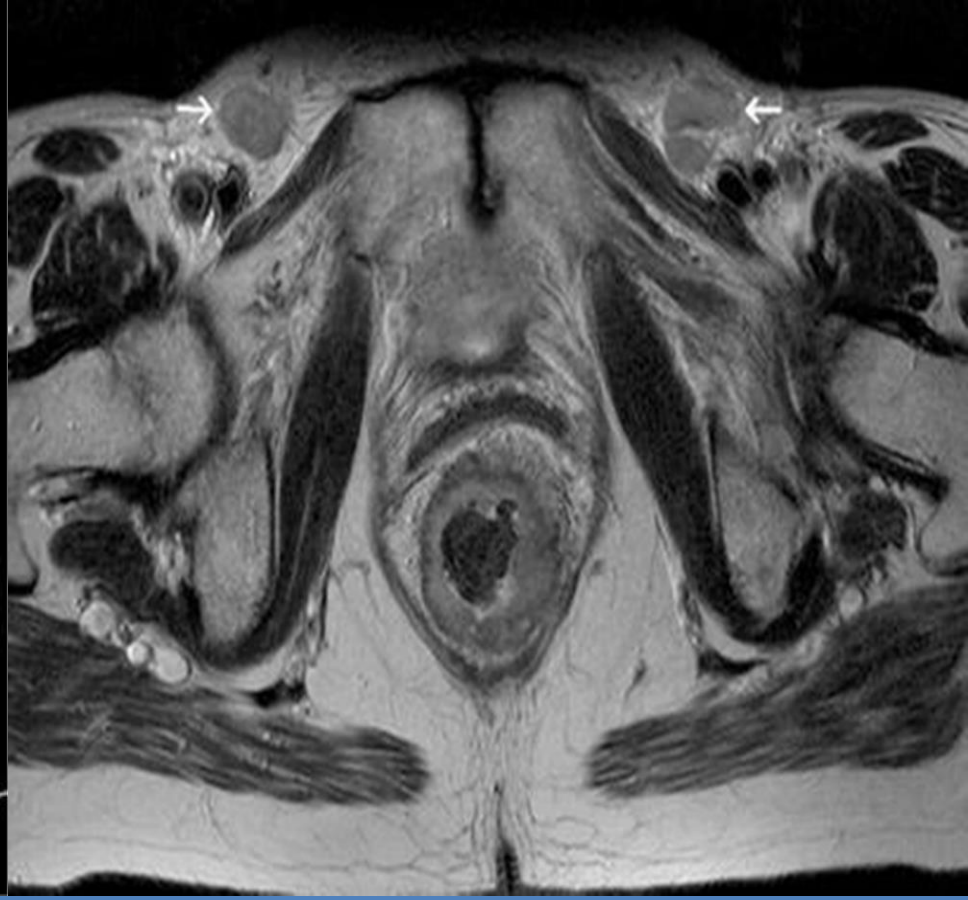


CT scan

Central fluid density (necrosis).

>1 cm in short axis.

+ / - round shape.

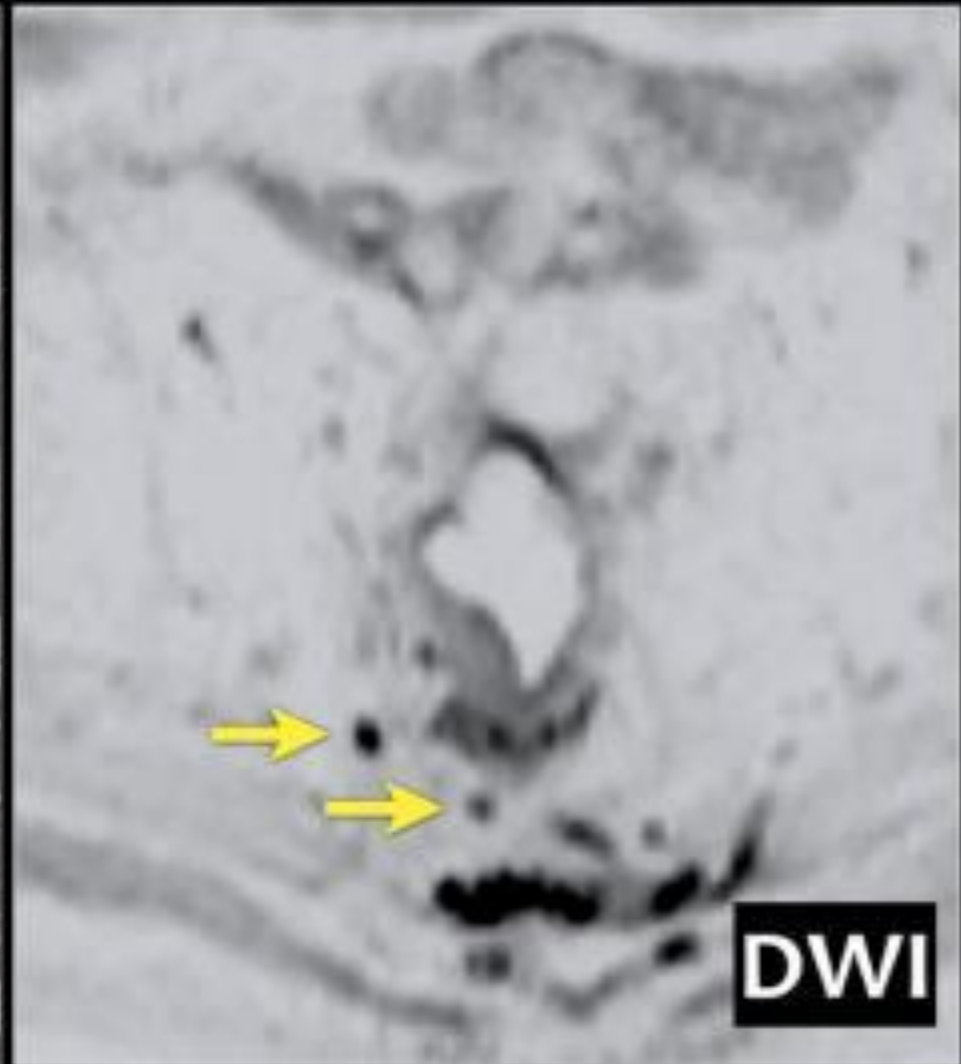
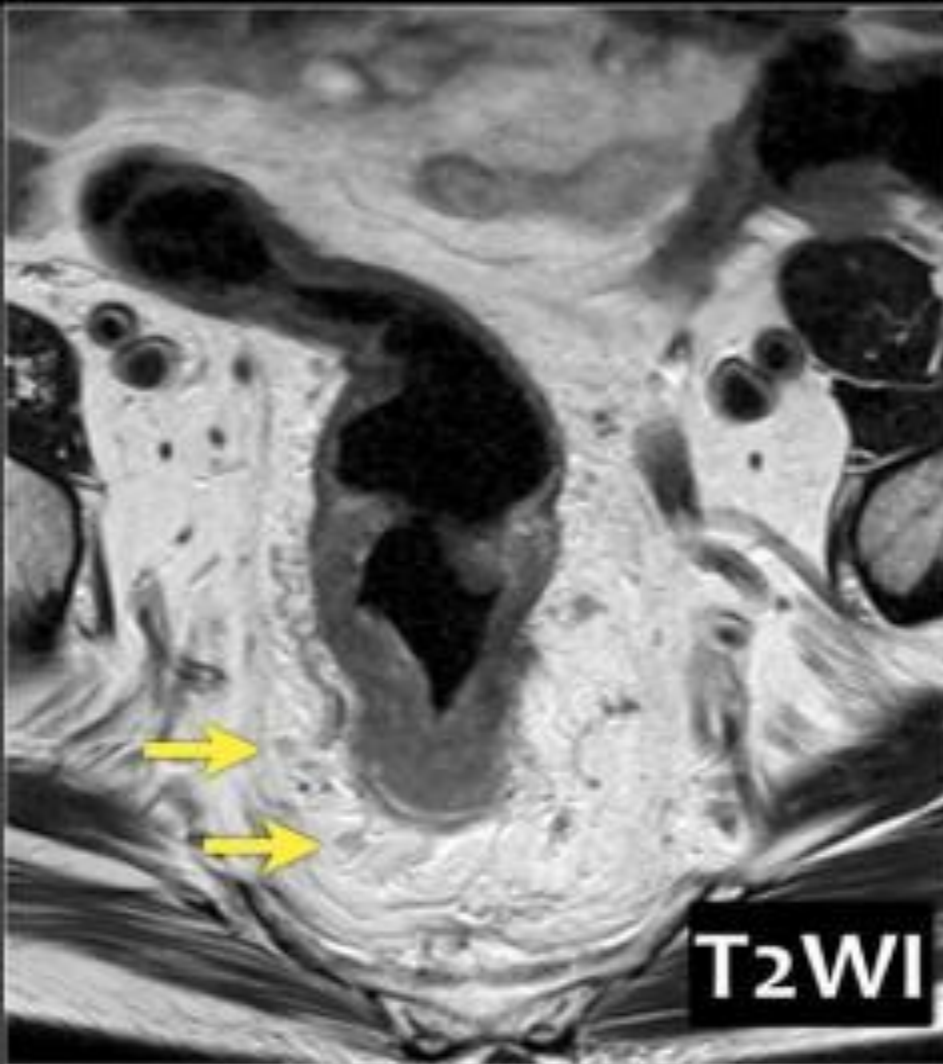


MRI

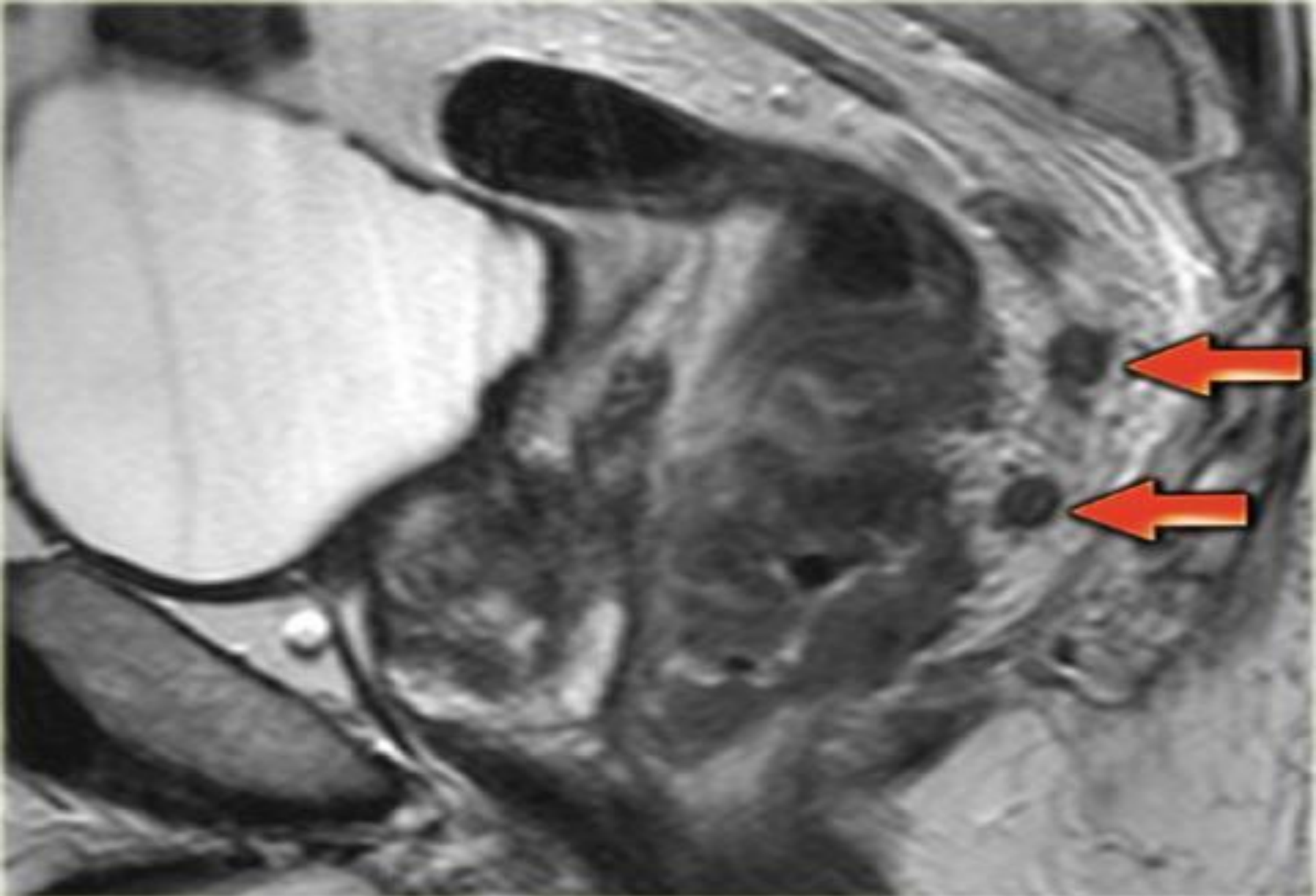
Hypointense.

>5 mm with ma. characteristics.

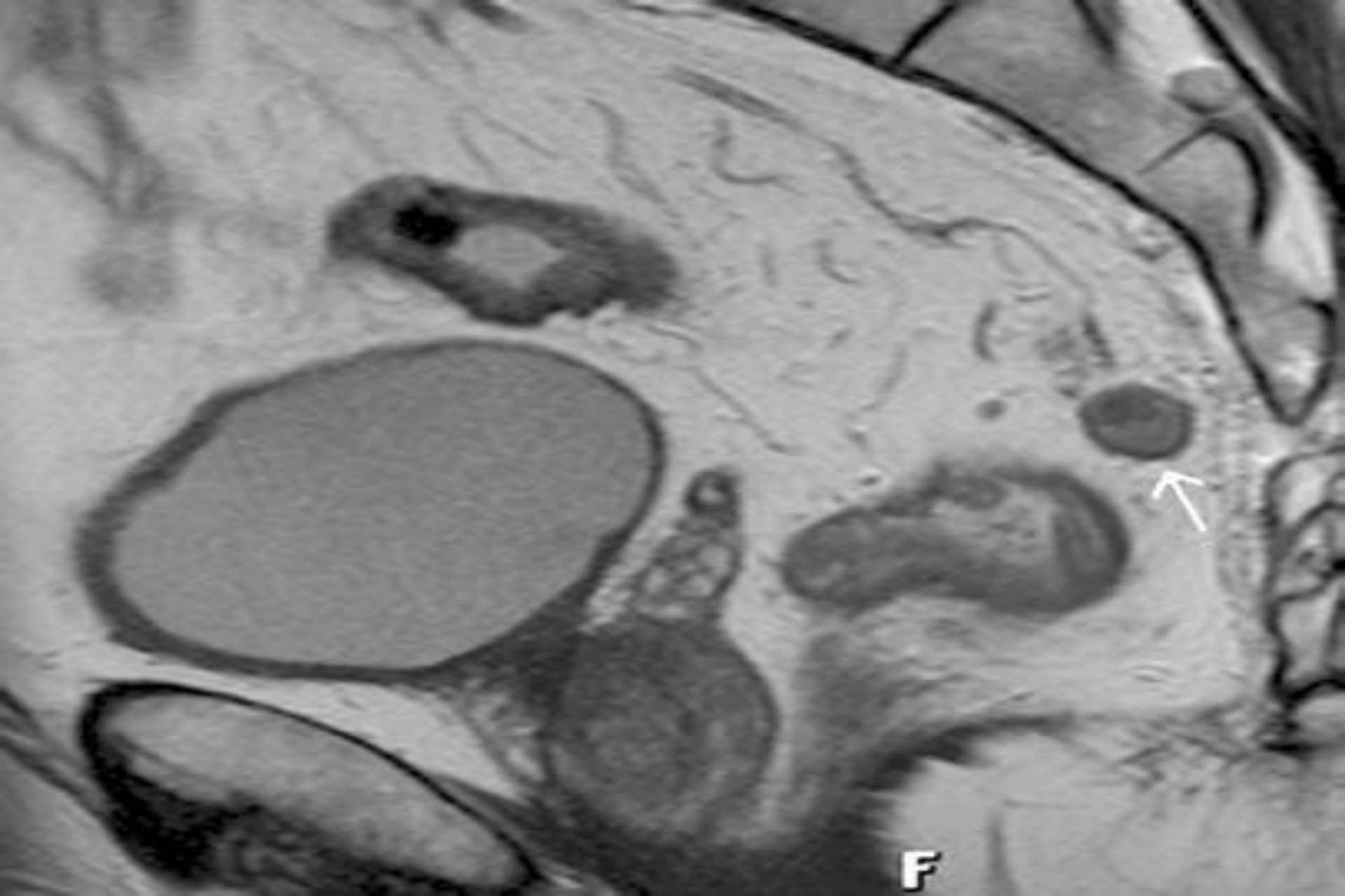
Usually round.



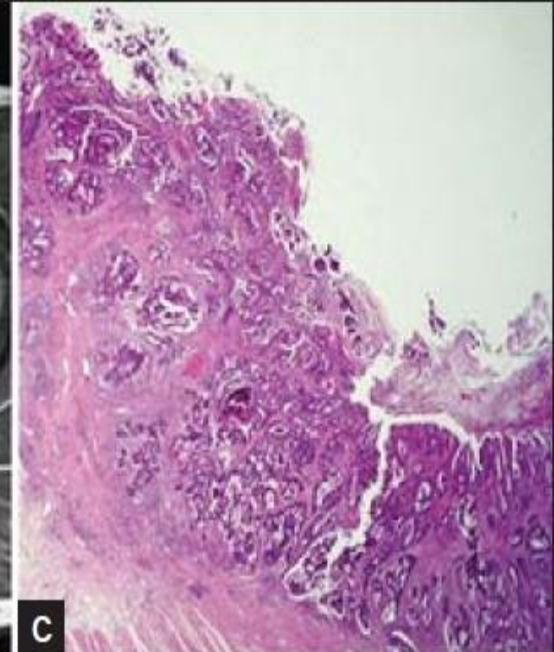
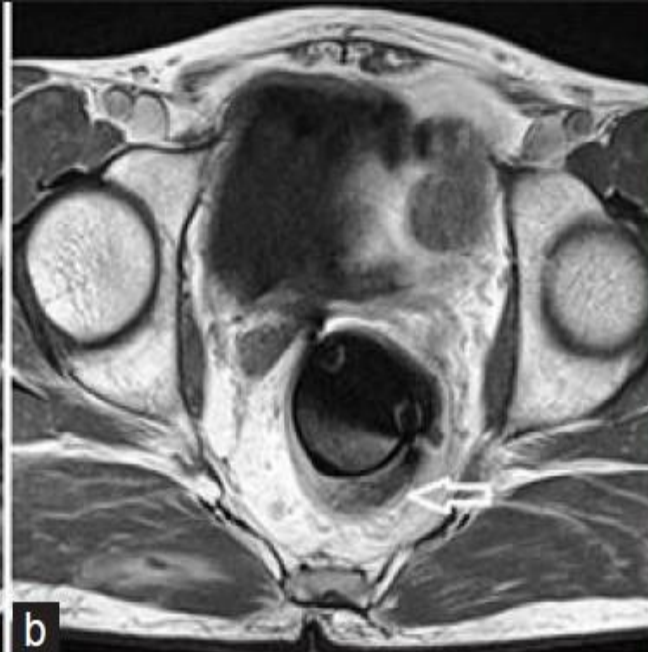
	T2WI	DWI
LN detection	less	more
Size	More helpful.	Less.
Morphology	More helpful.	Less.



On this sagittal T2W-image a low rectal cancer with multiple nodes in the mesorectal fat on the posterior side.



Sagittal T2-weighted FSE- enlarged mesorectal LN shows heterogenous signal intensity indicating tumor invasion.

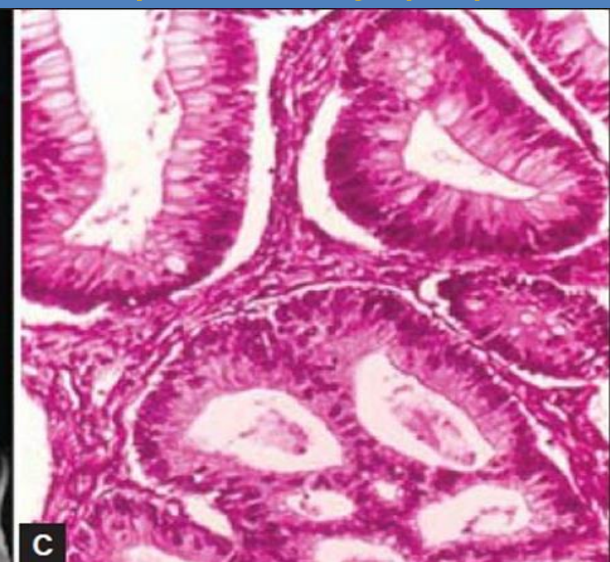
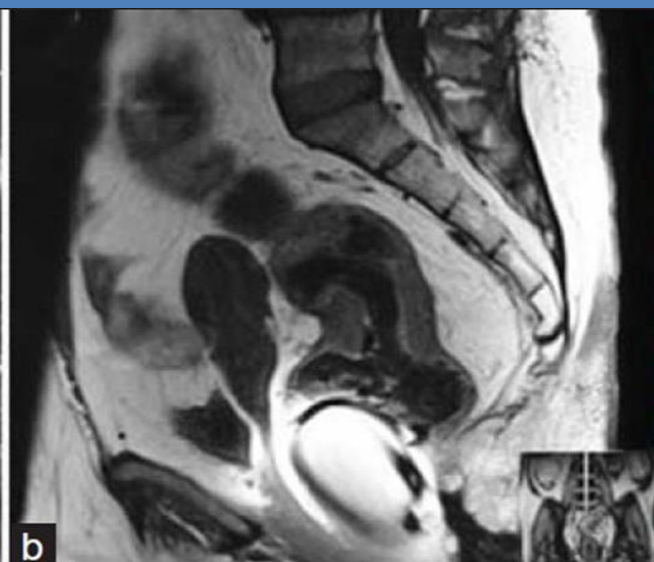
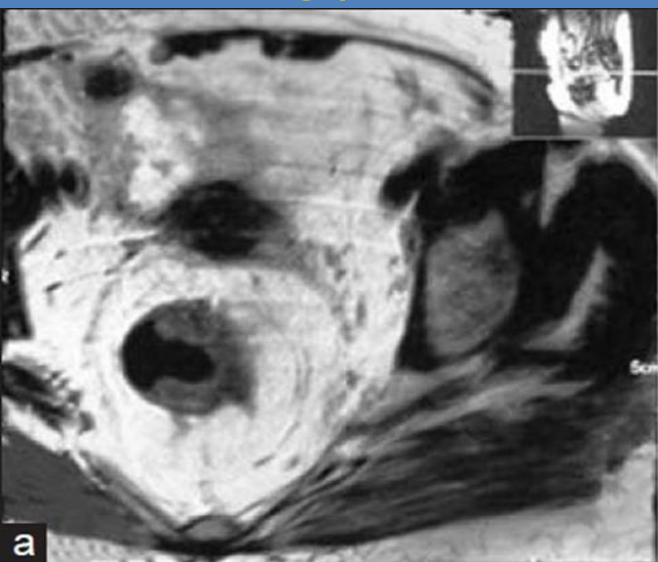


a

b

c

Lesion along posterior wall of rectum with infiltration of MRF posteriorly (T3).

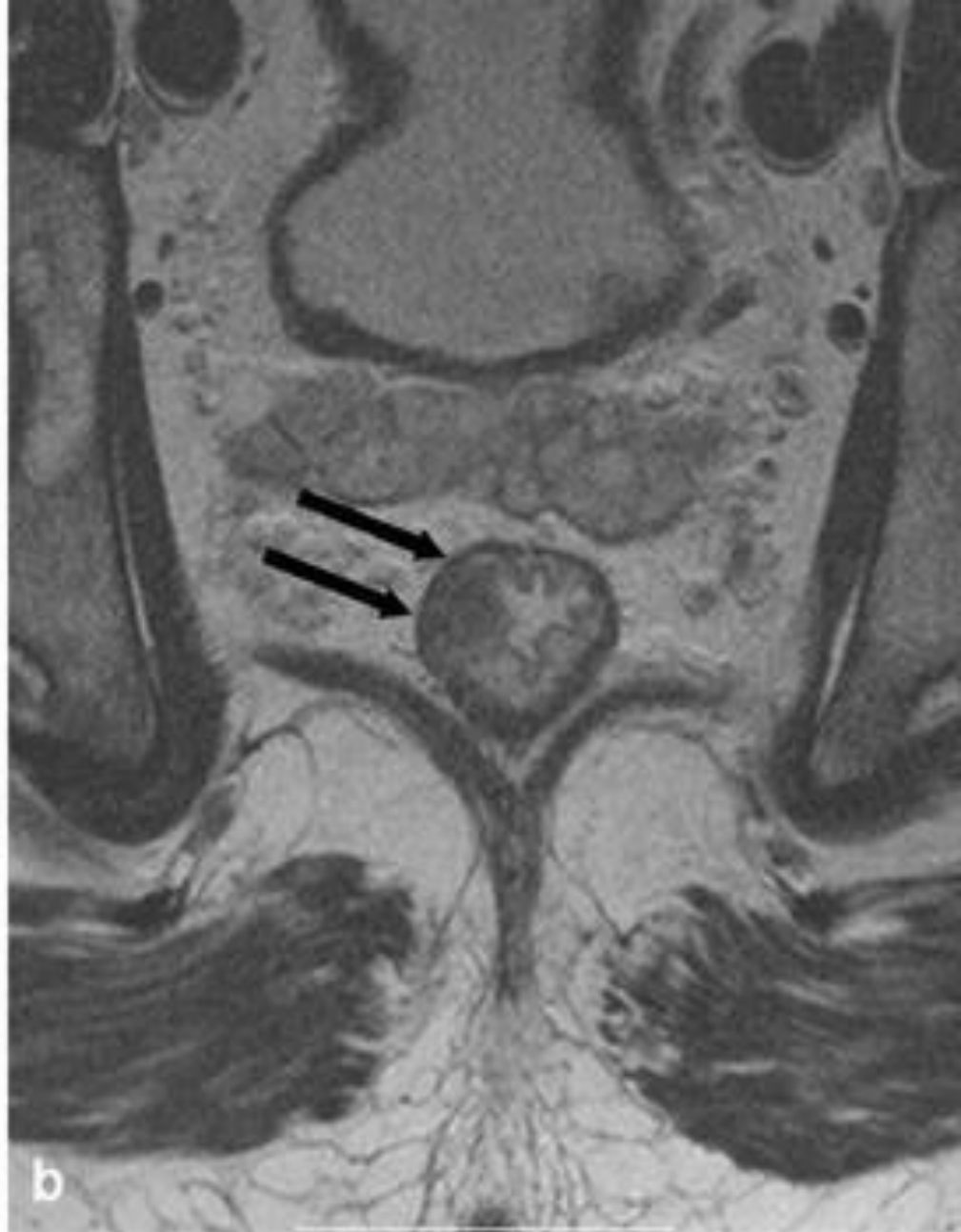


a

b

c

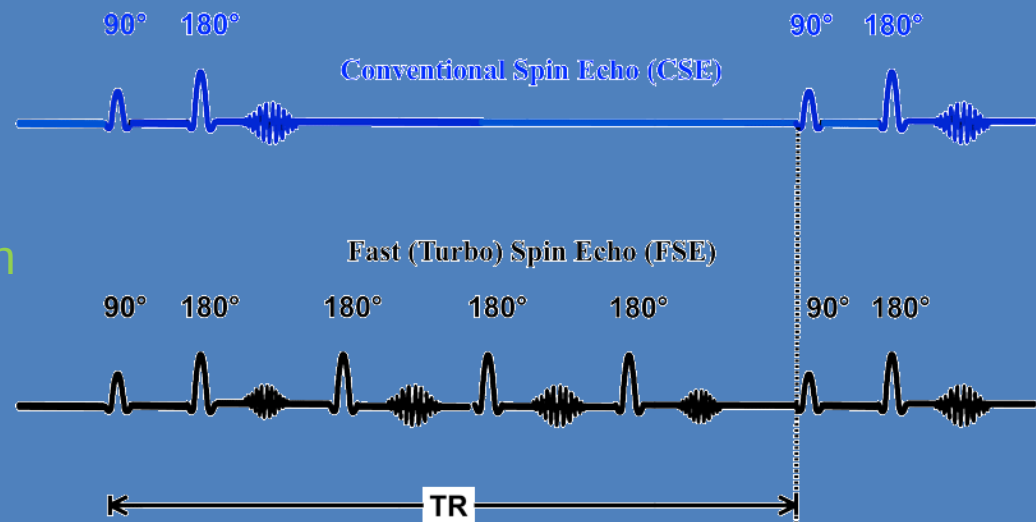
ECMRI-a. axial. B. sagittal view- circumferential rectal growth with no perirectal fat stranding (T2) and no perirectal lymphadenopathy (N0).

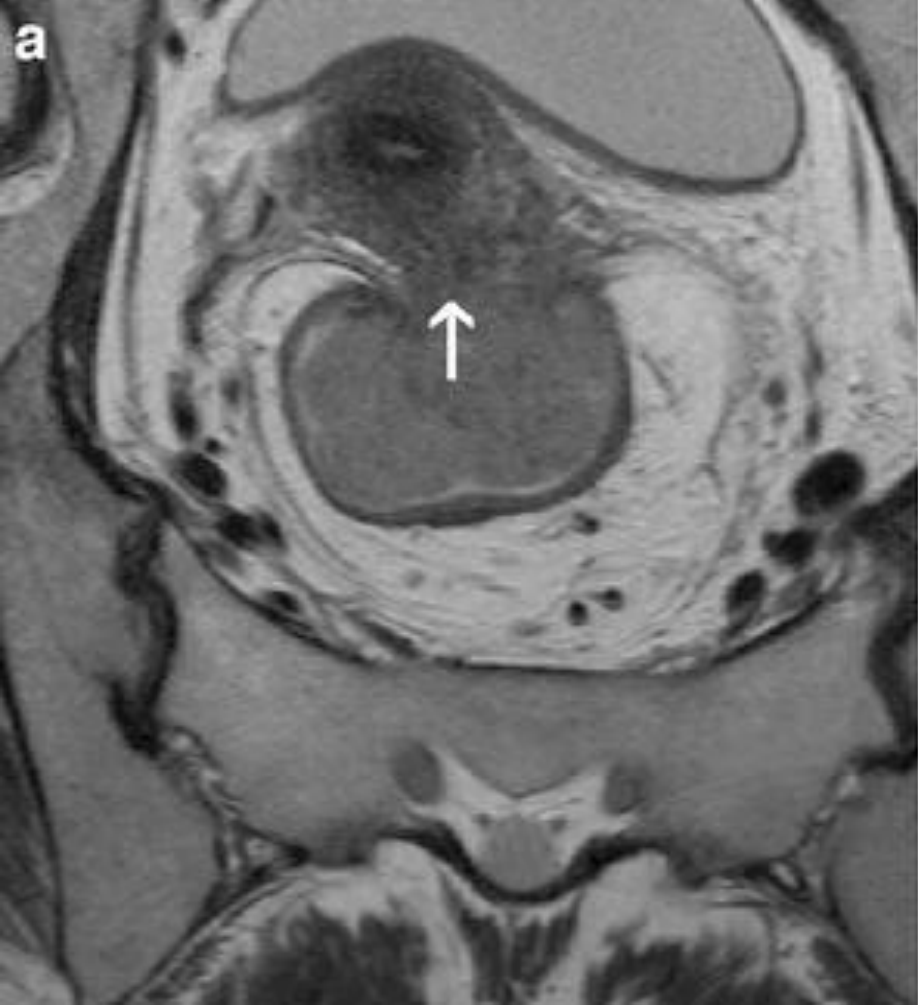


a. A small tumour (*arrow*). b. High-resolution TSE image (*black arrow*) T1 tumor.

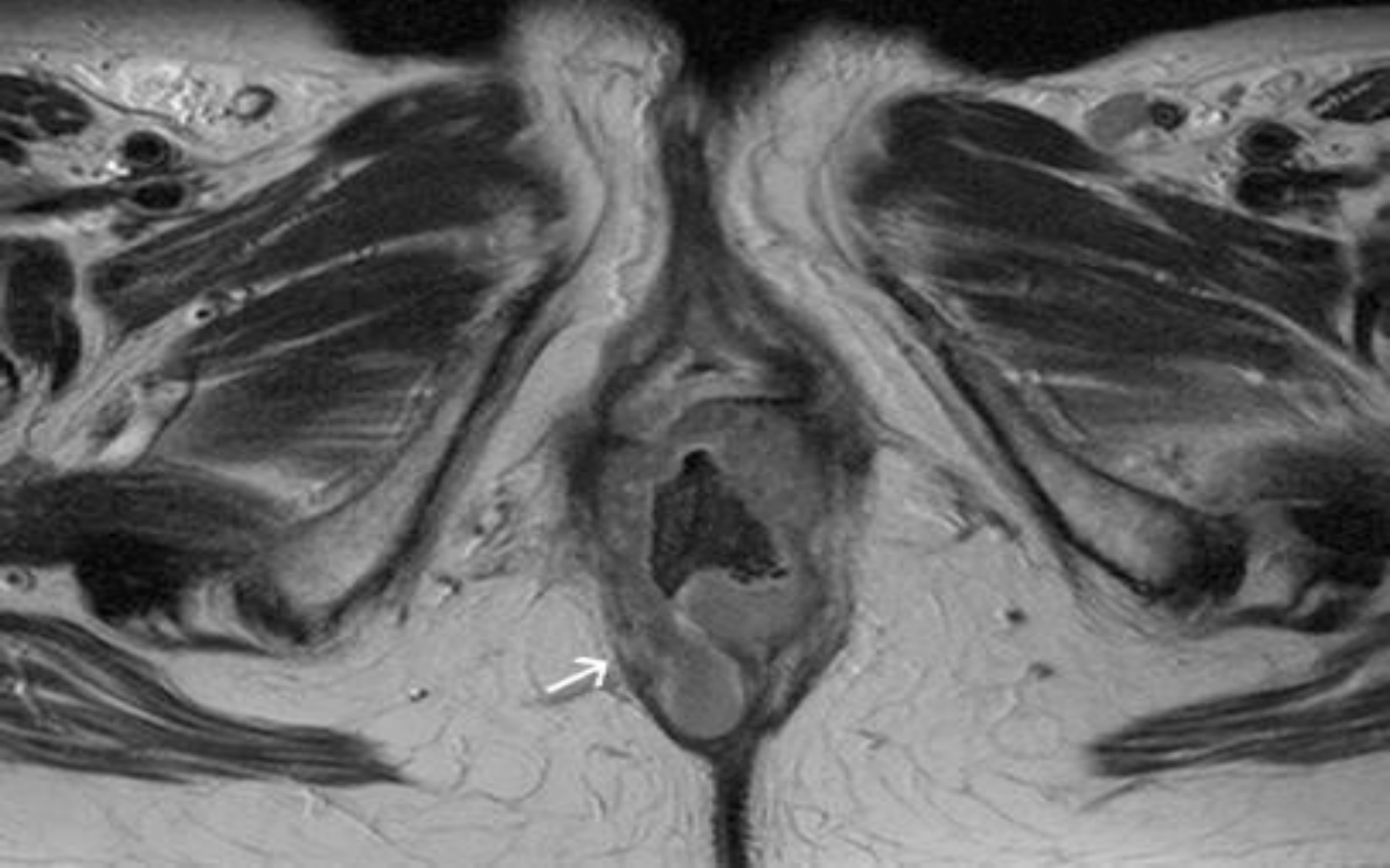
Fast spin echo (FSE) / Turbo spin echo (TSE)-

- RARE (Rapid Acquisition with Relaxation Enhancement) technique.
- Described by Hennig et al in 1986.
- Used in modern MR imaging.

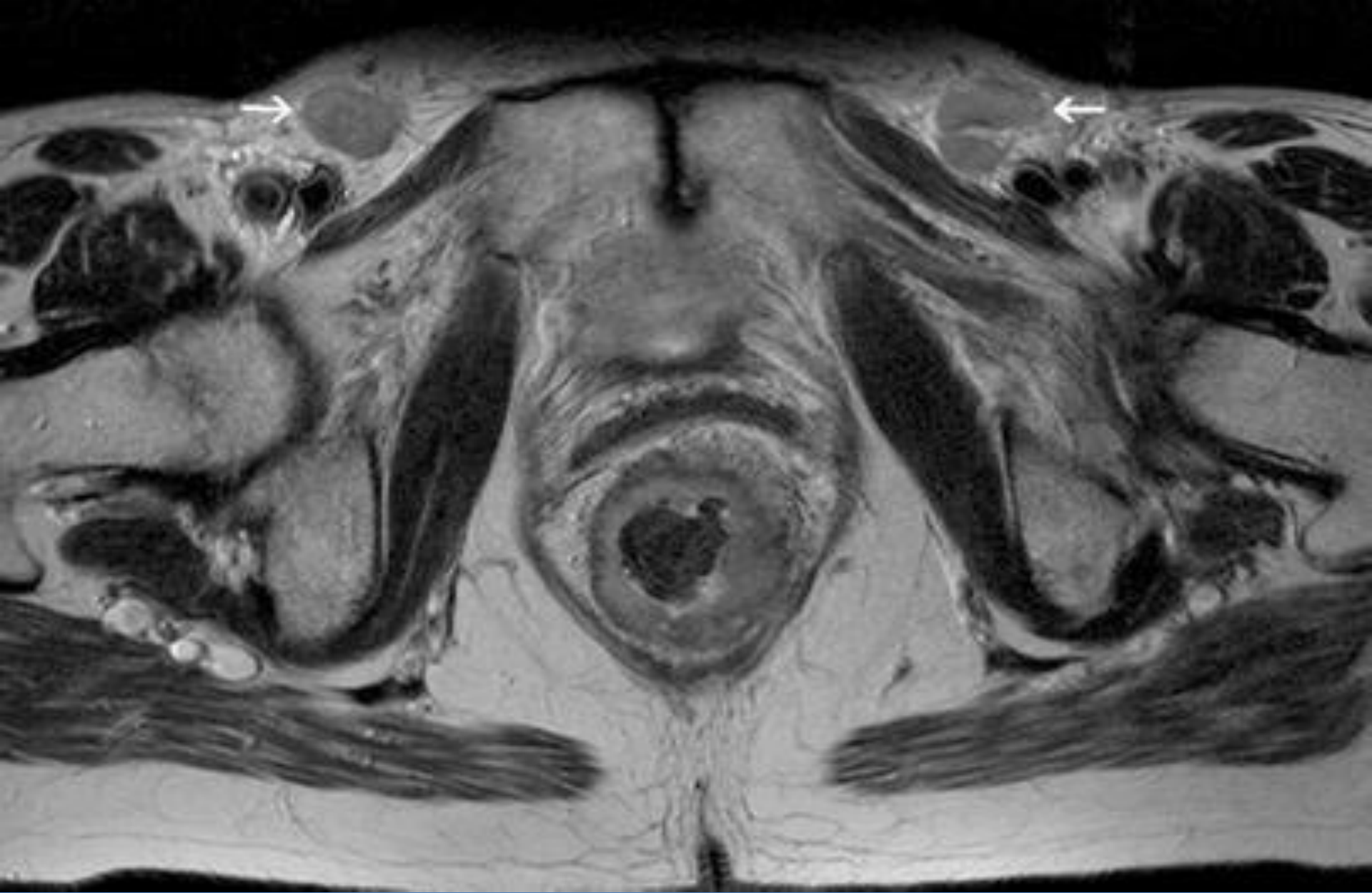




- Paraxial T2-weighted FSE (TSE) sequence and **b** sagittal T2-weighted FSE (TSE) sequence of a T4 cancer located in the upper third of the rectum invading the uterus (*arrows*)



Paraxial T2-weighted FSE (TSE) sequence of a low T4 rectal cancer with infiltration of the levator ani muscle (*arrow*)



Axial T2-weighted FSE (TSE) sequence. **Inguinal LN** metastases (*arrows*) in a patient with low rectal cancer



Thank You

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