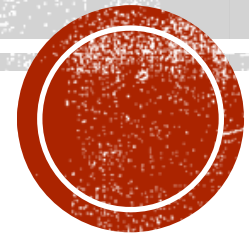
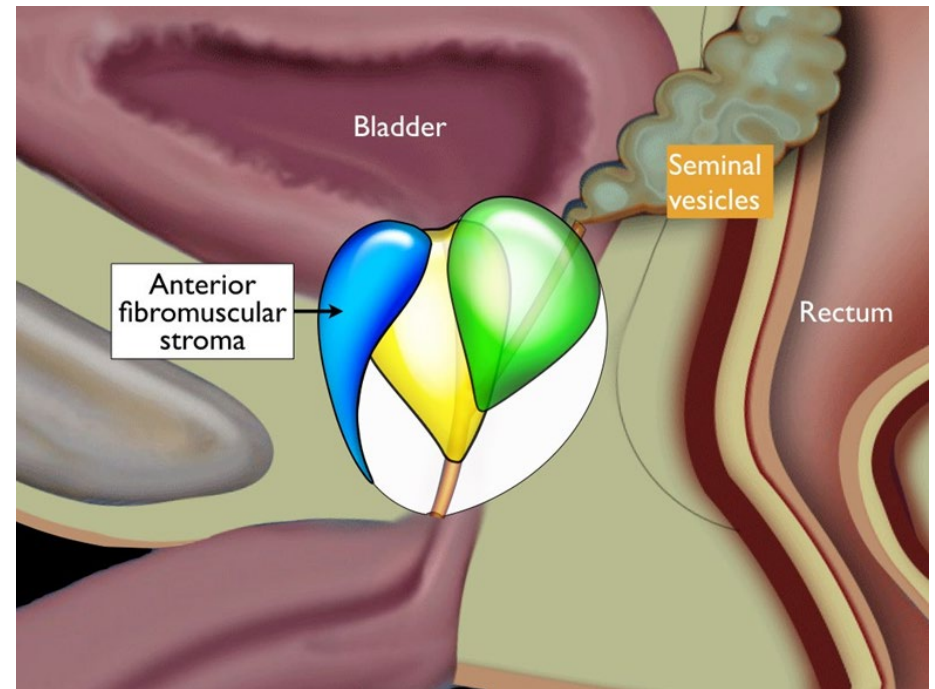
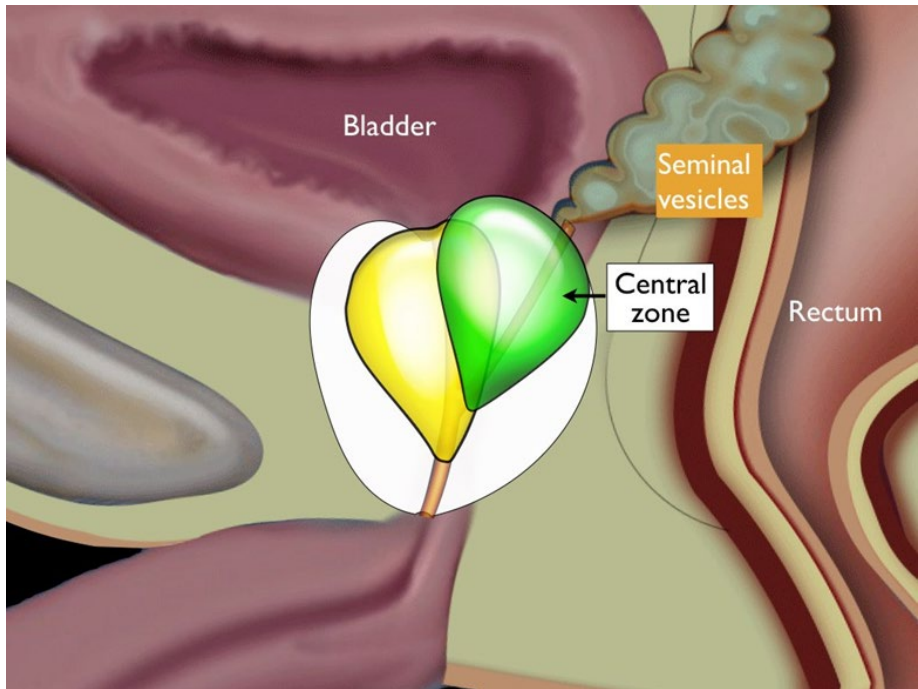
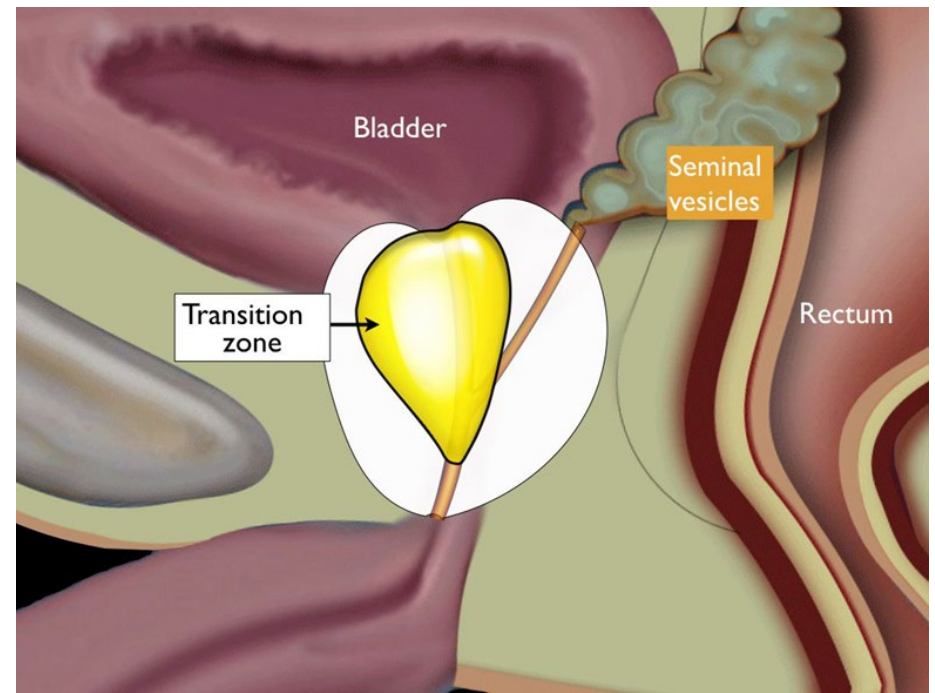
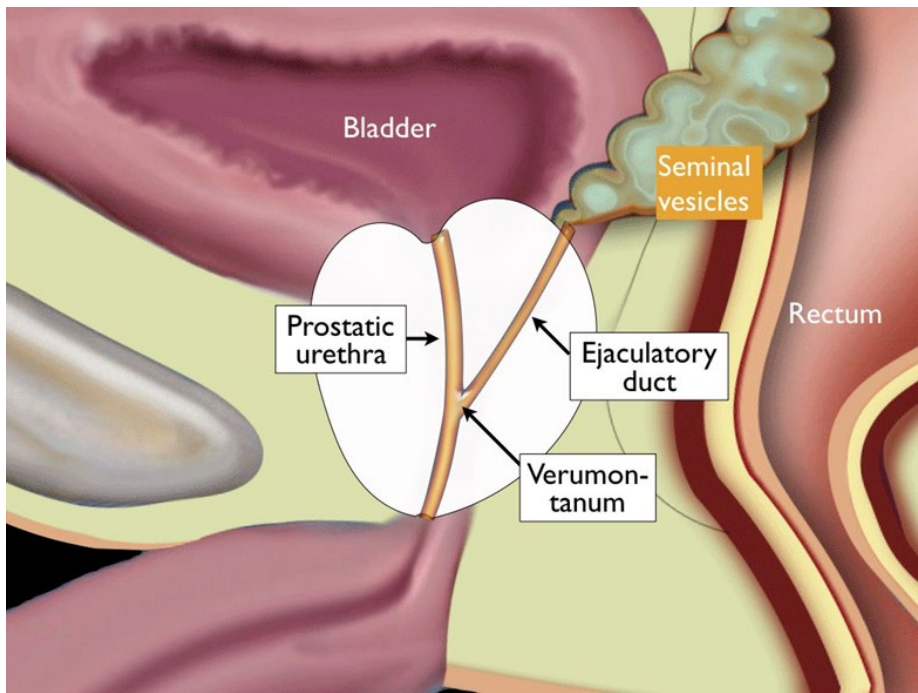
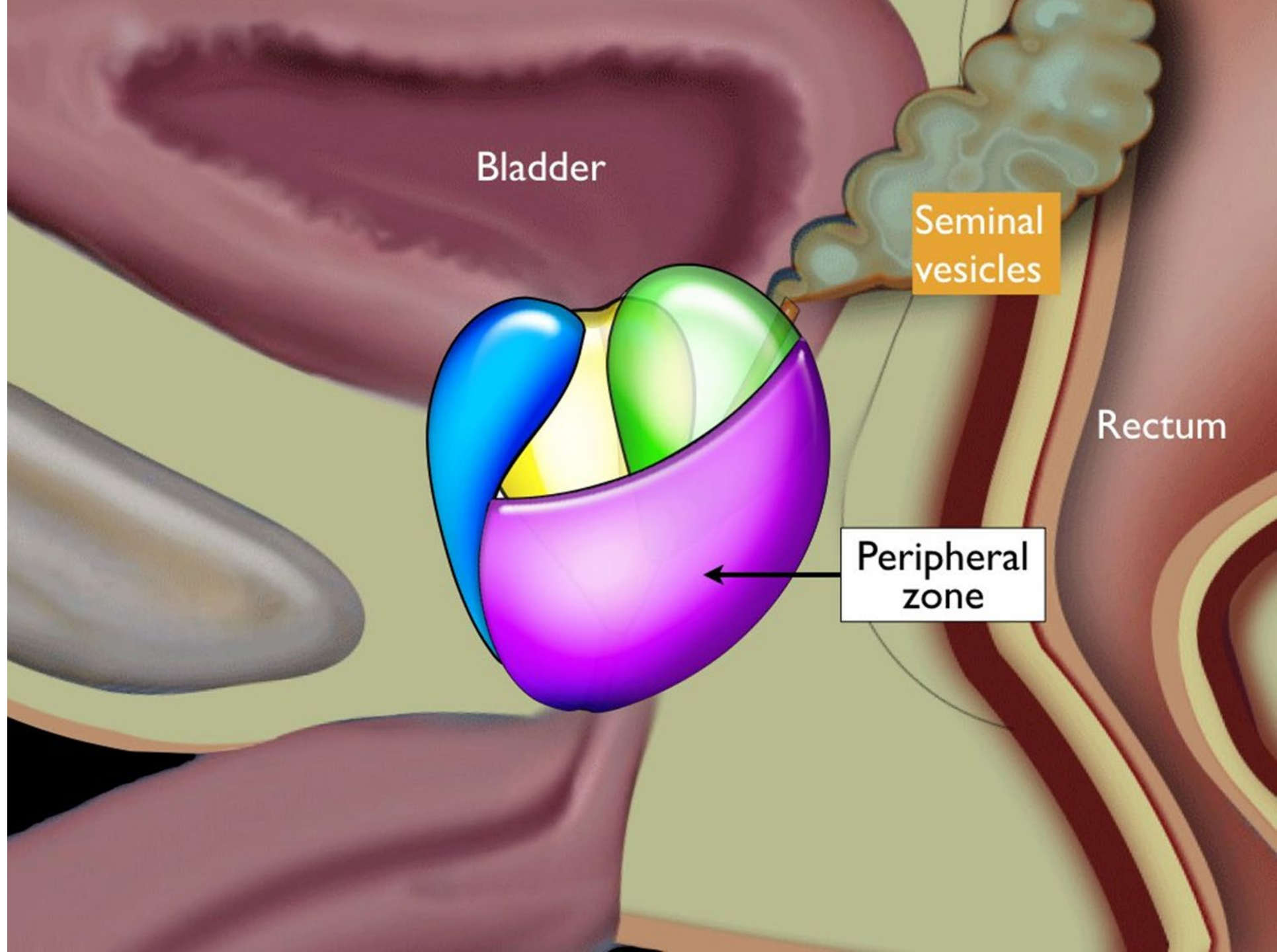


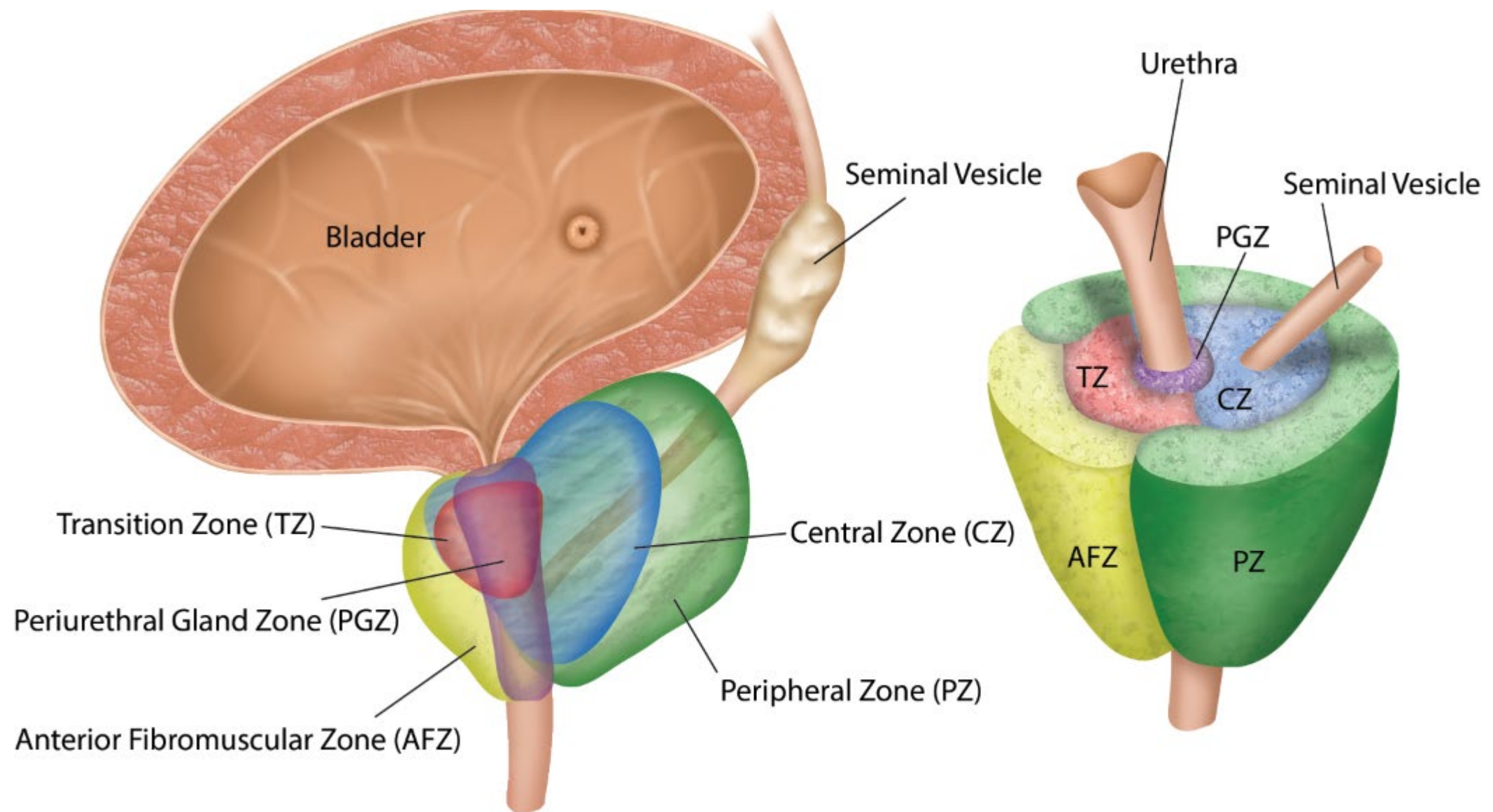
CLINICAL AND MRI ANATOMY OF PROSTATE

ALI AKBARZADE PASHA MD









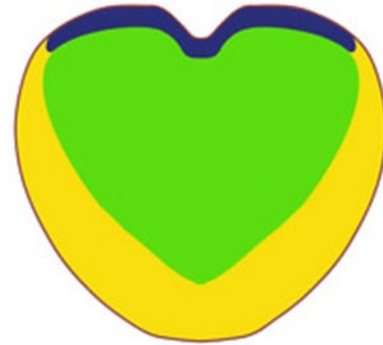
Zones of the Prostate



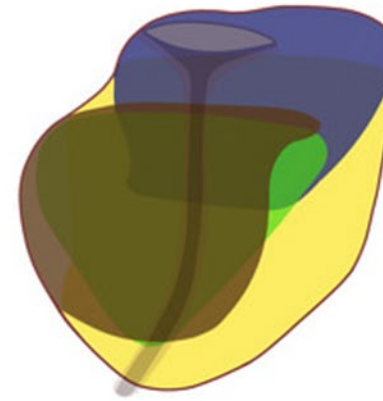
Prostate anatomy

Fibromuscular zone ■ Central gland — Central zone ■
Peripheral zone ■ Transition zone ■
Urethra ●

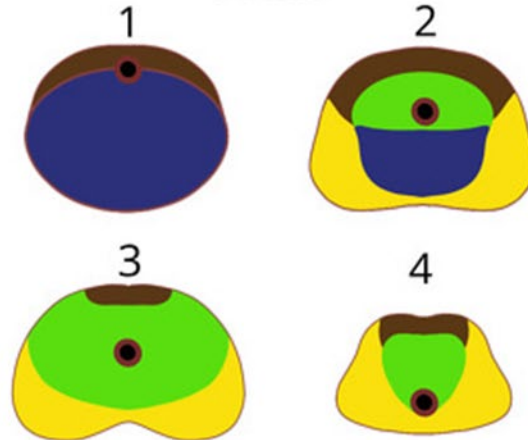
Coronal



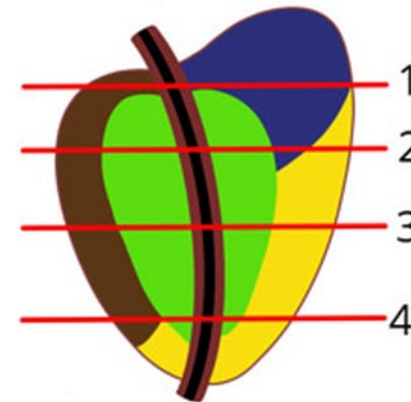
3D

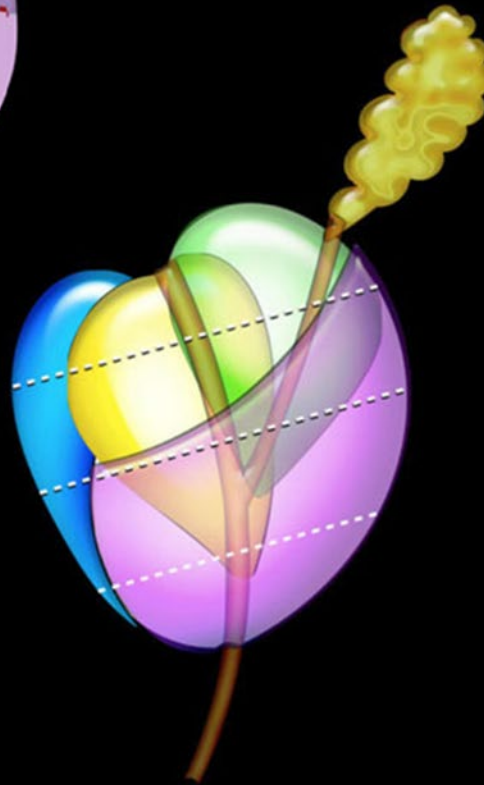
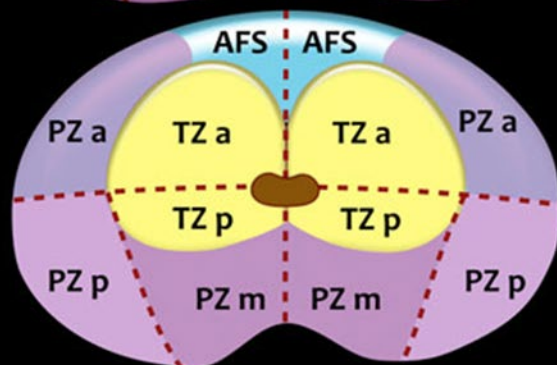
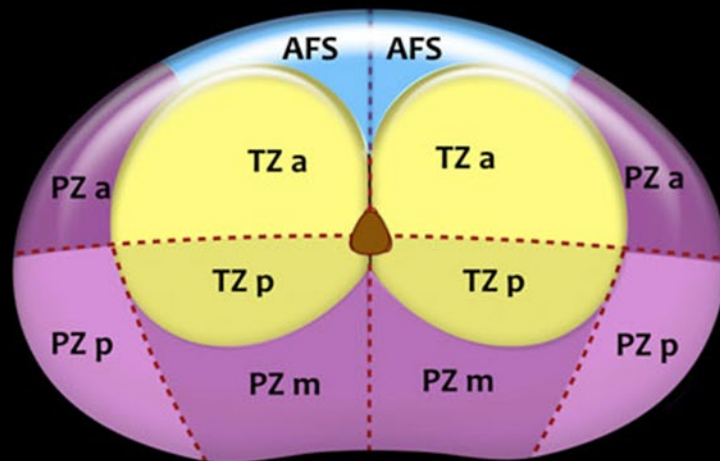
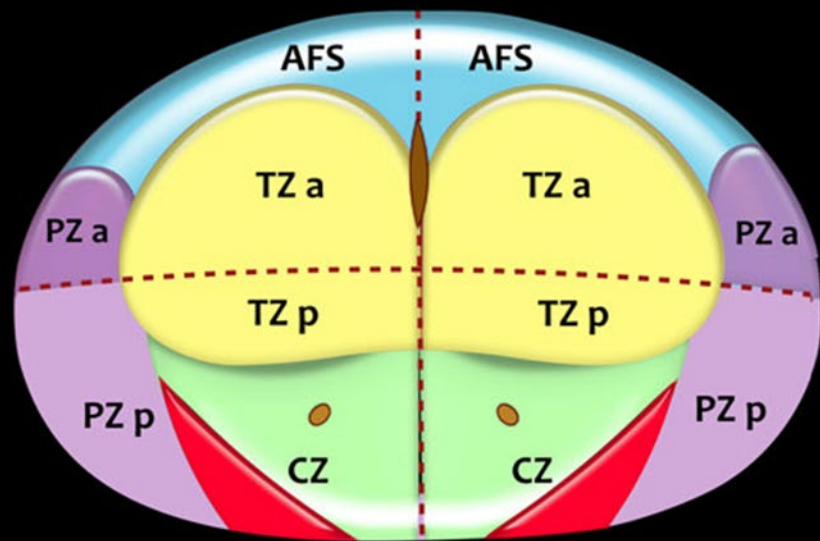


Axial



Sagittal





Base has 7 sectors on each side:

AS: anterior fibromuscular stroma

TZ: anterior and posterior transition zone

PZ: anterior and posterior zone

CZ: central zone around the ejaculatory ducts

Two additional sectors were added in version 2.1 for the right and left posterior medial PZ (PZpm) at the base (in red)

Midportion also has 6 sectors on each side:

AS: anterior fibromuscular stroma

TZ: anterior and posterior transition zone

PZ: anterior, posteromedial and posterolateral peripheral zone

Apex also has 6 sectors on each side:

AS: anterior fibromuscular stroma

TZ: anterior and posterior transition zone

PZ: anterior, posteromedial and posterolateral peripheral zone

Seminal vesicles are divided into left and right

Urethral sphincter is marked in the prostate apex and along the membranous segment of the urethra.

RS



INDICATION

- **Detection and localization of clinically significant prostate cancer in patients with negative biopsy or without a previous biopsy**
- **Active surveillance**
- **Locoregional prostate cancer staging**
- **Detection of locoregional recurrence in a post-prostatectomy setting**



PREPARATION

- Eating light meals 24 h before exam
- Fasting 4hr
- Take your medication
- Antispasmodic agents (e.g. hyoscine butylbromide – Buscopan)
- 6 weeks interval after biopsy
- Avoid sexual activity during the 48 hours prior exam
- Duration: 40 min
- Moderately filled bladder

PATIENT PREPARATION FOR PROSTATE MRI

1. Bowel Preparation



Low-residue diet the day before and enema 2–4 hours before the exam.

2. Bladder Status



Moderately filled bladder (drink water 1–2 hours before the exam).

3. Medications



Continue routine medications. Inform the radiologist about anticoagulants or allergies.

4. Fasting



4–6 hours fasting before contrast administration. (if contrast is planned)

5. Remove Metal Objects



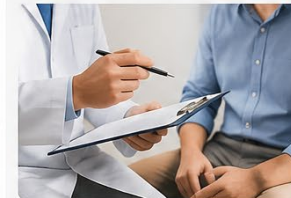
Remove all metal objects including watches, keys, cards, and belts.

6. Clothing



Wear comfortable clothing. You may be asked to change into a gown.

7. Explain the Procedure



The procedure will be explained before the exam. Ask questions if you have any concerns.

8. Relax and Stay Still



Stay calm and still during the exam for the best image quality.

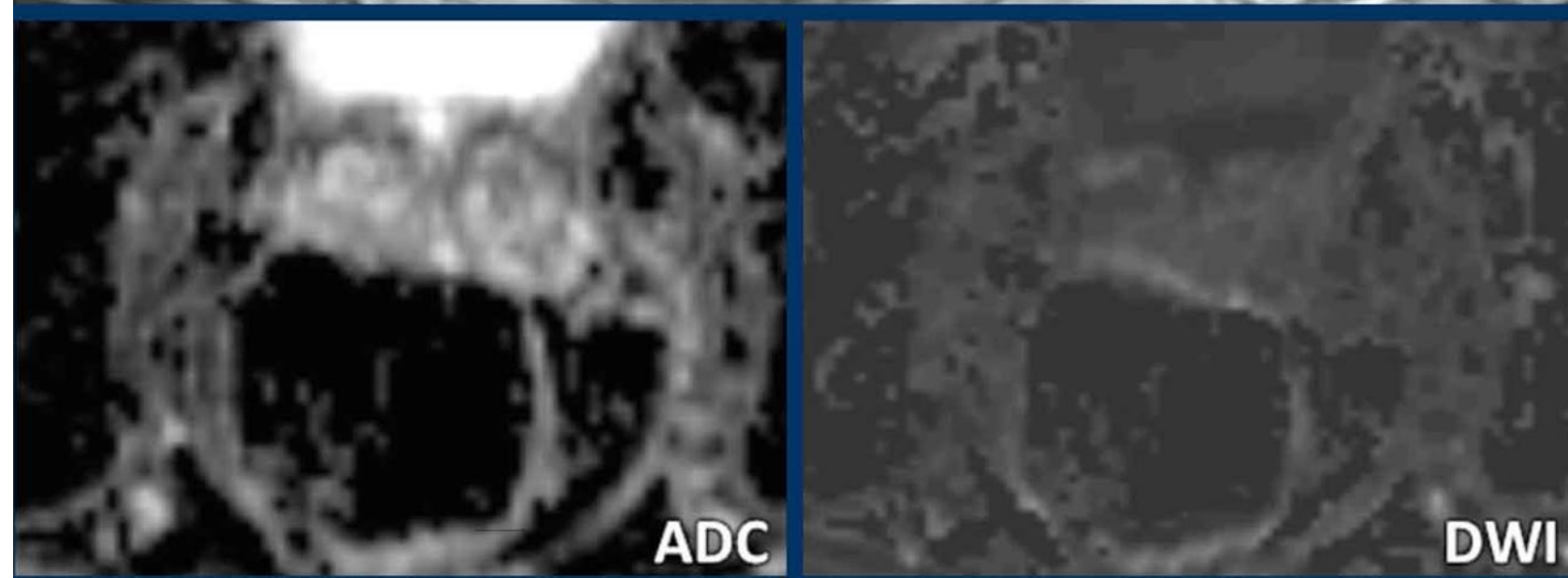


Inform the staff if you have claustrophobia, implants, or any health condition.





Spasmolytic agents can be considered prior to examination to reduce movements of the small and large bowel.



American College of Radiology (ACR), European Society of Urogenital Radiology (ESUR), and AdMeTech Foundation

MRI protocol

T2W	Axial to the patient or perpendicular to the long axis of the prostate Additional orthogonal plane (sagittal and/or coronal
DWI	b50-100 b800-1000 and Optionally b100-1000. b-value ≥1400 image set is also mandatory
DCE	Temporal resolution ≤15 seconds 3D T1W GRE

mpMRI

T1&T2
DWI
DCE

bpMRI

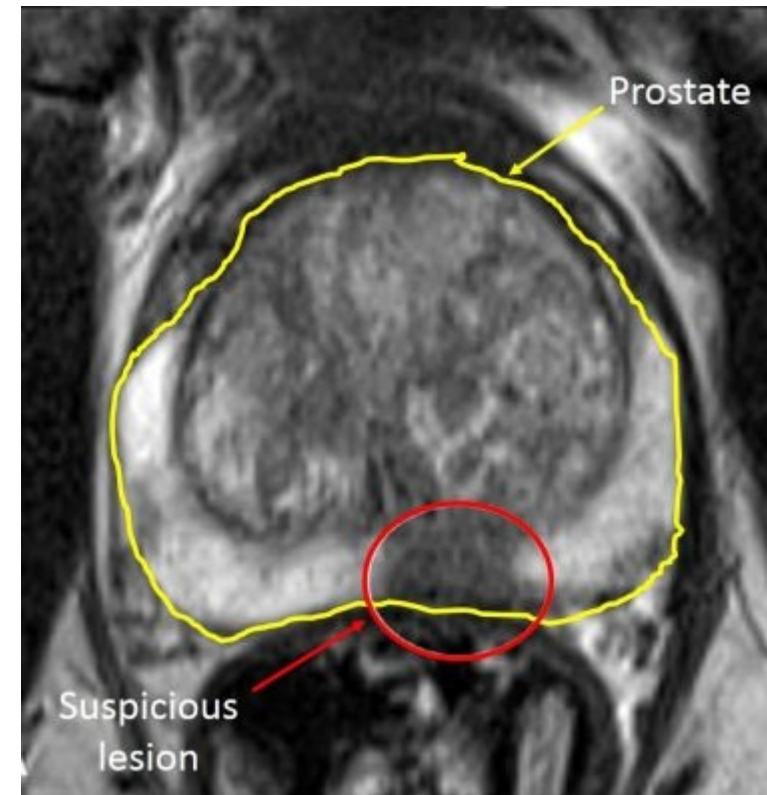
T1 & T2
DWI

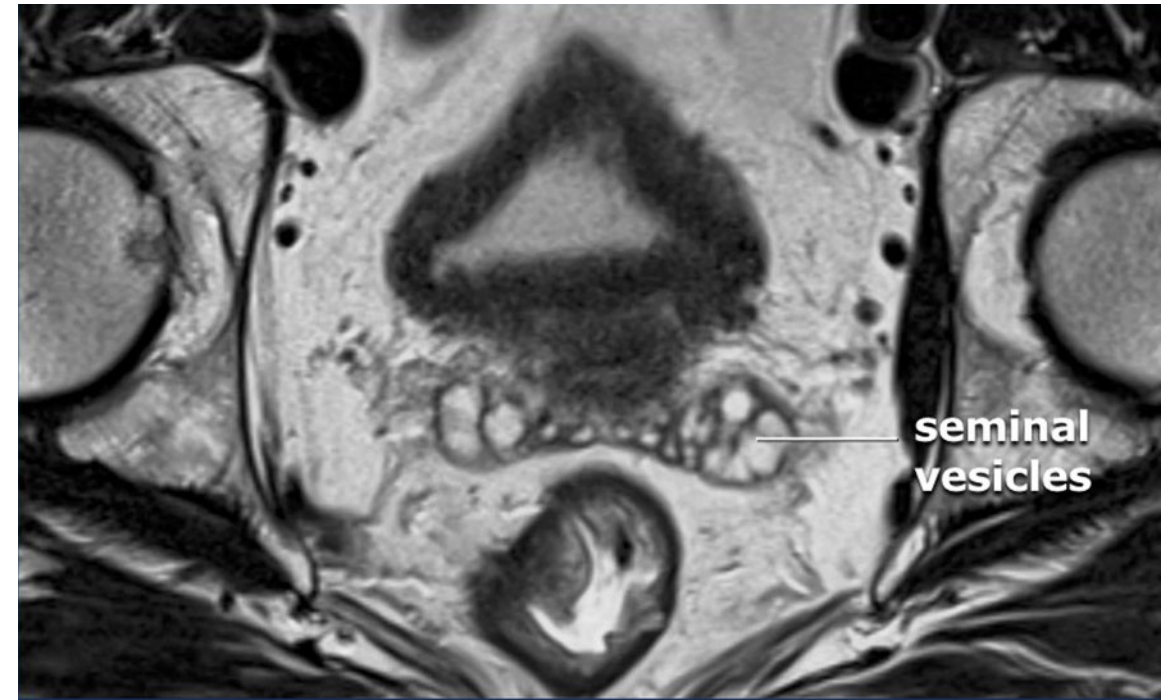
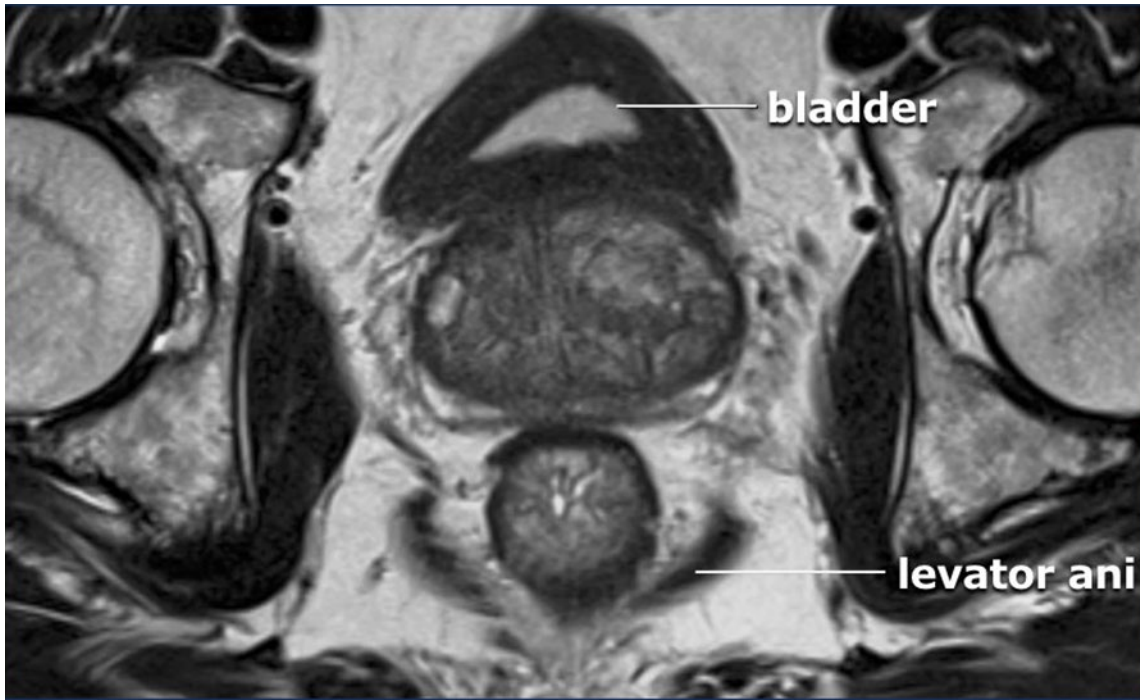
HM-MRI(hybrid-multidimensional MRI)

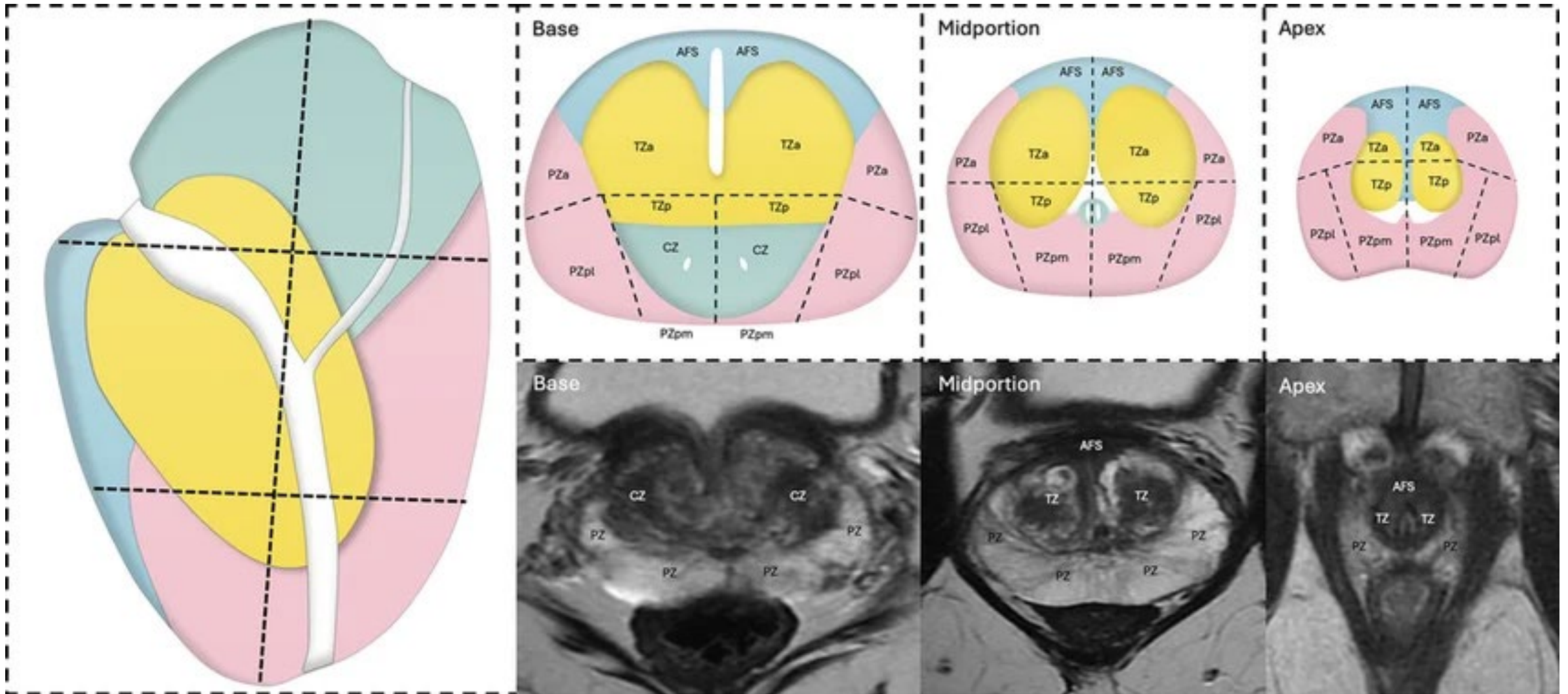


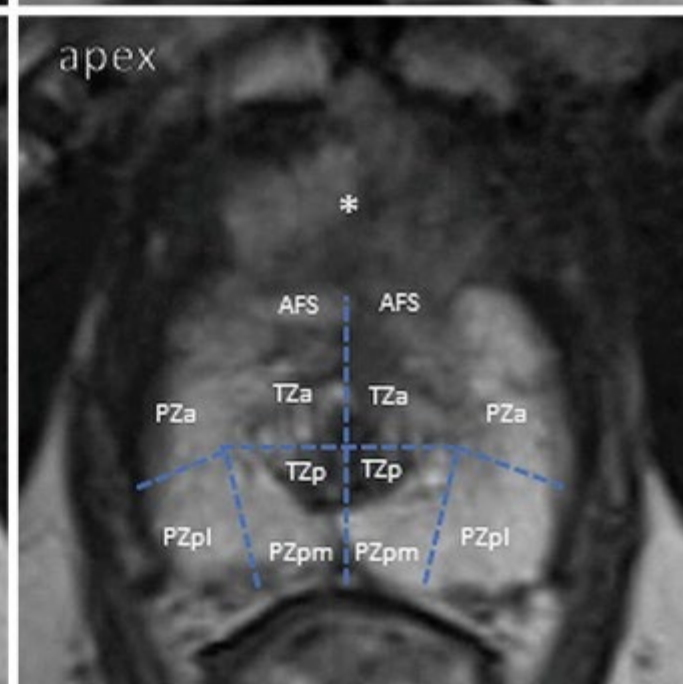
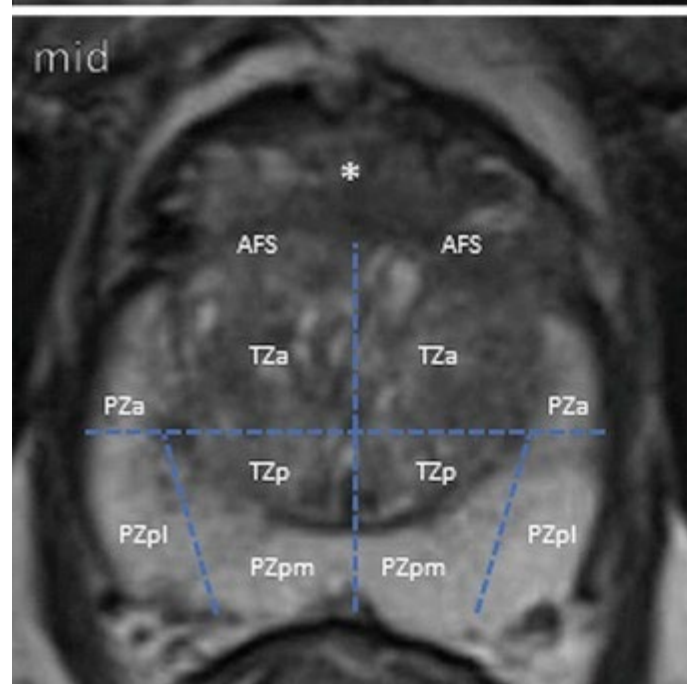
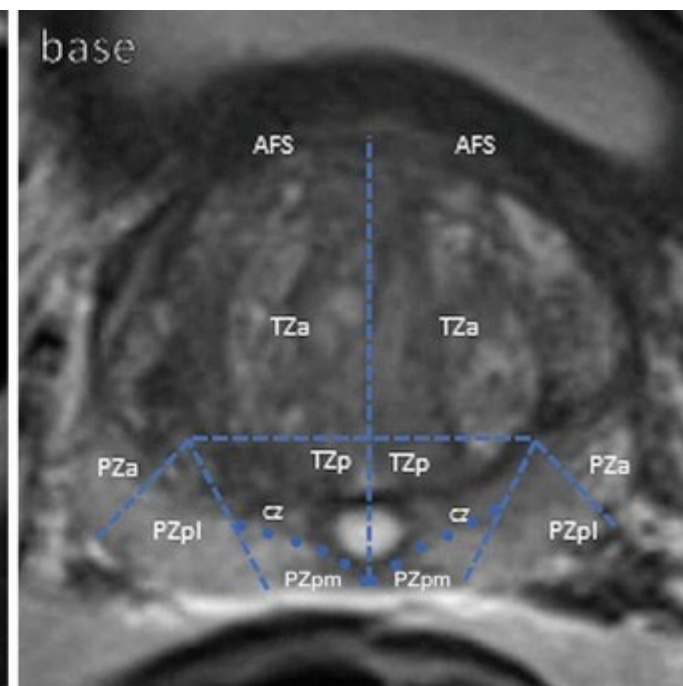
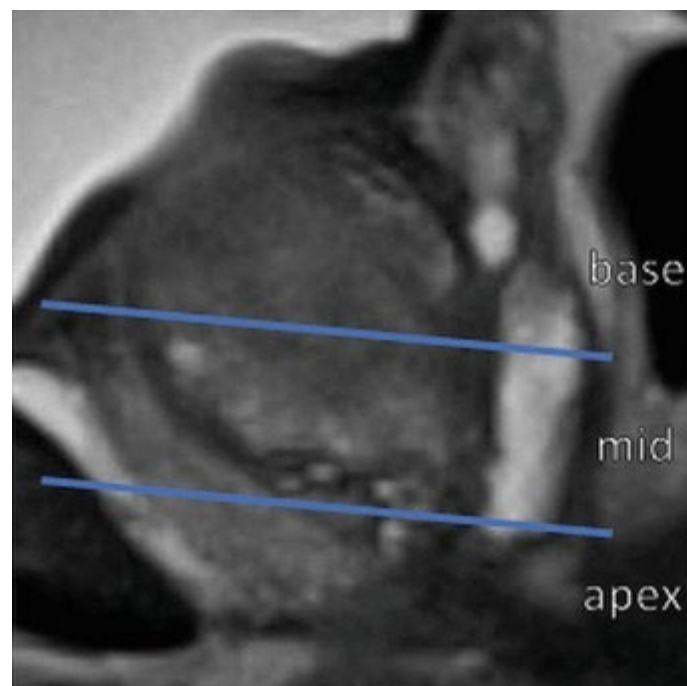
T2-WEIGHTED

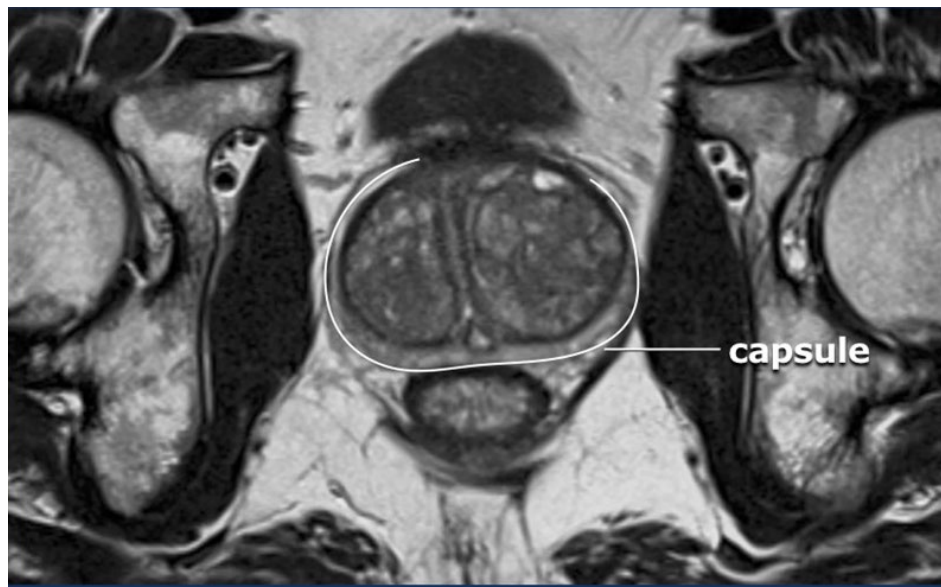
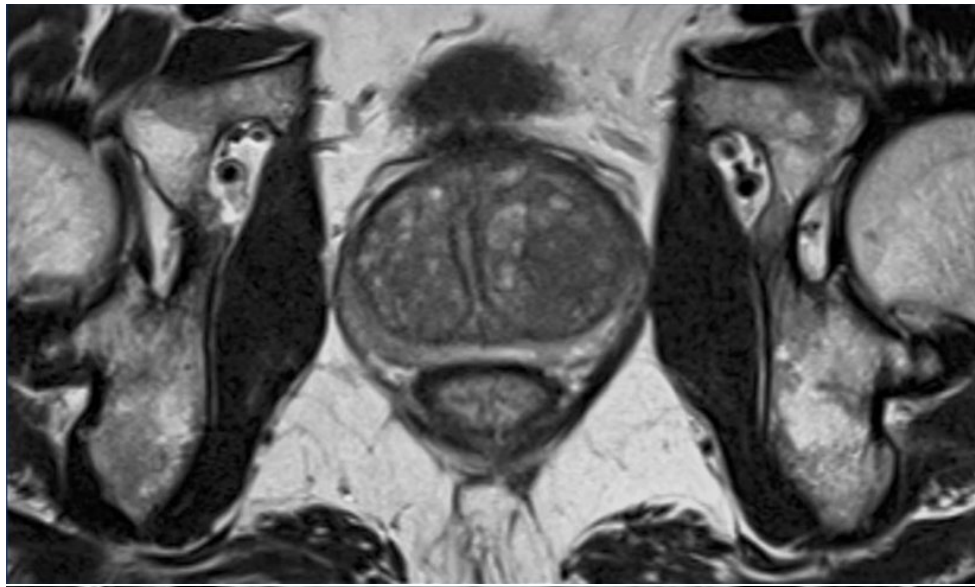
- **2D TSE/ FSE**
- **Axial Sag Coronal**
- **$\leq 3\text{mm}$**
- **FOV 16-20 cm**
- **TE 90-120 ms**
- **TR 3000-6000 ms**



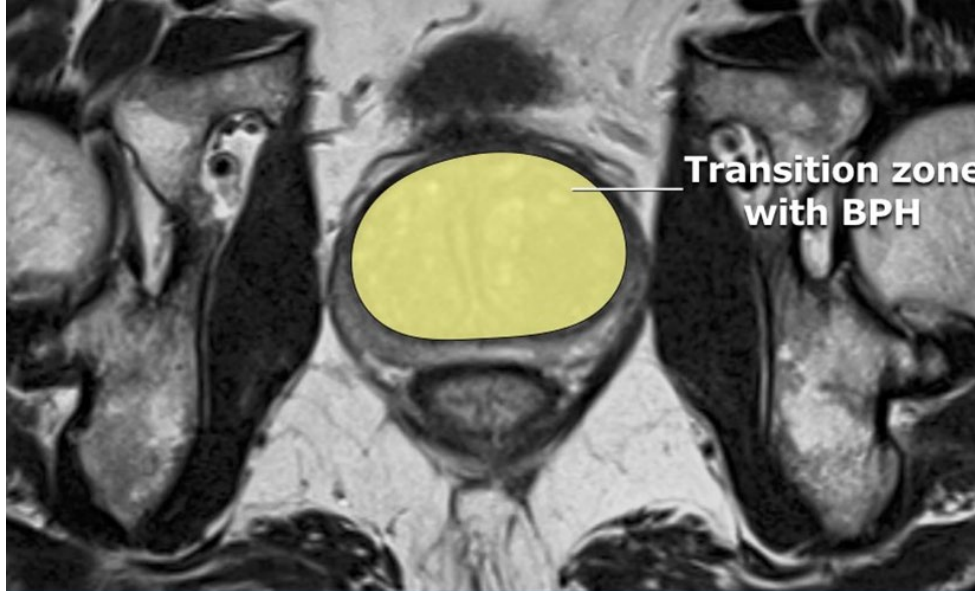






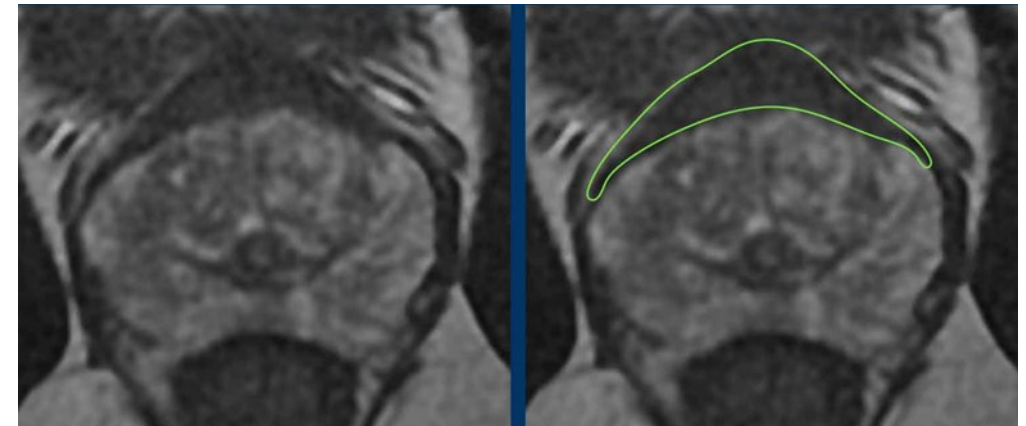
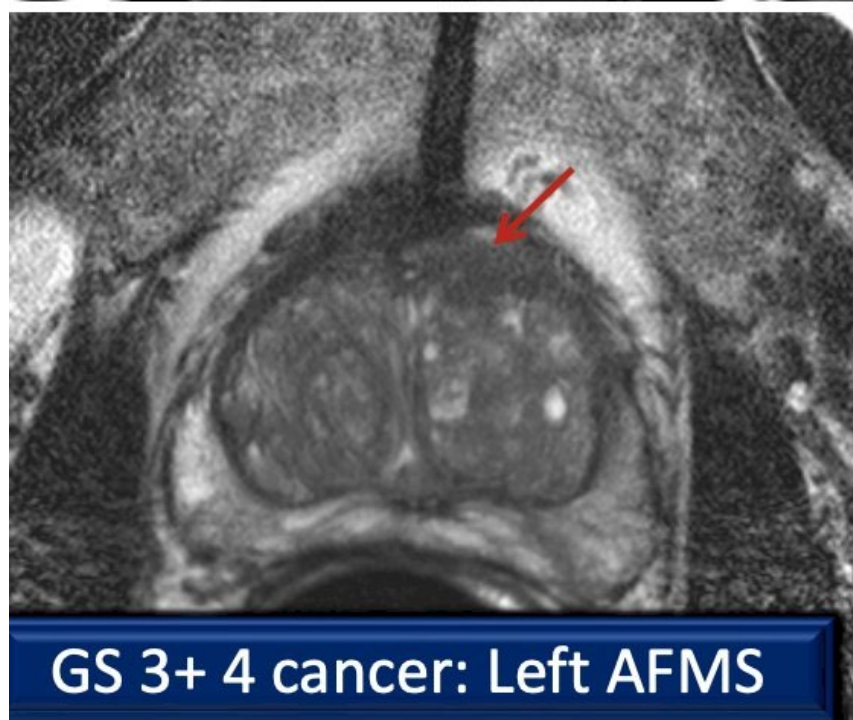
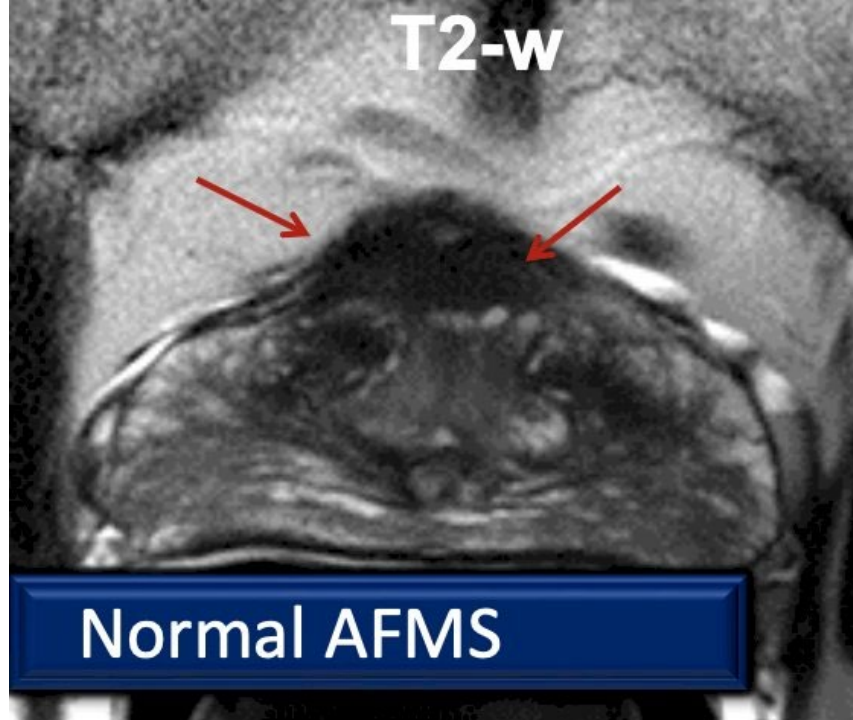


The prostate does not have a true capsule.



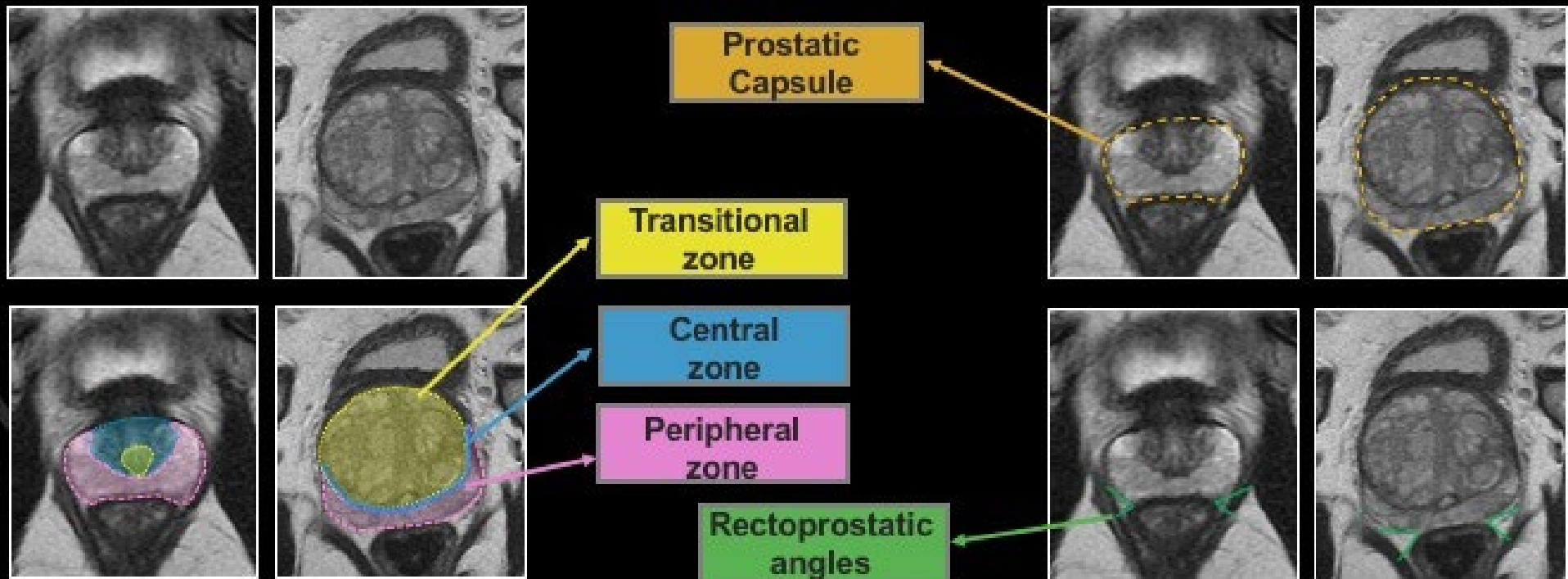
on MRI the outer border of the prostate does have a thin, hypointense line, which is histopathologically composed of **a fibromuscular band**.

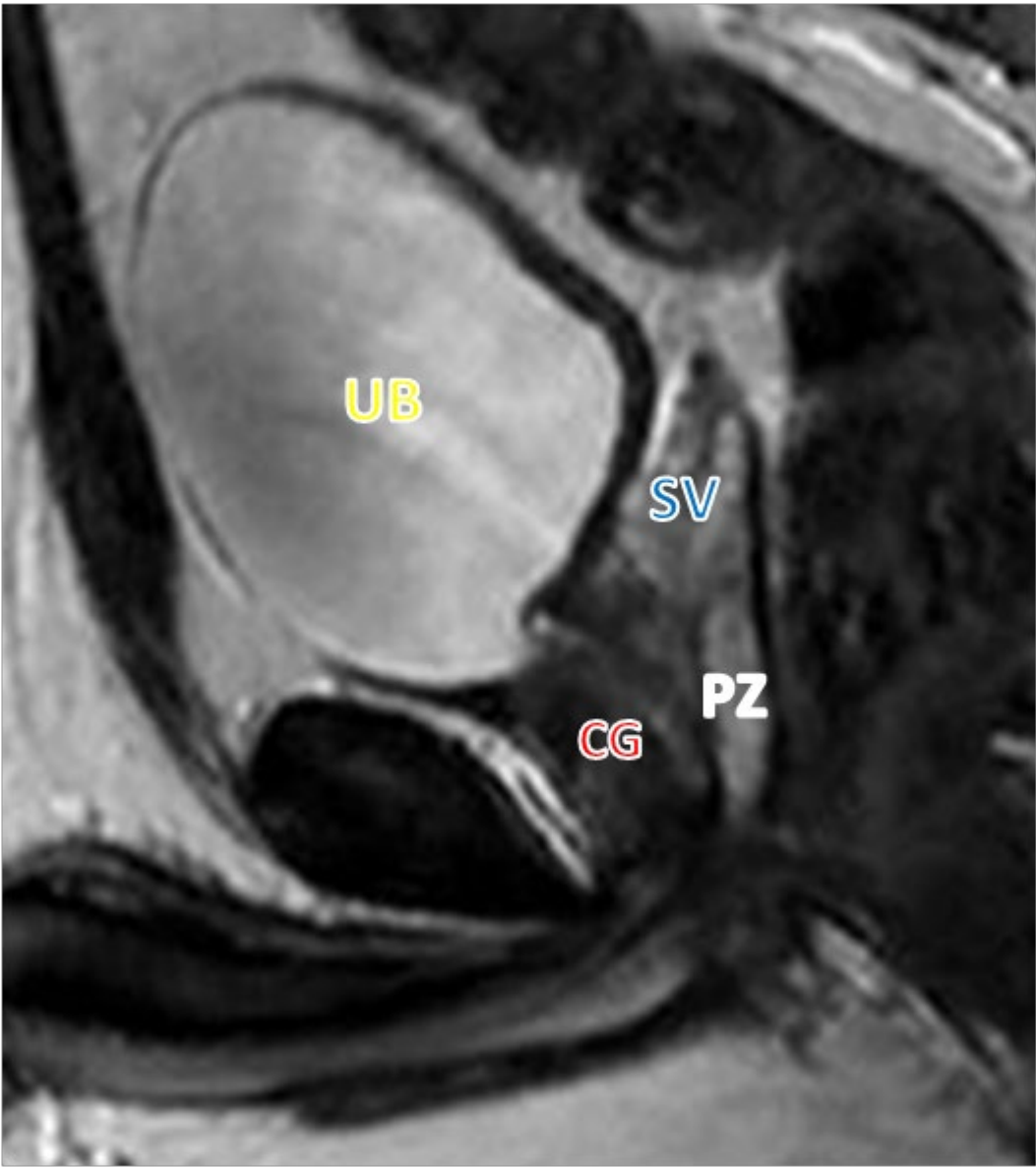
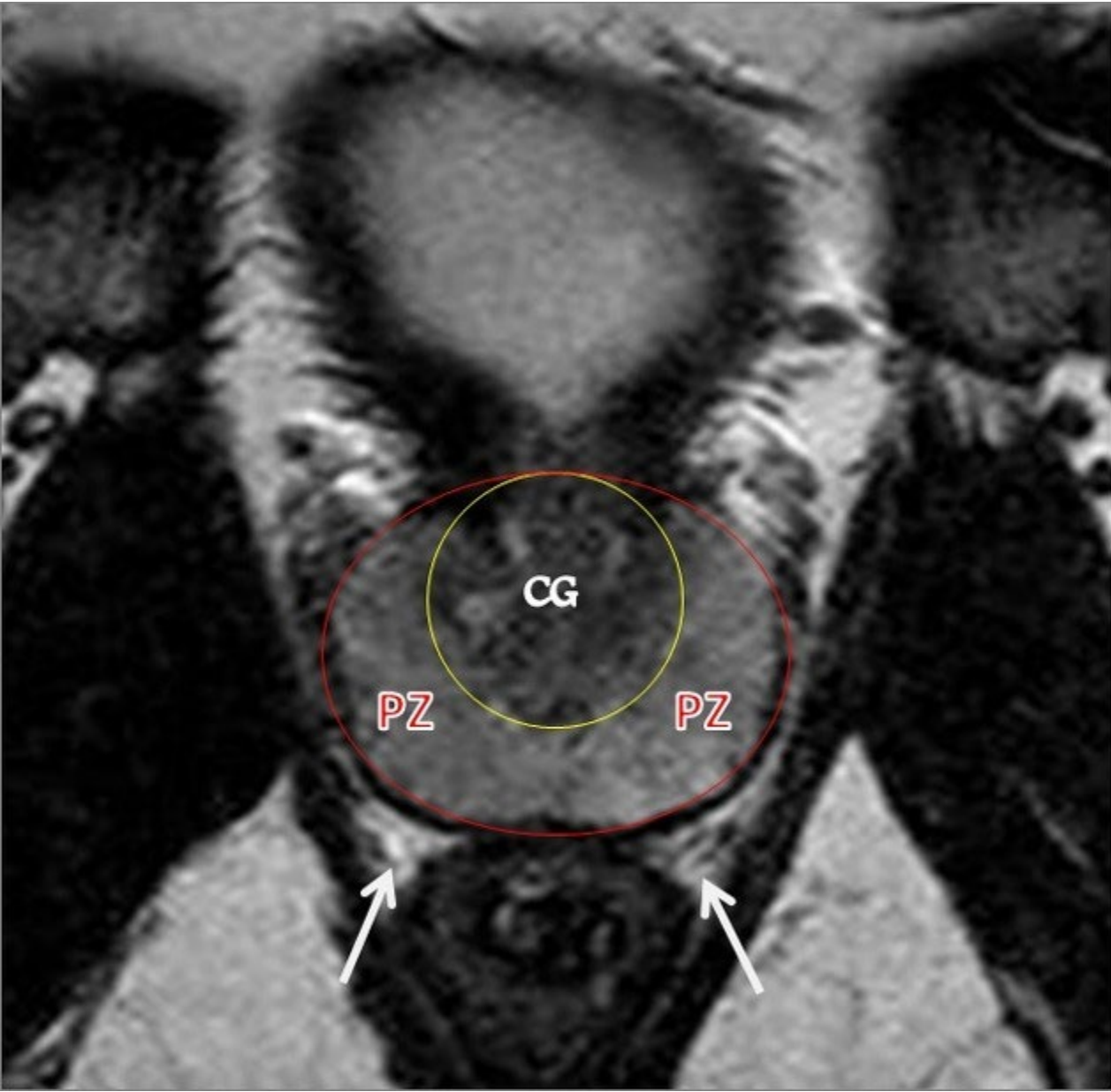




NORMAL ANATOMIC STRUCTURES

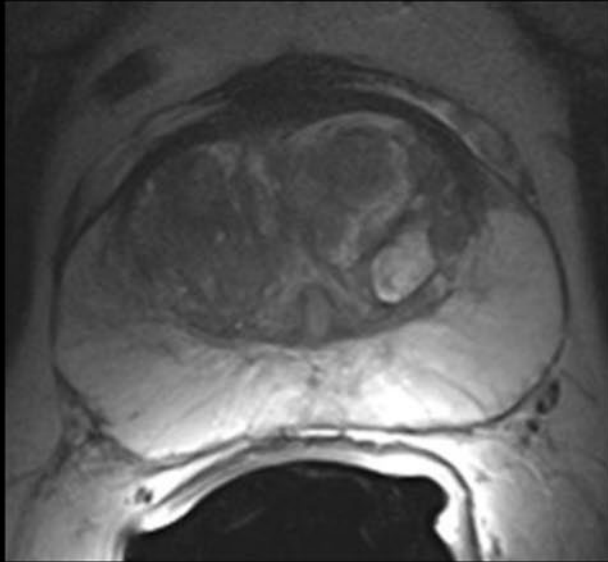
- It is so important to recognize the normal anatomy in order not to get confused with anomalies in the gland.



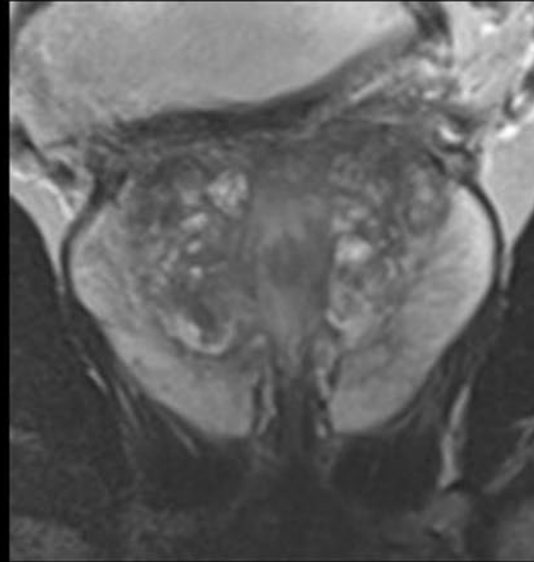


NORMAL PROSTATE • MP MRI

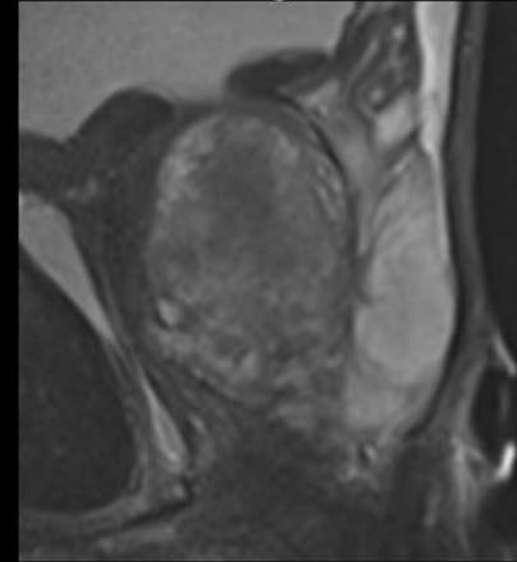
T2 Axial



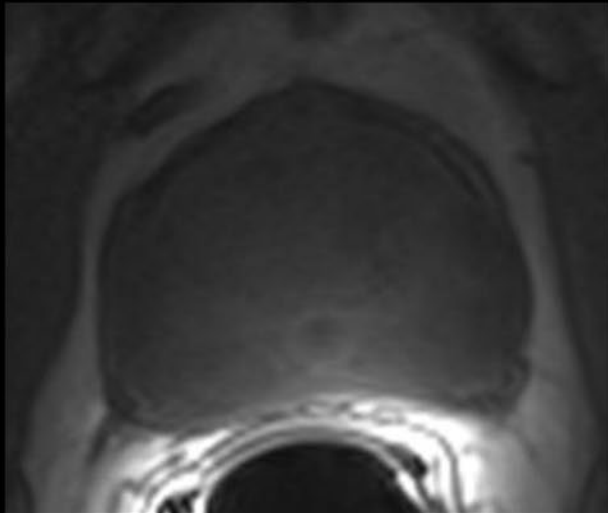
T2 Coronal



T2 Sagittal

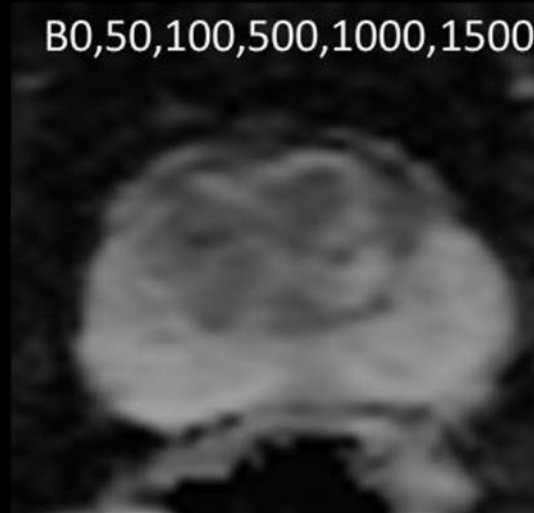


T1 Axial

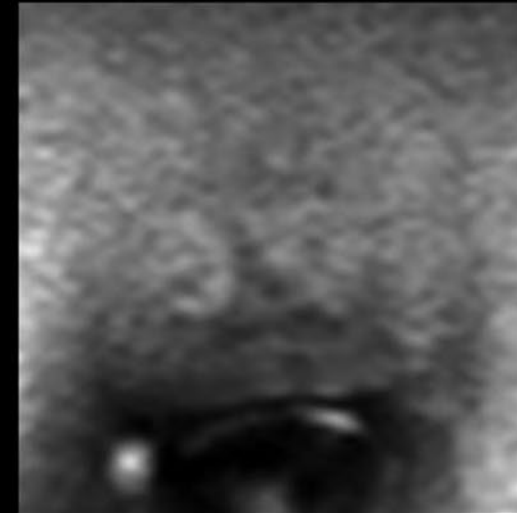


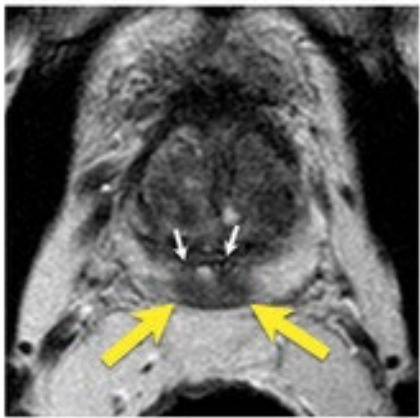
ADC

B0,50,100,500,1000,1500

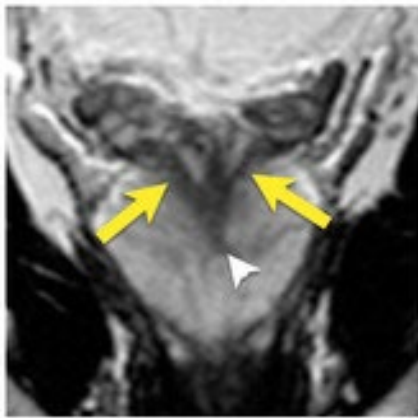


B2000 Diffusion

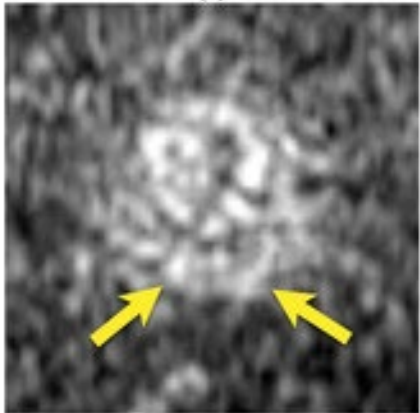




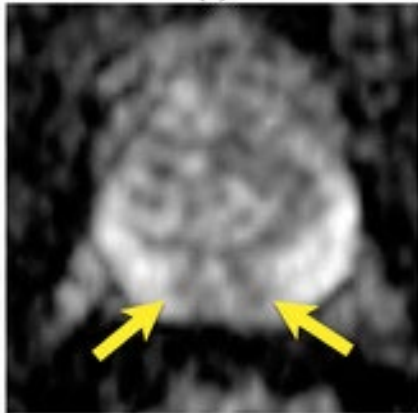
(a)



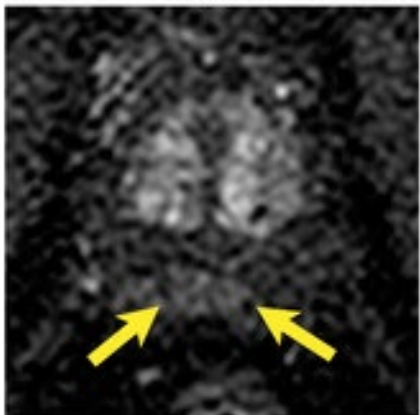
(b)



(c)



(d)



(e)

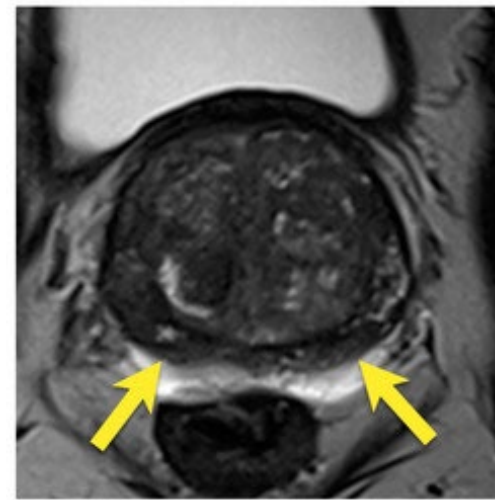
Normal CZ T2

Base to verumontanum
Homogenously hypo
Symmetric
Conical shape

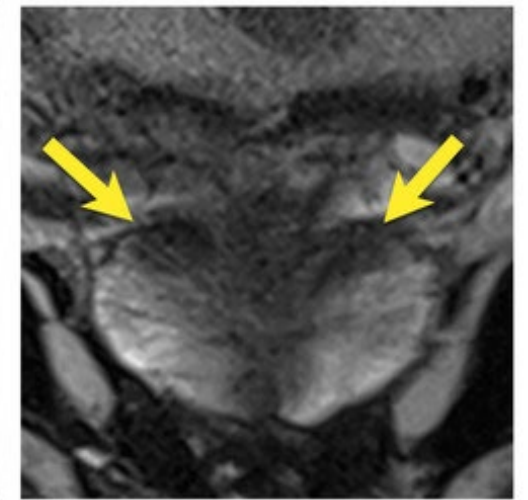
DWI b2000
Mildly increased

ADC
Mildly decreased

DCE
Diffuse mild enhancement of progressive type

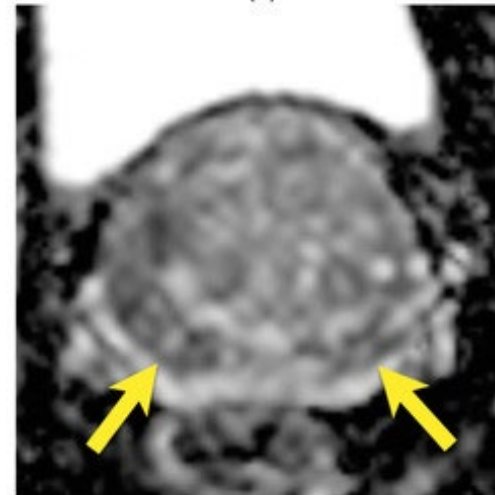


(a)



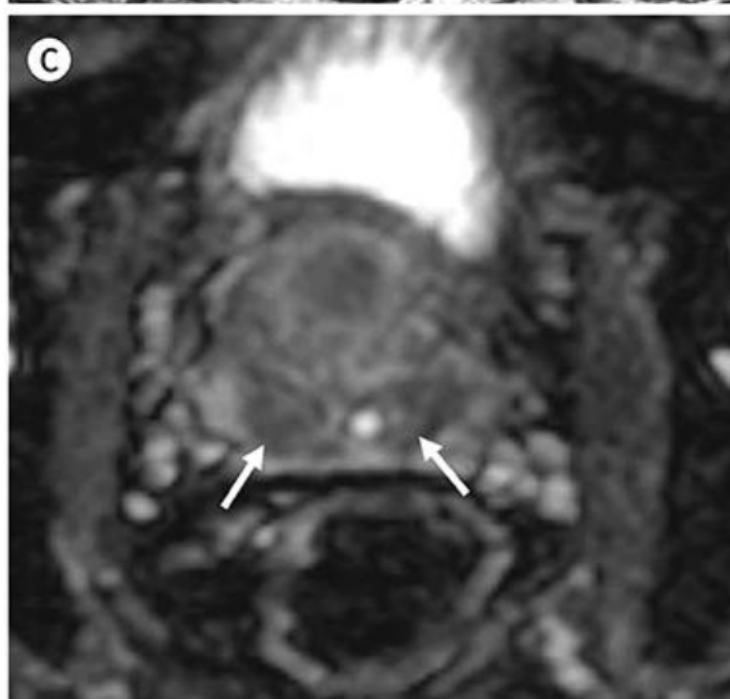
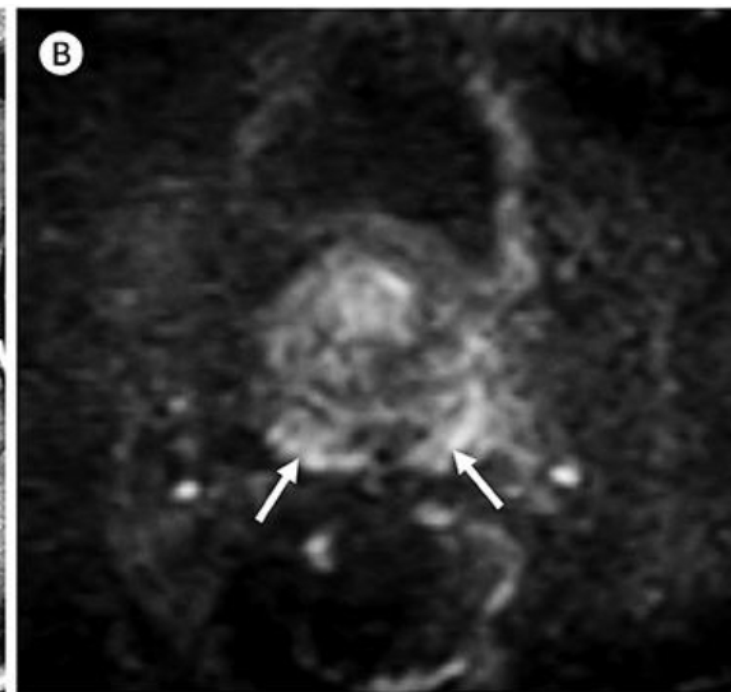
(b)

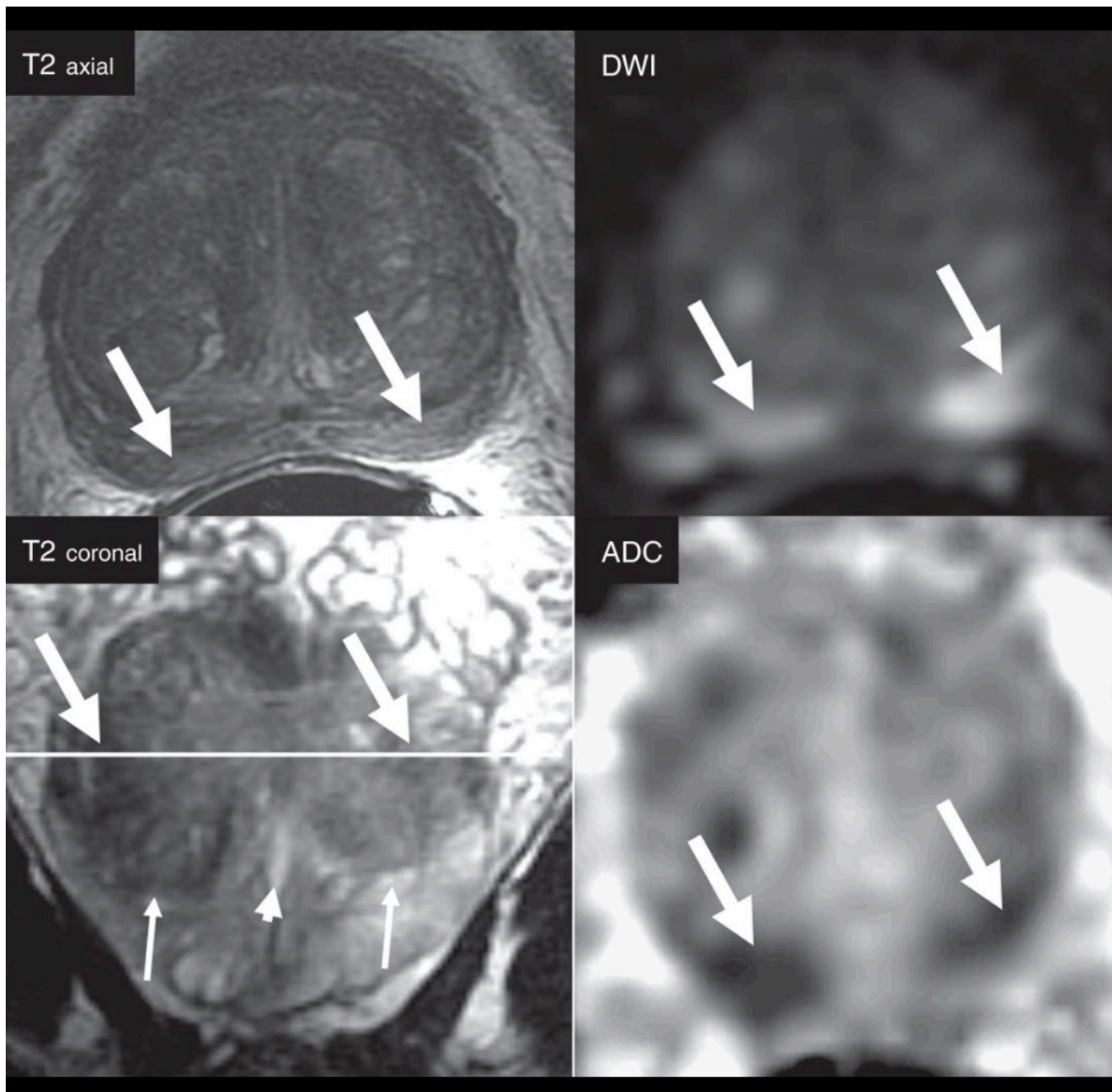
BPH
CZ displaced to base
Moustache sign



(c)



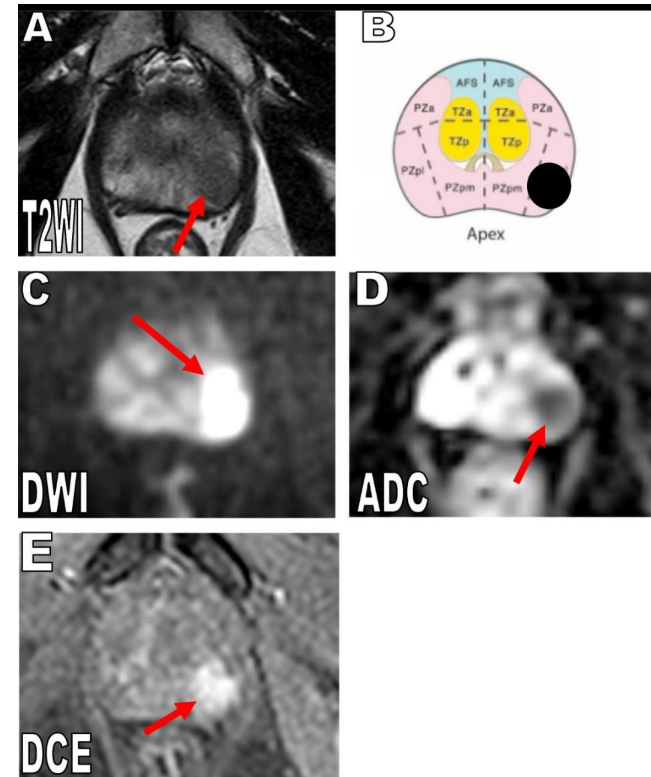




DCE

- TR <100
- TE <5
- Slice Thickness 3mm w/o gap
- Temporal Resolution ≤ 10 sec
- 3DT1 FS GRE (Siemens :VIBE)
- Subtraction(post c – pre c)
 - T1 precontrast high
 - Hemorrhage
 - Difficult detection of real enhancement
 - Motion = pseudolesion
- 0.1 mmol/kg
- 2-3 ml/sec
- Total observation time > 2min(4 min = 24 acquisition)

- **Early Focal Enhancement(30 – 60 s) Corresponding with T2/DWI**
- contemporaneous
- **PZ + DWI 3 + DCE positive = PIRADS 4**
- **TZ + T2 score 3 + DCE positive $\neq$ PIRADS 4**
- **TZ + T2 score 3 + DWI 5 = PIRADS 4**
- **BPH nodules can have early enhancement.**



DYNAMIC CONTRAST ENHANCED (DCE) MRI OF THE PROSTATE

Technique and Workflow

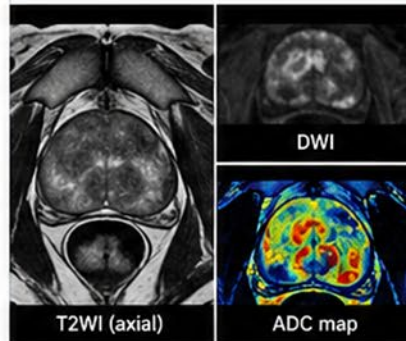
1. PREPARATION

- Patient in supine position
- Endorectal coil placement
- IV access for contrast administration



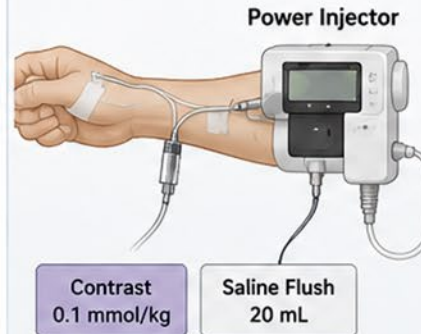
2. PRE-CONTRAST IMAGING

- Localizer
- T2-weighted imaging (axial, sagittal, coronal)
- DWI ± ADC map



3. CONTRAST ADMINISTRATION

- Gadolinium-based contrast 0.1 mmol/kg (0.1 mL/kg) injected IV
- Followed by 20 mL saline flush at same rate



4. DCE ACQUISITION

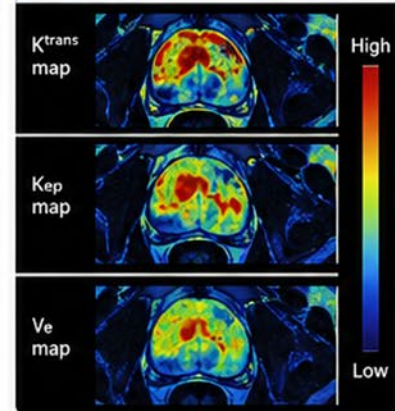
- 3D T1-weighted sequence with fat suppression
- Temporal resolution: ~10–15 seconds per phase
- Acquire for 5–7 minutes (at least 20–30 phases)



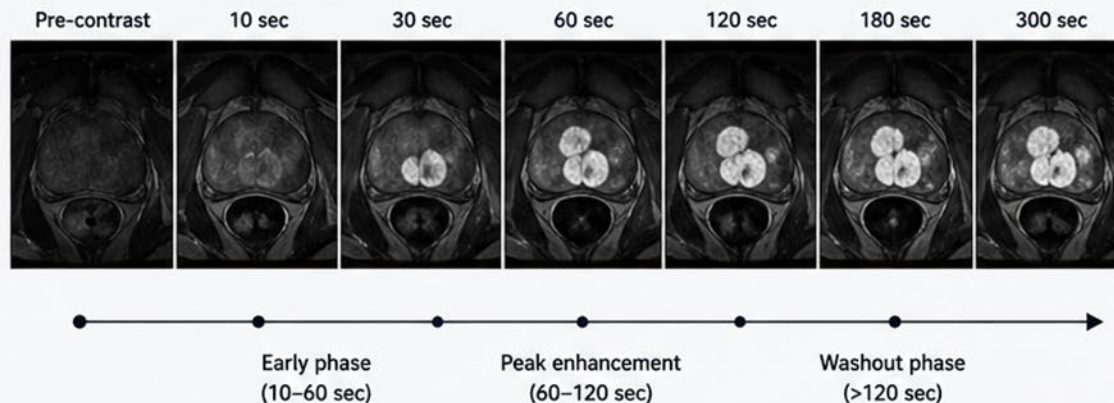
Total time
5–7 min

5. POST-PROCESSING

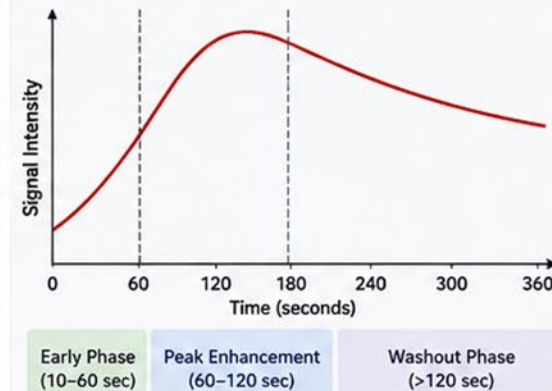
- Generate time-intensity curve
- Create parametric maps (K_{trans}, K_{ep}, V_e)



DCE TEMPORAL IMAGING



TIME-INTENSITY CURVE



KEY POINTS

- ✓ DCE helps in detecting and characterizing clinically significant prostate cancer.
- ✓ Early enhancement and washout are typical features of malignant lesions.
- ✓ Quantitative parameters (K_{trans}, K_{ep}, V_e) can improve diagnostic accuracy.



Consistent timing, adequate temporal resolution, and patient stability are essential for high-quality DCE imaging.



PROSTATE DCE-MRI (T1-weighted with fat suppression)

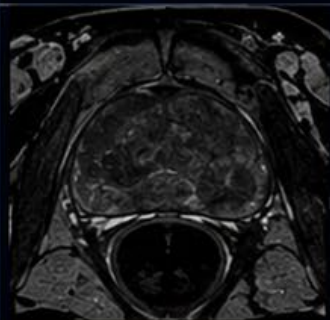
Temporal resolution = 10 seconds / phase | Total duration = 4 minutes (240 seconds)

Positive DCE = Focal early or contemporaneous enhancement relative to adjacent normal prostate.

Early enhancement typically occurs within ~10 sec after contrast arrival in the femoral arteries.

PRE-CONTRAST

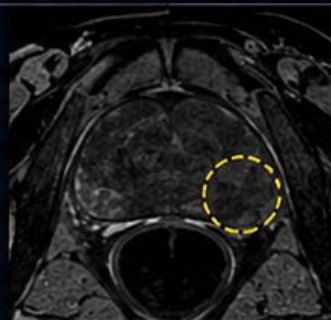
0 sec



Baseline

10 sec

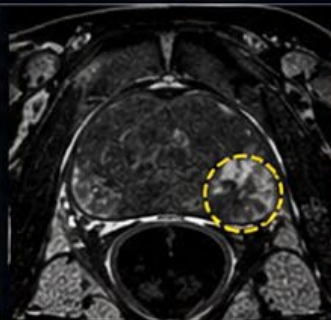
Very early



Contrast arrival in
femoral arteries

20 sec

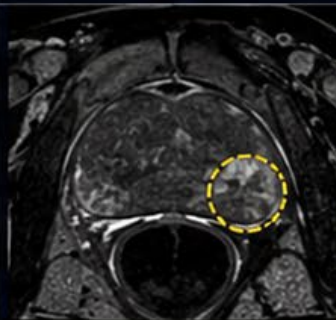
Early



Focal early enhancement
of the lesion (earlier than
adjacent normal PZ)

30 sec

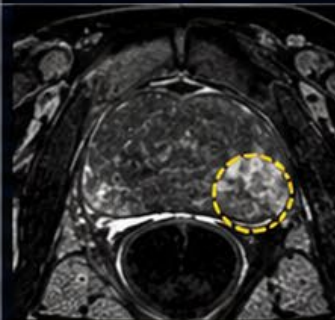
Early



Early enhancement
persists

40 sec

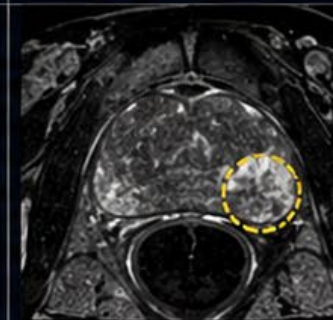
Early



Lesion remains
hyperenhancing

60 sec

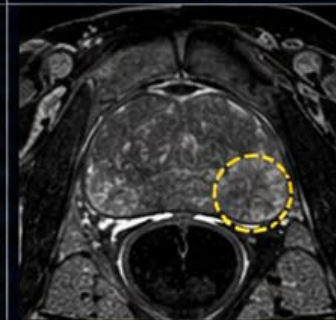
Early-intermediate



Enhanced but decreasing
relative to peak

120 sec

Late



Late phase

TIME (sec)

0

10

20

30

40

60

120

180

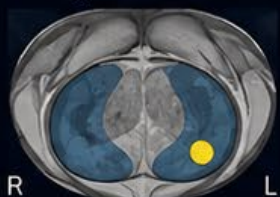
240

Early phase (10–60 sec)

Intermediate phase (60–120 sec)

Late phase (120–240 sec)

Typical location



Peripheral zone (PZ)

Key Points

- Look for focal enhancement that is earlier than or contemporaneous with adjacent normal prostate tissue.
- Best assessed on early phases: 10–60 seconds.
- Temporal resolution ≤ 15 sec is recommended (we used 10 sec).
- DCE is considered a supportive sequence in the Peripheral Zone.

Summary of acquisition (10-sec temporal resolution)

Phase	Time (sec)	Description
Pre-contrast	0	Baseline (no contrast)
Very early	10	Contrast arrival
Early	10–60	Evaluate focal early enhancement (most important)
Intermediate	70–120	Assess persistence / peak
Late	130–240	Late enhancement

What to report

Presence or absence
of focal early enhancement
corresponding to a
suspicious lesion on
T2WI and/or DWI.



Remember: We are looking for **FOCAL EARLY ENHANCEMENT**, not washout pattern.

1.5 T OR 3 TESLA ?

- uni or bilateral hip arthroplasty or other metallic implants of the pelvis
- MR conditional implants or devices requiring a lower field strength
- extensive tattoos in the pelvic girdle area

83 y 0 with PSA 8.3 ng/ml

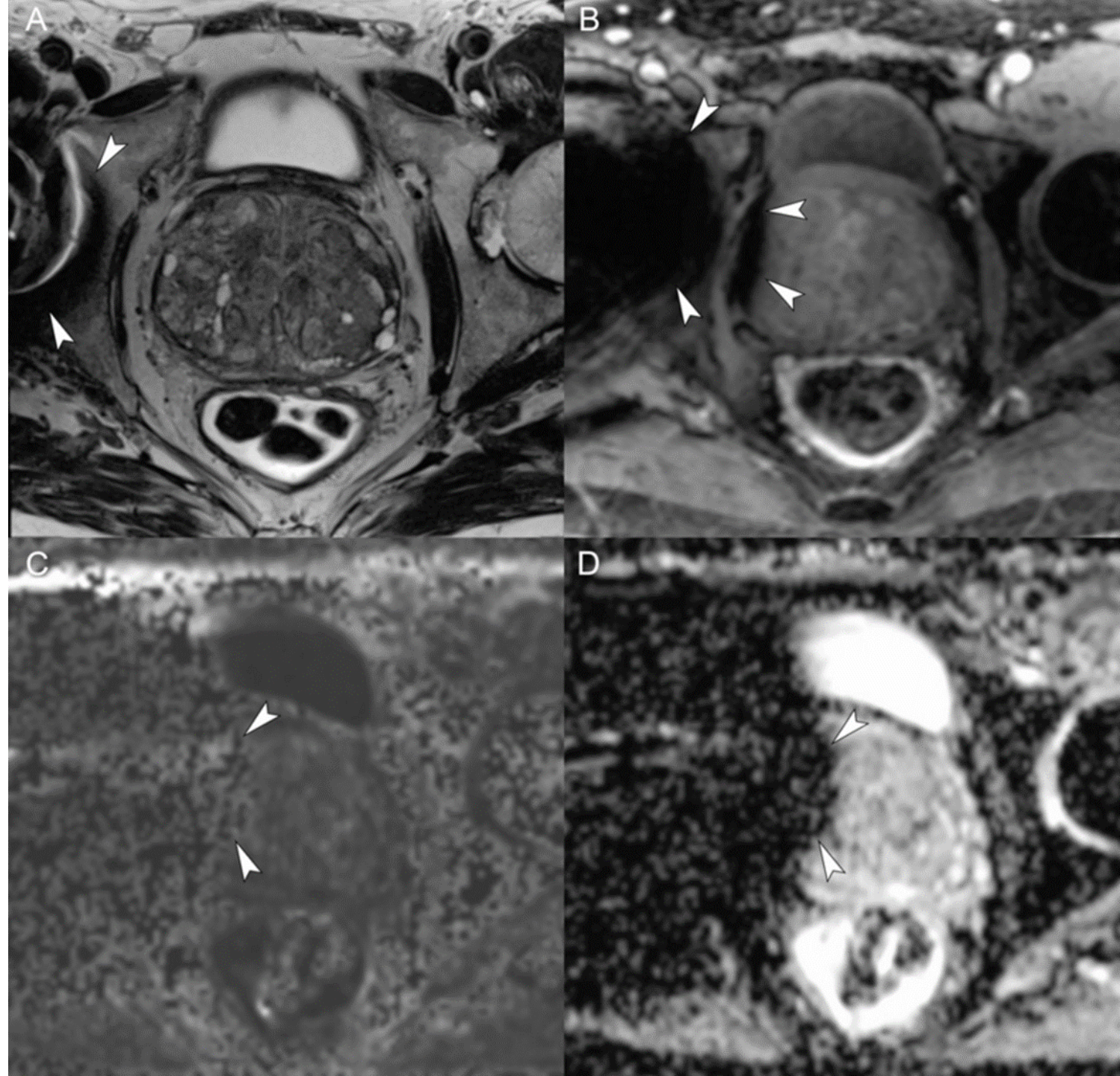
Metallic artifact due to Rt hip arthroplasty

T2 & DCE(short TE)

PI-QUAL 2

TSE/FSE < GRE or EPI

EPI is highly sensitive to magnetic susceptibility.



PI-QUAL v2 (Prostate Imaging Quality)

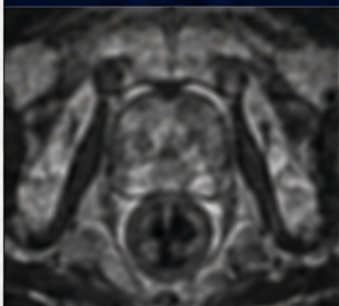
3-point scale to assess the overall technical quality of mpMRI based on T2W and DWI sequences.

PI-QUAL 1 – Inadequate

Study is not interpretable

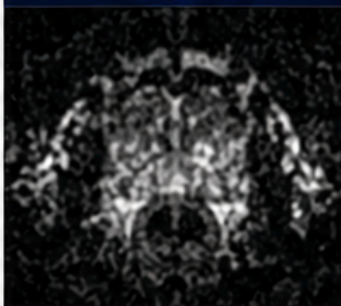
Image quality is so poor that detection of clinically significant prostate cancer is not possible.

T2-weighted



- Severe motion / distortion
- Anatomy not recognizable
- Signal void / artifacts preclude interpretation

DWI (high b-value)



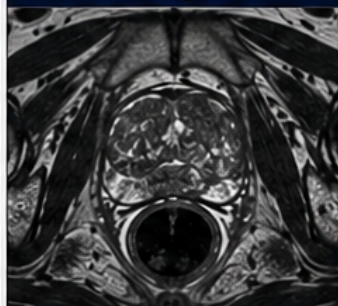
- Severe distortion / susceptibility
- Lesion assessment not possible

PI-QUAL 2 – Acceptable

Study is of acceptable quality

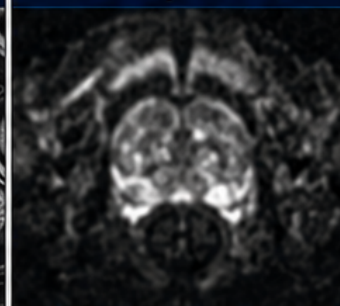
There are quality limitations, but the study is interpretable and csPCa detection is possible.

T2-weighted



- Minor to moderate motion
- Slight distortion
- Anatomic detail mildly limited
- Lesion evaluation possible

DWI (high b-value)



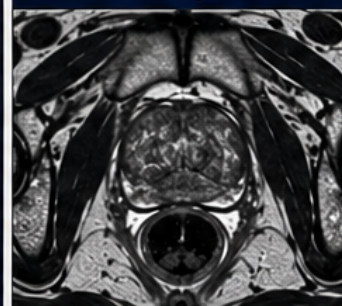
- Mild-moderate distortion / noise
- Lesion evaluation possible (with some limitation)

PI-QUAL 3 – Optimal

Study is of optimal quality

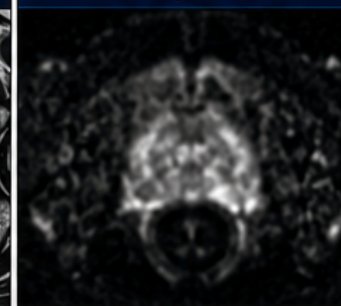
High-quality study with excellent visualization of the prostate and high confidence for csPCa detection.

T2-weighted



- Excellent anatomy
- No significant motion or distortion
- Sharp margins and details

DWI (high b-value)



- No significant distortion
- High SNR, lesion conspicuity is excellent

How to assess? (Only T2W and DWI are scored)

- 1 Evaluate T2-weighted imaging (anatomic detail, motion, distortion)
- 2 Evaluate DWI (high b-value and ADC maps) (lesion visibility, distortion, noise)
- 3 Assign the lowest score of the two (T2W and DWI) as the overall PI-QUAL score.



Key Point:

If either T2W or DWI is of lower quality, the overall PI-QUAL score is determined by that sequence.

DCE quality (not included in PI-QUAL score)

DCE is assessed separately using the following criteria. It can lead to upgrade or downgrade in PI-RADS assessment (especially in the peripheral zone with DWI score 3).

DCE-QUAL 0

Not evaluable

No enhancement or non-diagnostic (e.g., contrast failure, severe artifacts, or incomplete acquisition)

DCE-QUAL 1

Evaluable

Adequate enhancement with sufficient temporal resolution (≤ 15 seconds per phase)

What affects image quality?



Motion (patient, rectal peristalsis)



Susceptibility / distortion (air, bowel, surgical clips)



Inadequate bladder filling



Incorrect coil / patient positioning



Low spatial resolution



Low temporal resolution in DCE



Poor DCE timing / contrast bolus



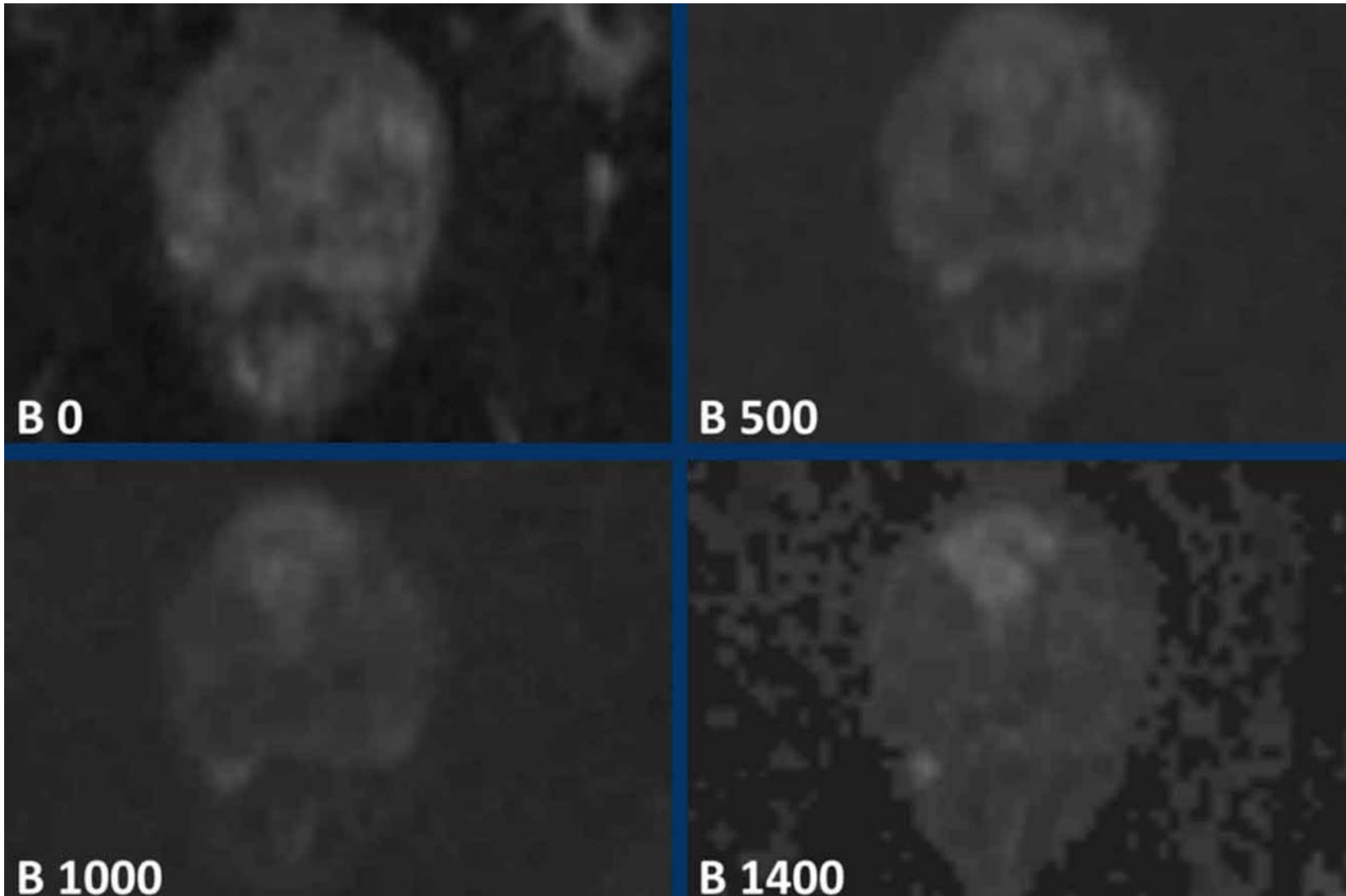
Remember: PI-QUAL reflects IMAGE QUALITY, not the likelihood of clinically significant prostate cancer.

PI-QUAL $\neq$ PI-RADS

(quality score $\neq$ likelihood score)

Goal: High-quality mpMRI is essential for accurate detection and reliable PI-RADS assessment.





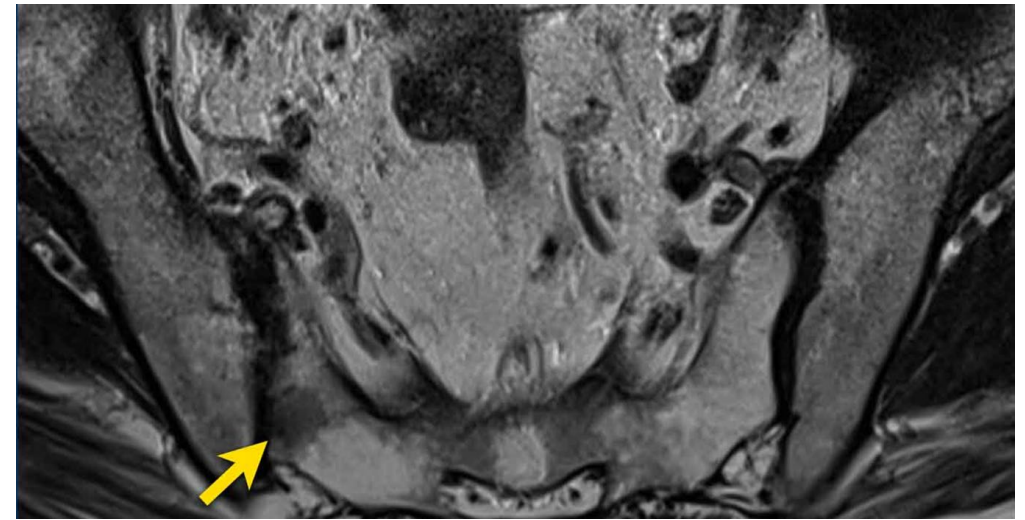
The exact ADC value of the lesion is inversely correlated to the likelihood of a malignant lesion.

High b-values are necessary to create a high signal-to-noise ratio.
B-value of at least 1400 is recommended.

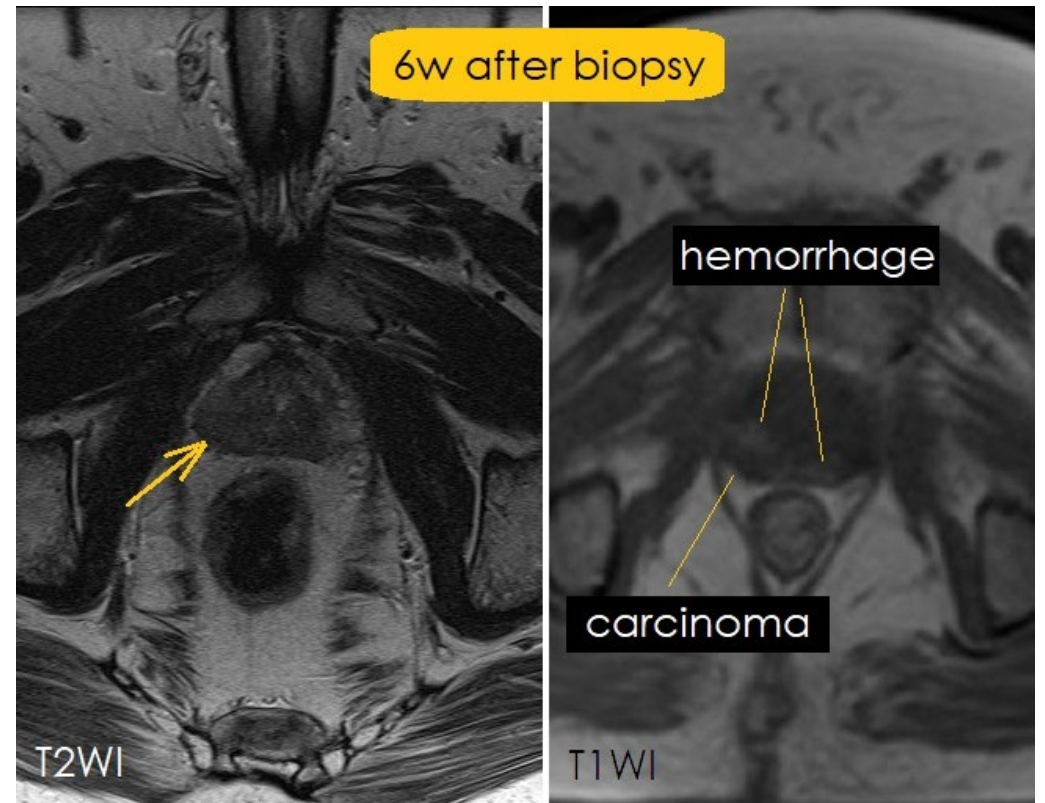


T1-WEIGHTED

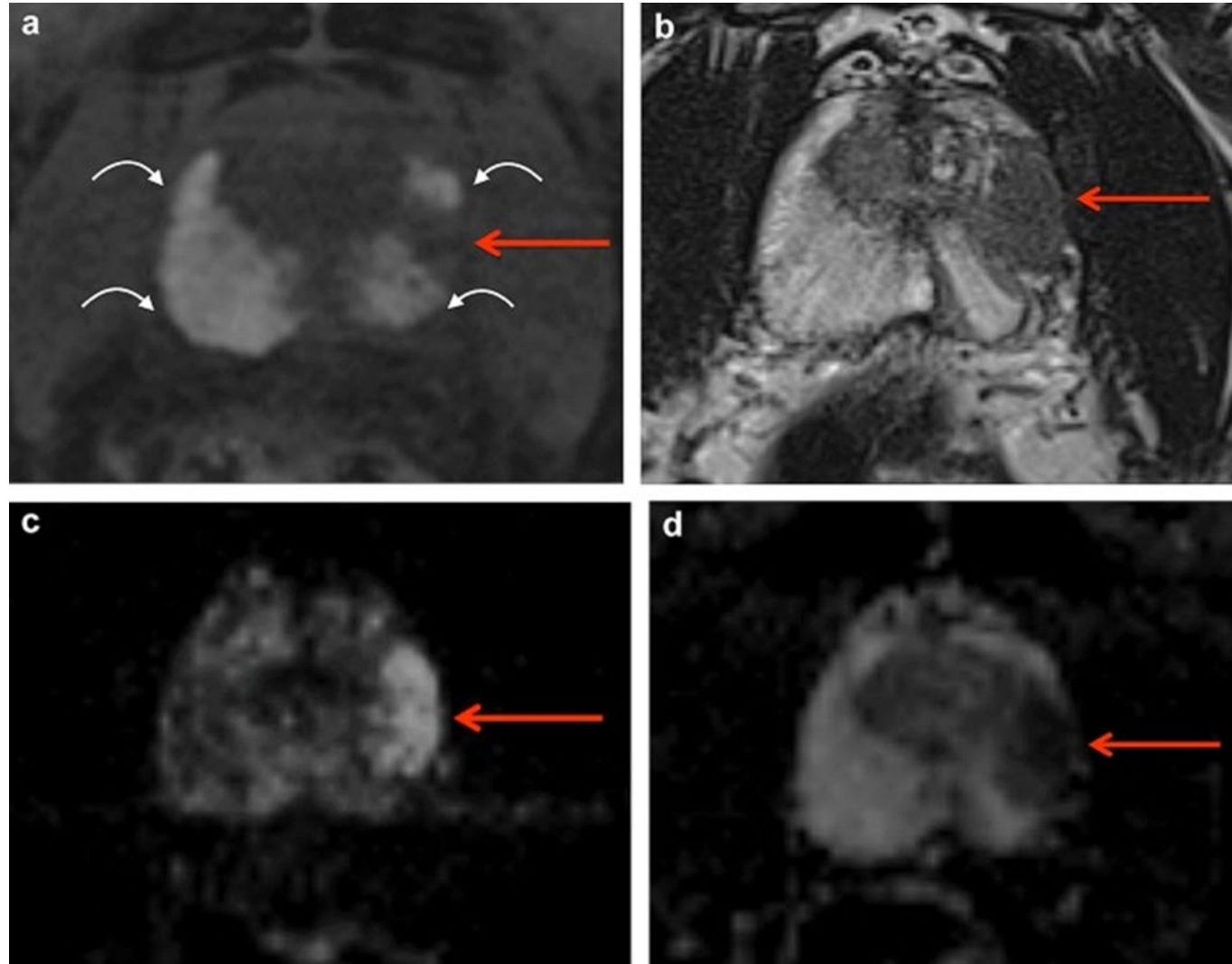
- Axial
- **Hemorrhage**
- **Lymph node**
- **Bone marrow**
- **Comparison with postcontrast**

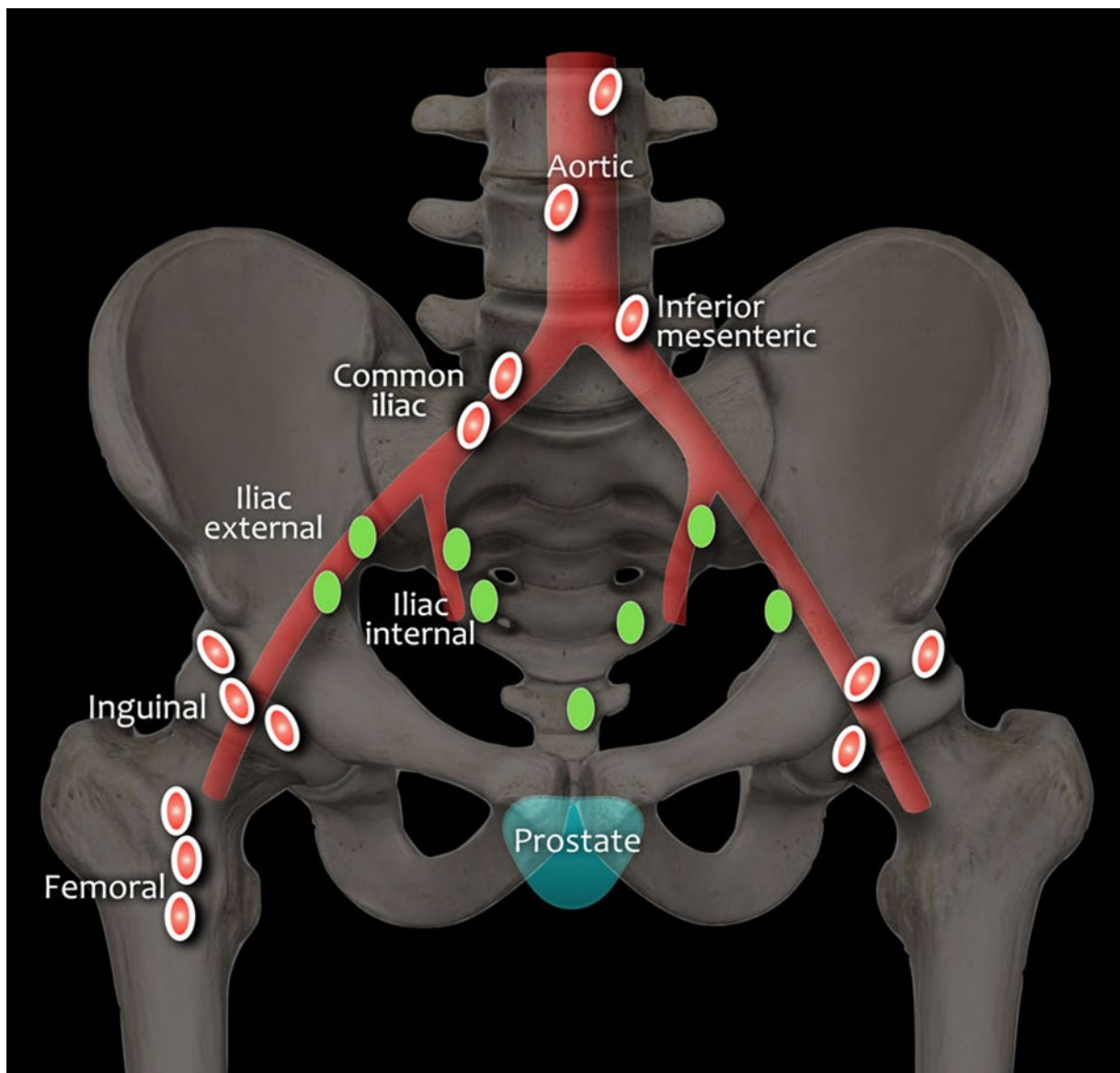


Hemorrhage exclusion sign



Hemorrhage exclusion sign





DWI is the best sequence for detection of lymph nodes.

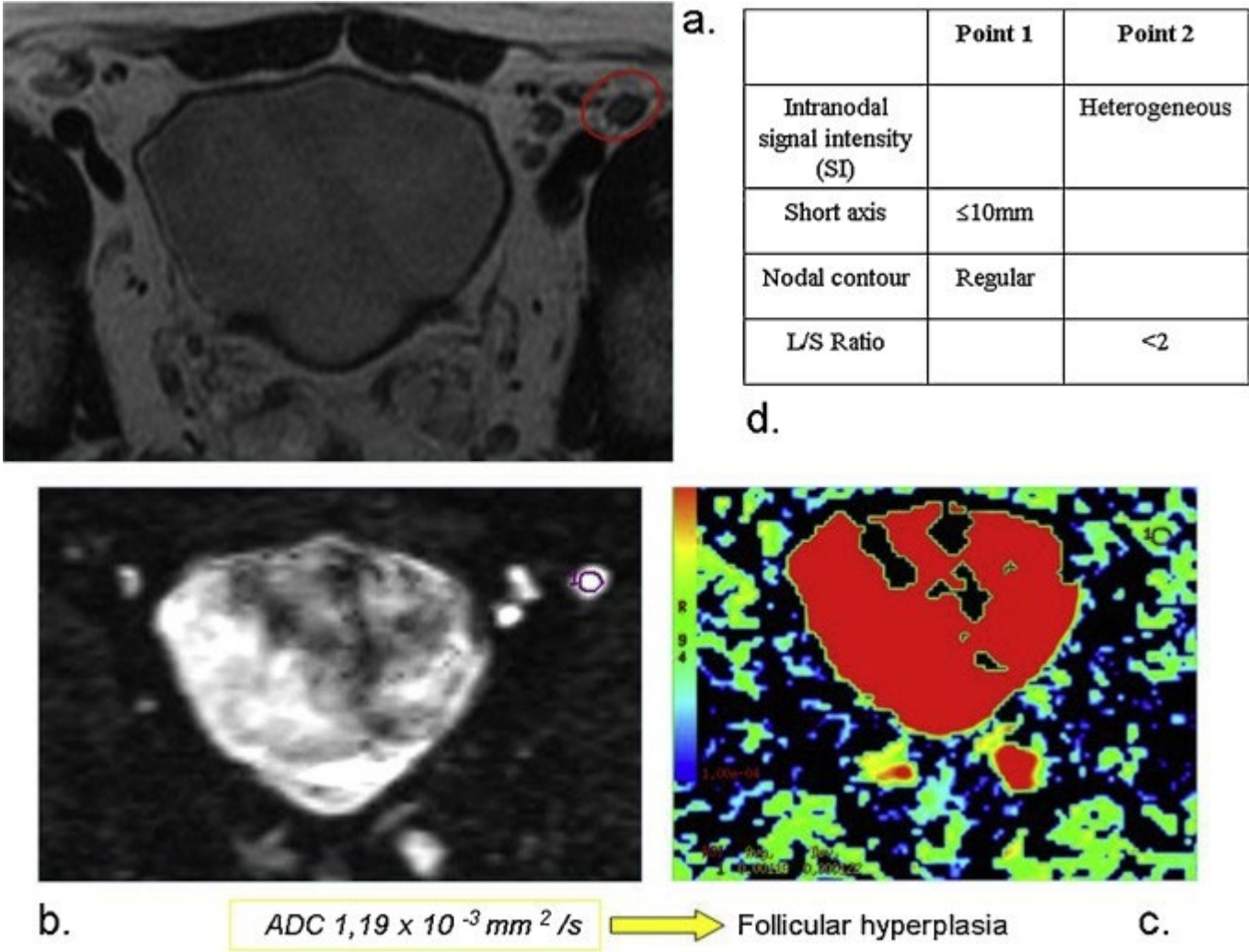
T1W series are useful for interpretation of the border contour and signal characteristics of lymph nodes.

MR has a low accuracy for distinguishing positive or negative lymph nodes if characterization is based on size alone.



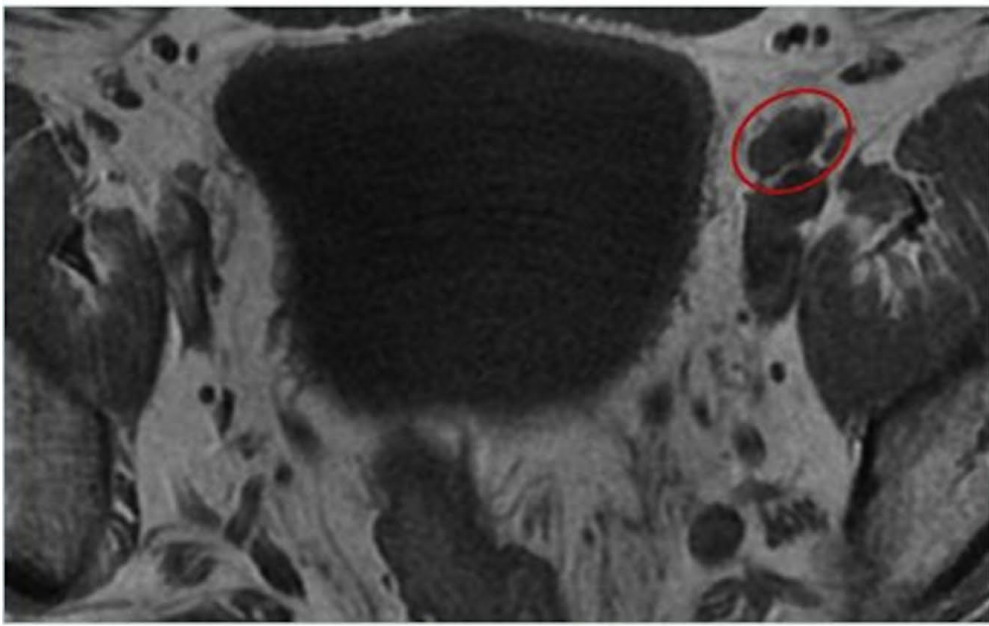
Suspicious LAP:

- Round shape and short axis of $\geq 8\text{mm}$
- Oval shape and short axis of $\geq 10\text{mm}$
- Heterogeneous appearance
- Irregular margins



An example of benign lymph node. (a) T2w image. (b) DW image. (c) ADC map. (d) Grading score = 6.

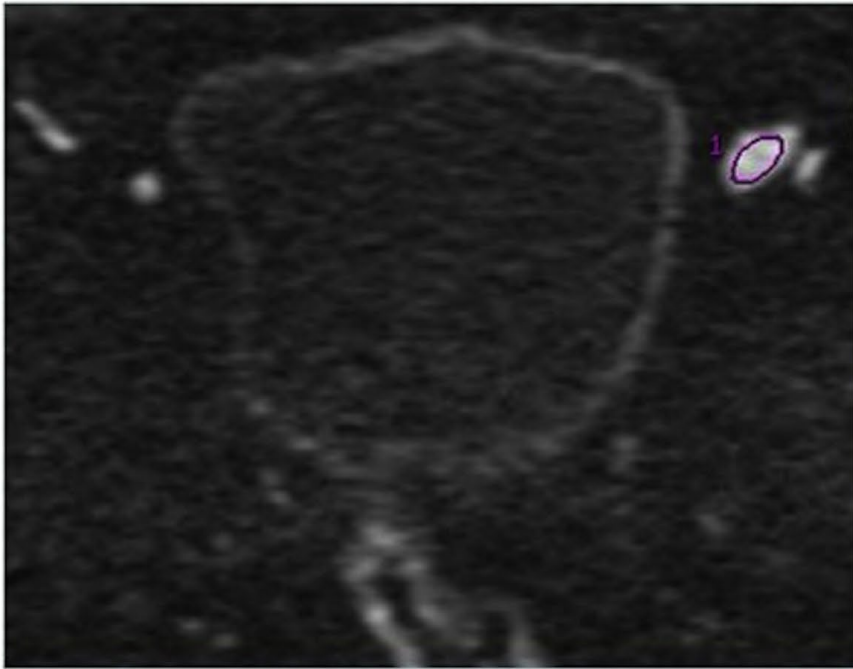




a.

	Point 1	Point 2
Intranodal signal intensity (SI)		Heterogeneous
Short axis	$\leq 10\text{mm}$	
Nodal contour		Irregular
L/S Ratio		< 2

d.

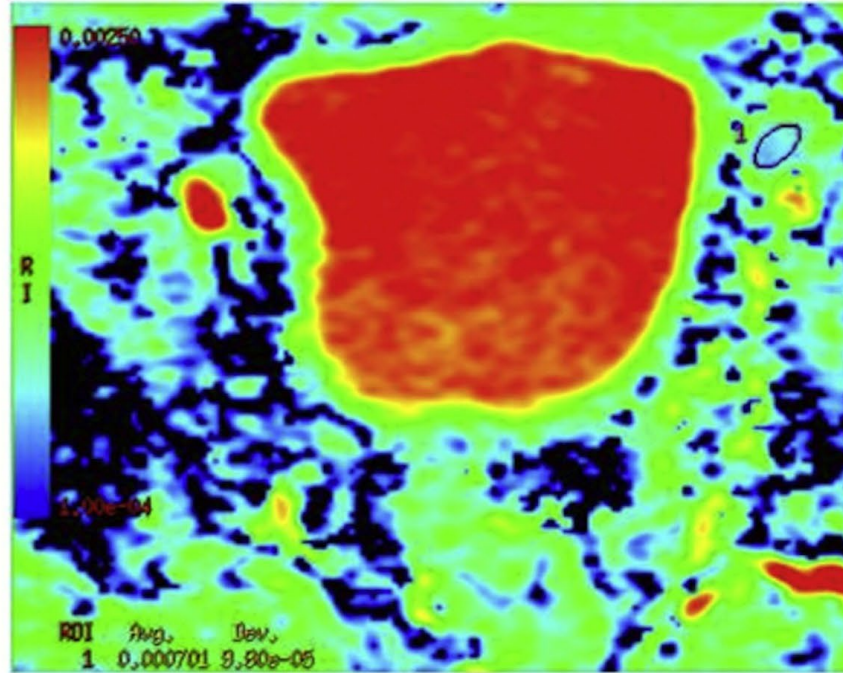


b.

ADC $7,01 \times 10^{-4} \text{ mm}^2/\text{s}$



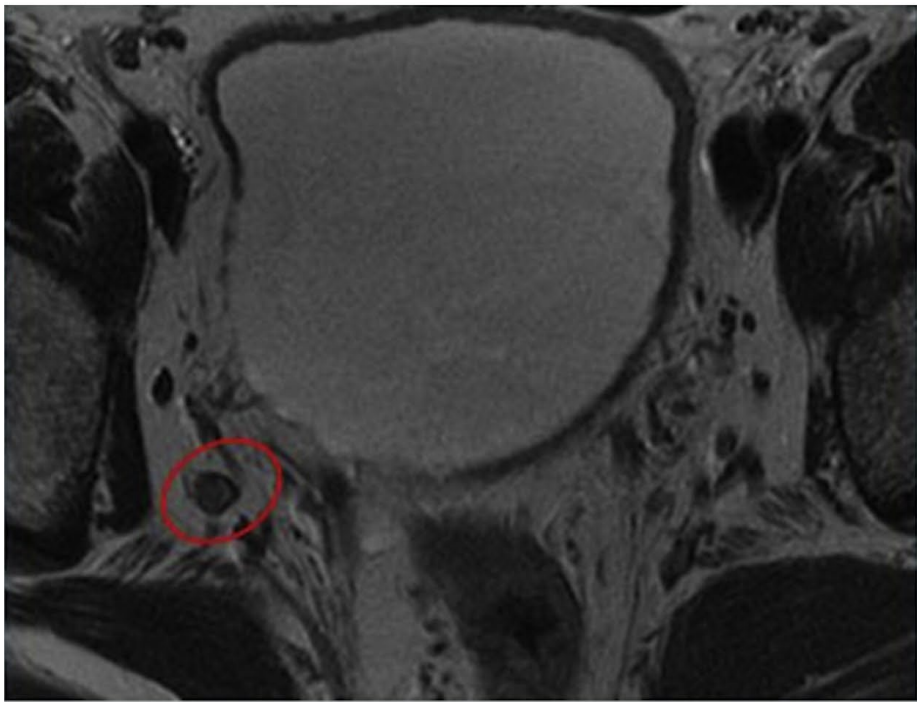
metastatic



c.

ADC value equal to or less than $0.91 \times 10^{-3} \text{ mm}^2/\text{s}$ lymph node metastasis

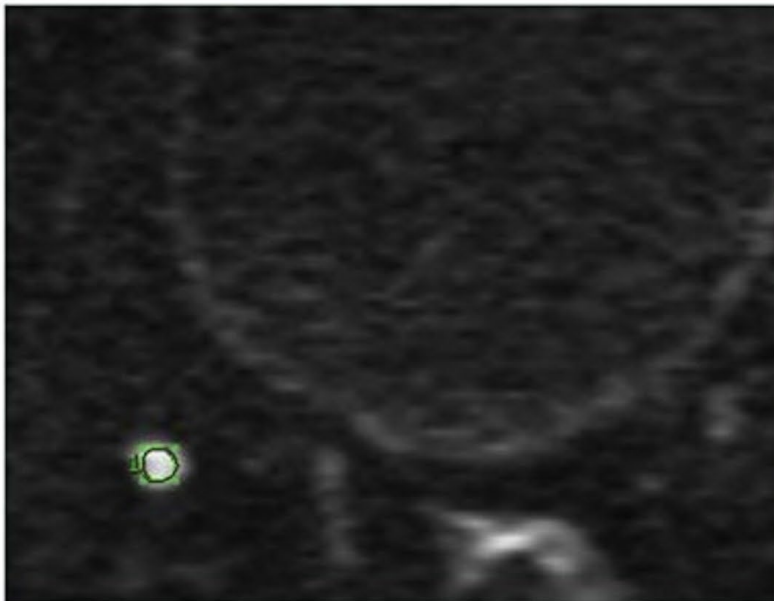




a.

	Point 1	Point 2
Intranodal signal intensity (SI)		Heterogeneous
Short axis	≤10mm	
Nodal contour		Irregular
L/S Ratio		<2

d.

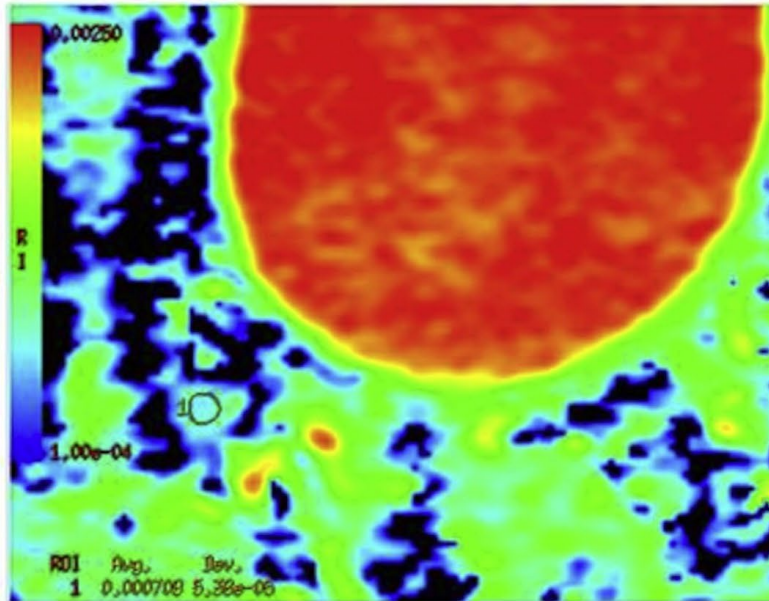


b.

$ADC\ 7.09 \times 10^{-4} mm^2/s$



metastatic



c.



However, to maximize accuracy in MRI-based lymph node staging, it is important to be aware of the following **potential pitfalls** of DWI:

Small nodes (<4 mm in long axis diameter) may be displayed and anatomically localised using DWI, but the presence of malignant disease cannot always be established based on the sole DWI findings.

ADC measurements in **normal-sized** lymph nodes may be degraded by partial volume effects.

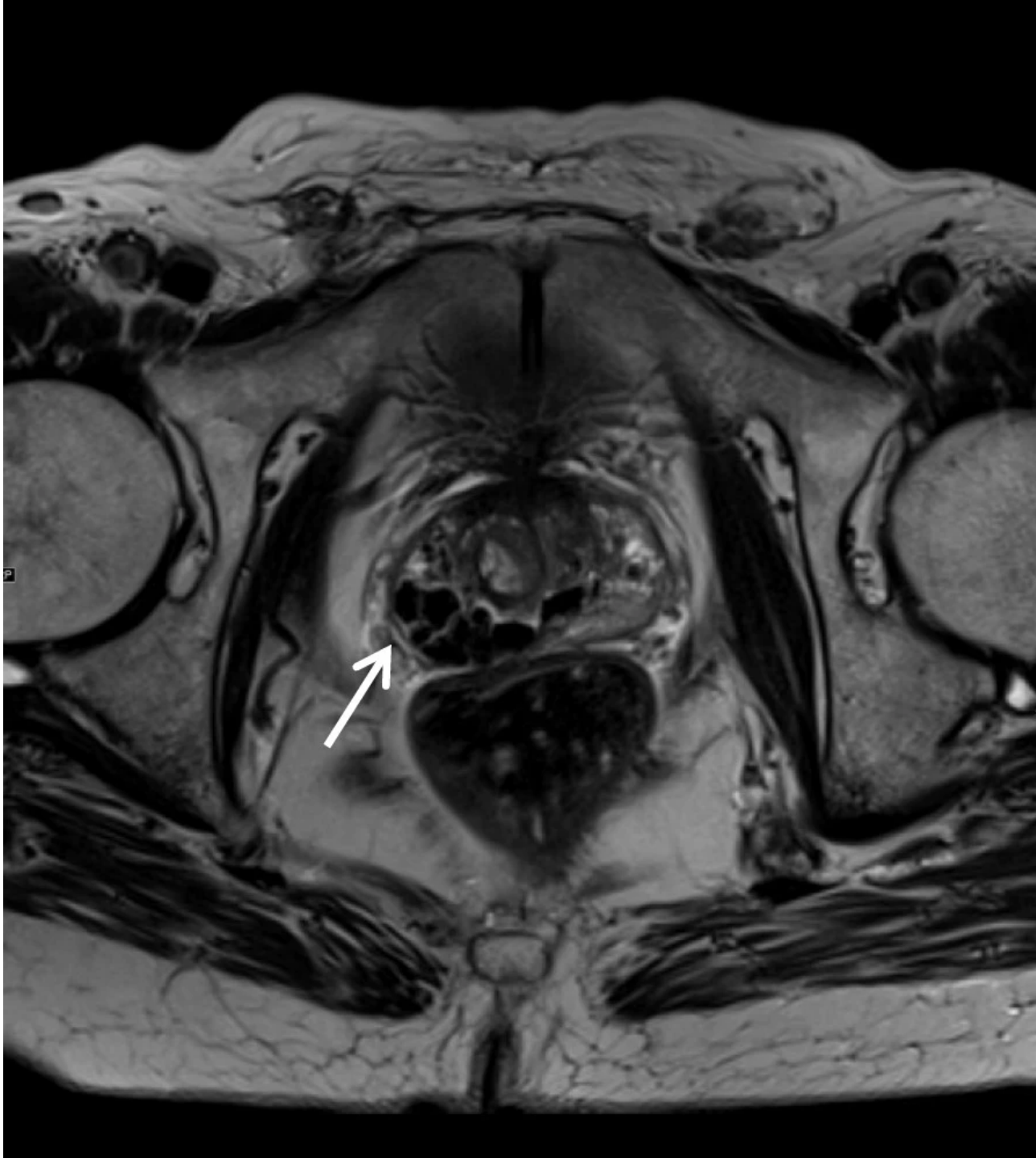
Necrosis inside metastatic nodes may lead to false-negative results due to the resultant ADC increase, and therefore macroscopic areas of intranodal necrosis must be carefully discarded.

Any **reactive** changes in lymph nodes may result in lower ADC values.

Technical factors such as image noise and motion artefacts can lead to systematic or random errors in ADC quantification.

Micrometastases in smaller lymph nodes with insufficient intranodal tumor burden may not impede water diffusion and can therefore lead to false-negative results .





Axial T2W image shows well-defined low T2 signal lesions in the right posterolateral prostate in keeping with prostate **calcification** .

