

PI-RADS: Utility and Pitfalls

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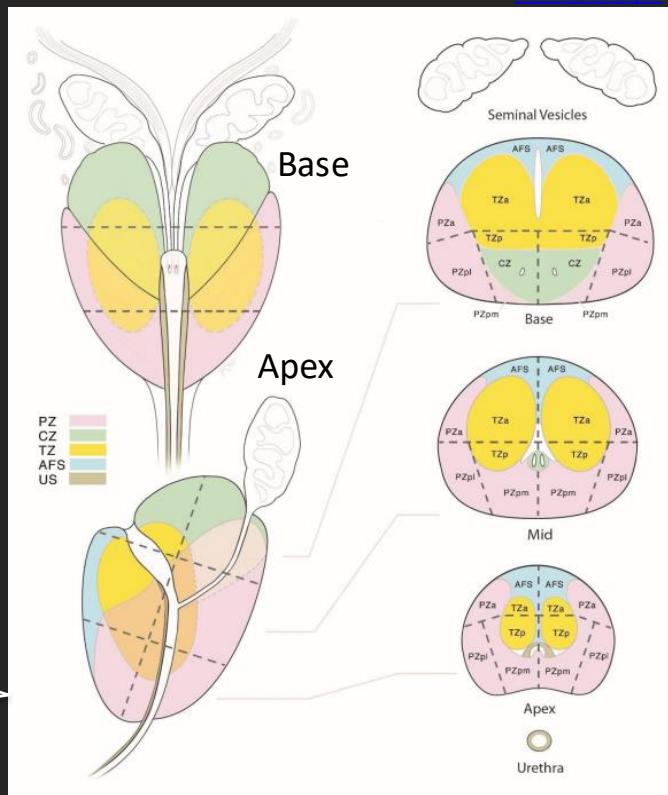
Objectives

- Provide a basic review of prostate anatomy.
- Distill the key features of PI-RADS v2.1 using multiple case examples.
- Define the common pitfalls in prostate MRI to improve diagnostic specificity.

Prostate Anatomy

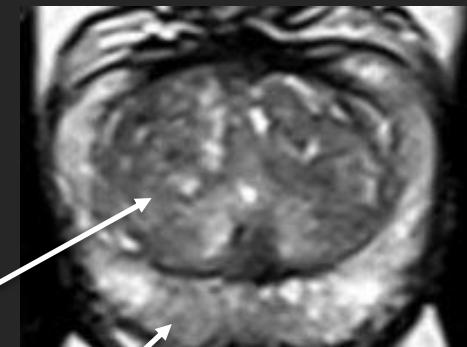
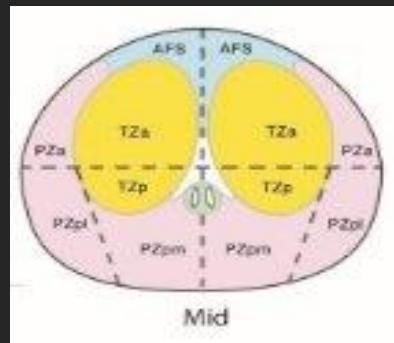
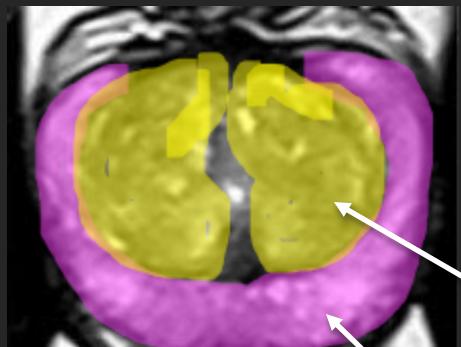
- Prostatic **base** is cranial and **apex** is caudal
- **Transition zone (TZ)** is bilobed, surrounds the prostatic urethra and enlarges in BPH
- **Peripheral zone (PZ)** occupies the posterior and lateral margins of the prostate and is the predominate tissue in the apex
- **Anterior fibromuscular stroma (AFS)** is a strip of tissue along the anterior prostate
- **Central zone (CZ) (base)** surrounds the bilateral ejaculatory ducts

PEARL:
~75% of cancers
originate in PZ.
~25% in TZ.





Normal PZ and TZ

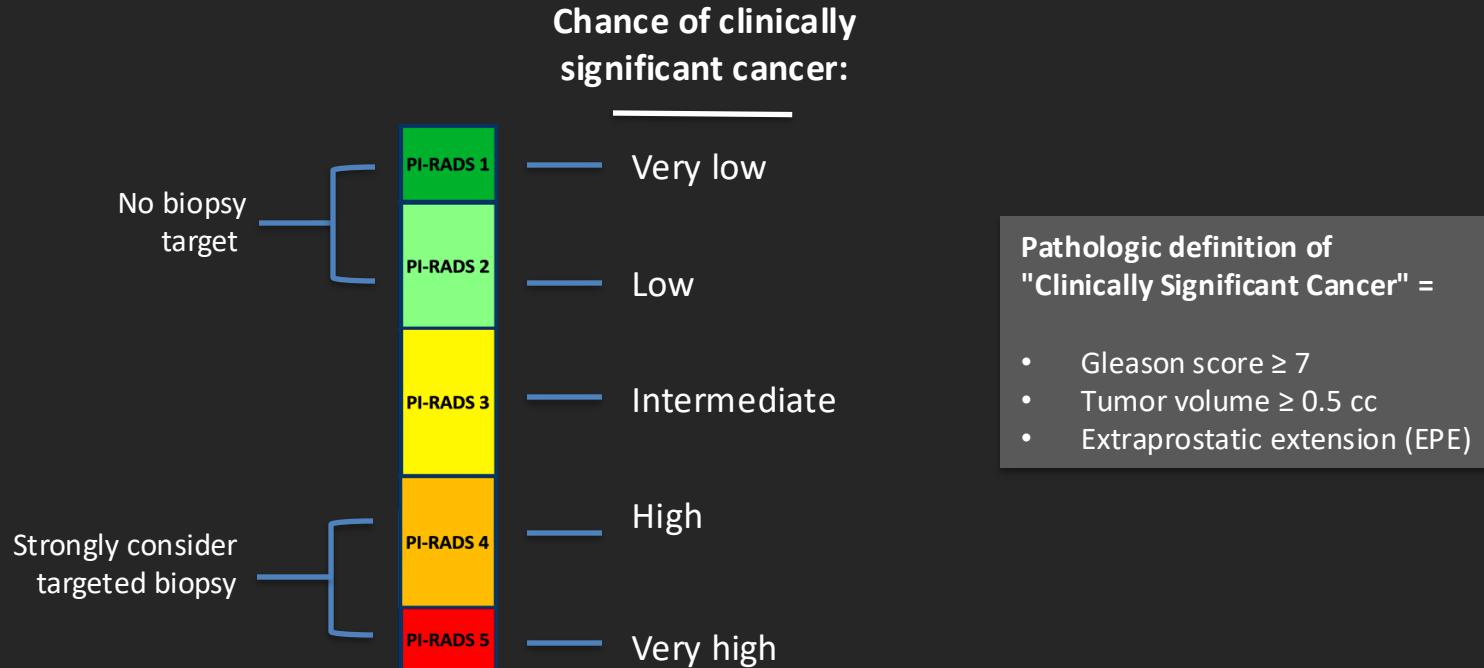


TZ: Entirely homogenous signal is rare.
PI-RADS 1 includes round, completely
encapsulated nodules.

Normal PZ: homogenous signal, T2 bright



PI-RADS Assessment Categories





MRI Features of Assessment Categories

The table is based on the PI-RADS version 2.1.
Changes from the old version 2.0 are indicated in light red.

PI-RADS v 2.1		Peripheral Zone	Transition Zone
		ADC / DWI	T2W
1	Normal	PI-RADS 1	Normal appearing TZ (rare) or round, completely encapsulated nodule 1
2	ADC: Linear/wedge shaped hypointense and/or DWI: linear/wedge shaped hyperintense	PI-RADS 2	Mostly encapsulated nodule or Homogeneous circumscribed nodule without capsule or Homogeneous mildly hypointense area between nodules. DWI ≤ 3 2
3	ADC: Focal hypointense and/or DWI: focal hyperintense May be markedly hypointense on ADC or markedly hyperintense on high b-value DWI, but not both. DCE -	PI-RADS 3	Same as above but DWI ≥ 4 2 Heterogeneous signal intensity with obscured margins. Includes others that do not qualify as 2, 4, or 5. DWI ≤ 4 3
3	Same as above but DCE +	PI-RADS 3	Same as above but DWI = 5 3
4	ADC: Focal markedly hypointense DWI: markedly hyperintense Diameter $< 1.5\text{cm}$	PI-RADS 4	Lenticular or non-circumscribed, homogeneous, moderately hypointense, $< 1.5\text{cm}$. any DWI 4
5	Same as 4, but $\geq 1.5\text{cm}$ or extraprostatic extension	PI-RADS 5	Same as 4, but $\geq 1.5\text{cm}$ or extraprostatic extension. any DWI 5

*When DWI is PI-RADS 3 in the PZ, **early** dynamic contrast enhancement (DCE +) may upgrade to PI-RADS 4.



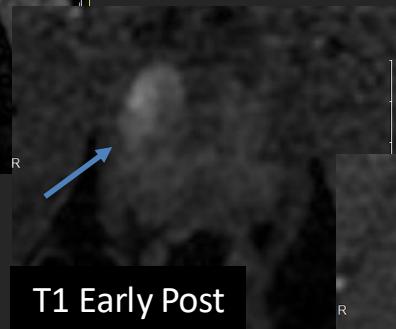
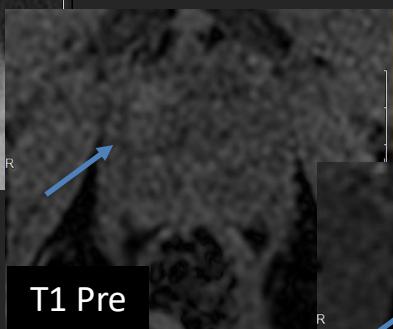
Predominant assessment sequences:

- TZ: ADC/DWI
- PZ: T2W

*Extraprostatic extension (EPE) automatically upgrades to PI-RADS 5!



Dynamic Contrast Enhancement (DCE)



- Criteria for (+) DCE:
 1. Focal and corresponding to suspicious finding on T2 and/or DWI.
 2. **Earlier enhancement than adjacent normal prostatic tissues.**

This category is commonly overcalled. Simple enhancement is not enough, it needs to be early relative to adjacent tissue!

REMEMBER:
(+) DCE can upgrade
a PZ lesion from PI-
RADS 3 to 4



Peripheral Zone: PI-RADS 3



[The Radiology Assistant : Prostate Cancer - PI-RADS v2.1](#)

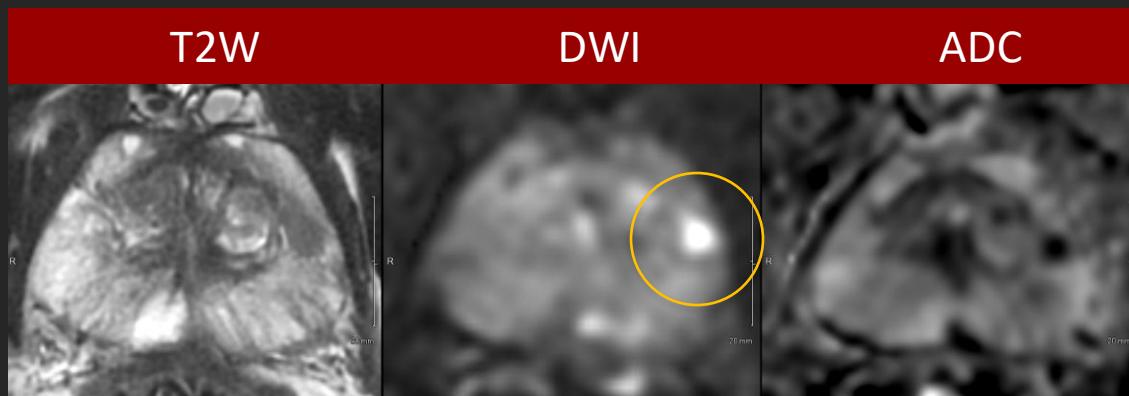
Primary features:

- Focal, not wedge shaped or linear
- Diffusion restriction is limited to mild/moderate on either DWI or ADC.

PZ	
ADC / DWI	
1 Normal	PI-RADS 1
2 ADC: Linear/wedge shaped hypointense and/or DWI: linear/wedge shaped hyperintense	PI-RADS 2
3 ADC: Focal hypointense and/or DWI: focal hyperintense May be markedly hypointense on ADC or markedly hyperintense on high b-value DWI, but not both. DCE -	PI-RADS 3
3 Same as above but DCE +	PI-RADS 4
4 ADC: Focal markedly hypointense DWI: markedly hyperintense Diameter < 1.5cm	PI-RADS 4
5 Same as 4, but ≥ 1.5cm or extraprostatic extension	PI-RADS 5



Peripheral Zone: PI-RADS 4

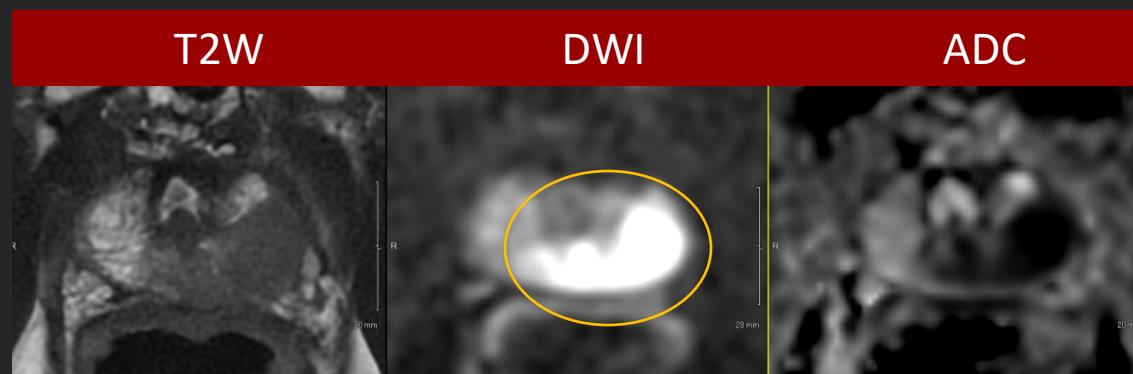


Primary features:

- **Marked** diffusion restriction on both DWI and ADC
- Focal and **< 1.5 cm**

PZ	
ADC / DWI	PI-RADS
1 Normal	PI-RADS 1
2 ADC: Linear/wedge shaped hypointense and/or DWI: linear/wedge shaped hyperintense	PI-RADS 2
3 ADC: Focal hypointense and/or DWI: focal hyperintense May be markedly hypointense on ADC or markedly hyperintense on high b-value DWI, but not both. DCE -	PI-RADS 3
3 Same as above but DCE + ADC: Focal markedly hypointense DWI: markedly hyperintense Diameter < 1.5cm	PI-RADS 4
5 Same as 4, but ≥ 1.5cm or extraprostatic extension	PI-RADS 5

Peripheral Zone: PI-RADS 5



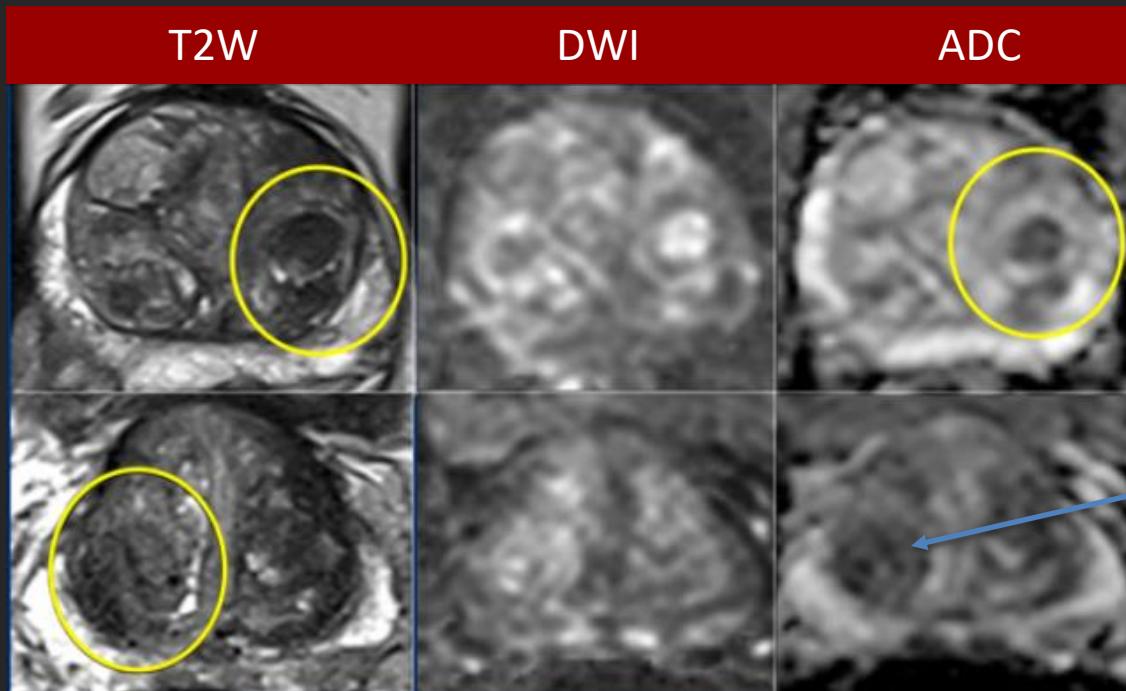
Primary features:

- **Marked** diffusion restriction on both DWI and ADC
- Focal and **> 1.5 cm**

PZ	
ADC / DWI	
1 Normal	PI-RADS 1
2 ADC: Linear/wedge shaped hypointense and/or DWI: linear/wedge shaped hyperintense	PI-RADS 2
3 ADC: Focal hypointense and/or DWI: focal hyperintense	PI-RADS 3
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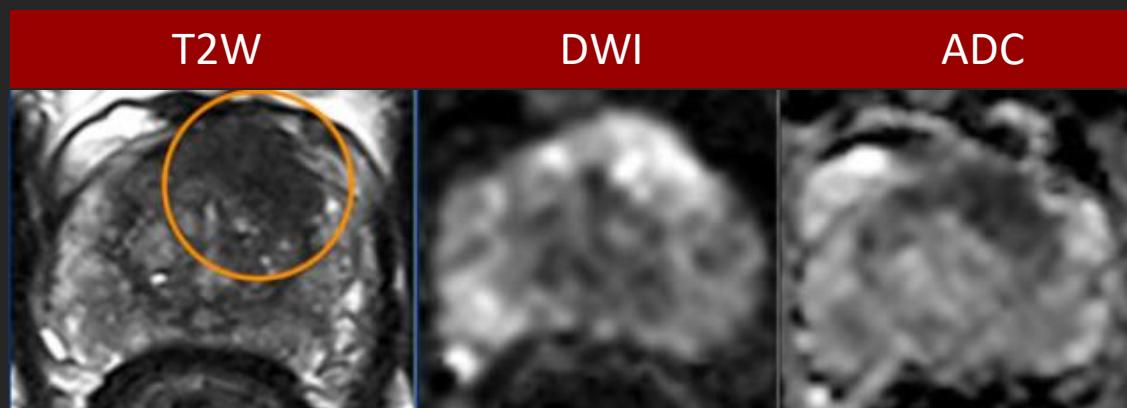


Transition Zone: PI-RADS 3



TZ	
T2W	
PI-RADS 1	Normal appearing TZ (rare) or round, completely encapsulated nodule
PI-RADS 2	Mostly encapsulated nodule or Homogeneous circumscribed nodule without capsule or Homogeneous mildly hypointense area between nodules. DWI ≤ 3
PI-RADS 3	Same as above but DWI ≥ 4 Heterogeneous signal intensity with obscured margins. Includes others that do not qualify as 2, 4, or 5. DWI ≤ 4
PI-RADS 4	Same as above but DWI = 5
PI-RADS 5	Lenticular or non-circumscribed, homogeneous, moderately hypointense, $< 1.5\text{cm}$. any DWI
	Same as 4, but $\geq 1.5\text{cm}$ or extra-prostatic extension. any DWI

Transition Zone: PI-RADS 4



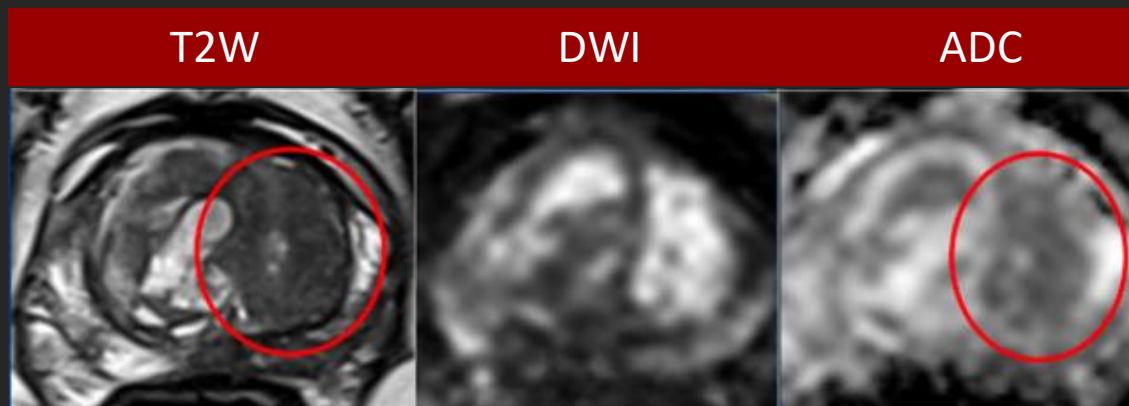
Primary features:

- Differs from PI-RADS 3 in that the T2 signal is **homogenous** and **moderately** intense.
- < 1.5 cm

TZ
↓

T2W	
PI-RADS 1	Normal appearing TZ (rare) or round, completely encapsulated nodule 1
PI-RADS 2	Mostly encapsulated nodule or Homogeneous circumscribed nodule without capsule or Homogeneous mildly hypointense area between nodules. DWI ≤ 3 2
PI-RADS 3	Same as above but DWI ≥ 4 2
PI-RADS 4	Heterogeneous signal intensity with obscured margins. Includes others that do not qualify as 2, 4, or 5. DWI ≤ 4 3
PI-RADS 5	Same as above but DWI = 5 3
PI-RADS 4	Lenticular or non-circumscribed, homogeneous, moderately hypointense, < 1.5 cm. any DWI 4
PI-RADS 5	Same as 4, but ≥ 1.5 cm or extra-prostatic extension. any DWI 5

Transition Zone: PI-RADS 5



Primary features:

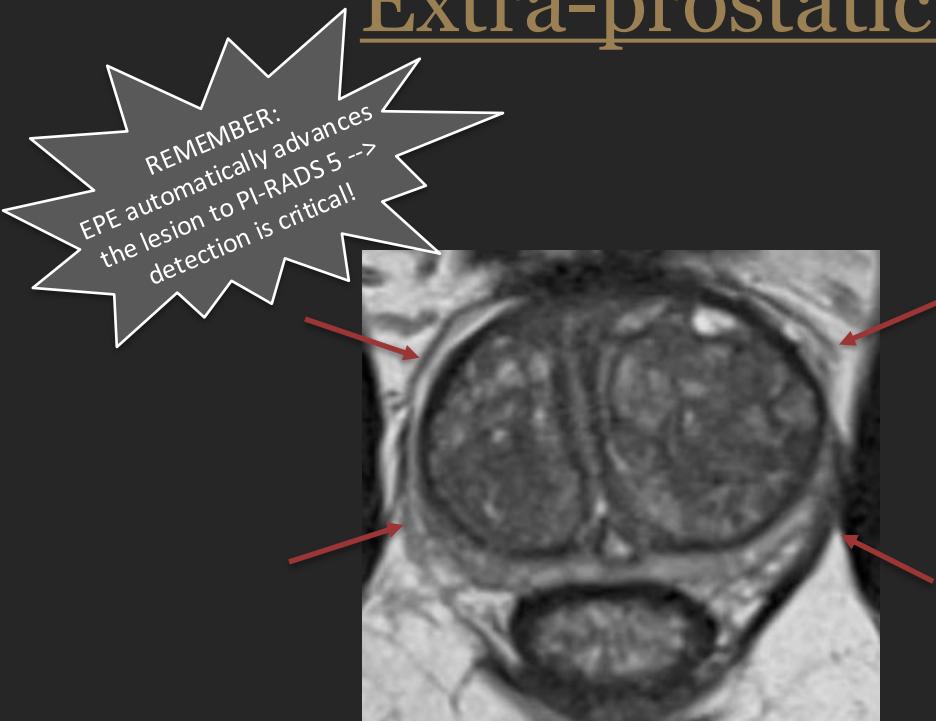
- T2 signal is homogenous and moderately intense.
- >1.5 cm

TZ
↓

T2W	
PI-RADS 1	Normal appearing TZ (rare) or round, completely encapsulated nodule 1
PI-RADS 2	Mostly encapsulated nodule or Homogeneous circumscribed nodule without capsule or Homogeneous mildly hypointense area between nodules. DWI ≤ 3 2
PI-RADS 3	Same as above but DWI ≥ 4 2
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PI-RADS 5	Same as above but DWI = 5 3
PI-RADS 4	Lenticular or non-circumscribed, homogeneous, moderately hypointense, < 1.5 cm. any DWI 4
PI-RADS 5	Same as 4, but ≥ 1.5 cm or extra-prostatic extension. any DWI 5



Extra-prostatic extension (EPE)



- There is no true anatomic prostate capsule.
- On MRI however, the outer border is seen as a thin hypointense line (arrows)
- This line is used to assess extra-prostatic tumor growth.

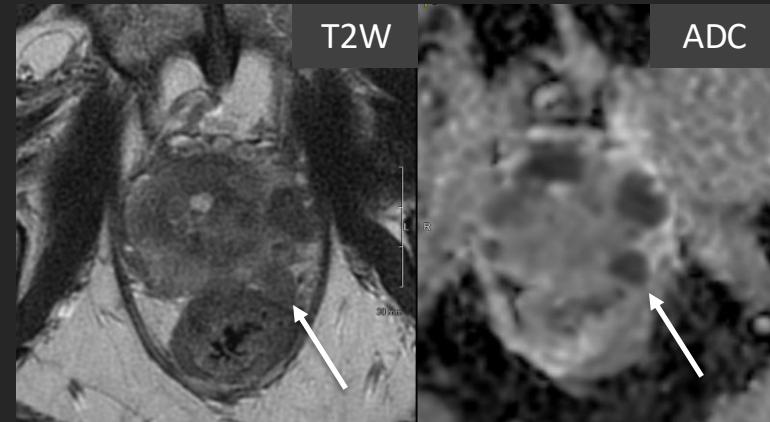
Nerve-sparing surgery is not possible when NV extension is seen.

Neurovascular Bundles



Normal neurovascular bundles are located posterolaterally at 5 and 7 o'clock.

Multiple PI-RADS 5 lesions with probable extension into the left neurovascular bundle (arrows)

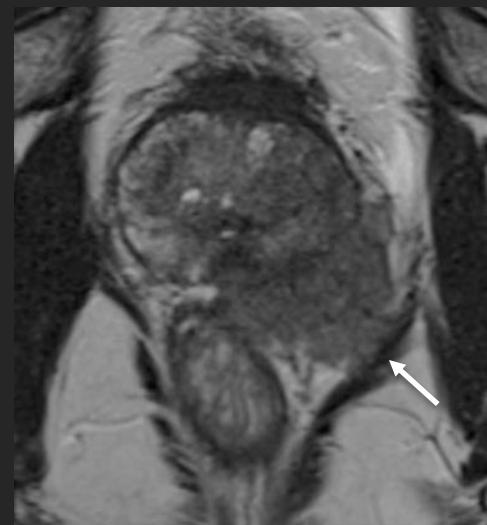




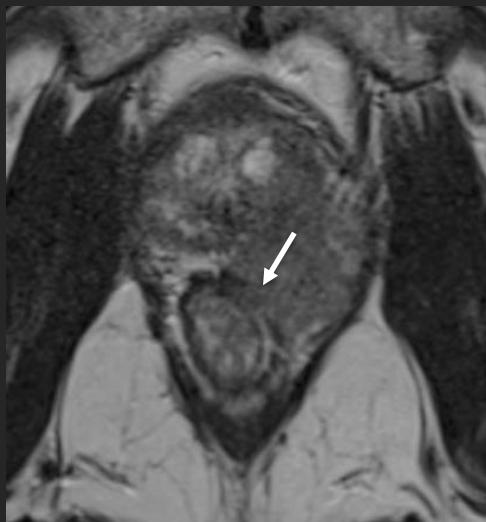
Extra-Prostatic Invasion

Tumor can invade adjacent structures including the:

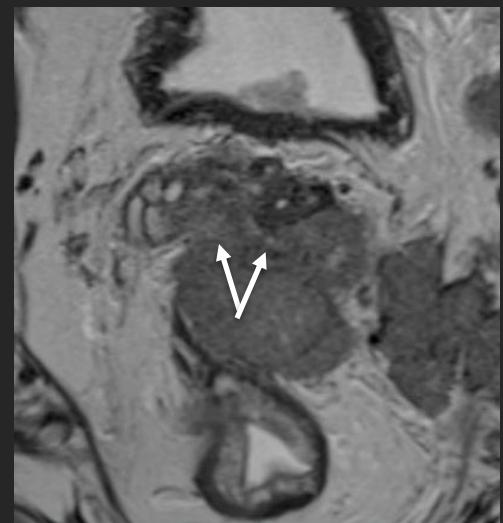
Pelvic floor



Mesorectum and rectum

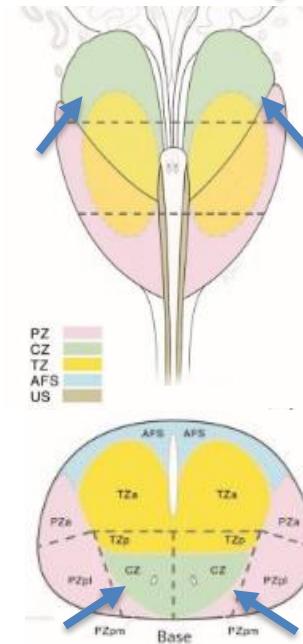
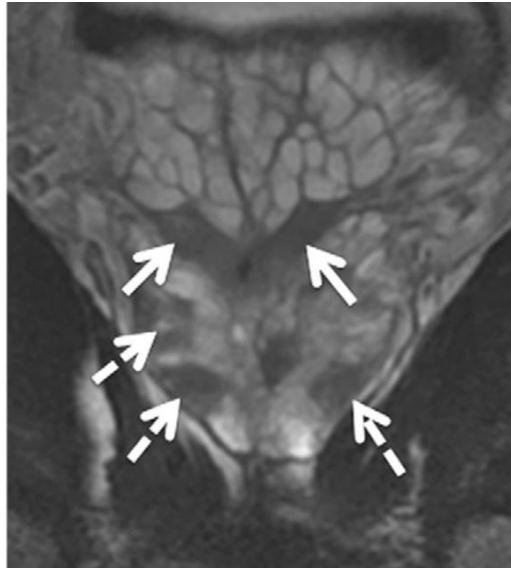
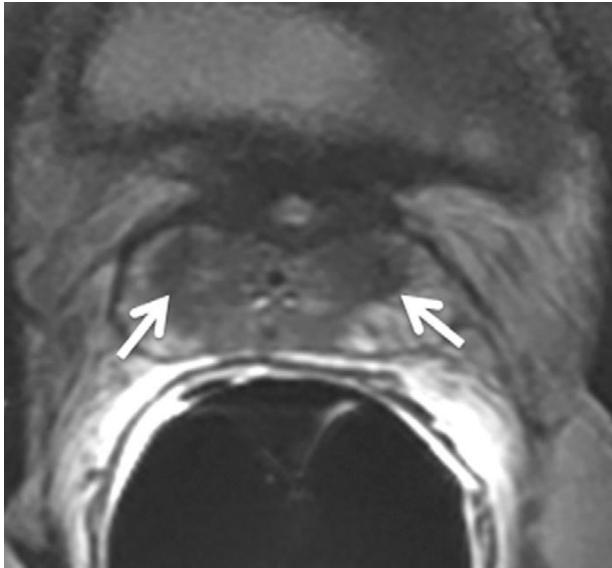


Seminal vesicles



Pitfall #1

Central Zone

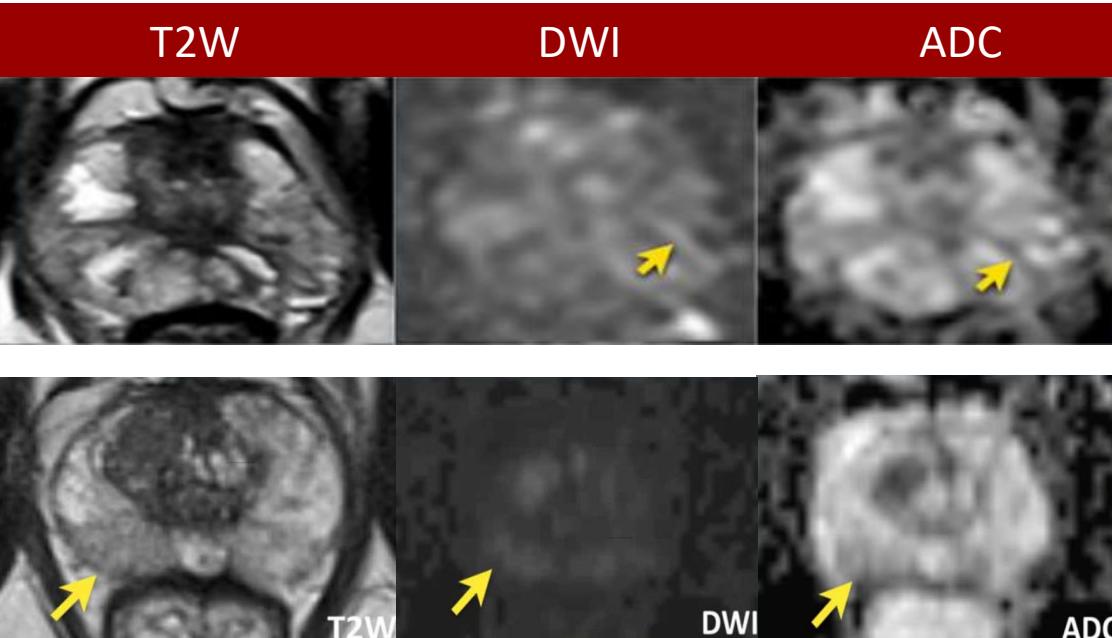


Normal central zone (solid arrows) has low T2 signal intensity and can resemble multifocal cancer (dash arrows).

PEARL:
CZ will typically be
symmetric, unlike
cancer!

Pitfall #2

Acute and Chronic Prostatitis (PZ PI-RADS 2)



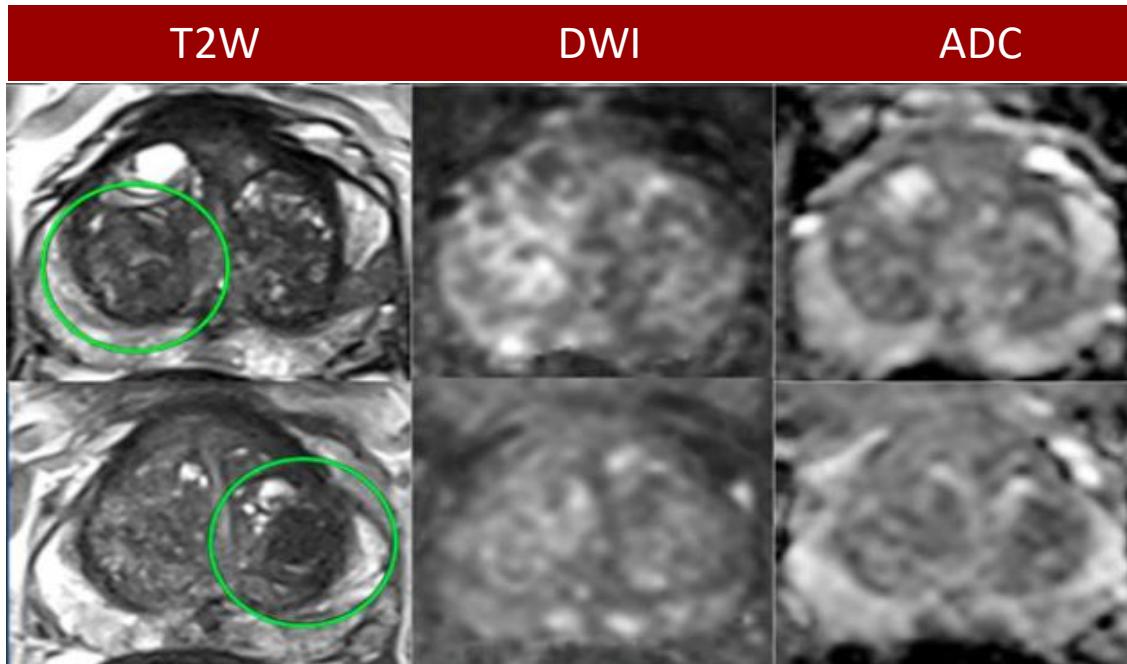
Differential

	Prostatitis	PZ Prostate cancer
Focus	<u>Linear</u> (e.g. 1) or <u>Wedge shaped</u> (e.g. 2)	Round or droplet shaped
Border	Sharp	Ill-defined
Diffusion Restriction	Mild	Marked

Pitfall #3

Stromal BPH Nodule (TZ PI-RADS 2/3)

PEARL:
Shape and border are
the primary
distinguishing factors!

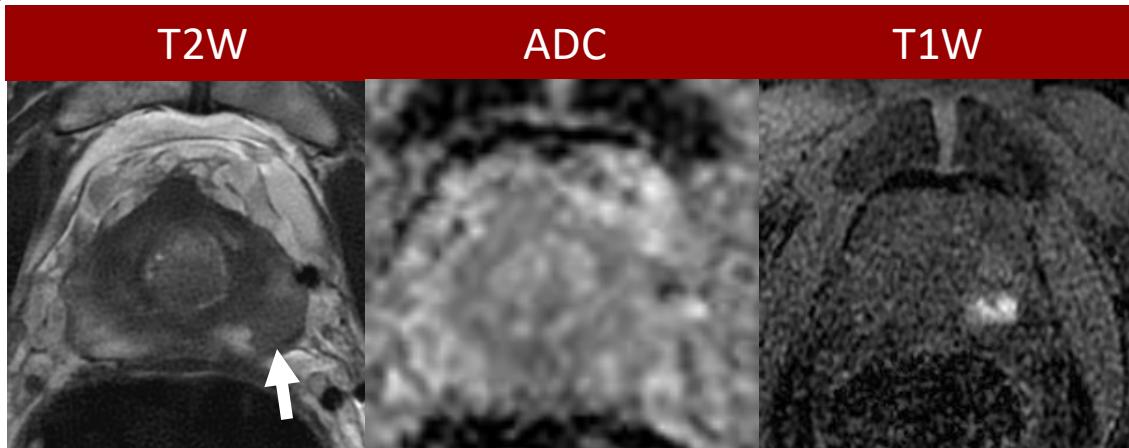


Differential

	Stromal BPH Nodule	TZ Prostate cancer
Shape	Spherical	Lenticular or irregularly shaped
Border	Encapsulated (e.g. 1) or non-encapsulated (e.g. 2)	"Creeping" border w/ possible extension into PZ or AFS
Diffusion Restriction	Mild	Marked

Pitfall #4

Post Biopsy Hemorrhage



Differential

	Hemorrhage	Prostate cancer
T1 Signal	High (subacute)	Low
T2 Signal	Heterogeneous	Low
Diffusion Restriction	None	Marked

Subacute hemorrhage (arrow) has high T1W signal and no diffusion restriction while cancer has low T1W signal and restricts diffusion.

Summary

Transition Zone: Primarily assessed with T2.

Peripheral Zone: Primarily assessed with DWI.

- (+) DCE can upgrade PI-RADS 3 to 4



Dynamic Contrast Enhancement: **Early** enhancement of the lesion **relative to** the normal prostatic tissue.

Extraprostatic extension: Significant prognostic factor and upgrades lesion to PI-RADS 5.

PITFALLS

1. Normal central zone
2. Acute/Chronic Prostatitis
3. Stromal BPH Nodule
4. Post Biopsy Hemorrhage



References

- Rosenkrantz AB, Taneja SS. Radiologist, be aware: ten pitfalls that confound the interpretation of multiparametric prostate MRI. *AJR Am J Roentgenol.* 2014 Jan;202(1):109-20.
- American College of Radiology® Committee on PI-RADS®. PI-RADS 2019 v2.1. Available at: <https://www.acr.org/-/media/ACR/Files/RADS/PI-RADS/PIRADS-V2-1.pdf>. American College of Radiology. Accessed on Jan. 1, 2025.
- The Radiology Assistant : Prostate Cancer - PI-RADS v2.1, Georgios Agrotis¹, Rhiannon van Loenhout², Frank Zijta², Robin Smithuis³ and Ivo Schoots⁴.



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