

Multiparametric Prostate MRI Techniques

Pranay Krishnan, MD FSABI

MedStar Georgetown University Hospital

Vice Chair Operations, Quality, and Safety



MedStar Health

Disclosures

None

Objectives

▮ Prostate MRI protocol-PIRADS v2.1

T2W

DWI

ADC

DCE
T1W

- ▮ 3T vs 1.5 T
- ▮ Endorectal coil
- ▮ Antispasmodic Agents
- ▮ Cleansing Enema
- ▮ Bi-parametric MRI

Prostate MRI protocol

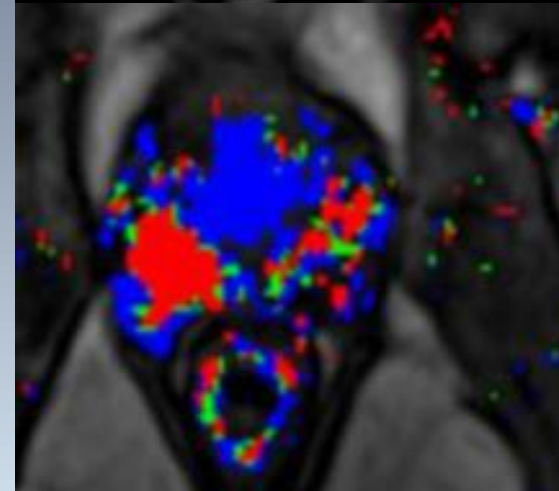
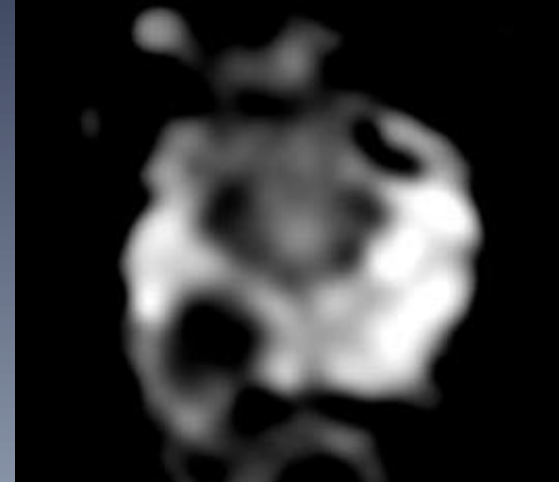
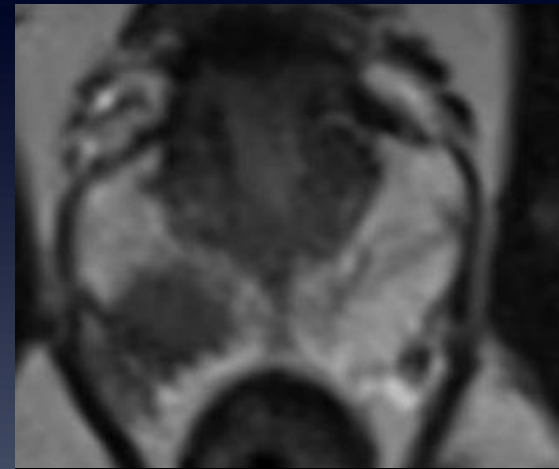
T2W

DWI

ADC

DCE

T1W



T2 Weighted Imaging

- ▮ Axial Plane (required)
 - ▮ Tumor Detection/Localization
 - ▮ Prostate Zonal Anatomy
 - PZ vs TZ vs CZ
 - ▮ Extra-prostatic extension
 - Capsule, NVBs, SVs
 - ▮ Relationship of tumor to urethra, bladder neck

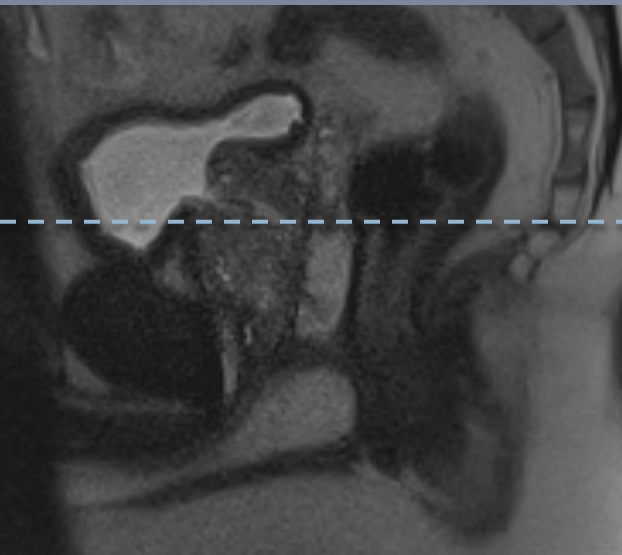
Turbo Spin Echo (TSE)
Fast Spin Echo (FSE)



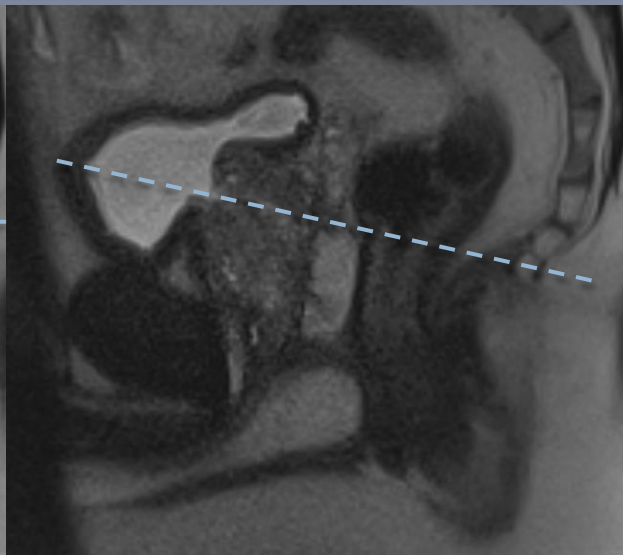
T2 Weighted Imaging

- ▮ Axial (required)
 - ▮ Same axial plane use for all axial sequences

Angled axial to patient



Angled axial to prostate



At my institution....

Angled axial to patient

Why?

--easier to perform consistently by all techs at all sites



T2 Weighted Imaging

- ▮ Axial (required)
- ▮ Coronal and/or Sagittal (required)

At my institution....

Coronal

WHY?

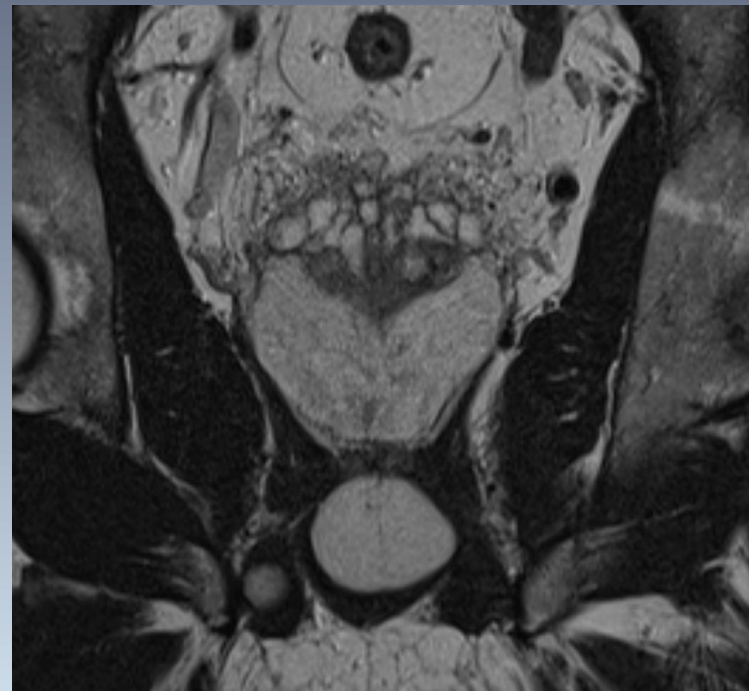
Blind spots in gland

Midline/Para-midline lesions

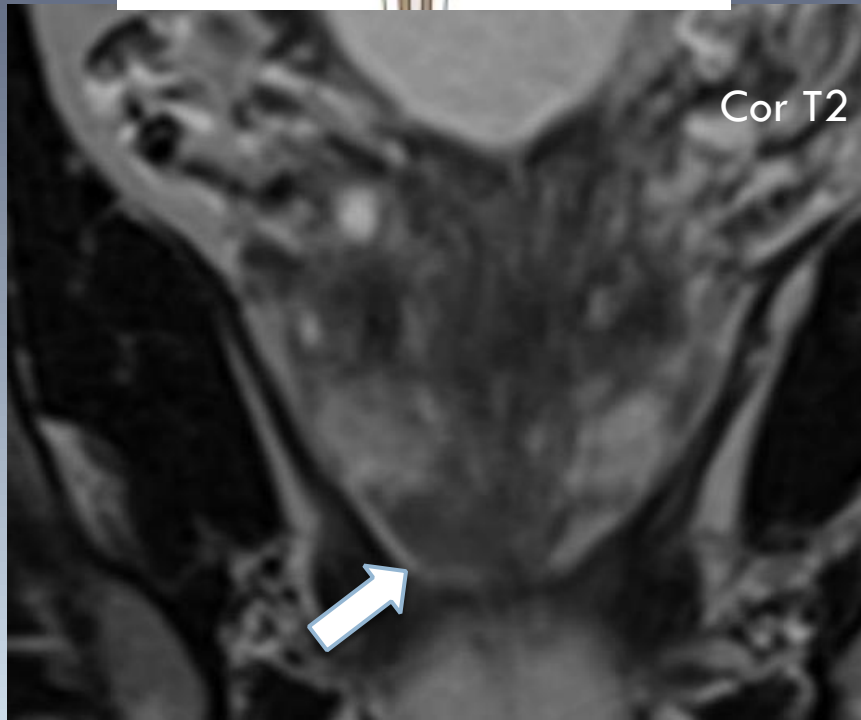
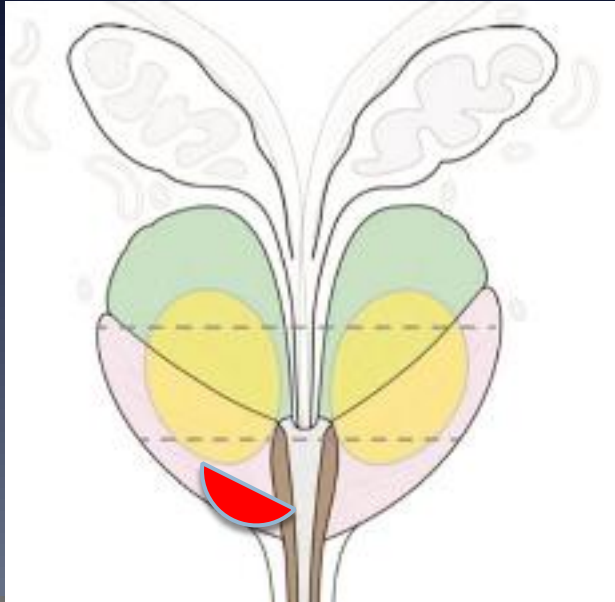
--Central Zone localization

Turbo Spin Echo (TSE)

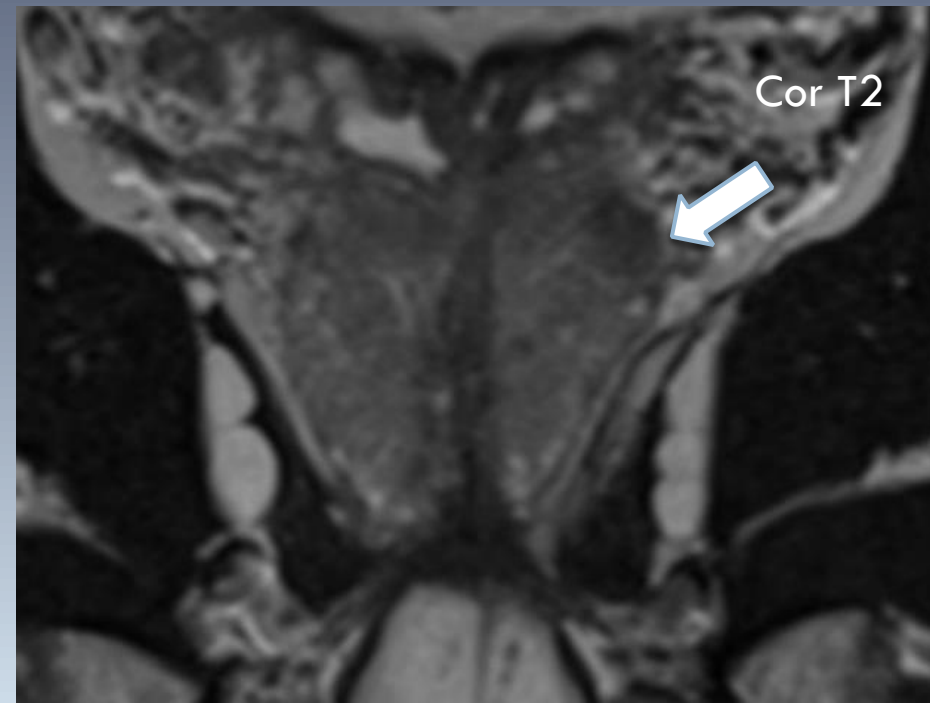
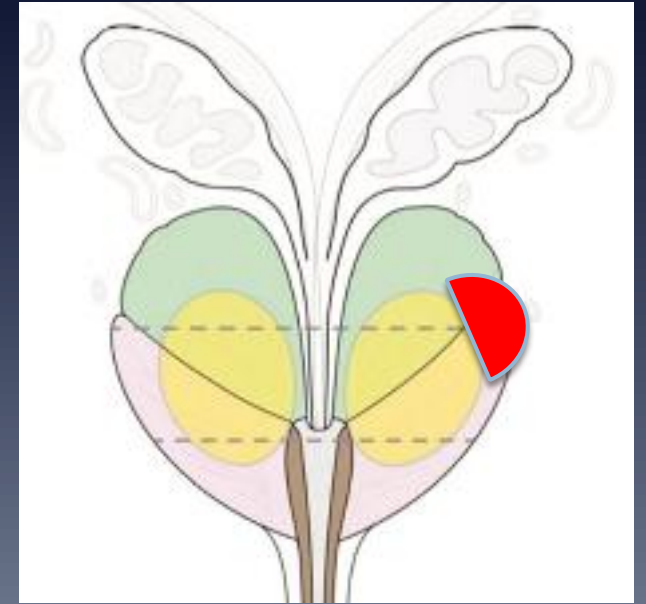
Fast Spin Echo (FSE)



Distal Apical

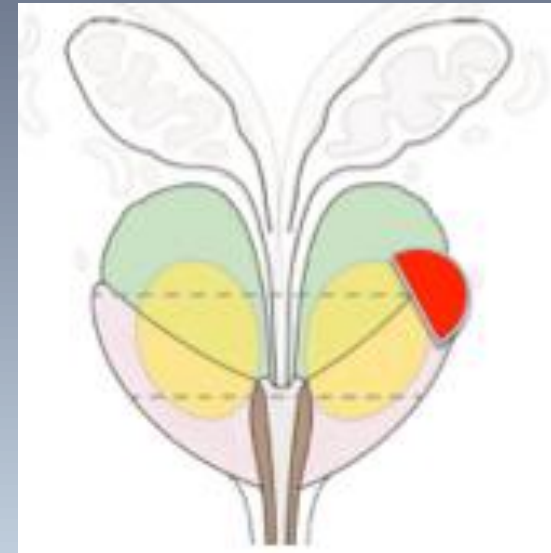
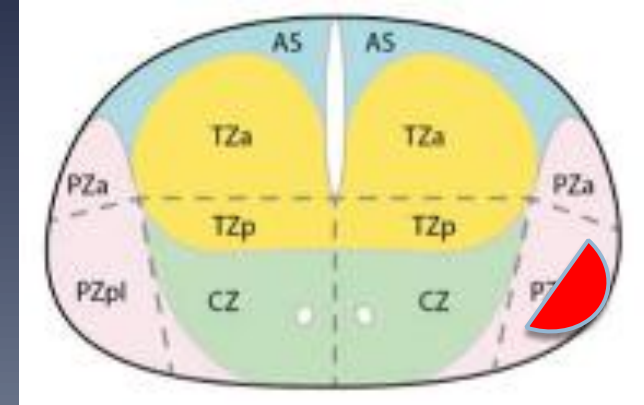
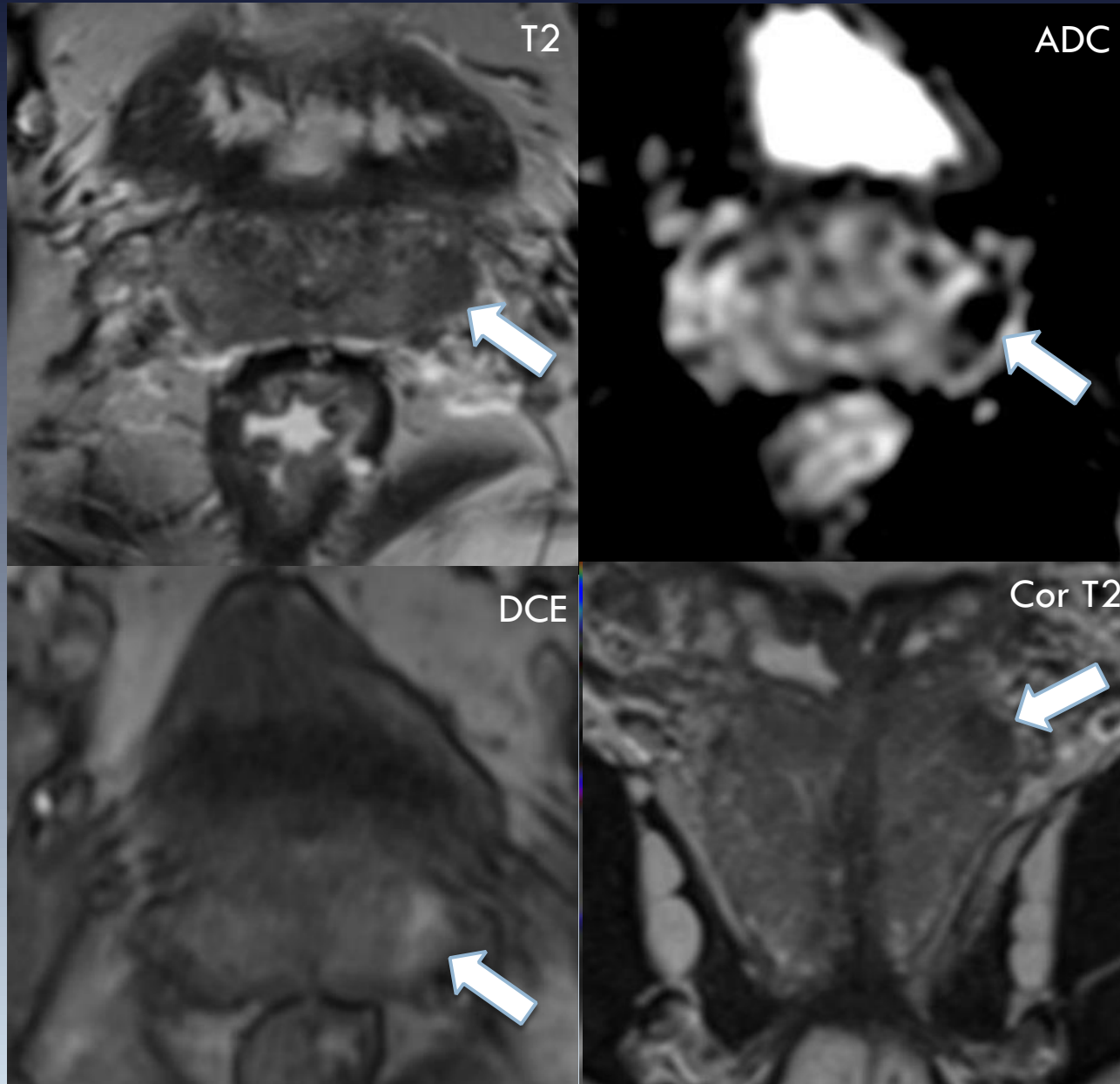


Lateral/Superior Base



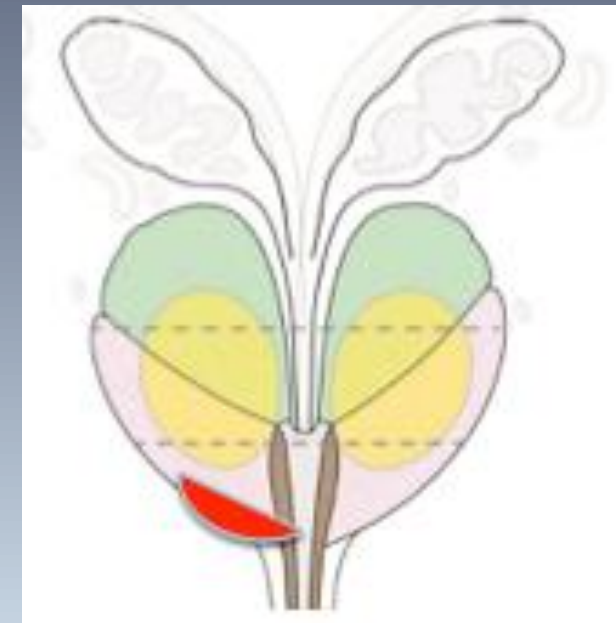
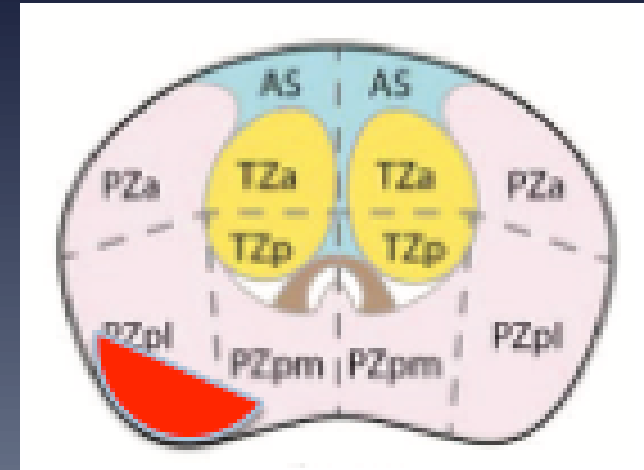
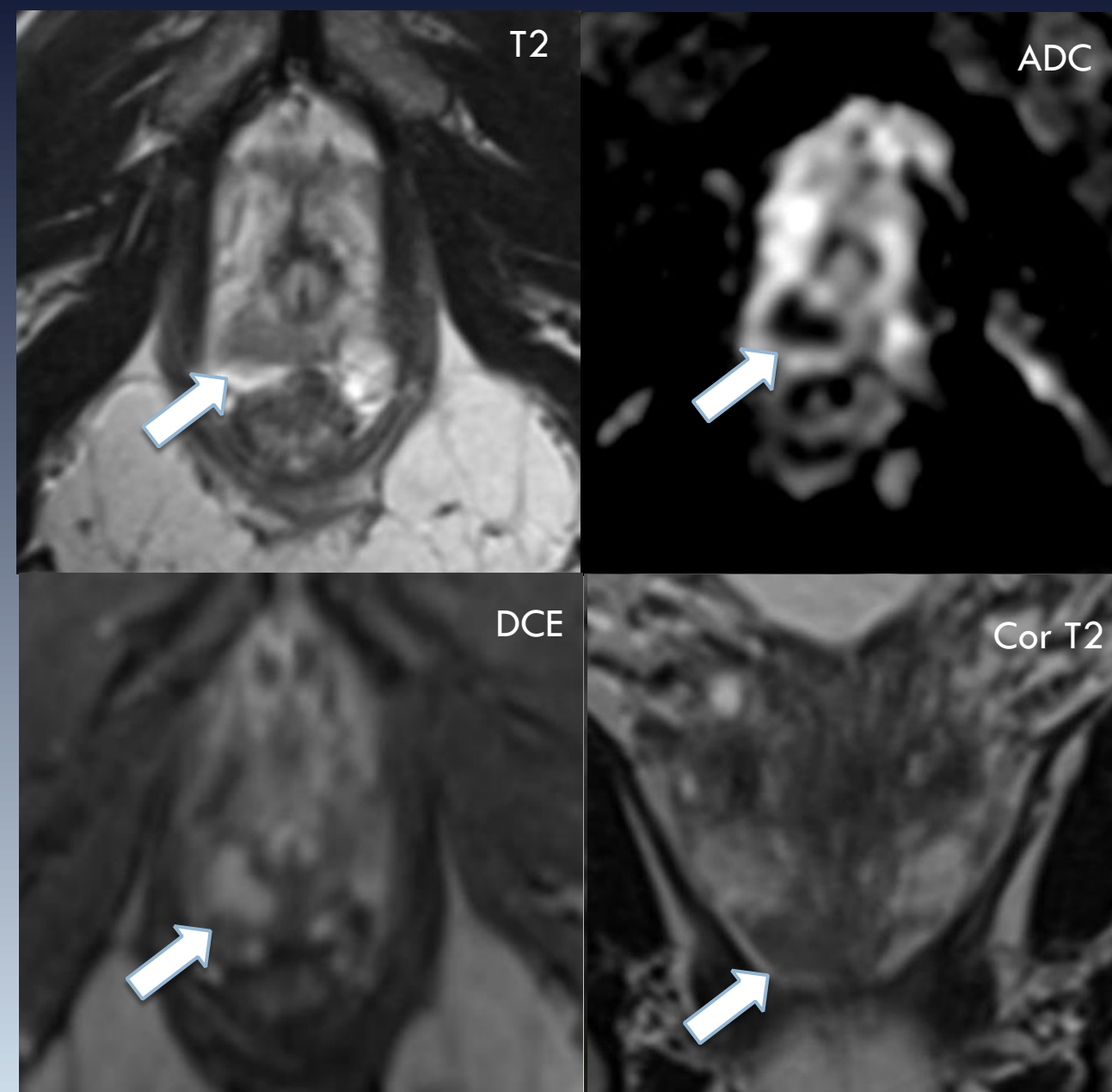
Lateral/Superior base

**Gleason 7 (4+3)—targeted
biopsy**

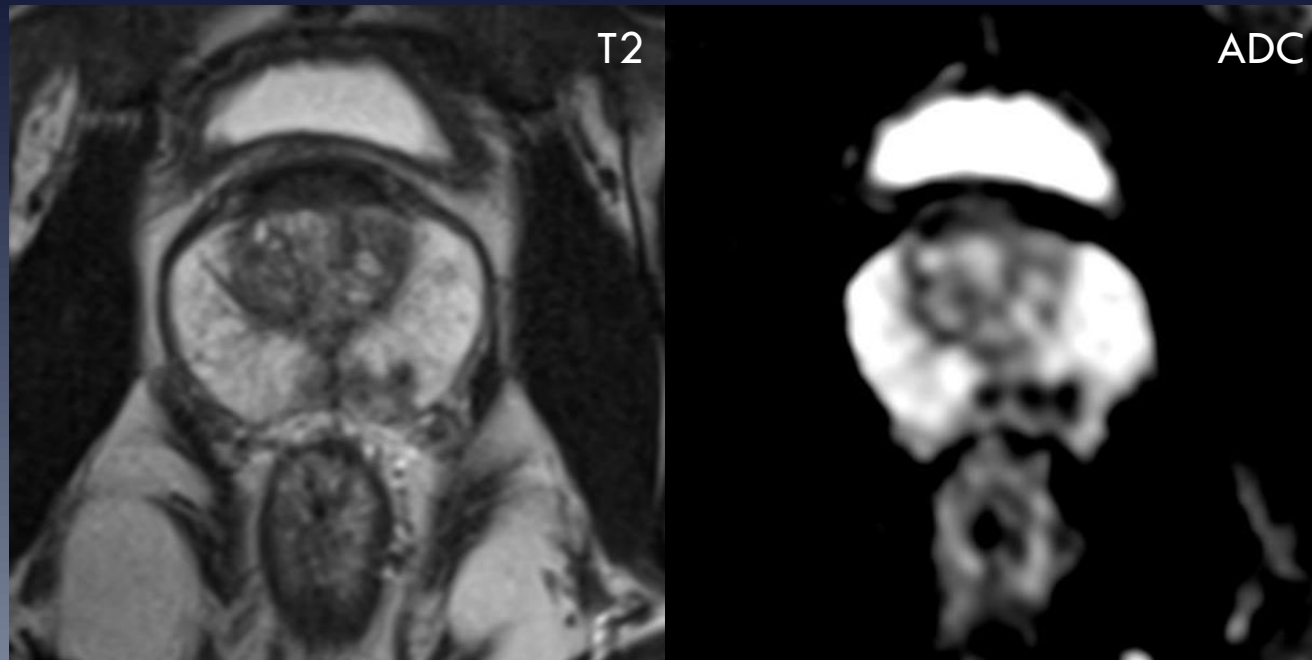


Distal Apical

**Gleason 7 (4+3)—targeted
biopsy**

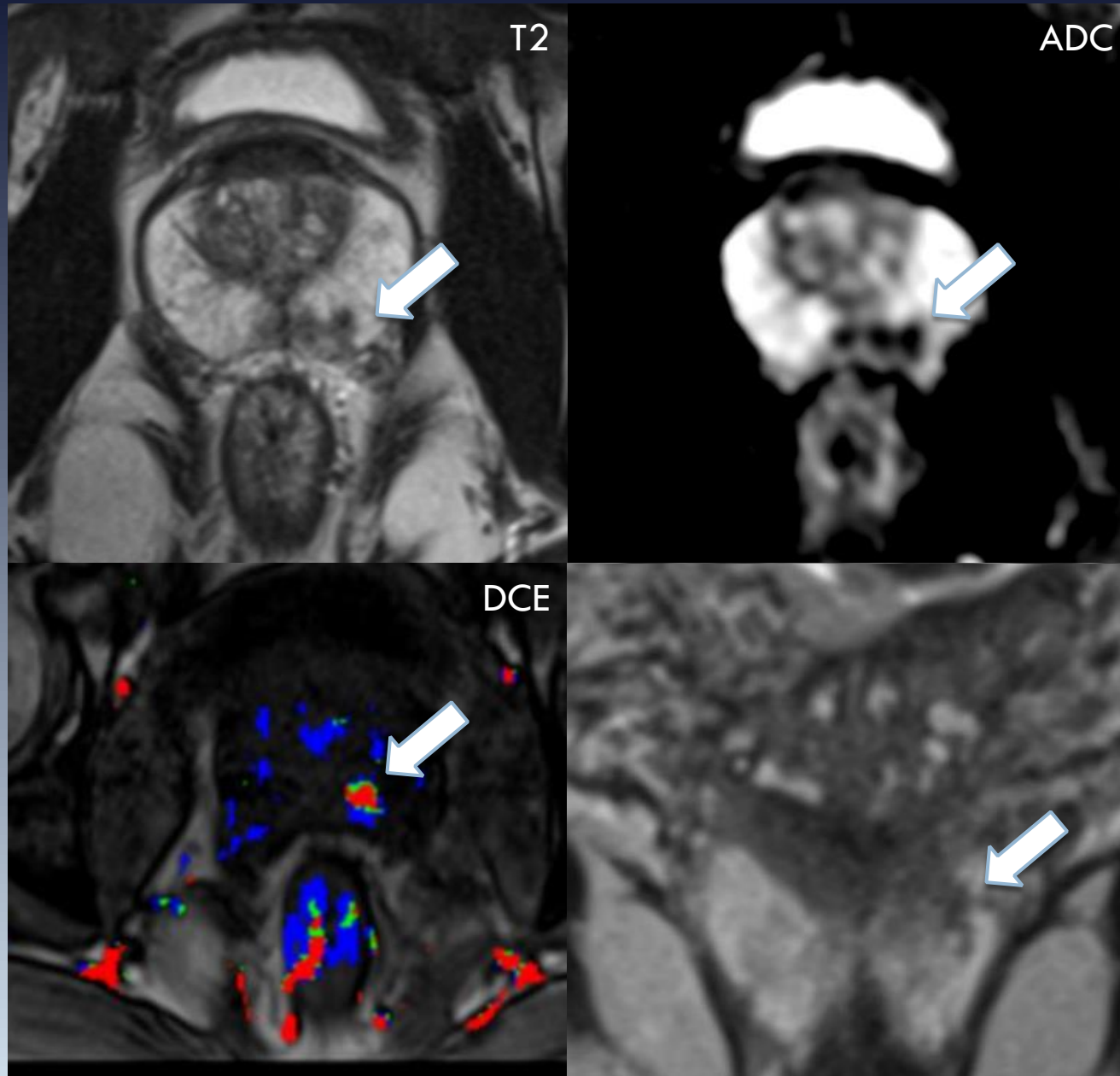


Midline/Para-Midline Peripheral Zone Tumors

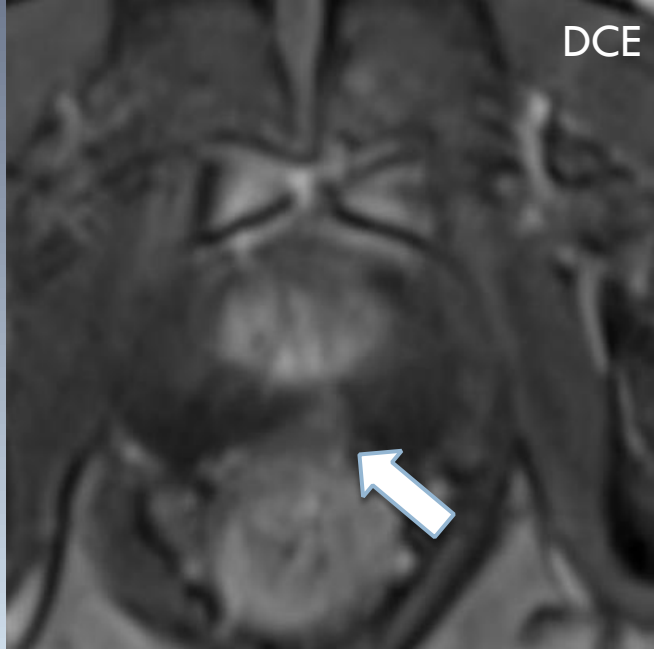
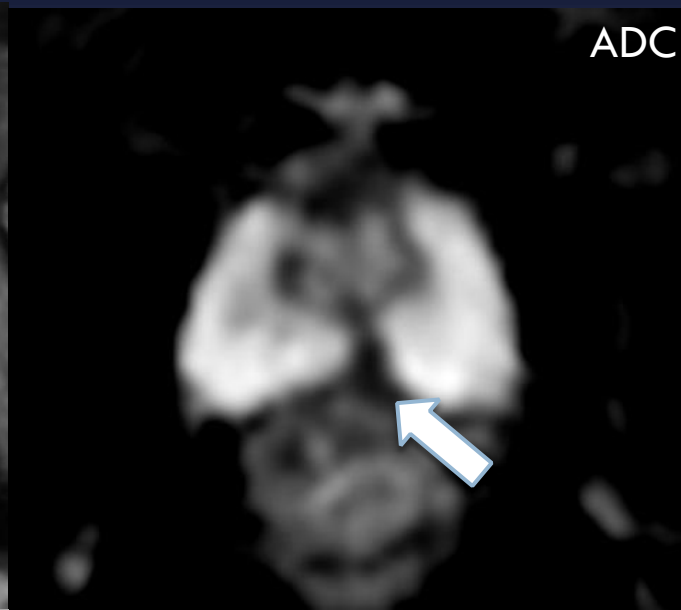


Midline/Para-Midline Peripheral Zone Tumors

**Gleason 7 (3+4)—targeted
biopsy**



Midline/Para-Midline Peripheral Zone Tumors



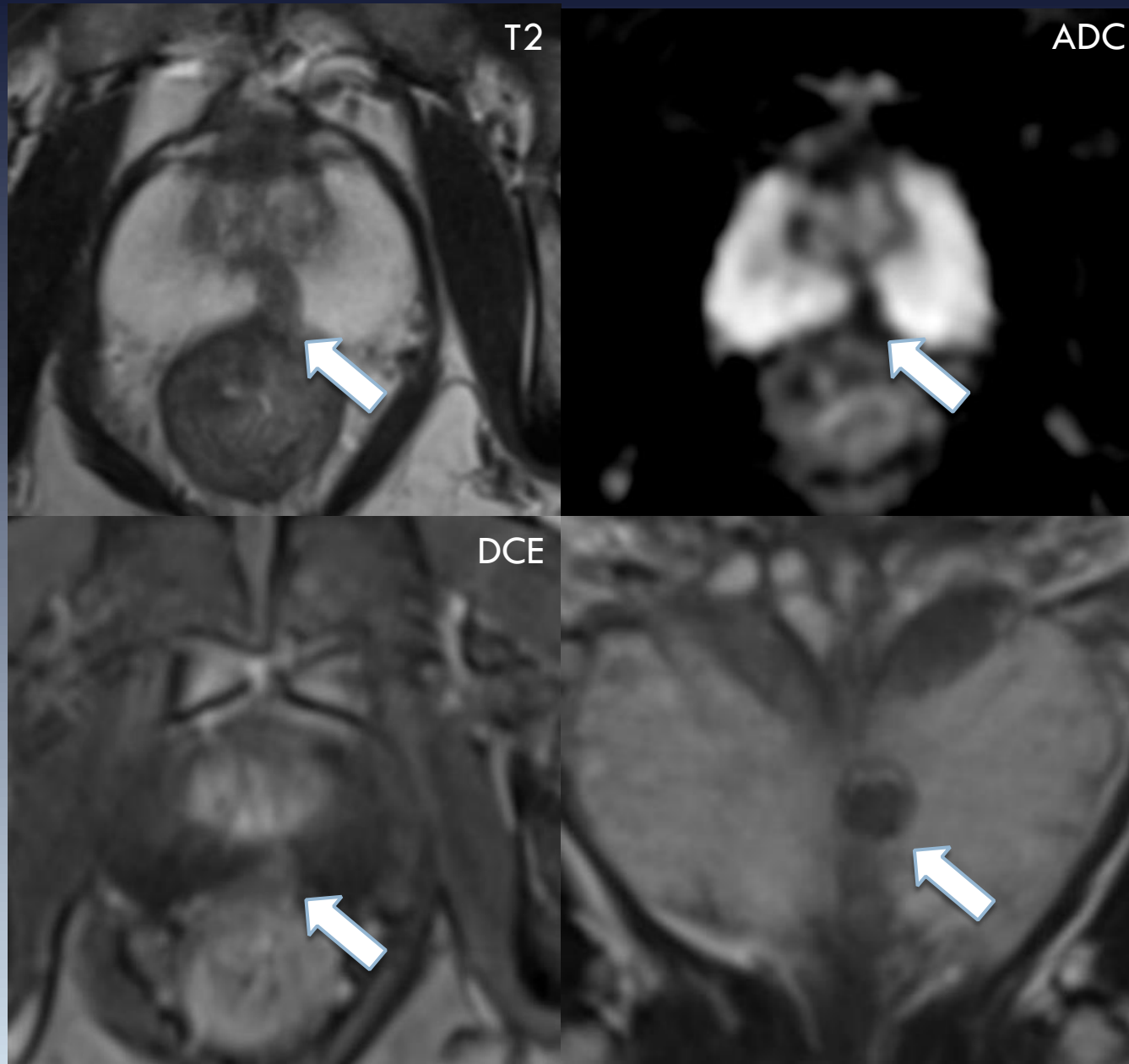
--Cancer (Medial Peripheral Zone)

--Cancer (Central Zone)

--Extruded Transition Zone nodule

--Normal Central Zone

Midline/Para-Midline Peripheral Zone Tumors

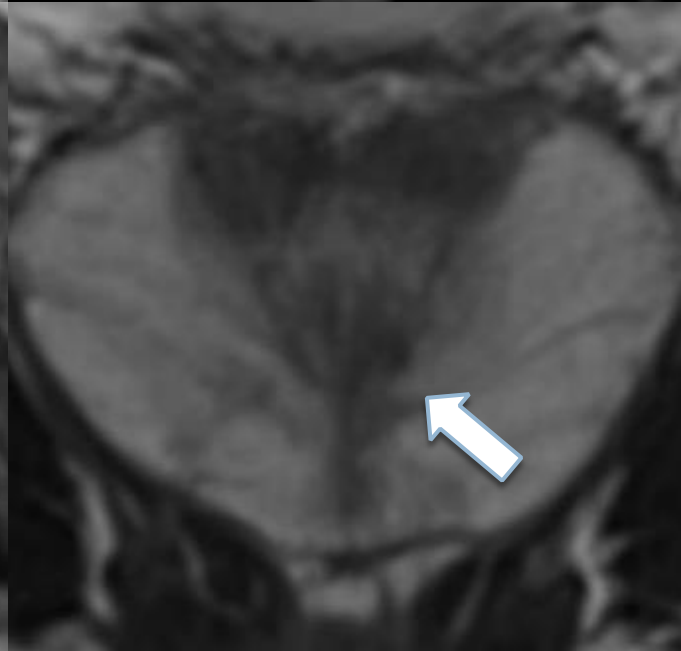
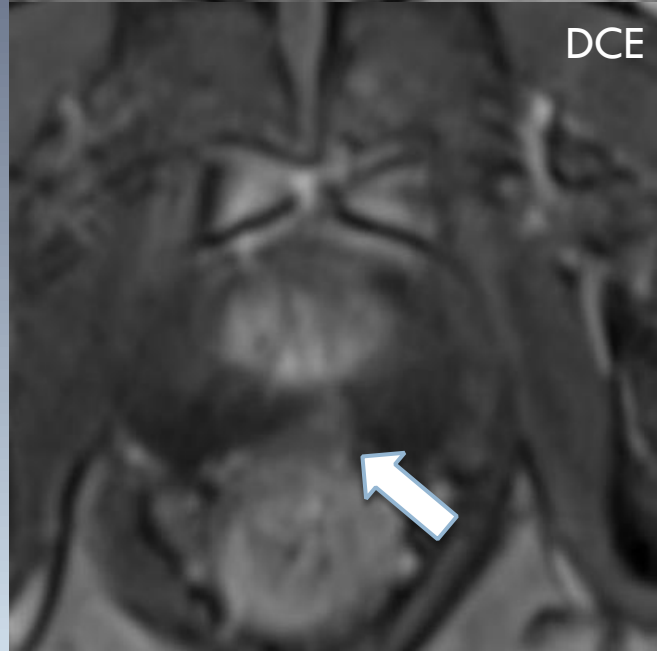
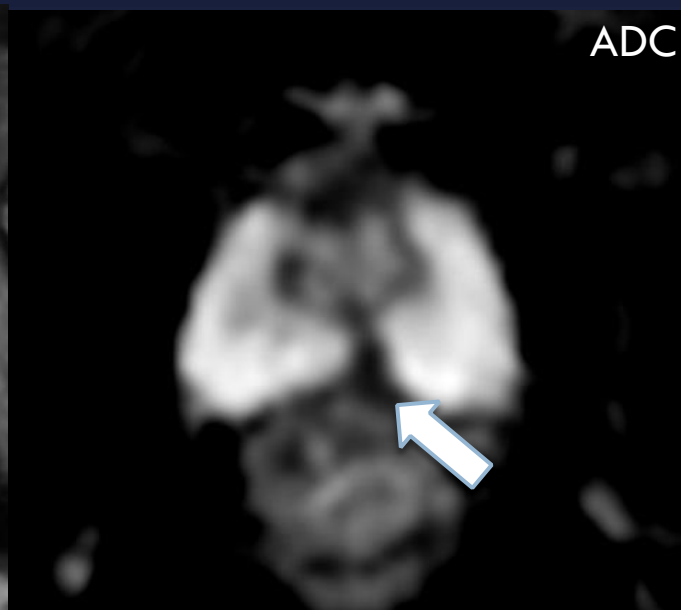


--Cancer (Medial
Peripheral Zone)

~~--Cancer (Central
Zone)~~

--Extruded Transition
Zone nodule

~~--Normal Central Zone~~



--Cancer (Medial
Peripheral Zone)

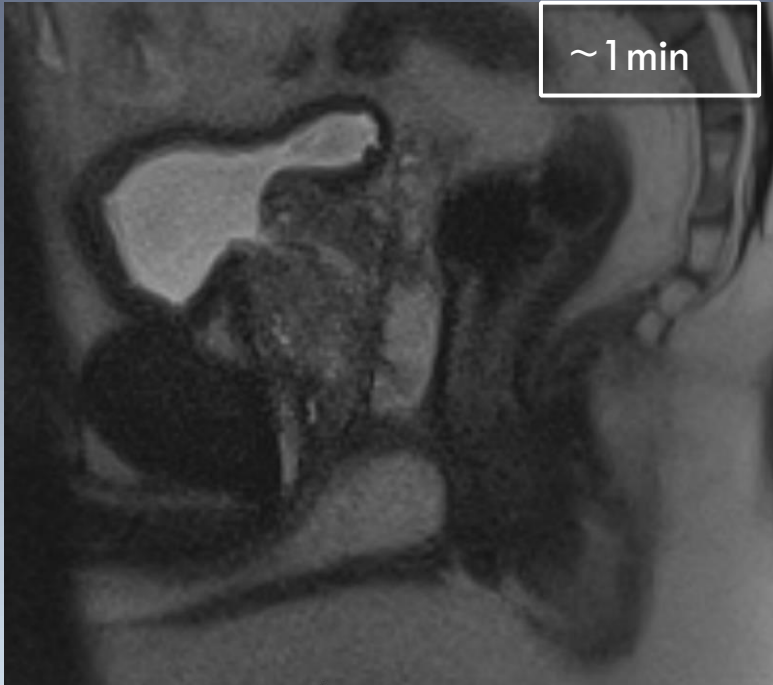
--Extruded Transition
Zone nodule

T2 Weighted Imaging

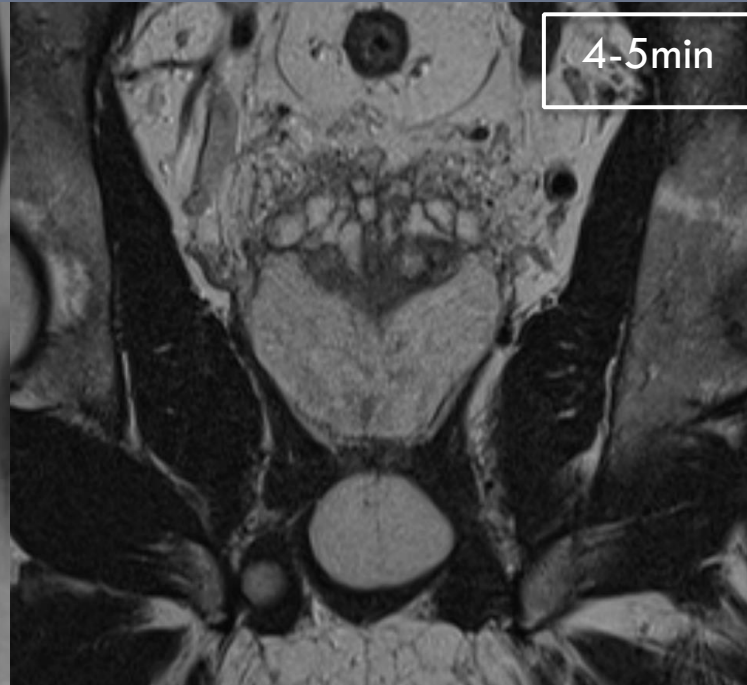
- ▮ Axial (required)
- ▮ Coronal and/or Sagittal (required)

At my institution....
Coronal

Single Shot Spin Echo (*HASTE*; *SS-FSE*)



Turbo Spin Echo (TSE)
Fast Spin Echo (FSE)



T2 Weighted Imaging

- ▮ Axial (required)
- ▮ Coronal and/or Sagittal (required)

Optional

3D T2W (near isotropic voxels)

--more detailed anatomy

--higher spatial resolution

--MRI-US Fusion planning

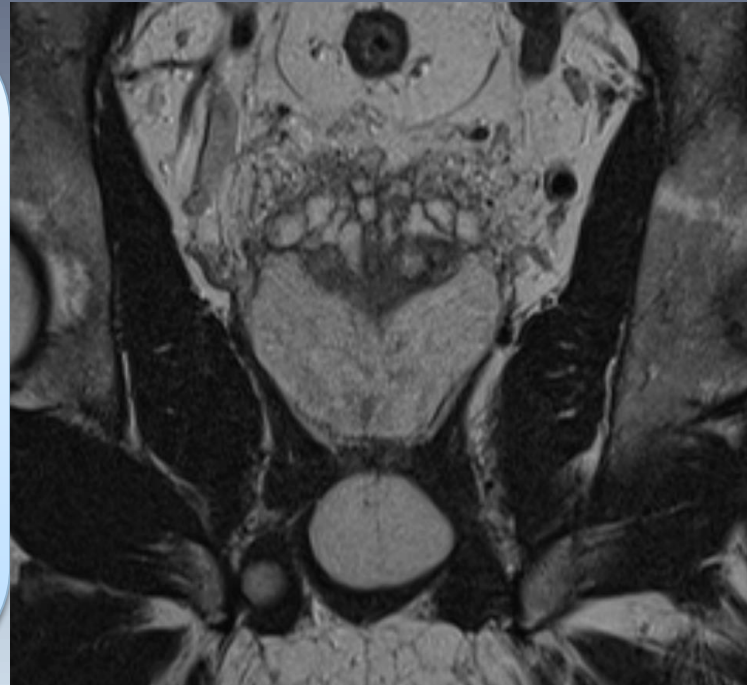
Penalty----(TIME of acquisition)

At my institution:

Do not perform routinely

Turbo Spin Echo (TSE)

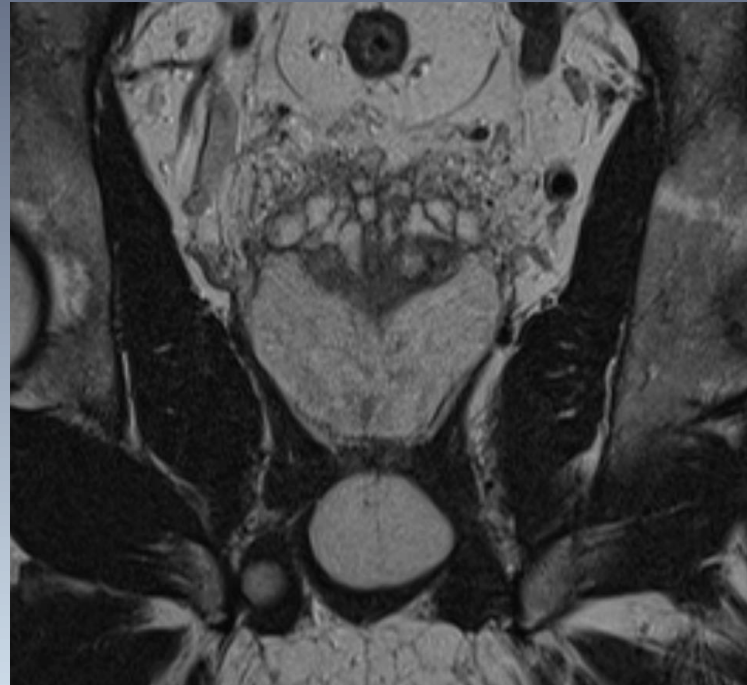
Fast Spin Echo (FSE)



T2 Weighted Imaging

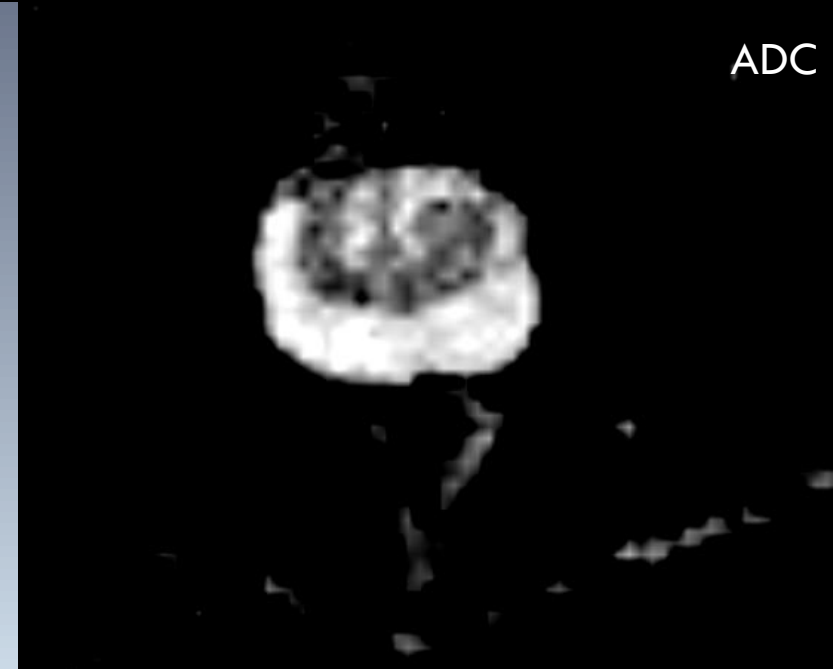
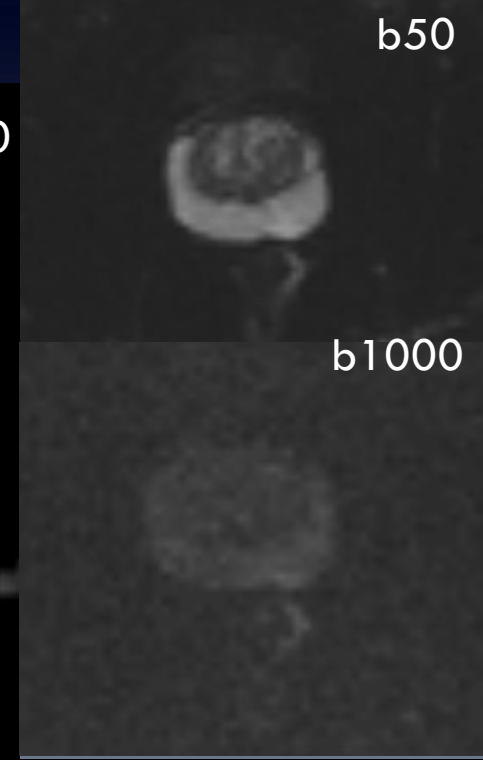
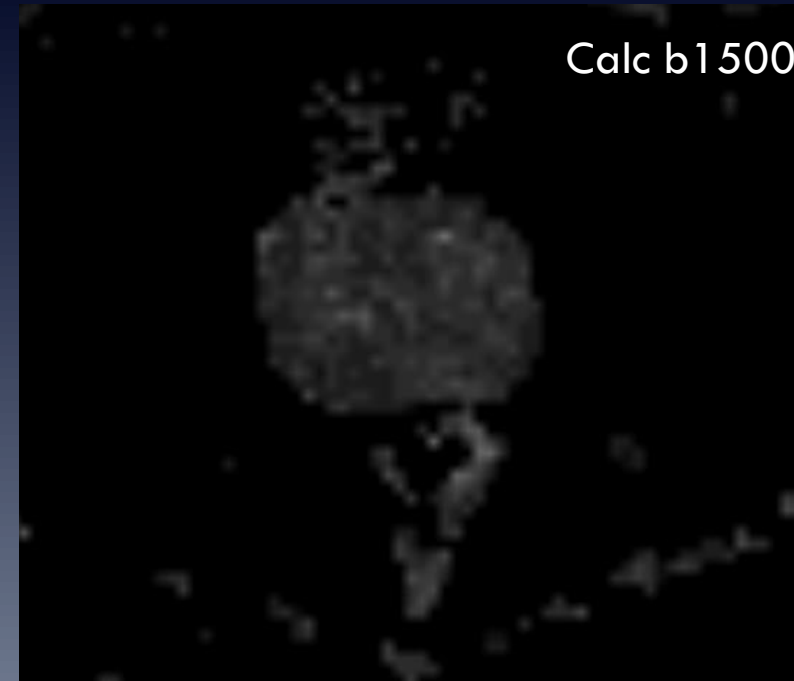
- ▮ Slice thickness 3mm (no gap)
- ▮ FOV (12-20cm)—include entire prostate and SVs
- ▮ In-plane spatial res
 - ▮ Phase $\leq 0.7\text{mm}$
 - ▮ Freq $\leq 0.4\text{mm}$

Turbo Spin Echo (TSE)
Fast Spin Echo (FSE)



Diffusion Weighted Imaging

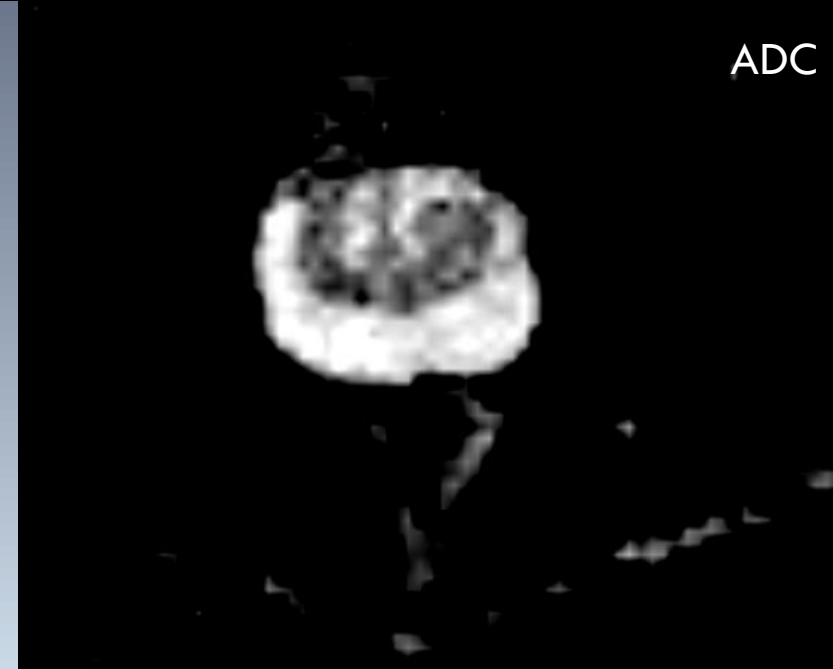
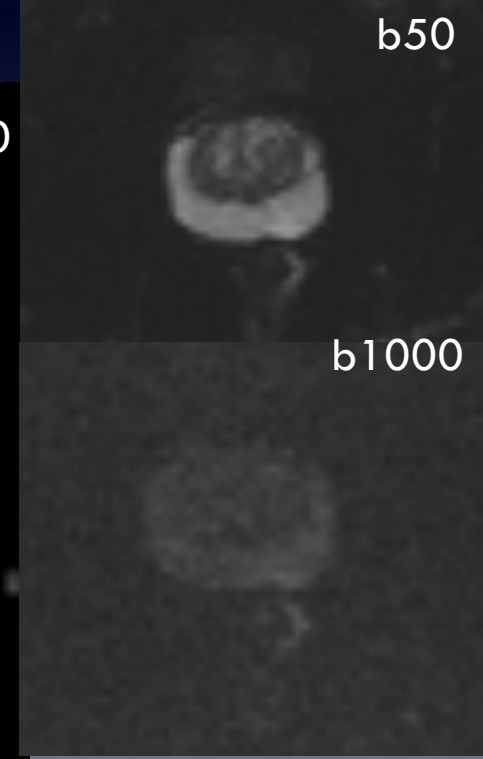
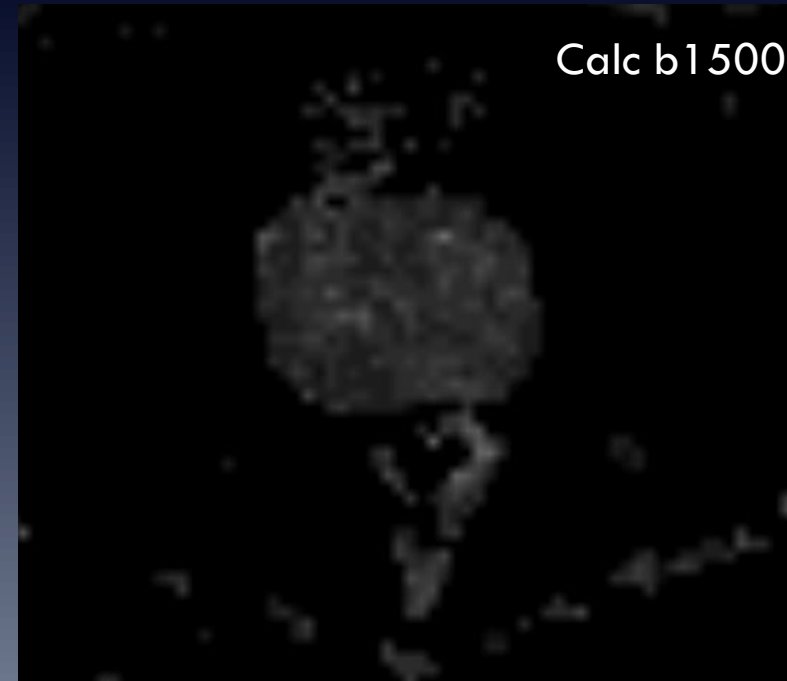
- ADC Map and high b-value DWI (required)
- Multiple b-values (0-1000) used to calculate ADC map
 - Minimum 2
 - (0-50 s/mm^2)
 - (800-1000 s/mm^2)



Diffusion Weighted Imaging

How to obtain high b-value DWI (≥ 1400)

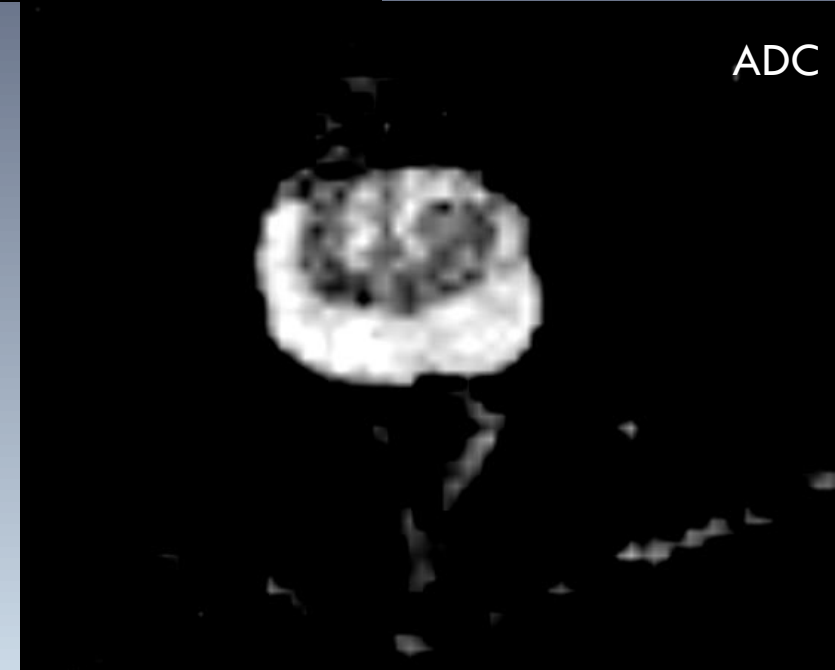
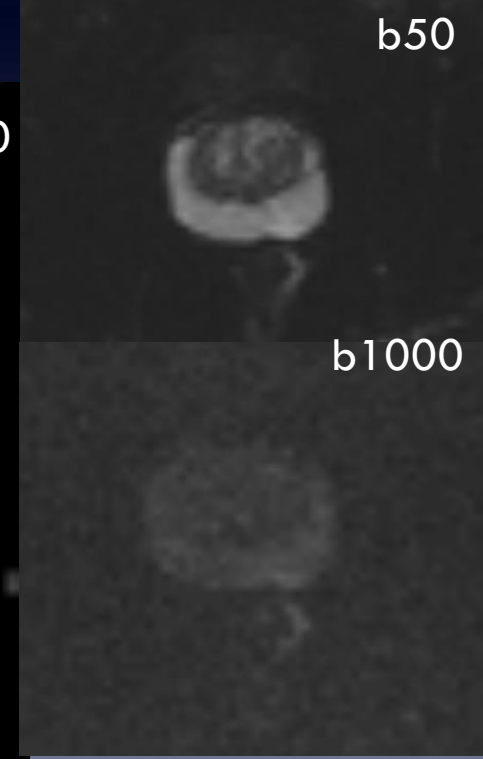
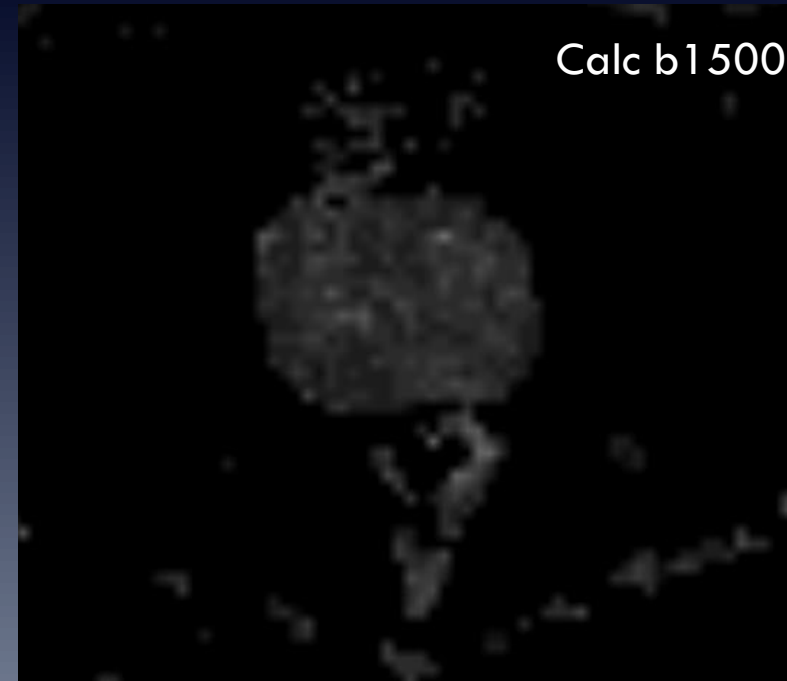
- Direct acquisition
 - Requires additional scan time
 - Prone to motion artifacts due to longer needed echo times
- Calculated from lower b value data used for ADC map



Diffusion Weighted Imaging

- ▮ Slice thickness $\leq 4\text{mm}$ (no gap)
- ▮ FOV (16-22cm)
- ▮ In plane resolution
 - ▮ $\leq 2.5\text{mm}$ (phase and freq)

↑ B-values → ↓ SNR

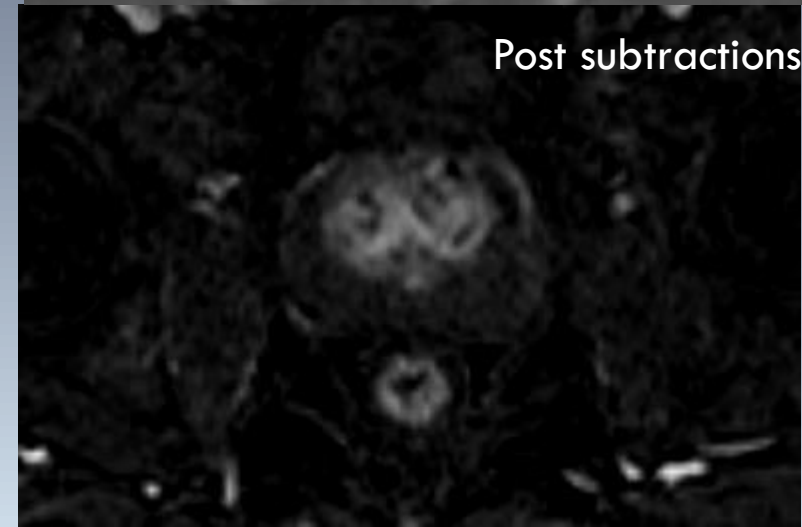
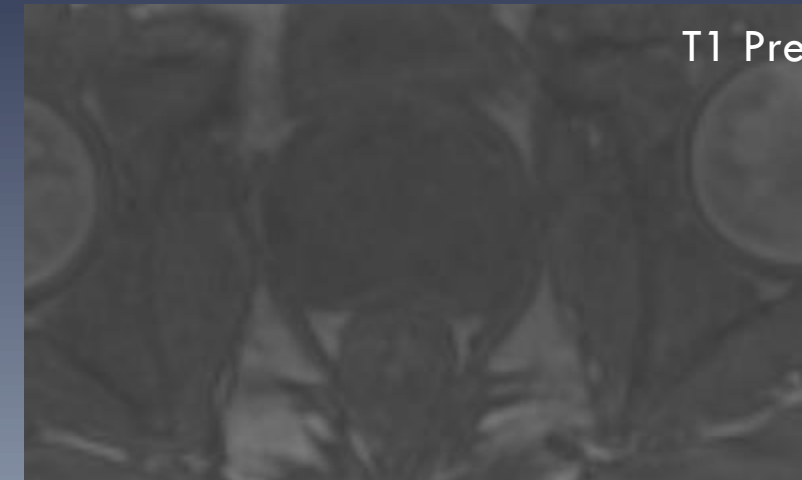


Dynamic Contrast Enhancement (DCE)

- ▮ 3D T1W GRE (Fat suppressed and/or subtractions)
- ▮ FOV (cover entire gland and SVs)
- ▮ In plane resolution
 - ▮ $\leq 2\text{mm}$ (phase and freq)
- ▮ Temporal Resolution $\leq 15\text{sec}$
- ▮ Imaging time $\geq 2\text{ min}$

At my institution....

Direct visualization with manual scrolling
or CINE

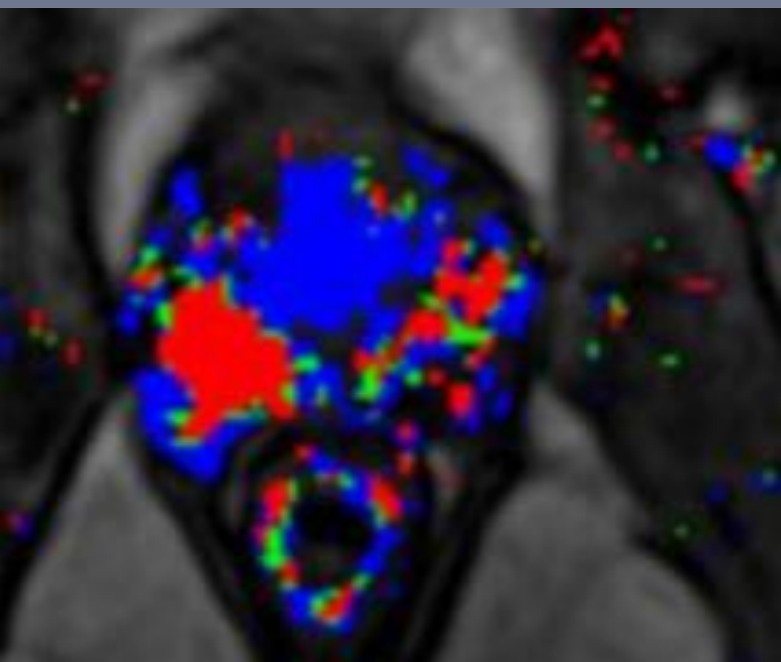


Dynamic Contrast Enhancement (DCE)

PIRADS v2.1

Currently insufficient peer reviewed published data or expert consensus to support routine adoption of pharmacokinetic analysis

Little evidence in the literature to support the use of specific curve types



PIRADS v2.1

Technical Specifications

	T2W	DWI/ADC	DCE
Sequence	2D RARE (TSE or FSE)	Spin echo EPI + fat suppression	3D T1W GRE + (Fat suppression or subtraction)
Plane	Axial + (Cor and/or Sag)	Matched to T2W	Matched to T2W
Slice Thickness	3mm No gap	≤4mm No gap	3mm No gap
Field of View	12-20cm	16-22cm	Include entire prostate and seminal vesicles
In plane spatial resolution	≤ 0.7mm Phase ≤ 0.4mm Freq	≤ 2.5mm Phase ≤ 2.5mm Freq	≤ 2mm Phase ≤ 2mm Freq
		B-values 0-1000 sec/mm ² ≥1400 sec/mm ²	Temporal Resolution ≤ 15secs Observation time ≥ 2min

Essential components of high quality prostate MRI

1. High spatial resolution imaging
2. High B-value DWI

Faster image acquisition times

Penalty

↓ SNR

- ▮ Deep Learning Reconstruction (DLR)
 - ▮ Imaging reconstruction technique utilizing convolutional neural networks to decrease noise within images

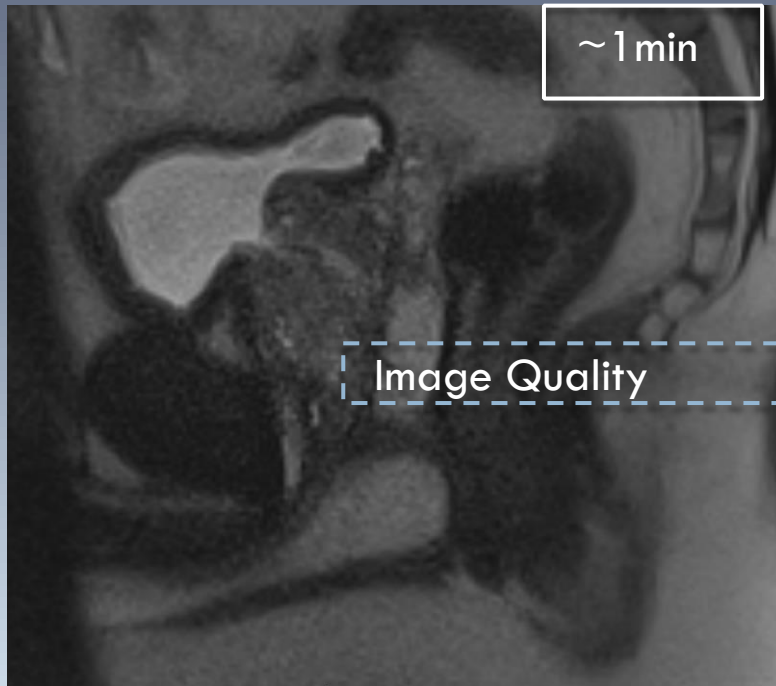
T2 Weighted Imaging

- ▮ DLR reconstruction (potential application)
- ▮ SS-FSE acquisition with comparable image quality to T2 TSE

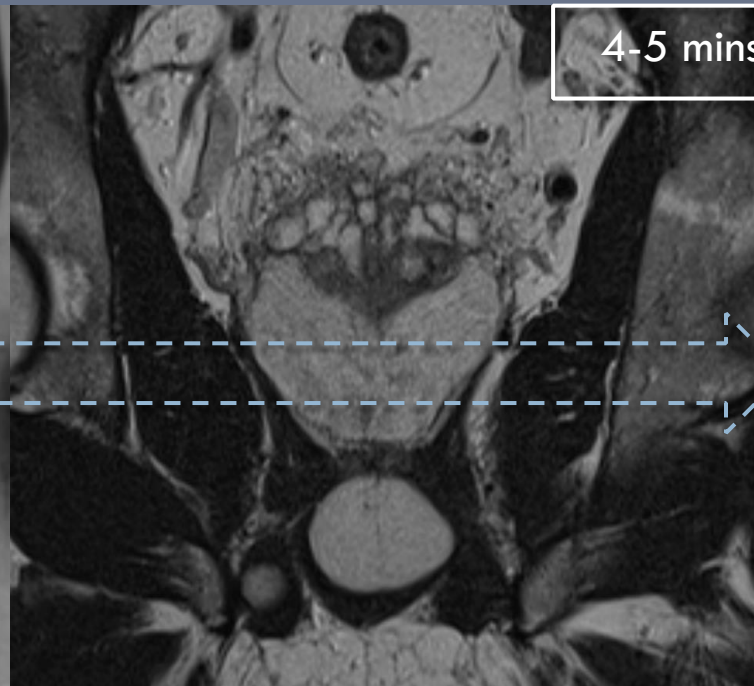
Liver Imaging

Herrmann et al. Diagnostic Confidence and Feasibility of a Deep Learning Accelerated HASTE Sequence of the Abdomen in a Single Breath-Hold. *Investigative Radiology* May 2021

Single Shot Spin Echo (*HASTE*; *SS-FSE*)



Turbo Spin Echo (TSE)
Fast Spin Echo (FSE)



T2 Weighted Imaging

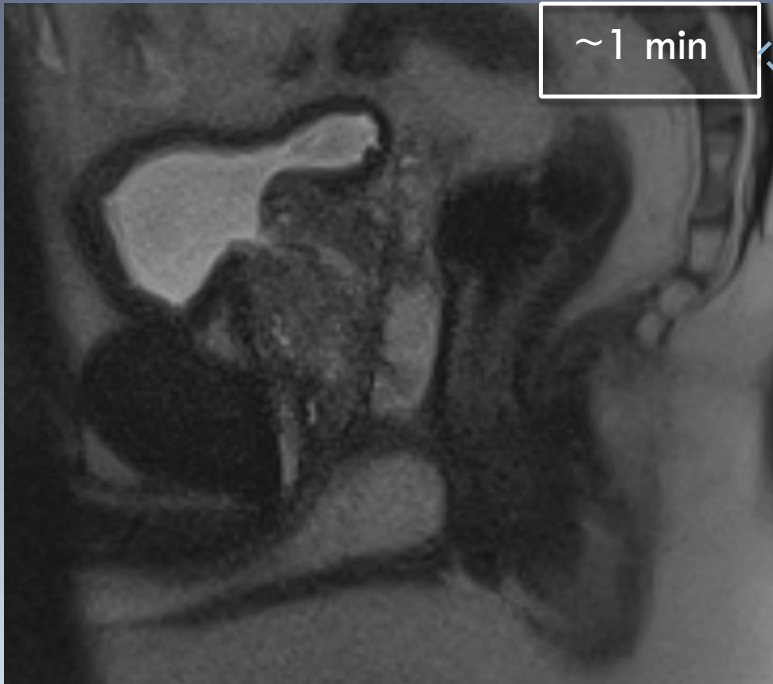
DLR reconstruction (potential application)

TSE :

- Reduce Acquisition time
- Maintain image quality of TSE

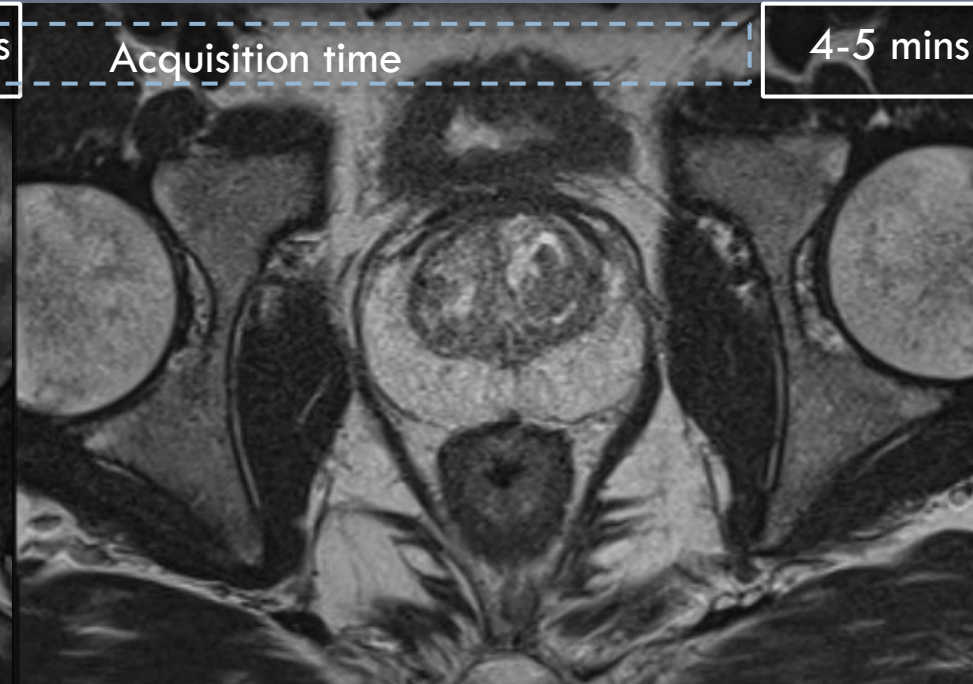
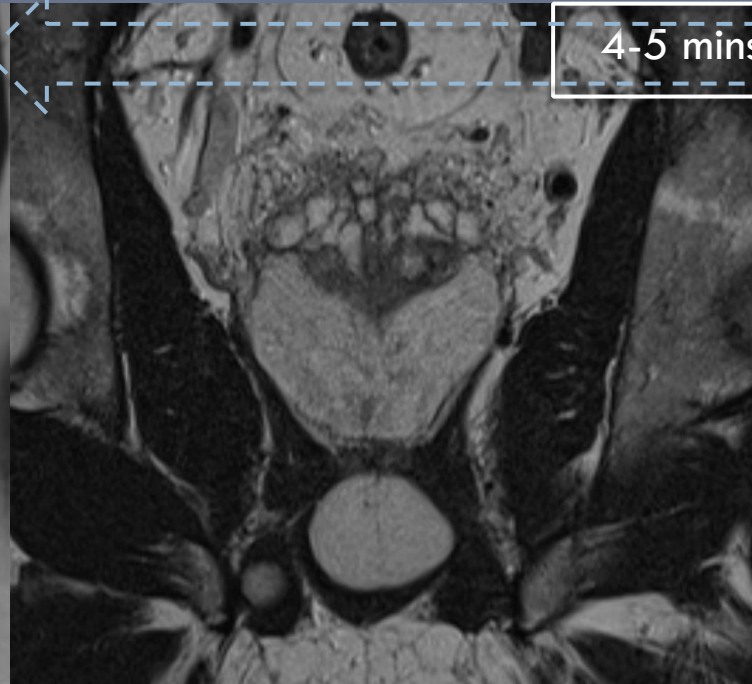
Gassenmaier et al. Deep Learning Accelerated T2-weighted imaging of the prostate: Reduction of acquisition time and improvement of image quality. *European Journal of Radiology* February 2021

Single Shot Spin Echo (*HASTE*; *SS-FSE*)



Turbo Spin Echo (TSE)

Fast Spin Echo (FSE)



Acquisition time

Deep Learning Reconstruction



CONS

- DLR does not magically create perfect MRI scans

- Successful implementation requires active monitoring and adaption of MR images/parameters to best optimize DLR denoising capability

- Image denoising may not be homogeneous
- DLR can introduce new artifacts

At my institution....

Has not been implemented yet

--Initial DLR experience—unsatisfactory
image quality

--Second attempt upcoming

- \$\$\$\$\$\$

- Vendor add-on to scanner (1 time payment)

- 3rd party subscription model (Pay per case)

- Vendor neutral

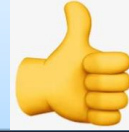
PROSTATE MRI: Let the Debate Begin

- ▮ 3T vs 1.5 T
- ▮ Endorectal coil
- ▮ Antispasmodic Agents
- ▮ Cleansing Enema
- ▮ Bi-parametric MRI

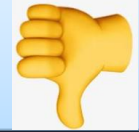
3T

1.5T

Endorectal
coil



Endorectal
coil



**Essential components of
high quality prostate MRI**

1. High spatial resolution imaging
2. High B-value DWI

Penalty

↓ SNR

3T

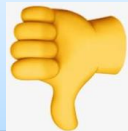
1.5T

DO YOU NEED
THEM BOTH?

**Endorectal
coil**



**Endorectal
coil**



High spatial resolution
imaging
High B-value DWI

↓ **SNR**

**3T +
Endorectal
Coil**

3T without Endorectal coil

At 3T without use of an ERC, image quality can be comparable with that obtained at 1.5 T with an ERC, although direct comparison of both strategies for cancer detection and/or staging is lacking.

PI-RADSv2.1

1.5T without Endorectal coil

Credible satisfactory results have been obtained at both 1.5T and 3T without the use of an ERC.

With some 1.5T MRI systems, especially older ones, use of an ERC is considered indispensable for achieving the type of high resolution diagnostic quality imaging needed for staging prostate cancer.

PI-RADSv2.1

**3T without
Endorectal coil**

At my institution....

**1.5T without
Endorectal coil (only
on some scanners)**

At 3T without use of an ERC, image quality can be comparable with that obtained at 1.5 T with an ERC, although direct comparison of both strategies for cancer detection and/or staging is lacking.

With some 1.5T MRI systems, especially older ones, use of an ERC is considered indispensable for achieving the type of high resolution diagnostic quality imaging needed for staging prostate cancer.

Credible satisfactory results have been obtained at both 1.5T and 3T without the use of an ERC.

PI-RADSV2.1

Prostate MRI with Endorectal Coil

▮ Advantages

▮ Improved SNR

- ▮ Increased speed of acquisition
- ▮ Better Spatial Resolution
- ▮ Improved quality of high B value DWI

▮ Disadvantages

▮ ITS AN ENDORECTAL COIL

- ▮ Coil can cause artifacts and distortion of gland
- ▮ Insertion/position/removal increases scan time
- ▮ Added source of image quality variability

Patient Preparation prior to Scan

At present, there is no consensus concerning all patient preparation issues.

PI-RADSv2.1

At my institution....

- ▮ Antispasmodic agent to reduce bowel peristalsis (i.e glucagon)
- ▮ Cleansing enema to reduce image distortion due to rectal air
 - ▮ Ask patient to use bathroom prior to scan



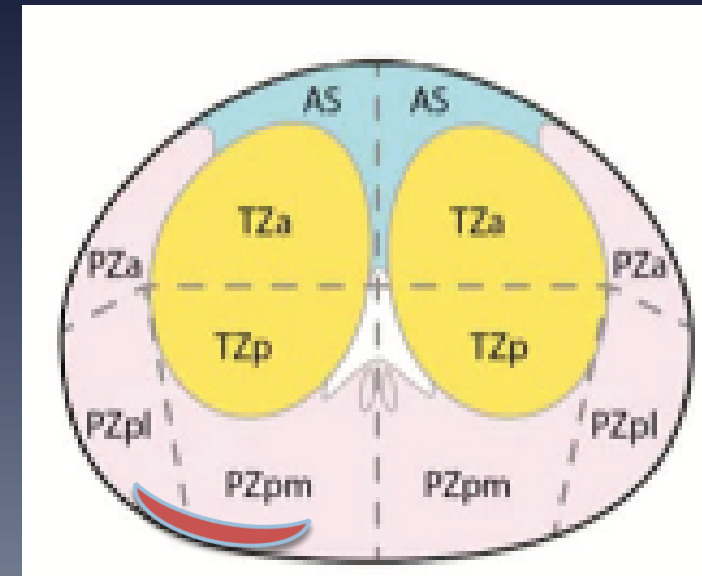
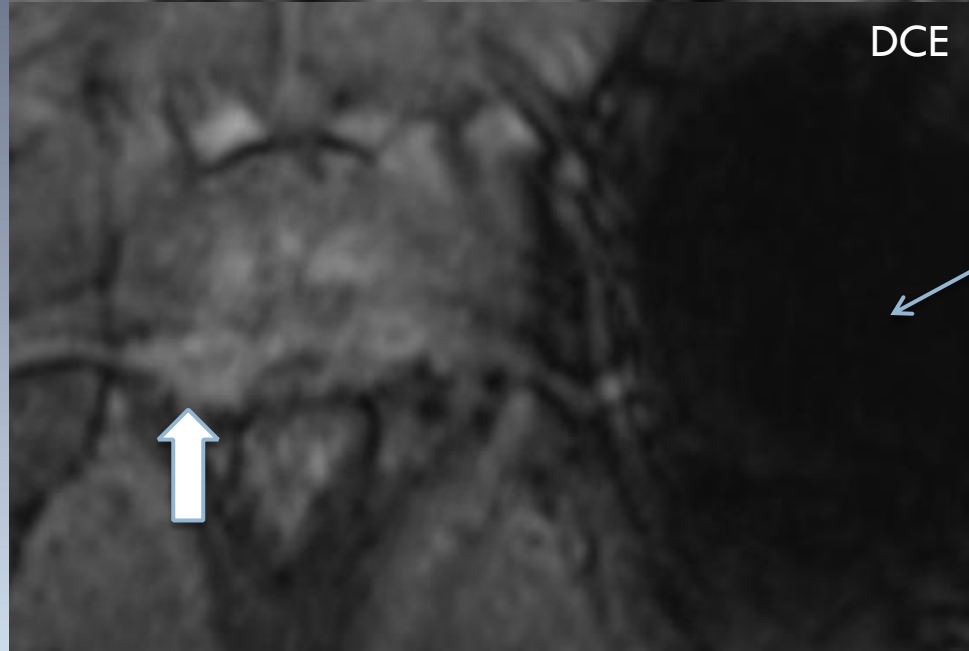
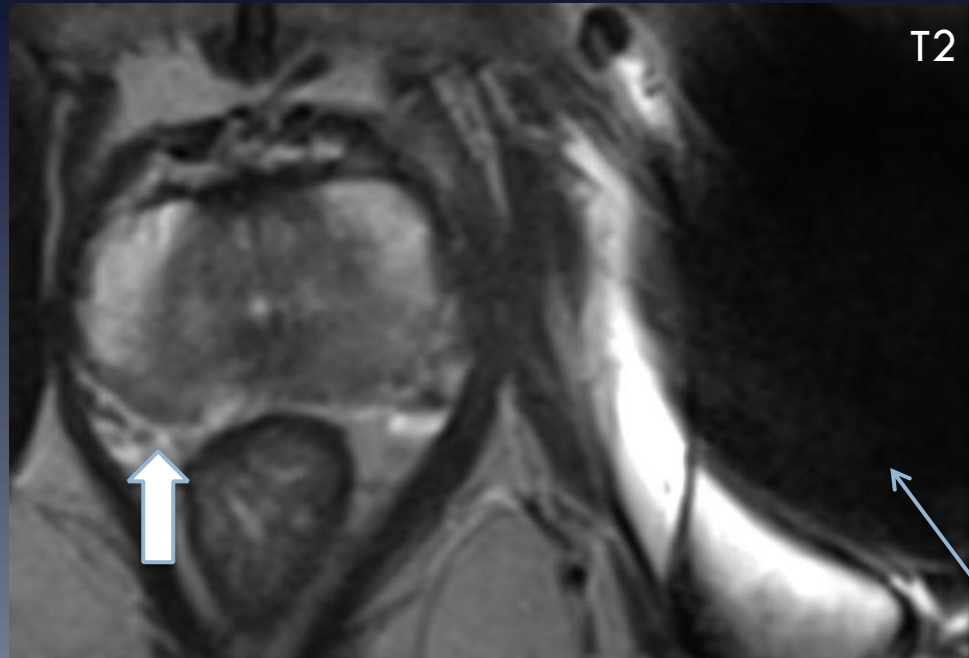
Bi-Parametric MRI (Non-contrast imaging only)

▮ Benefits

- ▮ Shortened Exam times leading to increased accessibility and availability of Prostate MRI

▮ PIRADS v2.1

- ▮ Exercise caution when eliminating contrast from Prostate MRI protocols
 - DCE is a “safety-net” “back-up” sequences when T2W and DWI/ADC are poor quality



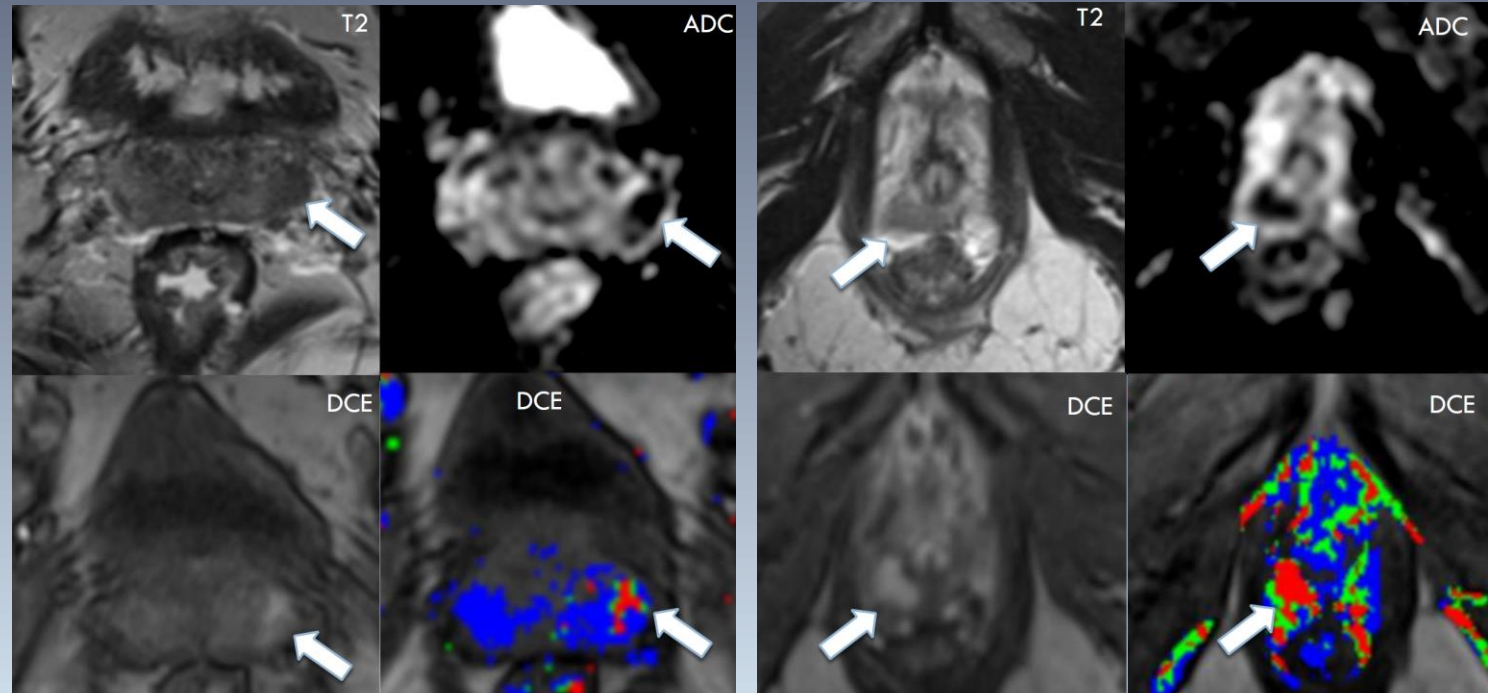
Subcapsular
Crescentic
Peripheral
Zone Tumor

Hip Hardware
Susceptibility
Artifact

Diffusion
weighted
imaging not
possible

Bi-Parametric MRI (Non-contrast imaging only)

- ▮ Benefits
 - ▮ Shortened Exam times leading to increased accessibility and availability of Prostate MRI
- ▮ PIRADS v2.1
 - ▮ Exercise caution when eliminating contrast from Prostate MRI protocols
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Bi-Parametric MRI (Non-contrast imaging only)

Do Not Eliminate DCE imaging if:

Indications:

- Multiple Negative bxs with rising PSA
- Active surveillance with fast PSA doubling times
- Detection of recurrent prostate cancer after radiation, hormonal therapy, and/or ablation
- Detection of prostate cancer in patients with hip replacement
- Strong family history
- Genetic predisposition

PIRADS v2.1

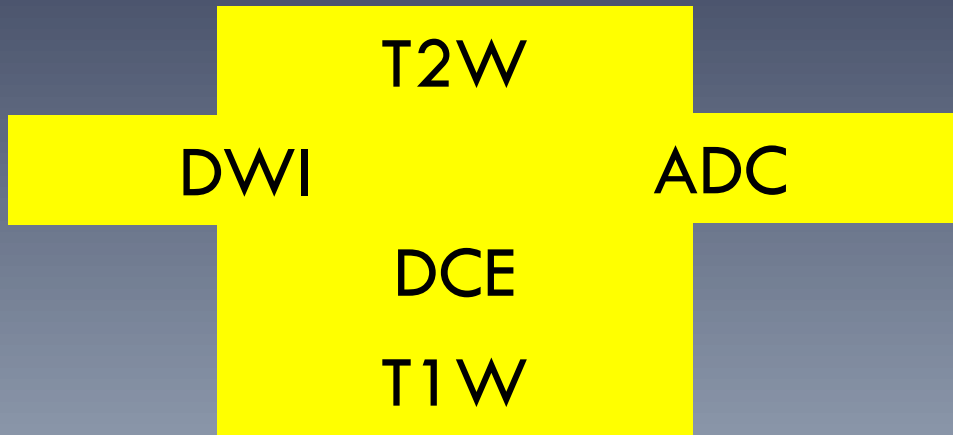
- Exercise caution when eliminating contrast from Prostate MRI protocols
 - DCE is a “safety-net” “back-up” sequences when T2W and DWI/ADC are poor quality

At my institution....

Give contrast routinely for Prostate MRI

Summary

▮ Prostate MRI protocol-PIRADS v2.1



High spatial resolution
imaging
High B-value DWI

- ▮ 3T vs 1.5 T
- ▮ Endorectal coil
- ▮ Antispasmodic Agents
- ▮ Cleansing Enema
- ▮ Bi-parametric MRI

	T2W	DWI/ADC	DCE
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MedStar Georgetown University Hospital

Vice Chair Operations, Quality, and Safety



MedStar Health