CONVENTIONAL IMAGING TECHNIQUES FOR TARGET VOLUME DELINEATION IN RADIATION ONCOLOGY

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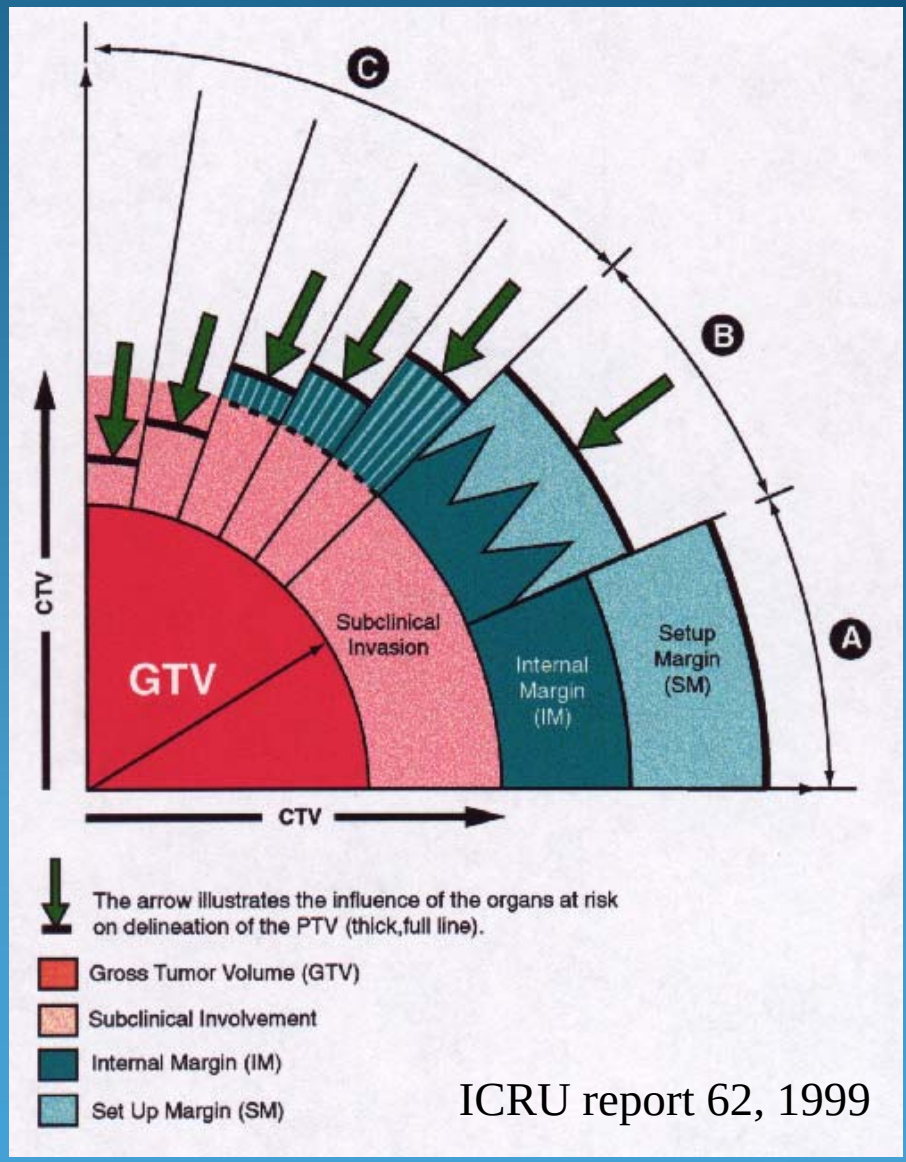
Target volumes in Radiation Oncology

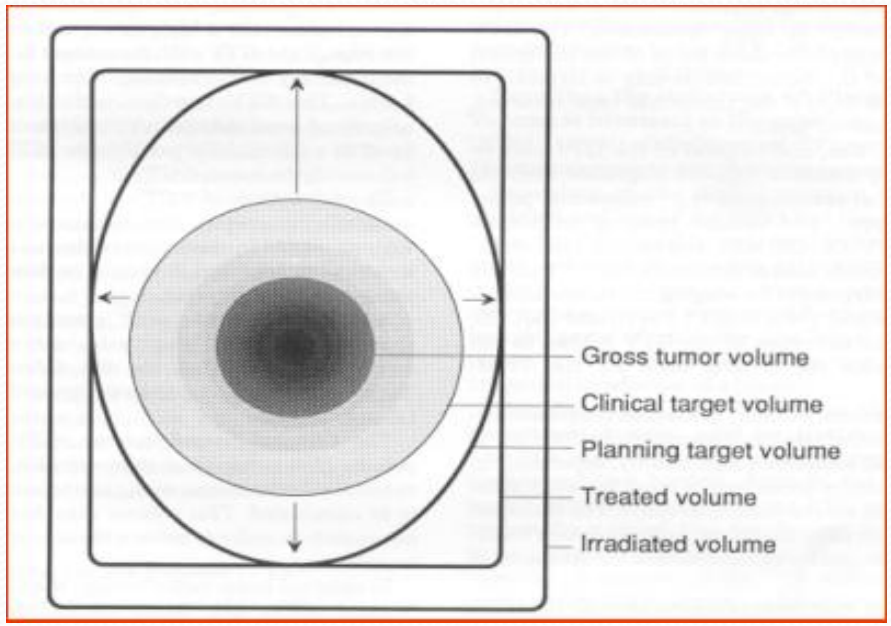
- Gross Tumor Volume: GTV
- Clinical Target Volume: CTV
- Internal Target Volume: ITV
- Planning Target Volume: PTV
- Organ at Risk: OAR
- Planning Organ at Risk Volume: PRV



ICRU report 62, 1999

Definitions form ICRU 50

- Gross Tumour Volume (GTV) = clinically demonstrated tumour
- Clinical Target Volume (CTV) = GTV + area at risk (*e.g.* potentially involved lymph nodes)
- Treated Volume = volume that receives dose considered adequate for clinical objective
- Irradiated volume = non negligible dose for normal tissues



Margins and ICRU 62

- The concept of margins was expanded on by ICRU report 62
  - Internal margin = due to organ motion
  - Set-up margin
- The two are often combined as independent uncertainties.
- Definition of target volumes could be subjective, and a number of studies have reported inter-observer and intra-observer variability

ULTRASOUND

ADVANTAGES

- Wide availability
- Cheap
- No radiation
- Cystic vs solid
- Real time
- Color Doppler Vascularity defined
- ? Role of USG contrast agents

DISADVANTAGES

- Air & acoustic window interference
- Body habitus
- Inter-observer variability
- Lack of reproducibility
- ? Incorporation into TPS

Magnetic Resonance Imaging

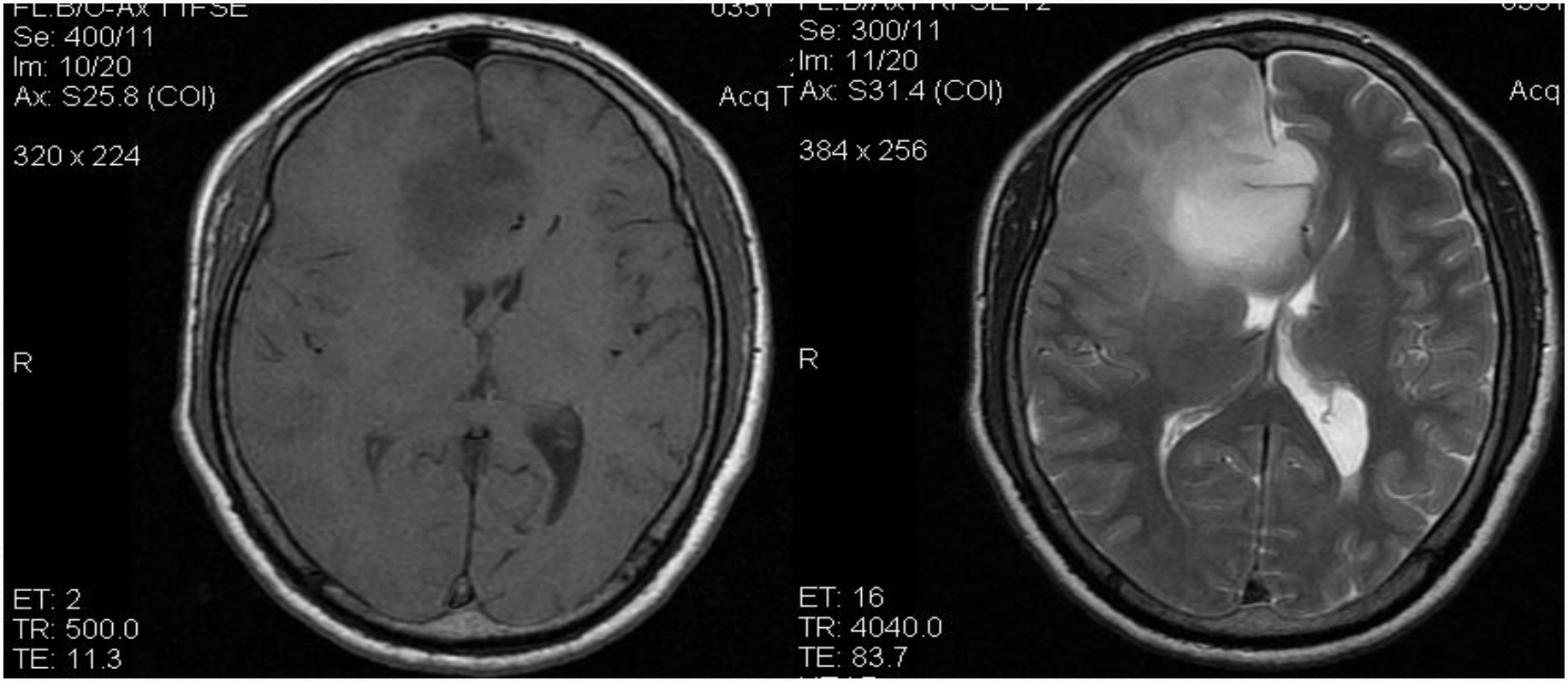
ADVANTAGES

- Exquisite soft tissue contrast
- Better tissue discrimination between tumor & adjacent normal structures
- Better delineation of organs at risk
- Multiplanar capability and increased imaging functionality
- May differentiate between recurrent tumor & post-treatment fibrosis & radiation necrosis.
- Avoid bony and metal artefacts seen with CT

LIMITATIONS

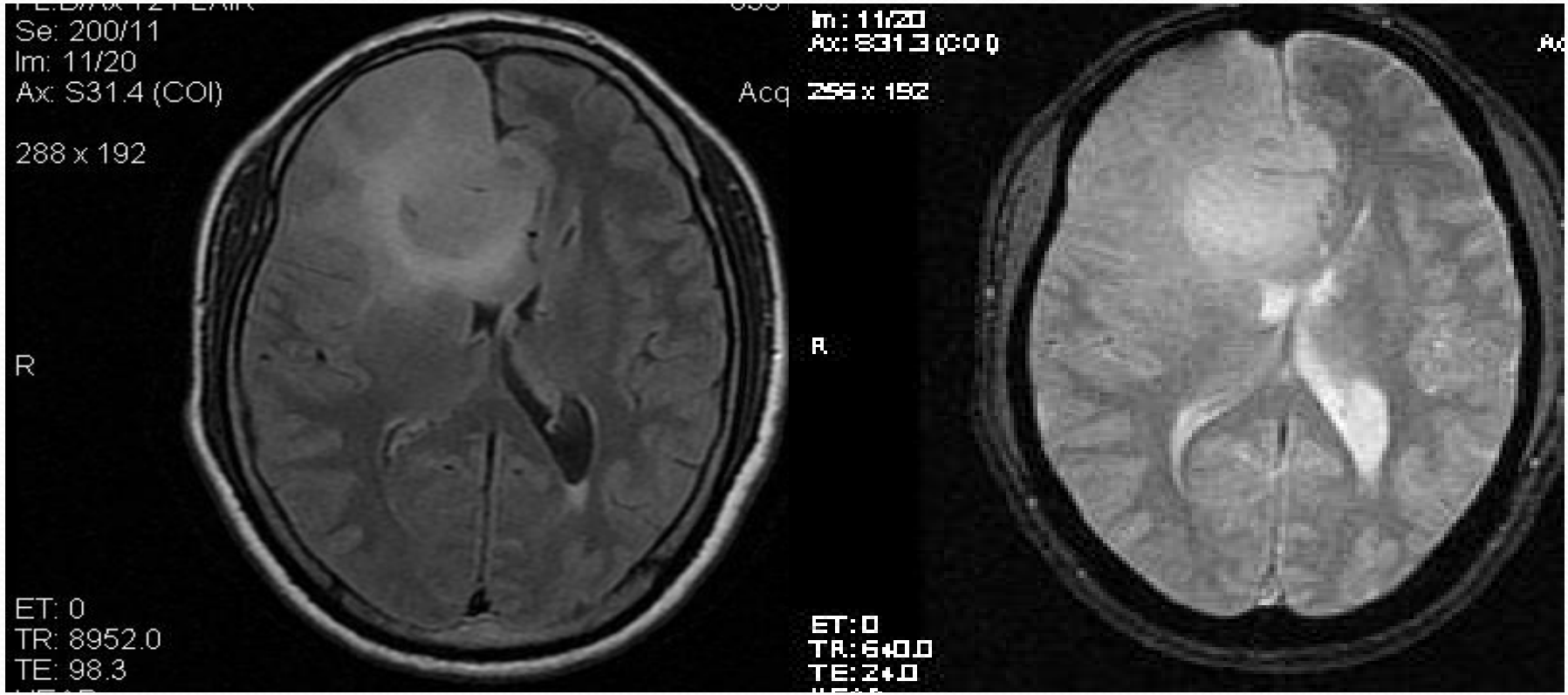
- No electron density information
- Contraindicated in patients with pacemakers & ferromagnetic implants
- Poor visualisation of bone
- Geometric distortion
- No Digital reconstruction registration

T1 & T2 WEIGHTED SEQUENCES



T1 W= provides anatomical details. Fluid black, Fat bright. Used also with IV contrast
T2 W=provides pathological details. Fluid bright. Fat Bright/black.

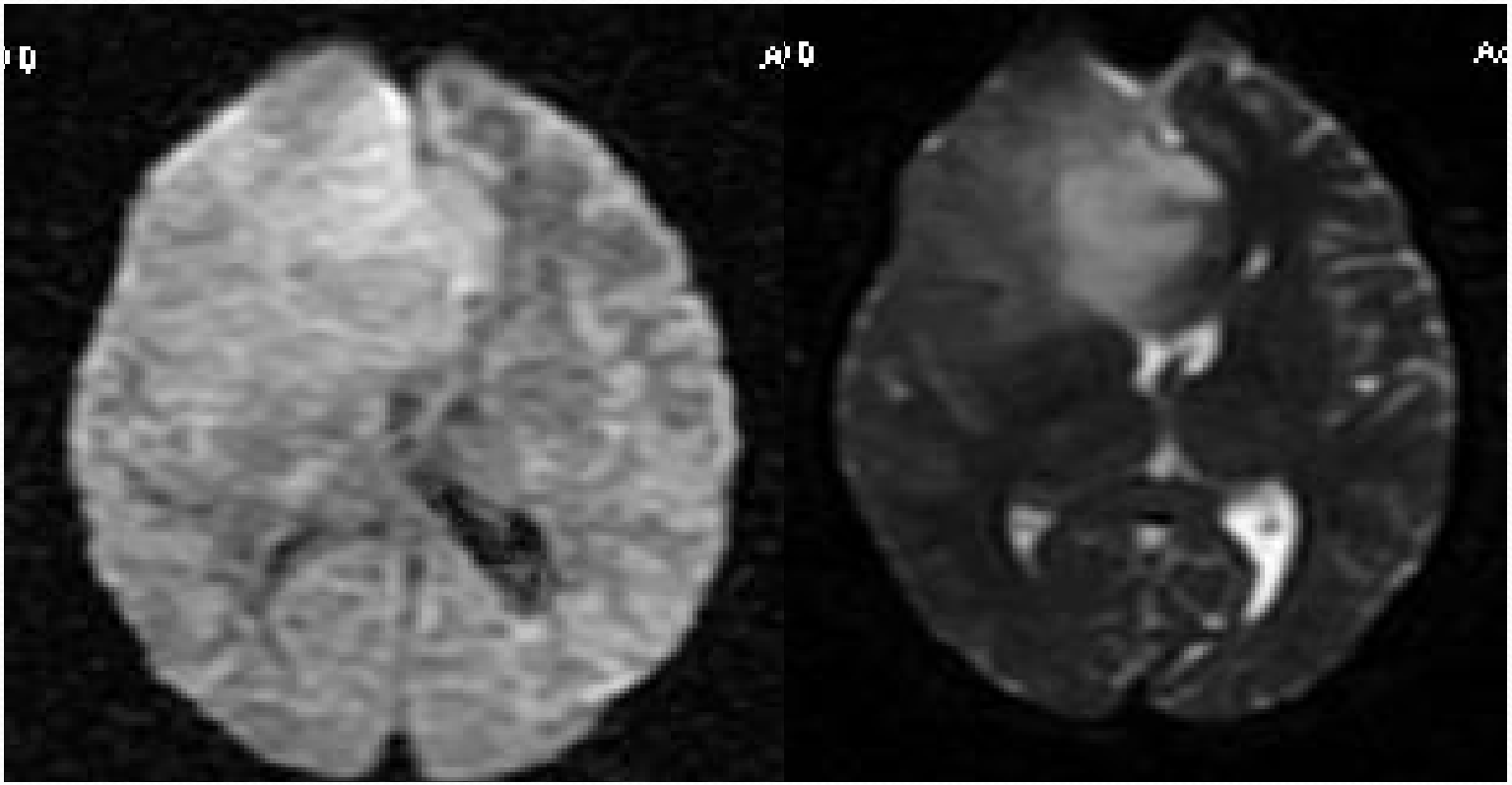
T2 FLAIR & T2* GRE WEIGHTED



T2 FLAIR=T 2 IMAGE WITH BLACK CSF

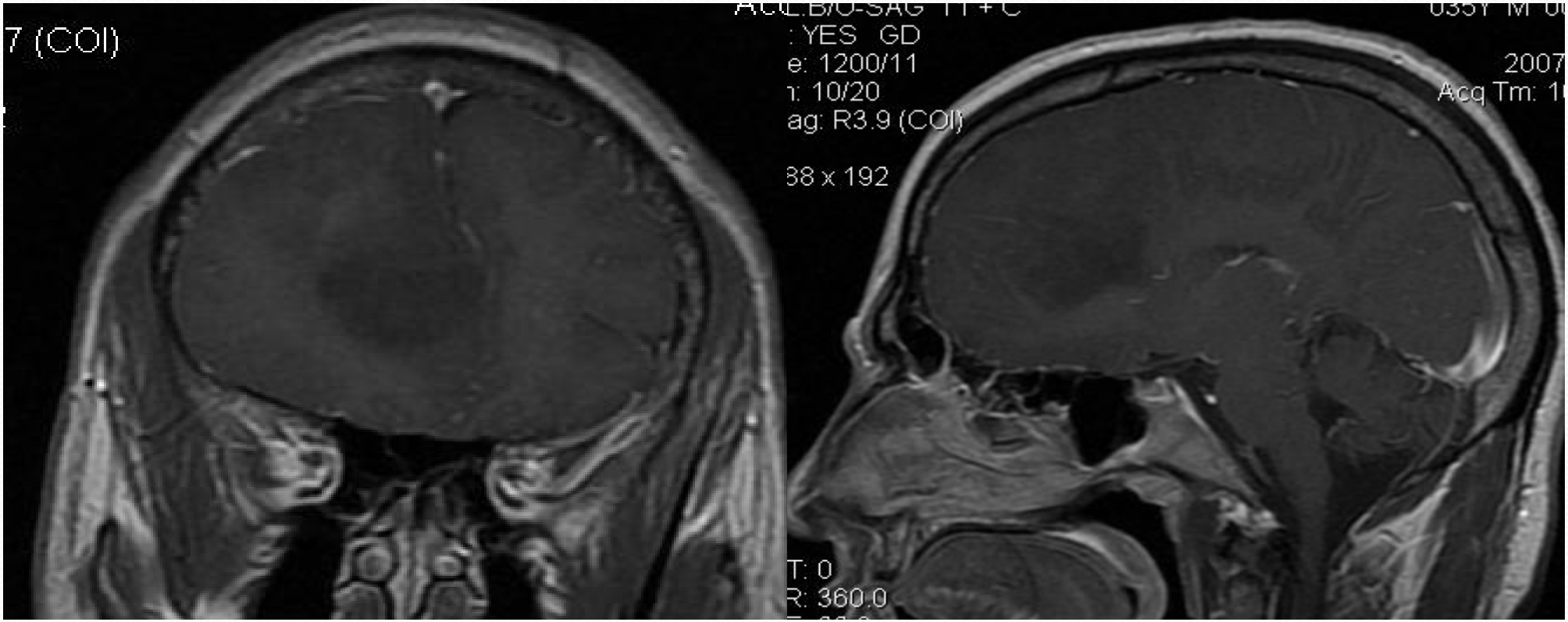
T2 GRE= GOOD FOR HEMORRHAGE. MORE SUSCEPTIBILITY ARTEFACTS

DWI & ADC WEIGHTED SEQUENCES

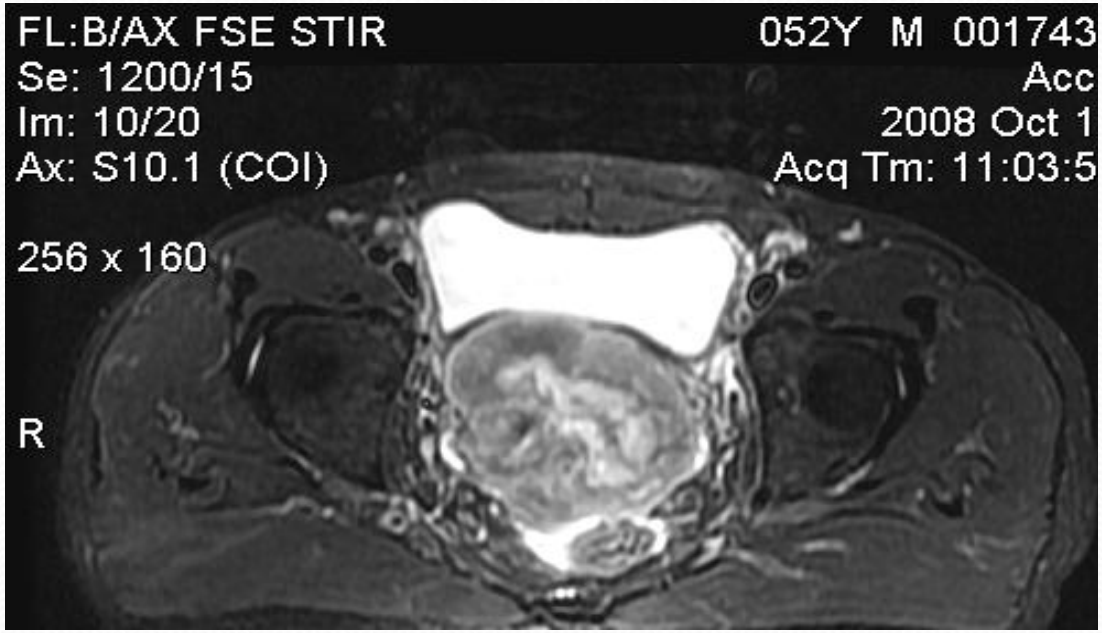


DWI=ABSCESS, ACUTE INFARCT, CELLULAR NEOPLASM BRIGHT, CYSTS=BLACK
PITFALL T2 SHINE THROUGH ARTEFACT. ADC=DWI RESTRICTED LESIONS =BLACK

MultiPlanar Imaging: Coronal & Sagittal



STIR & T1/T2 FAT SAT WEIGHTED



- Normal marrow fat is suppressed.
- On T2 edema and infective granulation/ neoplastic infiltrations =bright
- On T1 contrast enhancement better seen

Magnetic Resonance Spectroscopy

- 1H-MRS yields metabolic information.
- Tumor shows increased choline and reduced NAA

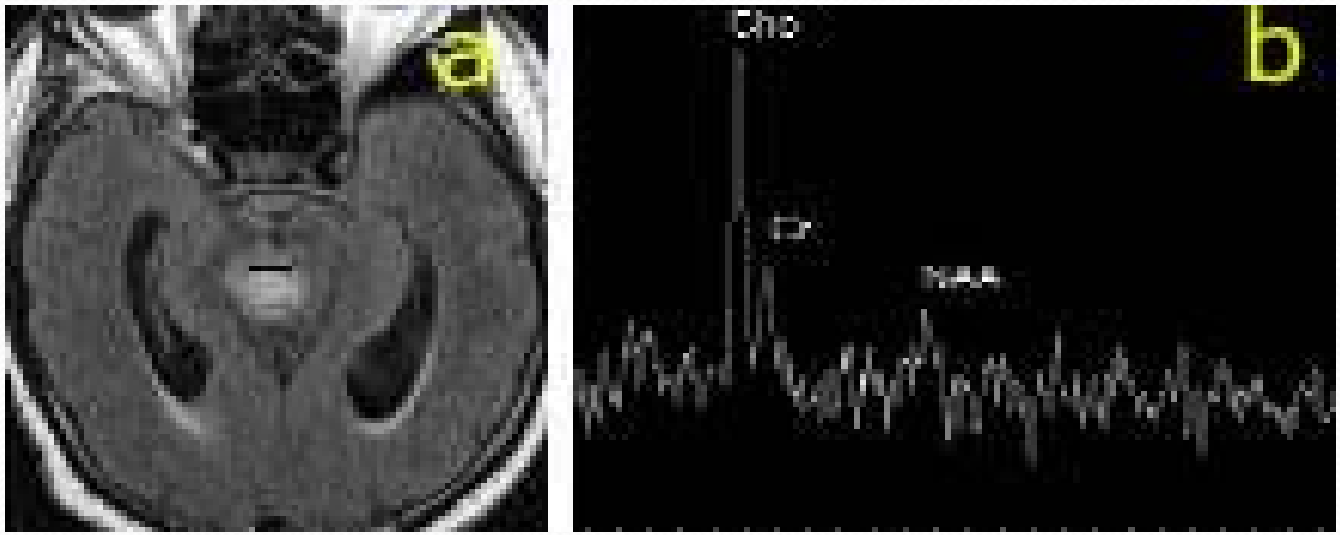
MONITORING TREATMENT

- A decrease in the abnormal Cho/Cr and Cho/NAA ratios and decline in the Cho peak indicates successful treatment

RADIATION NECROSIS VS RECURRENCE

- Increased Cho/Cr & Cho/NAA ratios is seen in areas of recurrent tumor. Cho/Cr ratio over 1.79 or lipid-lactate/Cho ratio less than 0.75 has a sevenfold increased odds of indicating tumor compared to pure necrosis

RADIATION NECROSIS VS RECURRENCE



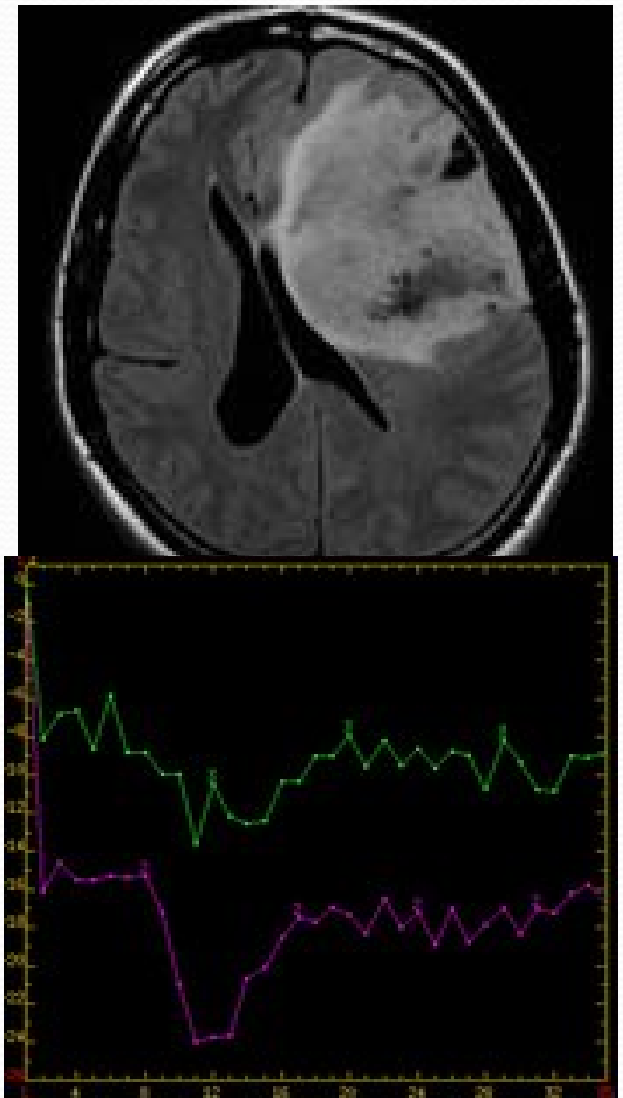
- Post RT new contrast-enhancing brainstem lesion in a 60 year male shows tenfold elevated signal intensity of the choline & decrease of NAA consistent with recurrence

Perfusion weighted MRI

- Use fast MR sequences timed to capture the sequential changes in vascular perfusion following injection of contrast agents. Time dependent enhancement curves can be produced.
- Advantages

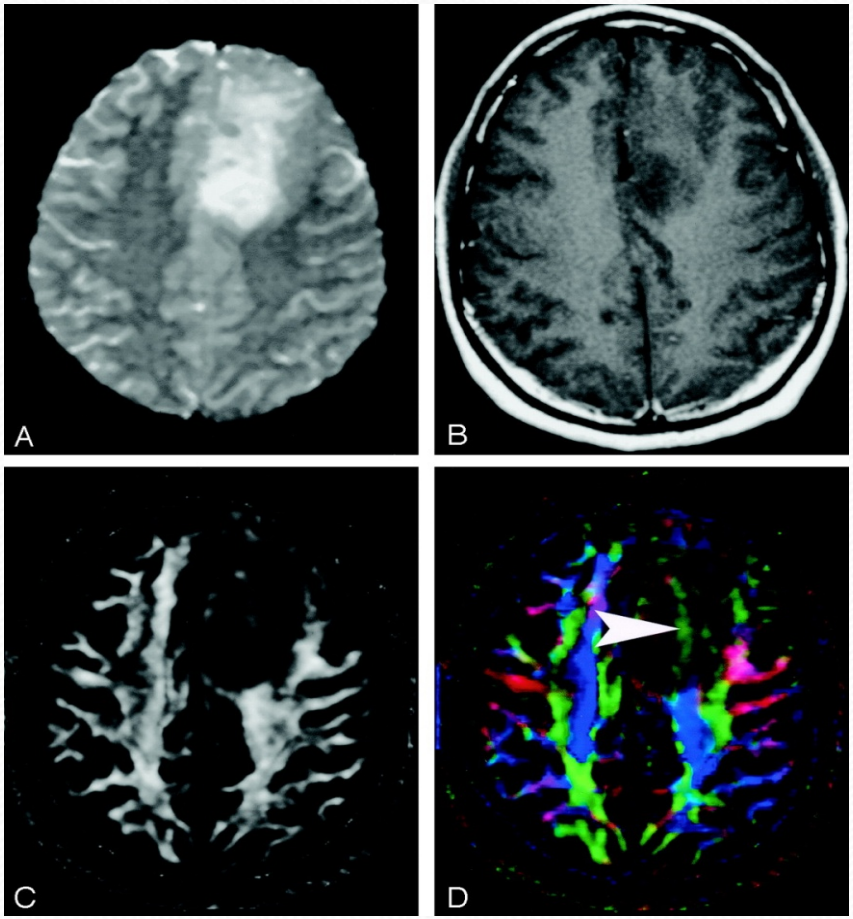
  Determine degree of malignancy of gliomas and in biopsy planning.

  Contoversial role in target delineation



Diffusion Tensor Imaging (DTI)

- DTI shows white matter abnormalities based on cerebral tissue anisotropy .
- DTI may be useful for assessing white matter infiltration by occult tumor
- DTI can also be used in RTP to limit doses to relevant functional regions to reduce specific radiation-induced injury



MRI IN Radiotherapy Planning

- On MRI, the hyperintense region on T2W or T2 FLAIR images can delineate CTV. For posttreatment, the contrast-enhanced regions depicting a mass effect can delineate GTV.
- All the target volumes delineated in MRI are significantly larger than on CT .
- Post RT changes in peritumoral brain tissue may result in pathological uptake of contrast that cannot be reliably distinguished from recurrent glioma. MRS may be useful.

CT Scan For Radiotherapy Planning

ADVANTAGES

Widely available

Relatively inexpensive

Fast imaging

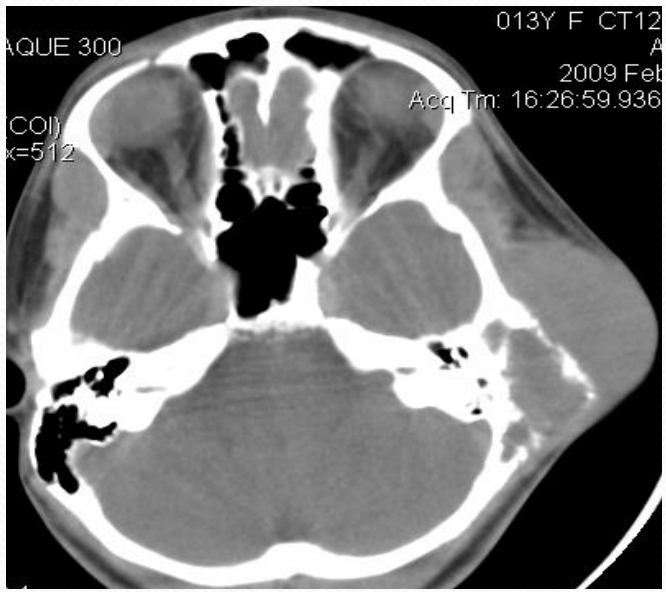
Good bony details

Electron density information available

LIMITATIONS

Soft tissue contrast less

Difficult to delineate tumor, peritumoral edema, and adjacent normal brain parenchyma



CT Scan For Radiotherapy Planning

Diagnostic vs RT Planning

- Supine or Prone
- Respiratory breathhold
- IV contrast useful
- Additional scan plane
- Variable pitch and scan time

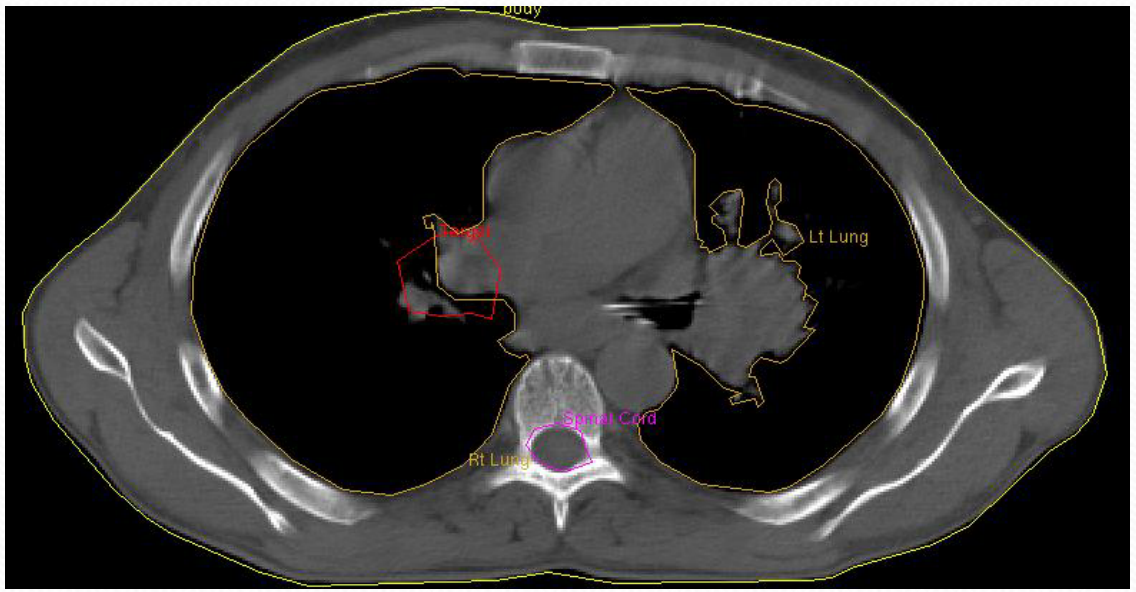
- Supine position
- Free respiration scan
- IV contrast complicates dose calculations
- Axial plane
- If pitch> 1, z axis distortion

Hounsfield Unit

- HU=1000 μ-μwater/ μwater
- μ = x ray linear attenuation coefficient
- WATER=0 HU defined
- AIR=-1000 HU defined
- LUNG=-200 TO -500 HU
- SOFT TISSUE= 20-50 HU
- BLOOD=70-90 HU
- IODINATED CONTRAST= 130 HU
- BONE=100-1000 HU

ISSUES WITH CT SCAN FOR TARGET SIZE DETRMINATION

- Motion-dependent volume aliasing during CT simulation causes target volume overestimation.
- More overestimation error with increased target motion amplitude and decreased target diameter.

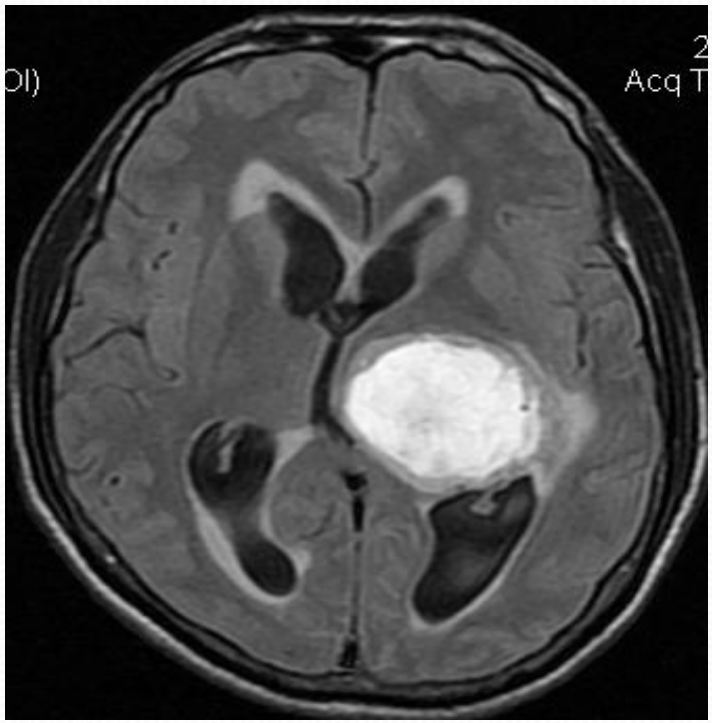


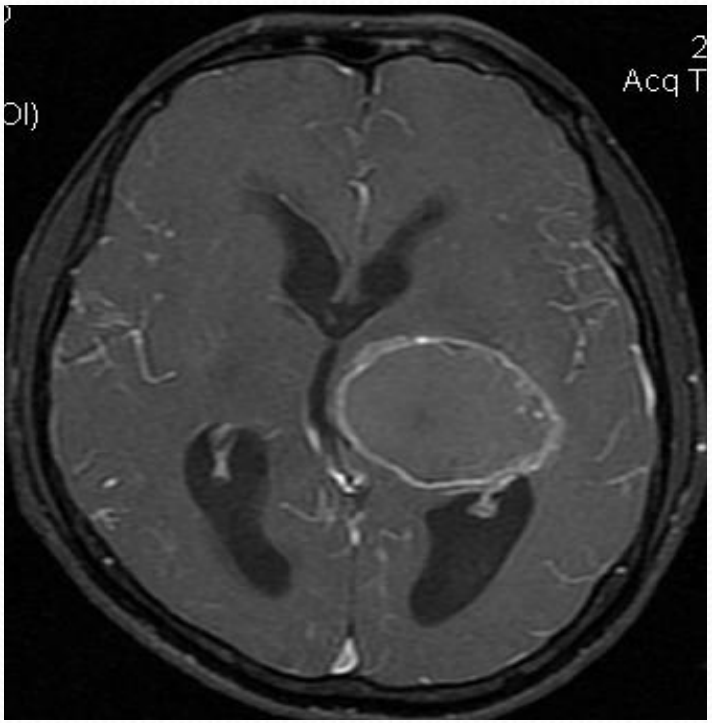
Regional considerations: Lung

- Cardiac and respiration related movement, which are often >1 cm & are important since the diameter of lung lesions treated with this method is typically < 4 cm.
- Conventionally lung tumors involves the use of CT and, if required, fluoroscopy to visualize the respiration-related movement of the lesion. The degree of tumor movement is added IM to the GTV.
- Cine MRI can evaluate intrathoracic tumour mobility.

Regional Considerations:CNS

- MRI shows improvements of up to 80% of cases in target volume definition with the addition of MRI to 3D CT based treatment planning
- However, CT is able to provide information on the extent of bony erosion from tumour not available with MRI.





Regional Considerations: Head & neck

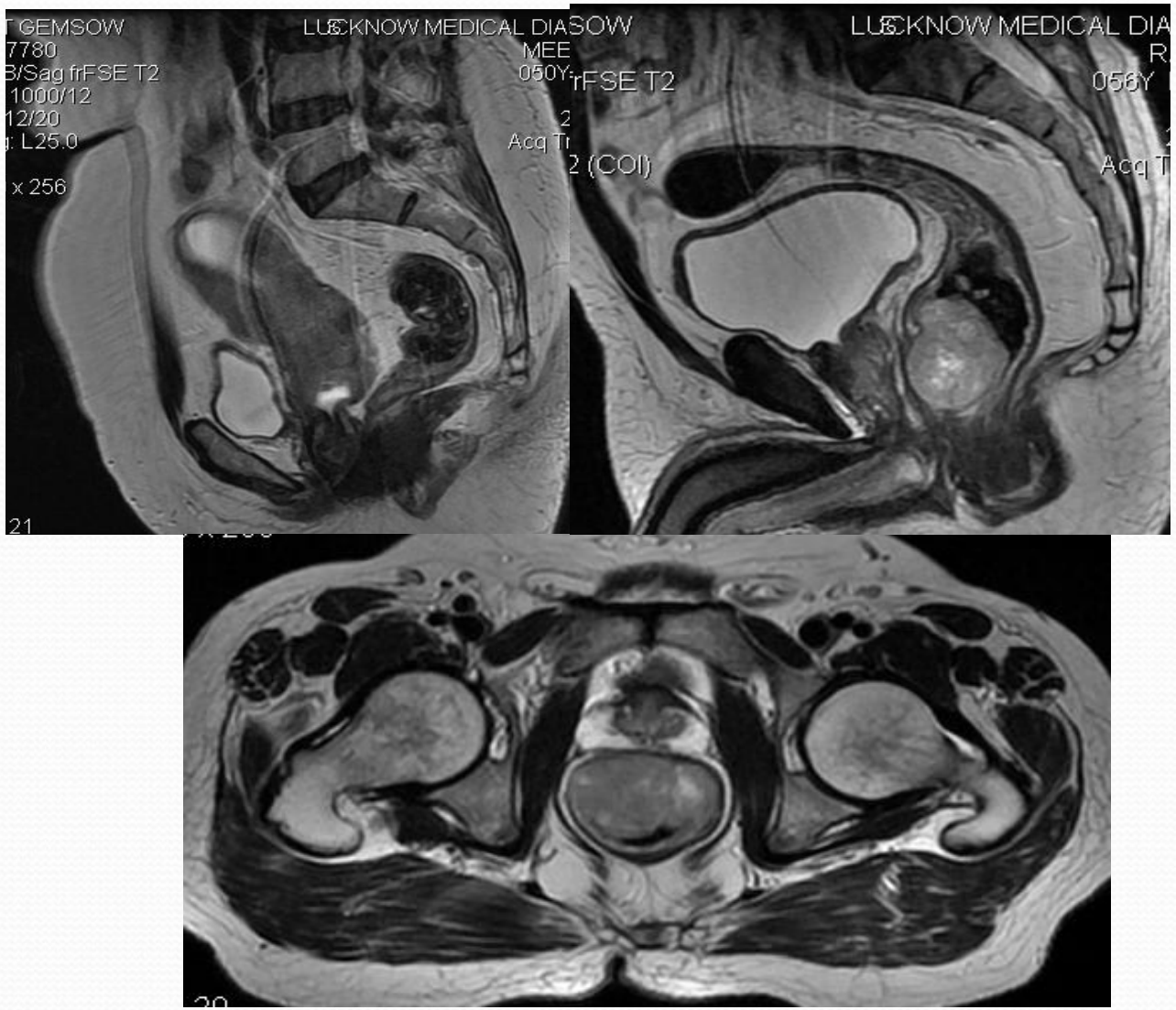
Complex anatomy makes infiltrations difficult to define.

MRI assists in delineation of 1) longitudinal tumor infiltration along aero-digestive tract & fascial planes 2) infiltration of tissue planes such as the pterygoids & tongue 3) perineural infiltration & intracranial extension, *eg* nasopharyngeal ca(4) nodal mets.

Regional considerations: Pelvis

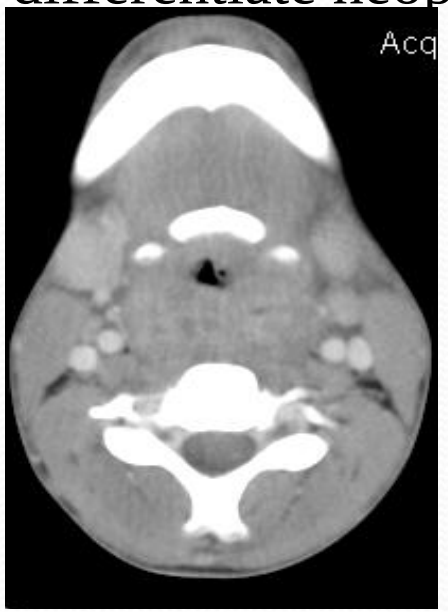
- In the pelvis, MRI has provided improved target delineation for urological, gynaecological and gastrointestinal cancers.
- MRI more informative in post-operative patients
- It also aids in delineation of adjacent normal tissue structures such as rectal wall, recto-vesicle fascia of Denonvillier, urogenital diaphragm, penile bulb, periprostatic venous plexus, neurovascular bundle, levator ani and anal sphincters.

Regional Considerations: Pelvis



Regional Considerations:Lymph Nodes

- Signal intensity and degree of contrast enhancement cannot reliably differentiate neoplastic & nonneoplastic
- Up to 20% of normal size lymph nodes can be positive for microscopic disease whilst up to 30% of enlarged lymph nodes may be nonneoplastic.
- USPIO particles appear to differentiate neoplastic and nonneoplastic.



4 D RADIATION THERAPY

- 3D imaging often produces images with motion artifacts.
- 4D radiation therapy – the inclusion of temporal changes to patient anatomy in order to remove such motion artifacts.

NOW CAN YOU SEE THE TARGET

READY FOR SOME ACTION !