

BASICS OF DIFFUSION MRI

- DWI is a fast sequence , Consuming not more than 2 m.
- it is a sequence of great value , in few time
- Diffusion : 2 Types - Isotropic = Free
 - Non isotropic = inbetween cells
- What is the appearance of lesions in DW MRI ?
- Either **Restricted** or **Free** Diffusion.
- • Free → Rapid Motility Molecules → Low signal.
- • Restricted → low motility → High signal.

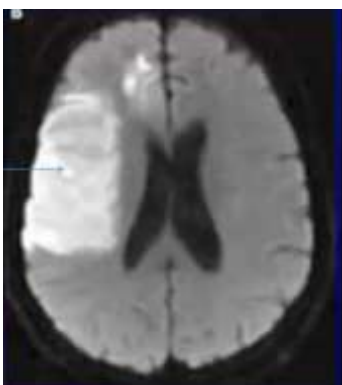


Sequences & parameters in Diffusion are the same in T2

But The Gradient added in Diffusion

• → inversion of T2 effect on fluidsi.e.

physiological fluids in Diffusion appears of low signal “Black”.

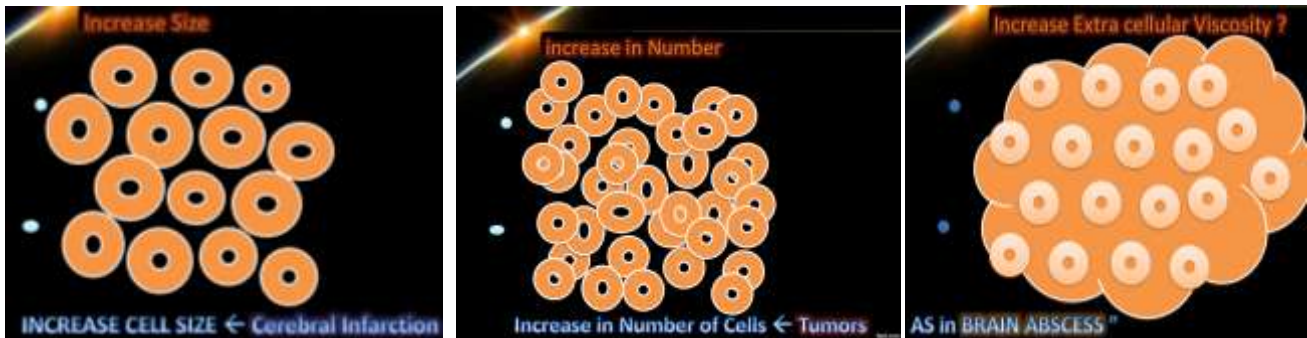


- CSF = Free Diffusion
- Bright lesion = Restricted Diffusion

*** What are the pathological principles of DWI ?**

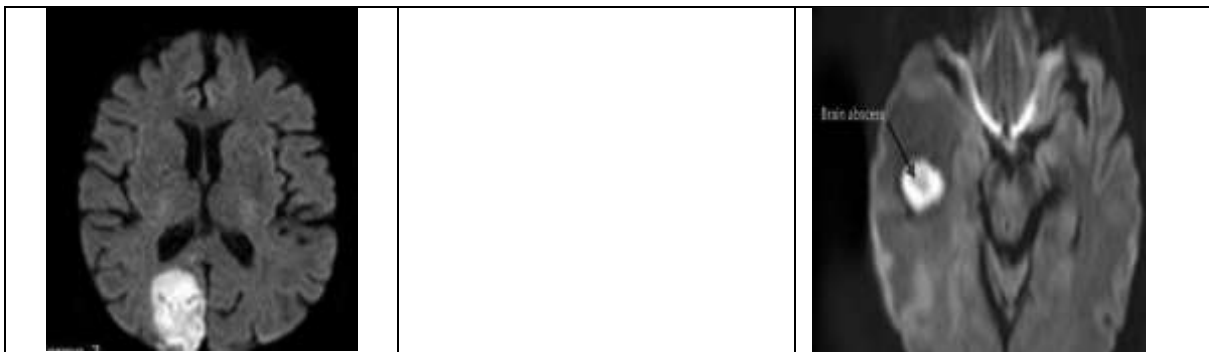
- Fluid Molecules diffuse in between Cells
- Thus, increase in Cells
- **Size - Number - Viscosity** of intercellular Fluid

→ DECREASE “Restrict” Diffusion



What are the main 3 states of Restricted Diffusion ?

- Increase Cell Size → as in *Cerebral Infarction*
- Increase Cell Number → as in *Tumors*
- Increase Viscosity of intercellular Fluid → As in *Brain Abscess*



Cerebral Infarction

In cerebral infarction

- Cut off blood supply □ disturbance of salts exchange → Na in ward
→ Cells swollen i.e. “cytotoxic edema “
- Swelling of the cells = increase its size → Diffusion Restriction

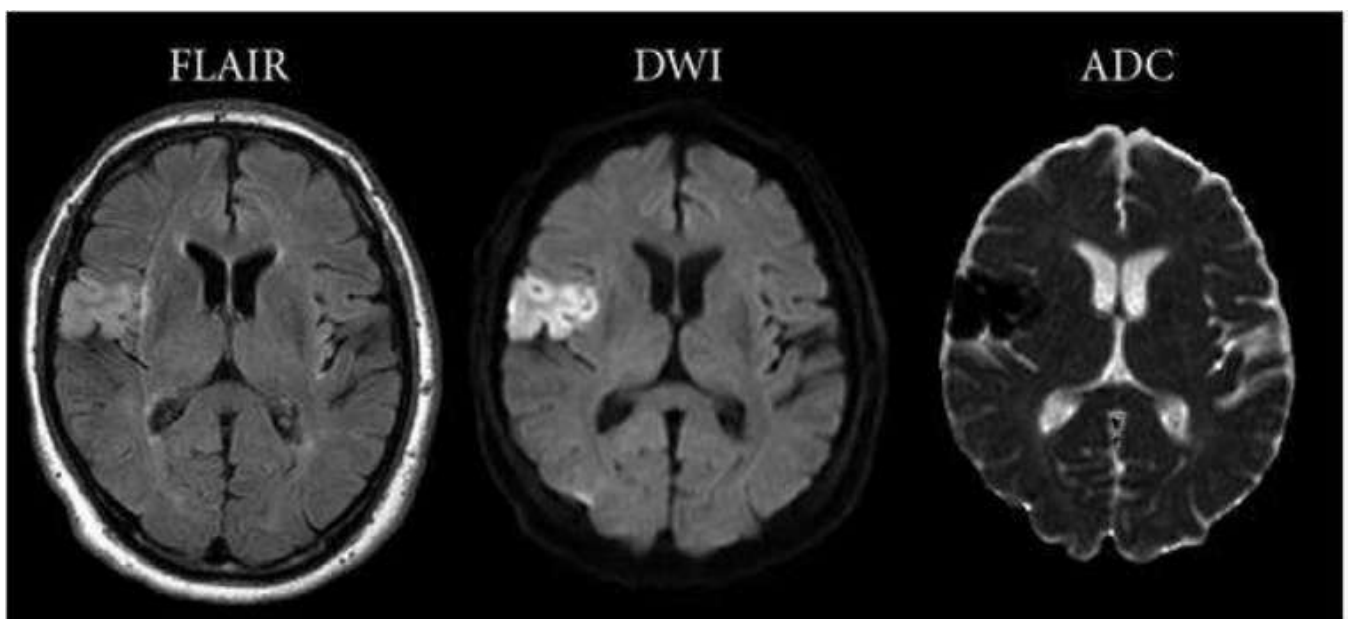
.DWI is the Fastest method to diagnose Cerebral Infarction

1st 3 Hours are the golden time for Thrombolytic therapy

- DWI can diagnose infarction in **hyper acute** stage
- This early state not diagnosed by CT or may Not by MRI

BUT DWI can diagnose in WITH IN MINUTES of occurrence !!!

Infarction Stage	Duration
Hyper-acute	< 6 H
Acute	6 h : 3 Days
Sub-acute	3 days : 3 weeks
Chronic	>3 weeks



⇒ **ADC MAP**

ADC = Apparent Diffusion Coefficient

- it represent the rate of an anisotropic diffusion.

What is b Factor ?

= Degree of diffusion “mm²/sec”

- it depend on :

– Gradient amplitude

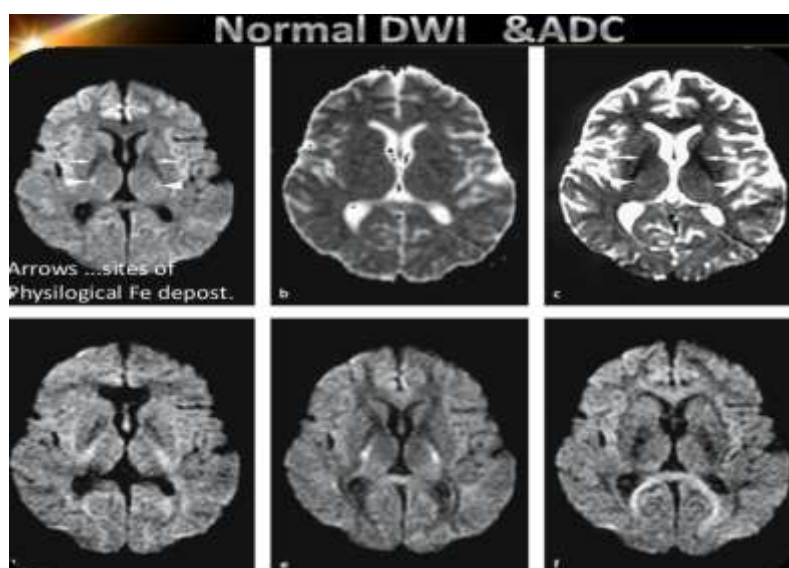
– Time

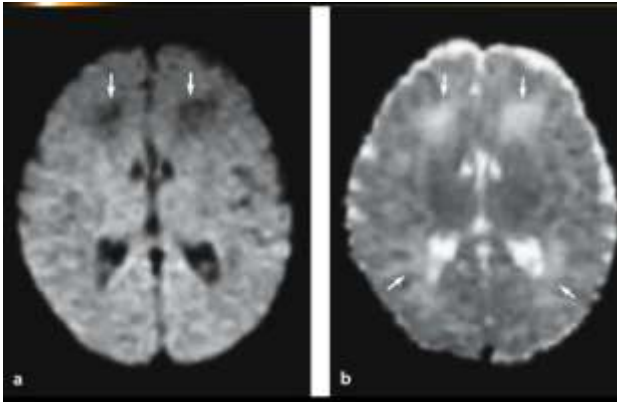
– intervals in-between



.....**Thus , More b Factor More Chance of Diffusion**

- ADC Map is a computerized image.
- Obtained by taking multiple Diffusion images on different b Factors.
- This series of images make the rate of diffusion of different molecules can be calculated in numbers.
- The ADC Map image **is inverted** in colors i.e. **restricted is black** & **Free is White**





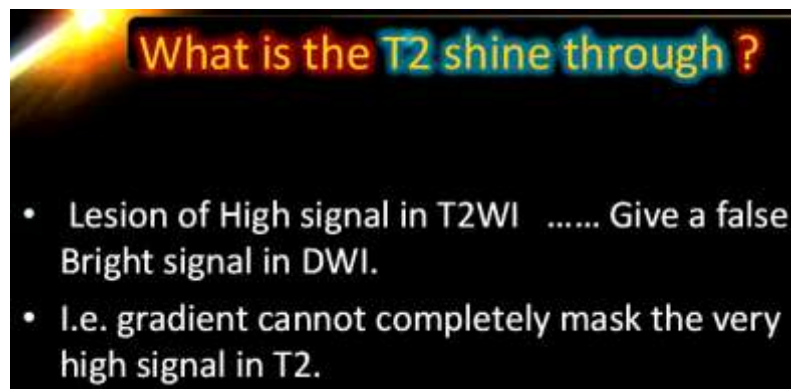
Normal neonatal brain. normal to have low DW signal intensities in the frontal deep white matter (arrows.)

•The appearance of the pediatric brain on DW images varies with age

•b - ADC values of the corresponding areas are high in neonatal brain

= To interpret ADC Image :

- Look at : Diffusion Image & ADC Map
- Area of **Restricted** Diffusion: -High signal in DWI & Low in ADC& Vice versa

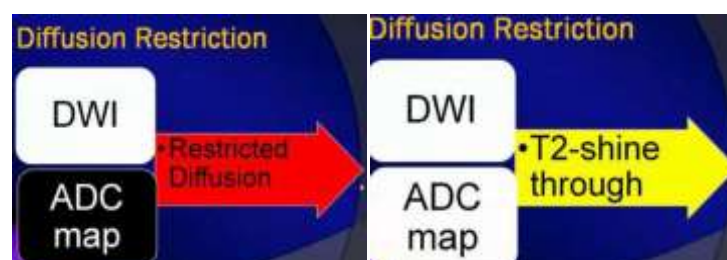


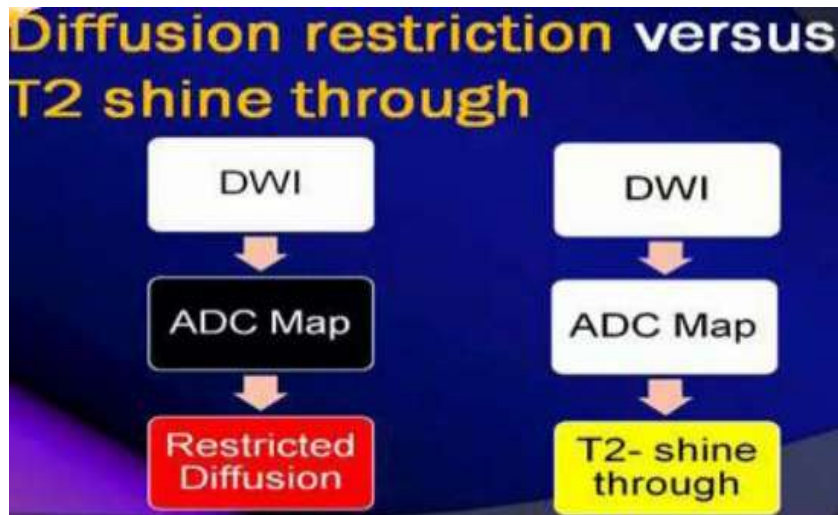
Thus

As regarding DWI Restricted Diffusion & lesions of very high signal in T2 → appears Bright

How to Differentiate ?

- Area of Restriction Bright in DWI Dark in ADC
- Very Hi T2 lesion Bright in DWI Bright in ADC

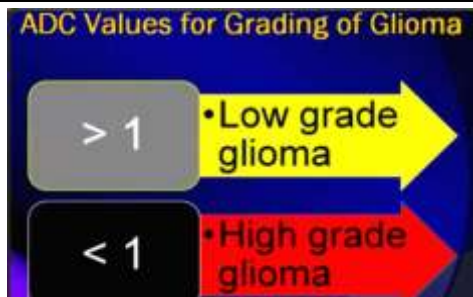




⇒ Value of Diffusion in ADC Map is represented by ADC Value.

ADC Value & Tumors

- Malignant Vs Benign
- Low grade Vs High Grade
- Higher Cell number →More Restricted Diffusion → Less ADC Value



⇒ **ADC Value & Tumor Cellularity?**

- ⇒ **Tumors of High Cellularity :**
- ⇒ Lymphoma ADC Value 0.51 : 0.71
- ⇒ High grade Glioma 0.58 : 0.88
- ⇒ Metastasis
- ⇒ Medulloblastoma
- ⇒ **Tumors of Low Cellularity :**
- ⇒ Low grade Glioma ADC Value > 1.05

⇒ All Malignancy has High Cellularity ? ?

⇒ Usually Yes

- But Few Malignancies has Low Cellularity .
- Best Example → **CHORDOMA**
- Chordoma has low celularity → High ADC value

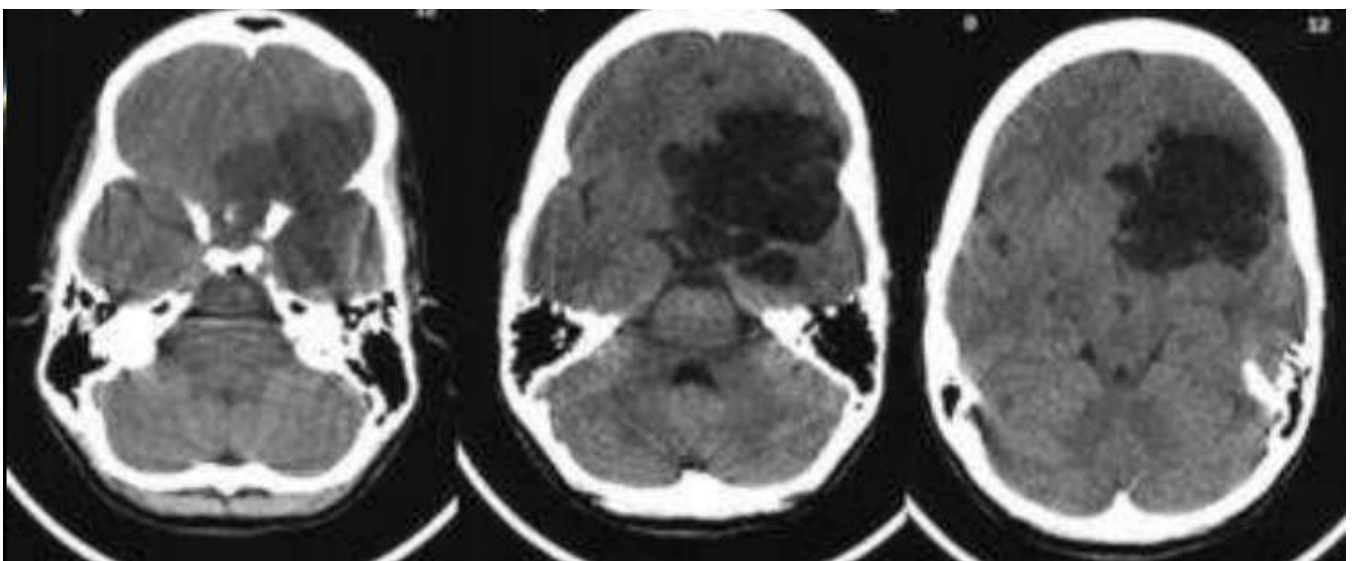
ADC Values & Differentiation Between Similar Tumors

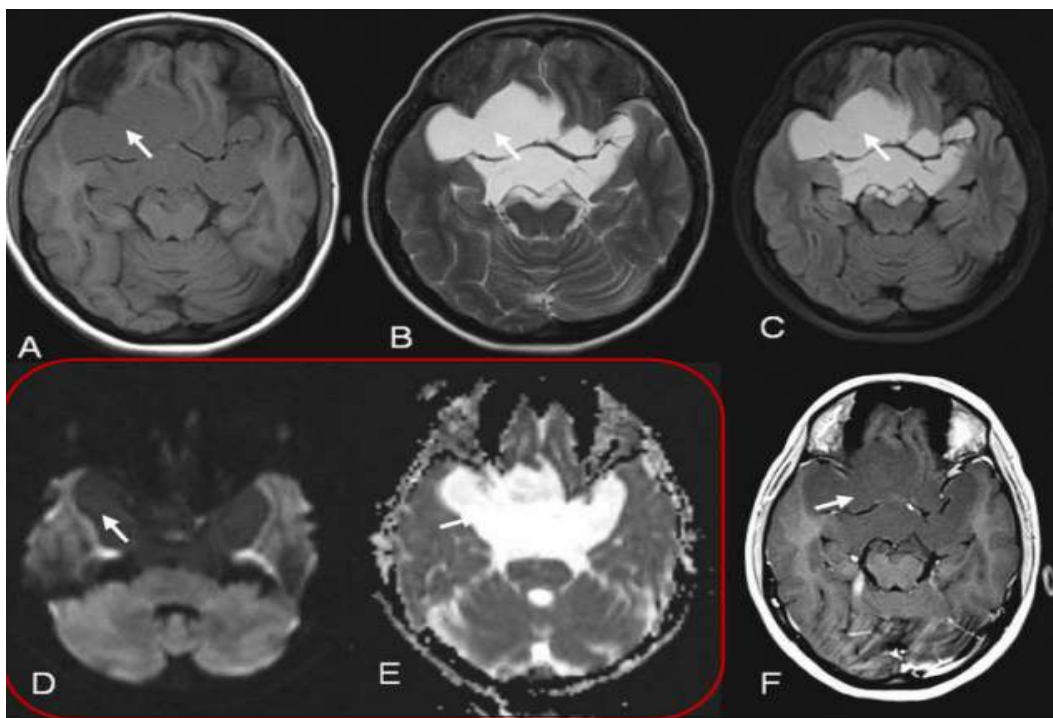
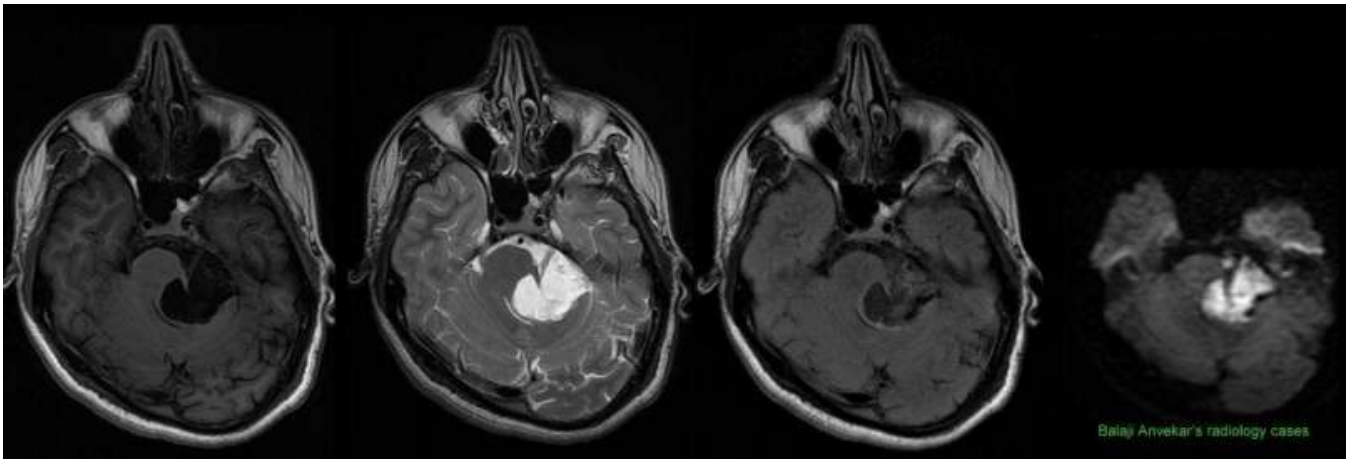
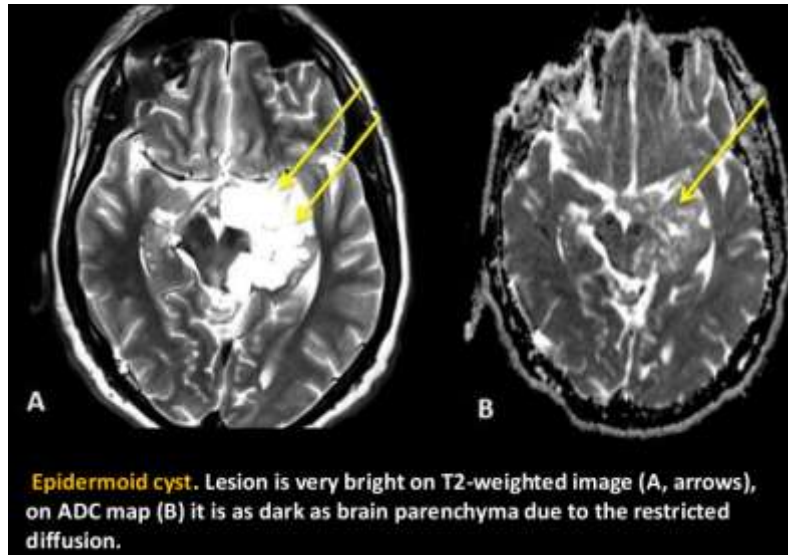
• Medulloblastoma	Vs	Ependymoma
• PNET	VS	Chordoma
• Hi Cell / Low ADC		Low Cell / Hi ADC

Epidermoid Cysts

Benign & non-neoplastic , Congenital or Acquired cysts.

- Contain dense fluid + epidermal elements → restricted diffusion.
- **DWI differentiate** it from other cysts, especially :
 - **arachnoid cyst**, → do not show any restricted diffusion. "CSF LIKE"



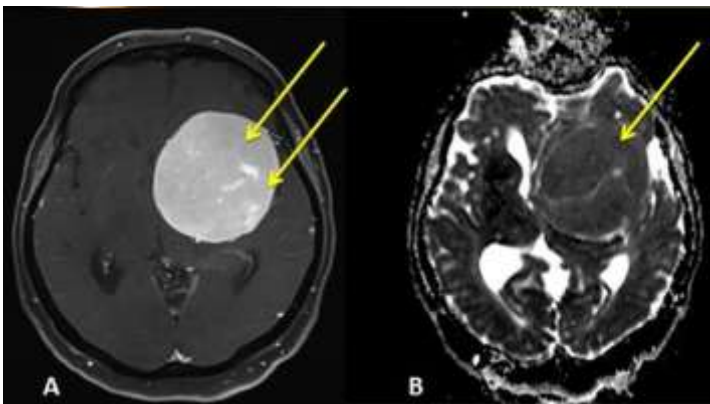


Meningiomas

Extra-axial Dural Neoplasm

- **Homogenous** intense enhancing +/- Dural tail.
- Their typical appear → easier to be diagnosed on routine MR images.
- **Subtypes**: * Typical, * Atypical * Malignant

– A typical and malignant meningiomas show much **more prominent restricted** diffusion.



Meningioma. Post-contrast T1-weighted image (A) shows intense enhancement of

(the tumor (arrow

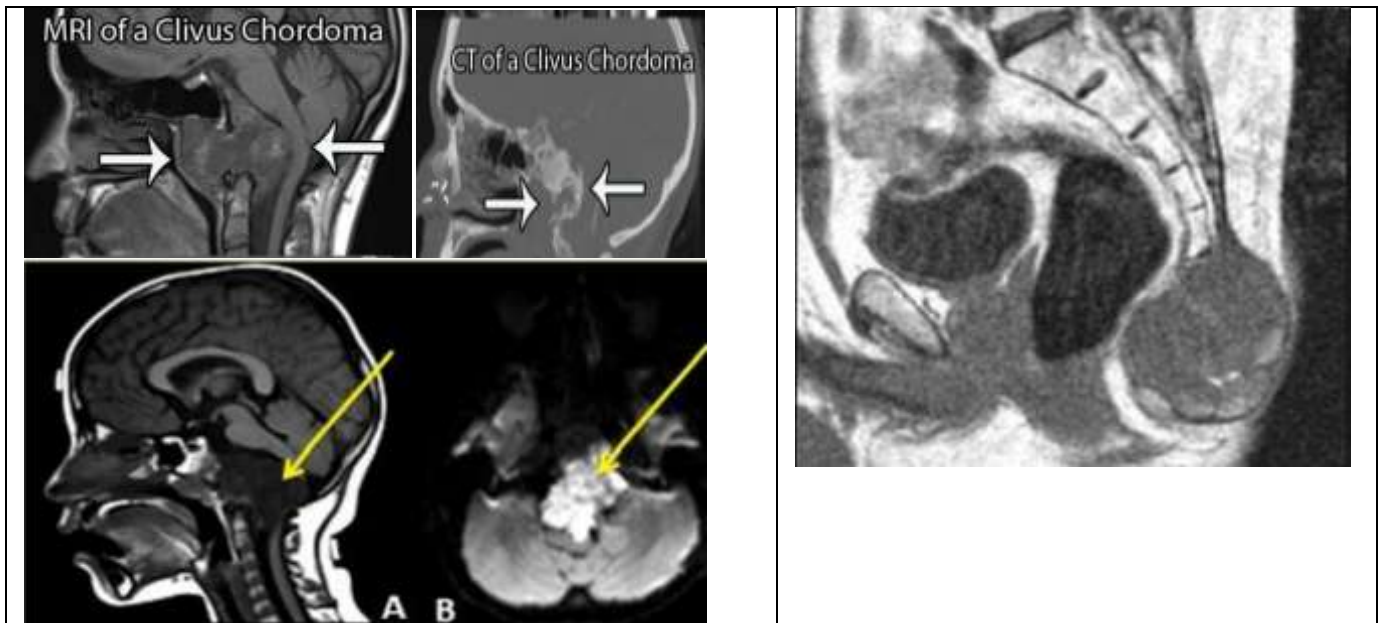
On ADC map, the mass is dark, due to the restricted diffusion. Pathology: Atypic

meningioma, WHO grade 2

Chordomas

Chordomas Vs chondro-sarcomas

- Rare
- Primary bone tumors
- it Involves:
 - skull base, especially the clivus.
 - sacrococccigeal region.
- DWI :
 - Especially poorly differentiated chordomas → more restricted diffusion than chondro-sarcomas



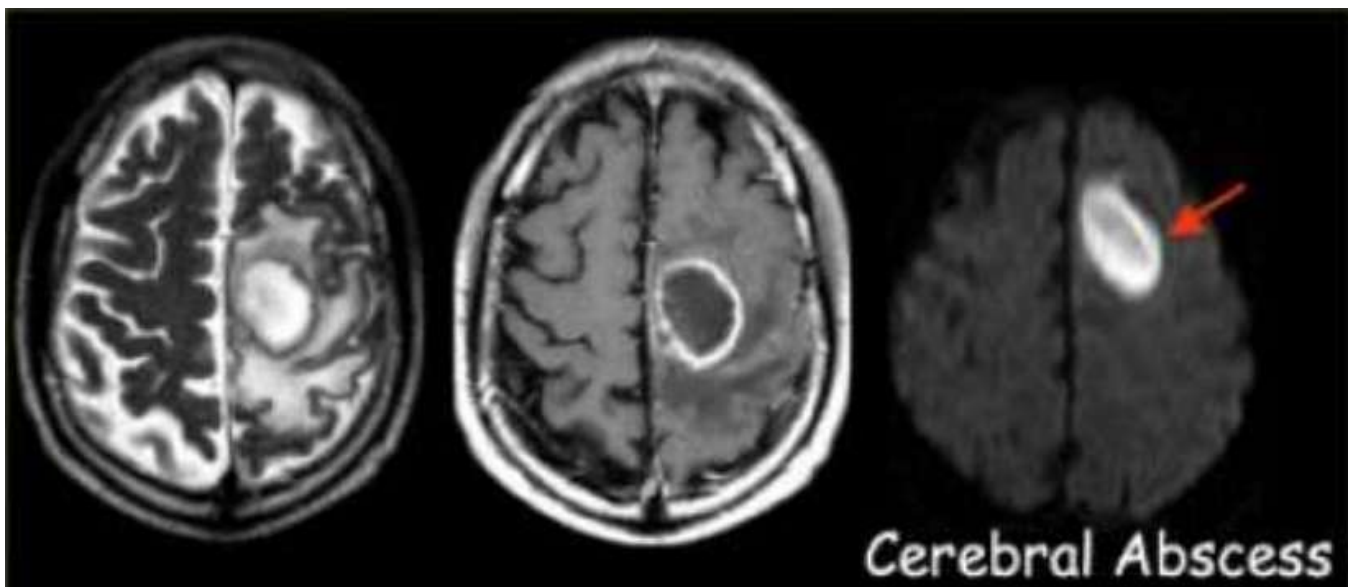
Lymphomas

• *Lymphoma Vs Glial Tumors.*

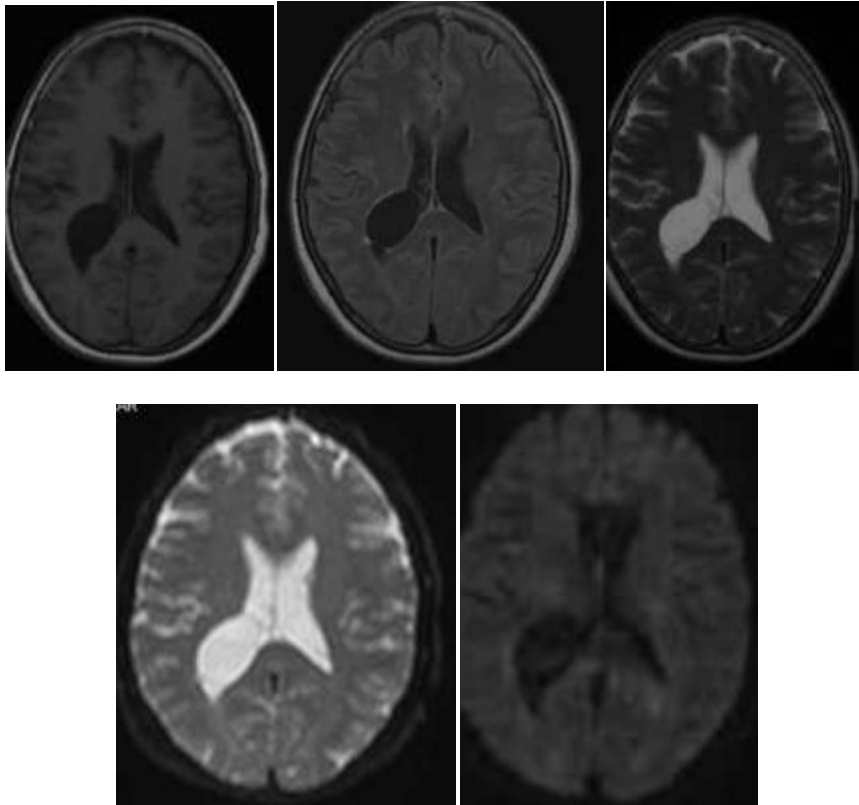
- Site: periventricular/sub ependymal.
- Intense Homogenous enhancement.
- Their diffusion is more restricted compared to glial tumors
 - Also, they show lower perfusion than glial tumors.

Abscess .

- Sometimes can be mistaken as necrotic tumors on imaging,*
- Both show **peripheral contrast enhancement.**
- Clinical presentation is important for the differential diagnosis.
- On MRI, liquid content of the abscesses show markedly restricted diffusion , → extremely helpful for the diagnosis .



Choroid Plexus Cyst



- Diffusion-weighted MRI (DWI) has been applied to extracranial sites since the 1990s.
- Several investigators have reported that 3-T DWI can improve :
 - the diagnostic accuracy of tumor detection,
 - staging,
 - targeted biopsy,
 - posttreatment follow-up,
 - Assessment of therapeutic response

Assessment of Hepatic Tumors

- Assessment of body lymphoma
- Evaluation of Prostate Cancer

SUMMARY

- DWI is a fast sequence * Gradient its magic
- DWI is the best to assess hyper acute infarction
- Restricted diffusion = high signal in DWI / Low in ADC..... vice versa
- Increase in “cells size/Infarction- “ Numbers / Tumors “ – "Fluid Viscosity / Cyto-toxic edema"
- ADC Map give a numerical values as in CT Hu.
- Highest ADC value of free Diffusion is 3
- ADC value of :
 - high grade Tumors < 1 , Low grade > 1
- DWI is an important part of MR imaging for the evaluation of brain masses.
- DWI can not be used alone.
- Data obtained from routine T1, T2 and FLAIR sequences as well as post contrast images should be evaluated altogether.
- Perfusion imaging → evaluate vascularity of masses.

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