

Amit tudni akarsz az MR-ről ...
2014. május 9.

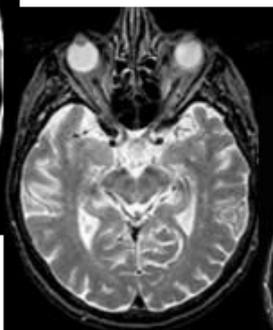
A normál és patológiás szövetek MR megjelenése

Martos János
Országos Klinikai Idegtudományi Intézet

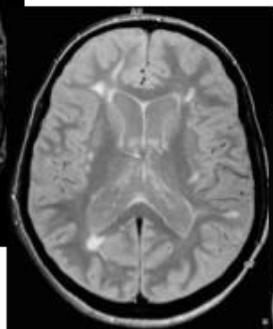
Multiparametrikus képalkotás



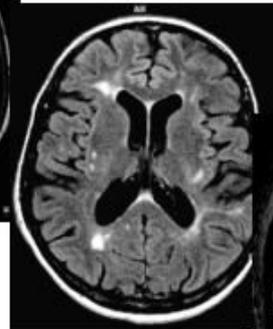
T1 súlyozott



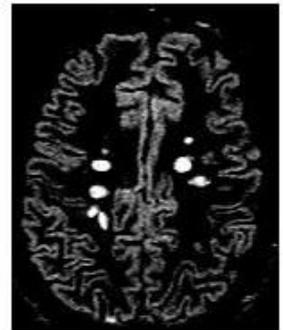
T2 súlyozott



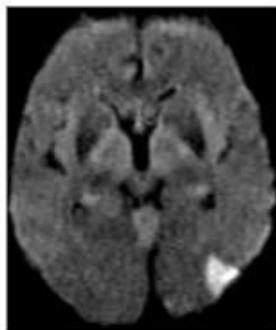
Protodenzitású



FLAIR



SWI





Felix Bloch

Edward Mills Purcell



Történelmi áttekintés

- 1946 F. Bloch (Stanford) és E.M. Purcell (Harvard): NMR
- 1952 Nobel díj: F. Bloch + E.M. Purcell
- 1971 Damadian: a daganatok T1 és T2 paraméterei
- 1973 Lauterbur: "Zeugmatography"
- 1976 Moor és Hinsaw: első emberi felvétel
- 2003 Nobel díj: Sir Peter Mansfield, Paul C. Lauterbur



Paul C. Lauterbur



Sir Peter Mansfield



Raymond Damadian

Az MR jel intenzitása

$$S_{SE} \approx P * e^{-TE/T2} * (1 - e^{-TR/T1}) * f(\Delta)$$

$$S = f(P, T1, T2, \Delta, TR, TE, \alpha, Ps)$$

Szöveti jellemző
(intrinszc)

P: protondensitás = f(víz tartalom, térerő, hőmérséklet)
T1: T1-relaxációs idő = f(víz tartalom, zsírtartalom, szöveti mágneseesség, térerő)
T2: T2-relaxációs idő = f(víz tartalom, kémiai eltolódás, szöveti inhomogenitás)
Δ: mozgás (diffúzió, véráramlás, liquorpulzáció)

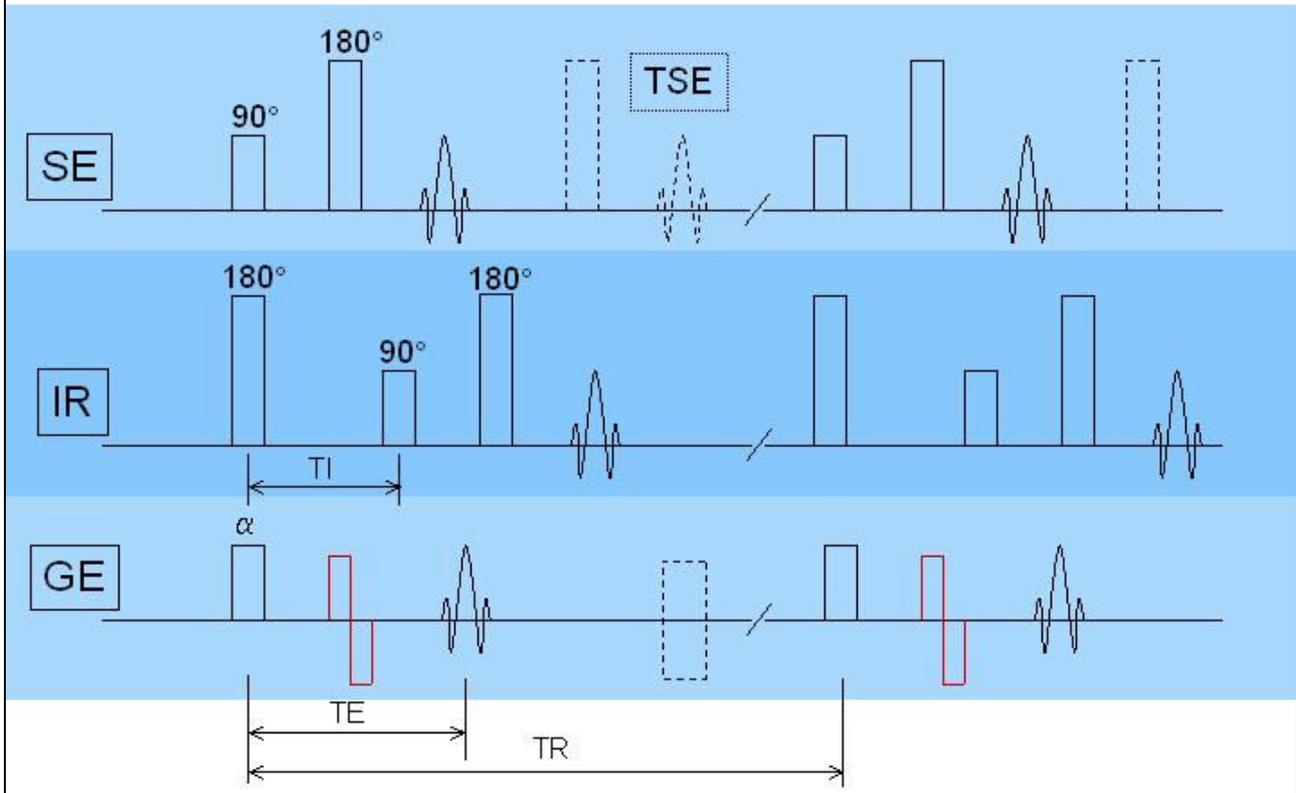
Változtatható
(extrinszc)

TR: repetíciós idő
TE: echó idő
α: kibillentési szög (gradiens-echó)
Ps: preszaturáció (térbeli, frekvencia szelektív (MTC, FATSAT), inverzió (TI))

sejtközötti víztartalom
 cytoplasma víztartalom
 zsírtartalom
 fehérjetartalom

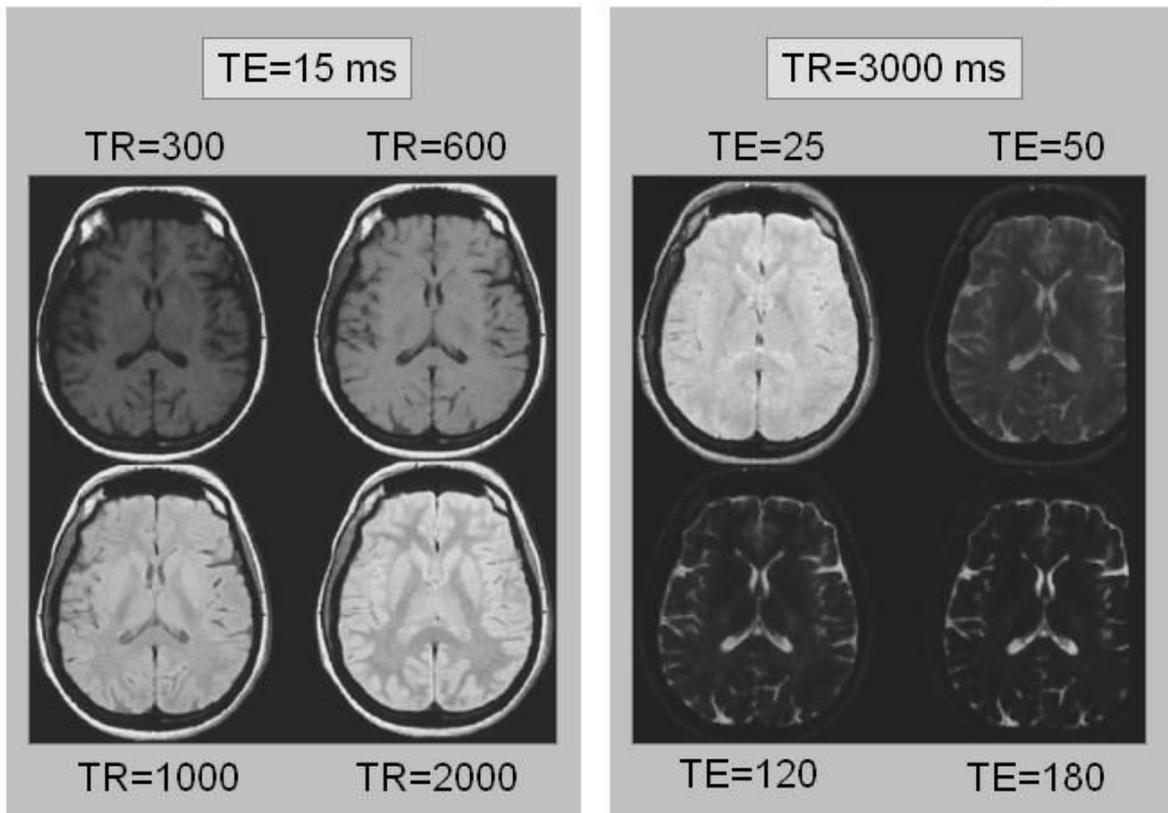
rostos szerkezet
 myelin állapota
 gliosis
 cellularitás
 sejtmag/plasma arány
 paramágneses anyagok, fémek

Szekvenciák

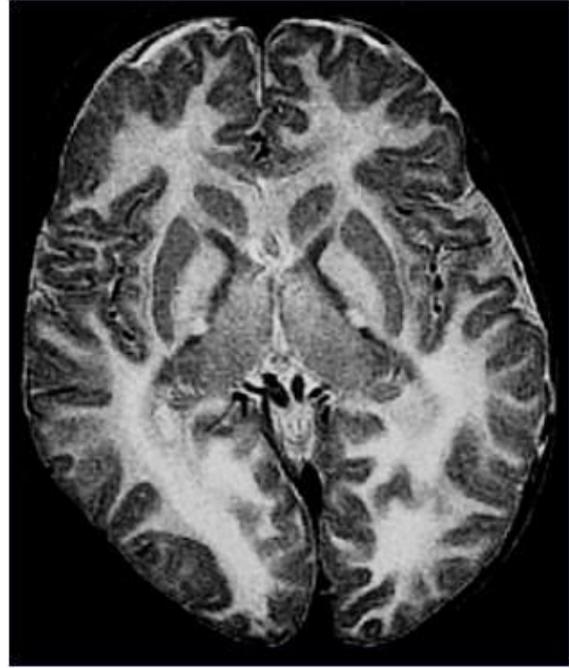
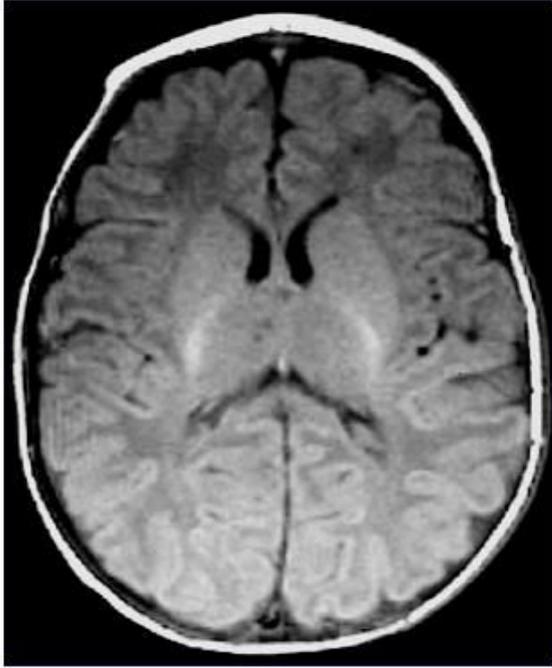


Az MR jel intenzitása

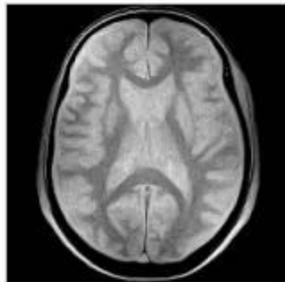
Spin-echó



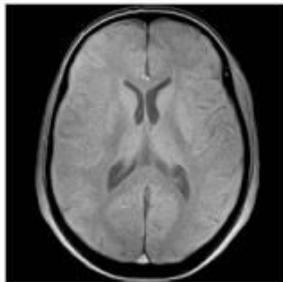
Protondenzitású, T1 vagy T2 súlyozott?



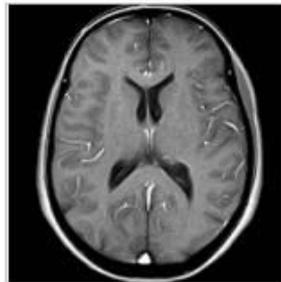
A GE kép kontrasztja



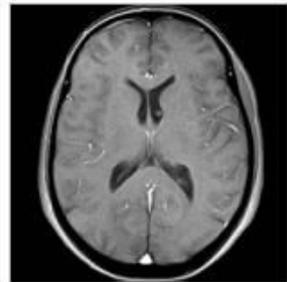
FA=10



FA=20



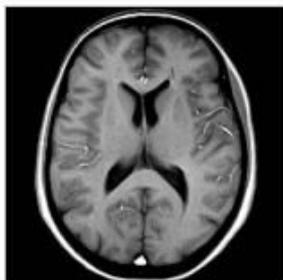
TR=20



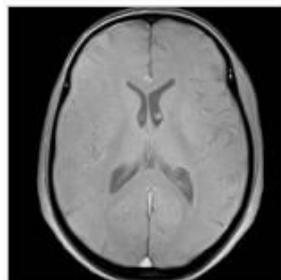
TR=50



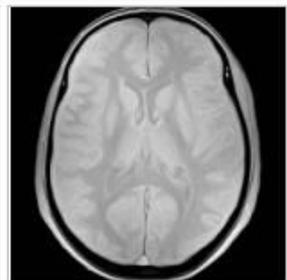
FA=40



FA=70



TR=150



TR=400

Az MR jel intenzitása

A jelintenzitást növeli:

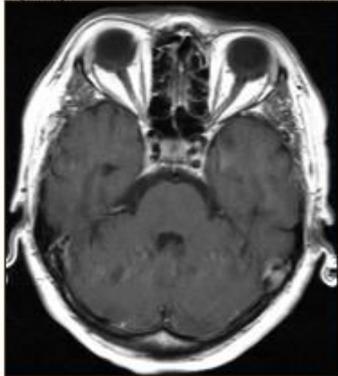
- a nagyobb protonszűrűség
- a hosszabb T2 relaxációs idő
- a rövidebb T1 relaxációs idő

A jelintenzitást csökkenti:

- a kisebb protonszűrűség
- a rövidebb T2 relaxációs idő
- a hosszabb T1 relaxációs idő

Az MR jelet befolyásoló tényezők

(SE)

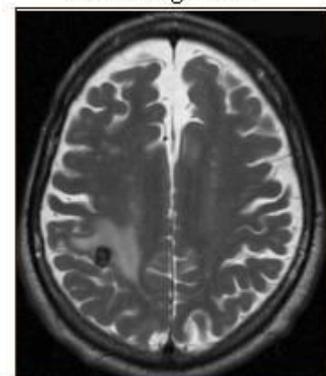


Mozgás

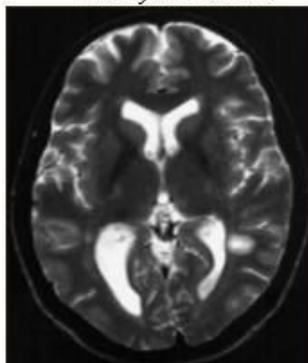


(GE)

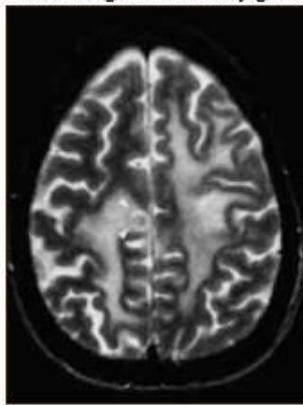
Inhomogenitás



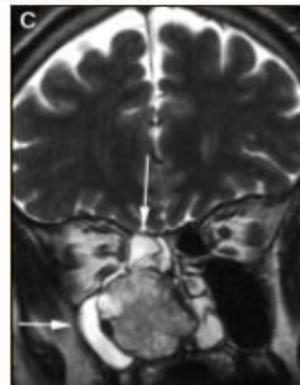
Demyelinizáció



Paramágneses anyagok



Cellularitás



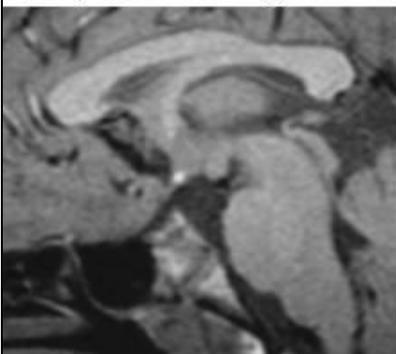
T1 hyperintenzitás

Rövid T1 relaxációs idő (zsír, subacut vér, Gd)

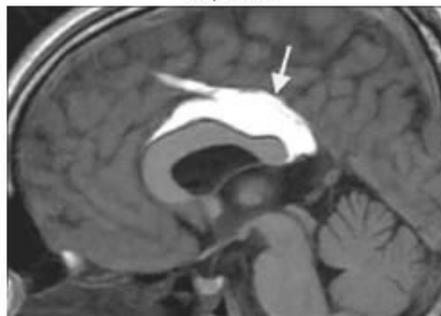
- Lipidek (zsír, olaj és faggyú tartalmú anyagok)
- Myelin
- Paramágneses anyagok (Gd, mangán, magnézium, réz, vas)
- Vér (metHgb vizes oldata -> hemolysis)
- Melanin
- Kalcium (meszesedés)
- Fehérje (15-35 mg/dl vizes oldat, pl.: mucinosus váladék)
- Lassú áramlású vér (flow-related enhancement)

T1 hyperintenzitás

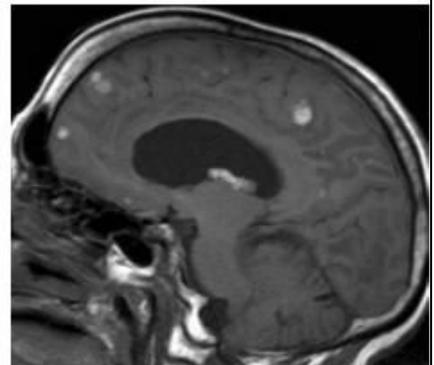
Ectopias hátsó lebeny



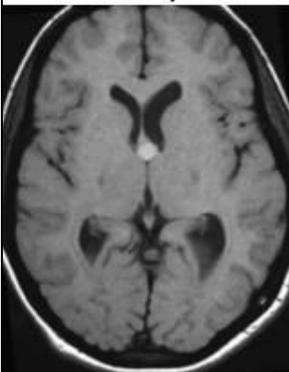
Lipoma



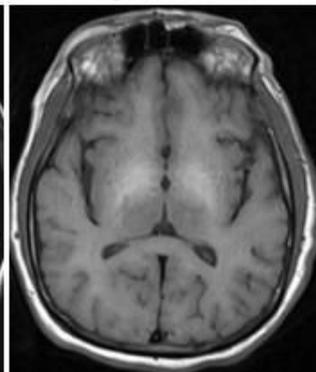
Melanoma met.



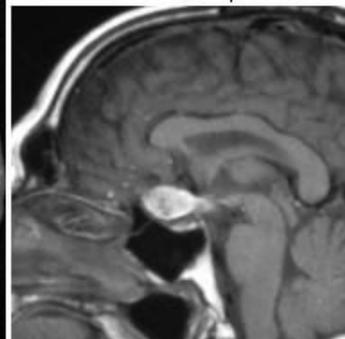
Colloid cysta



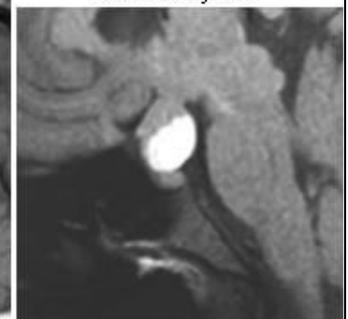
Mangán lerakódás



Dermoid ruptúra

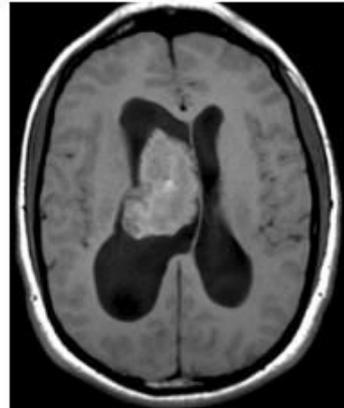
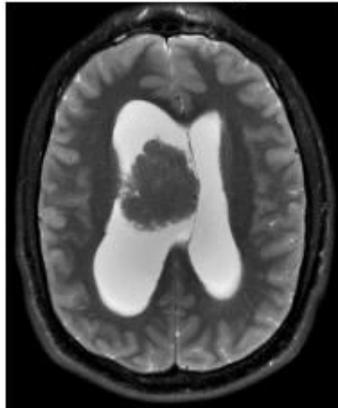
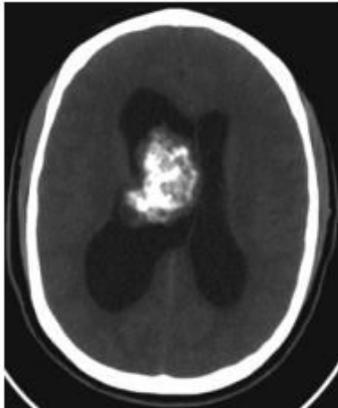


Rathke cysta

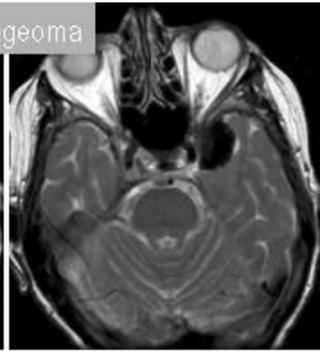
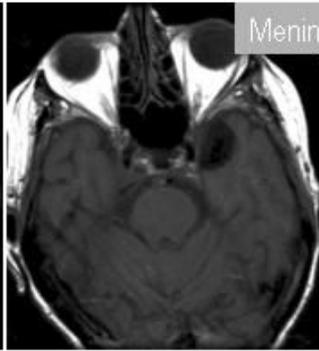
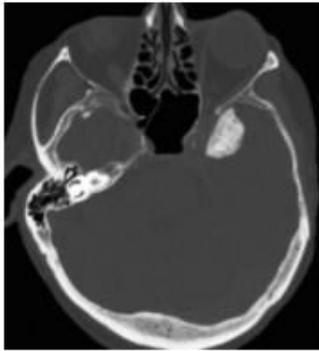


Meszesedés

Centralis neurocytoma



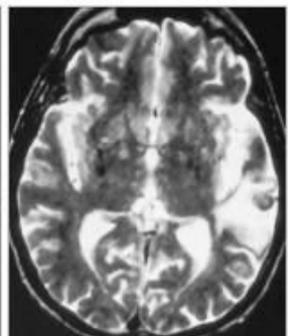
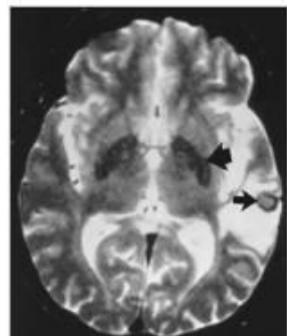
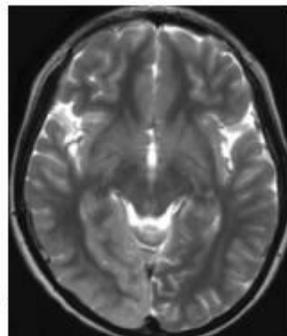
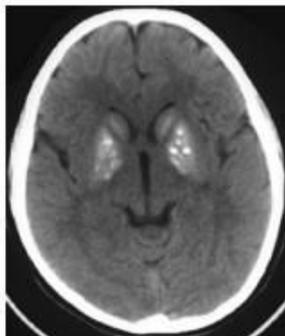
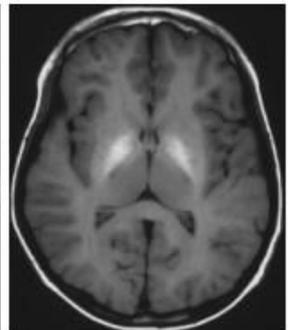
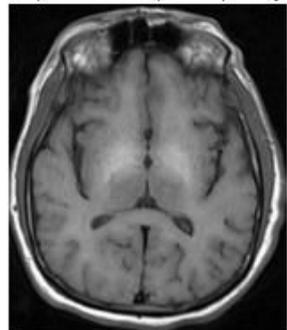
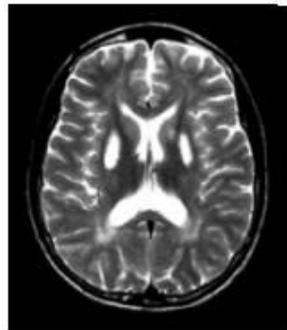
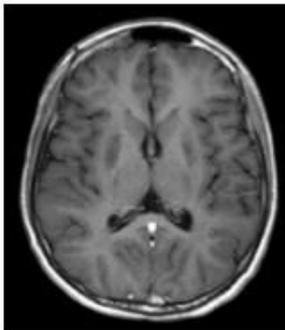
Meningeoma



Basalis ganglionok

Hepatic encephalopathy

Wilson-kór

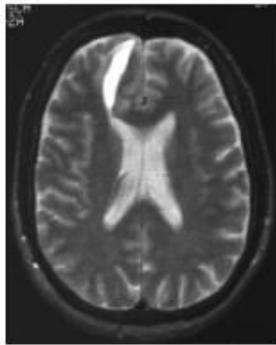


CSE

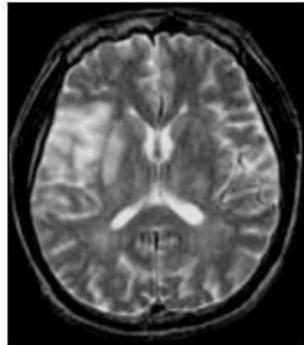
FSE

T2 hyperintenzitás

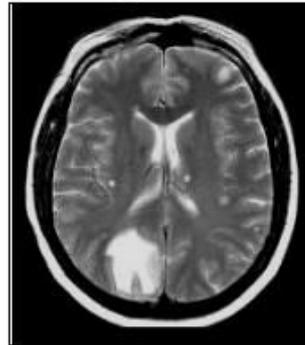
Hosszú T2 relaxációs idő (víztartalom)



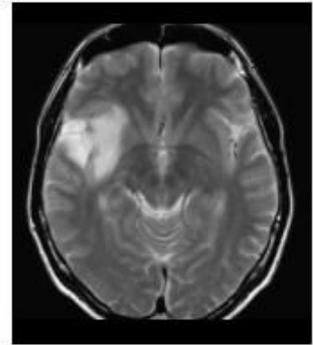
Subacute ICH



Infarctus

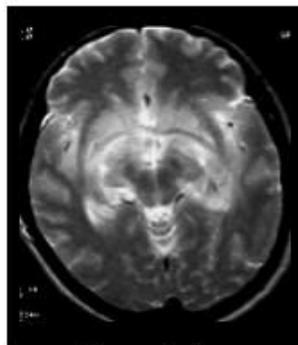


Metastasis

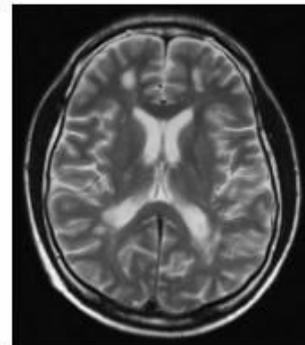


Astrocytoma

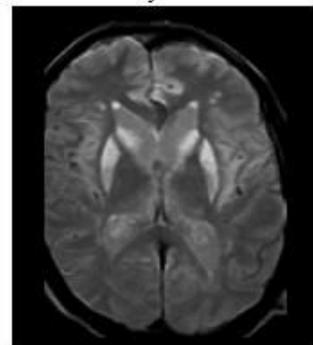
- Vasogén ödéma
- Cytotoxikus ödéma
- Demyelinizáció
- Cysta
- Gliosis



Gliomatosis



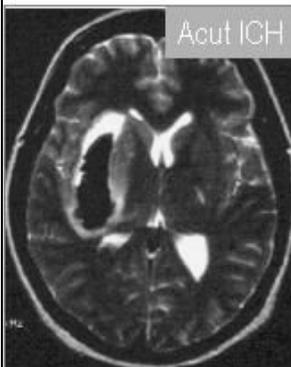
SM



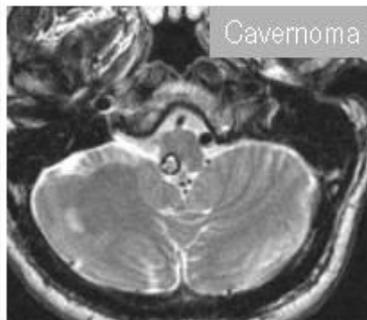
JCD

T2-hypointenzitás

Rövid T2 relaxációs idő (szuszeptibilitás különbségek)



Acute ICH



Cavernoma

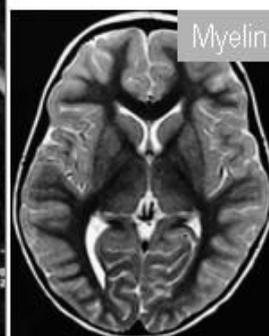
- Kémiai eltolódás
- Inhomogenitás
- Cellularitás
- Myelin épsége
- Intracelularis paramágneses anyagok
- Acute vér
- Intravascularis paramágneses anyagok
- Sejtközötti állomány
- Alacsony protondenzitás



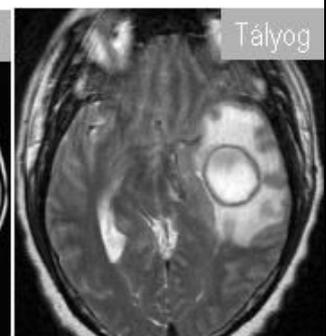
Heg



Szalagok



Myelin

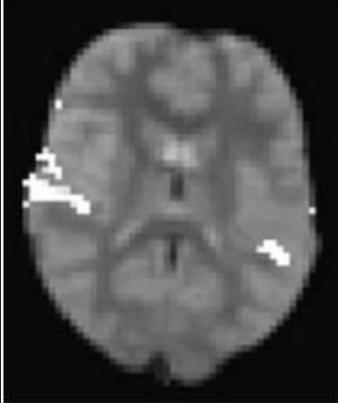


Tályog

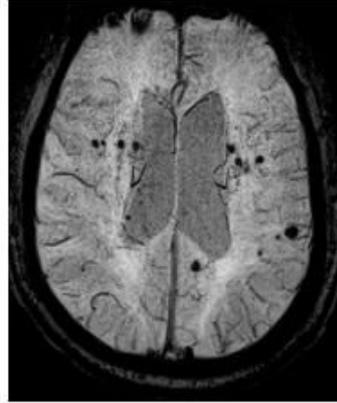
T2-hypointenzitás

Intravascularis paramágneses anyag

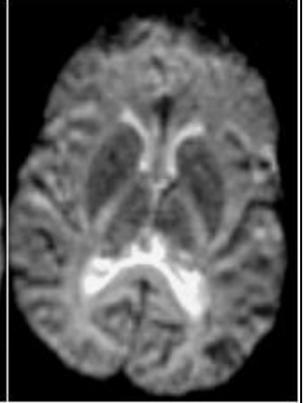
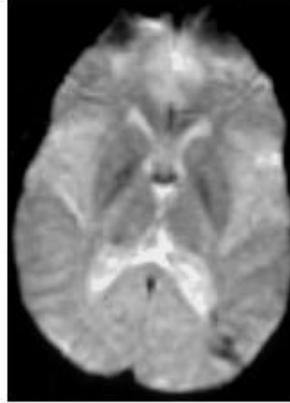
BOLD



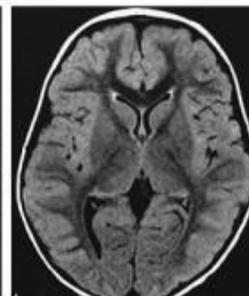
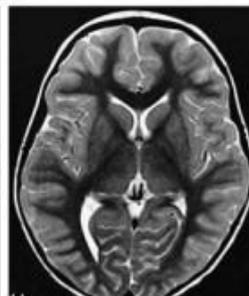
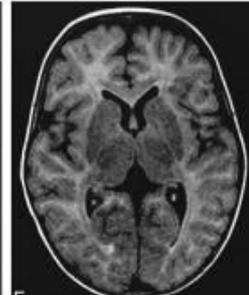
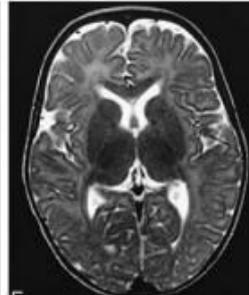
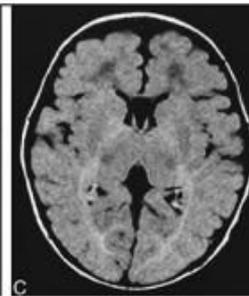
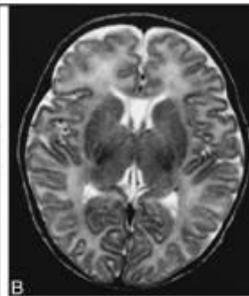
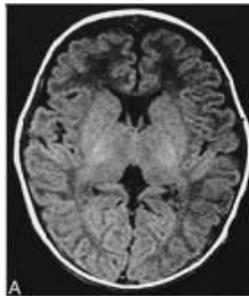
SWI



PWI

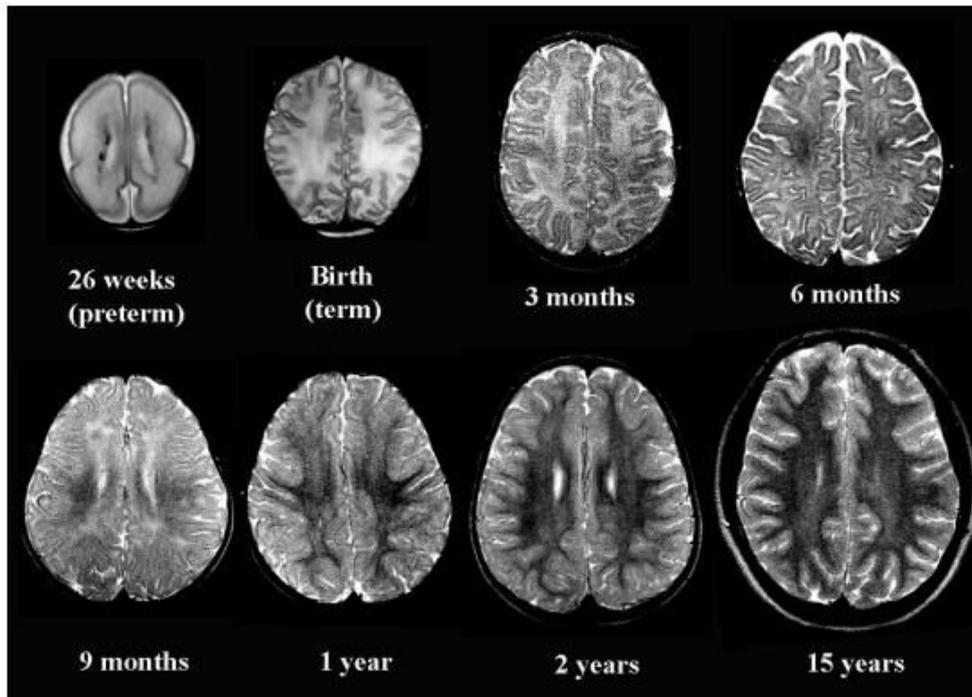


A normális myelinizáció



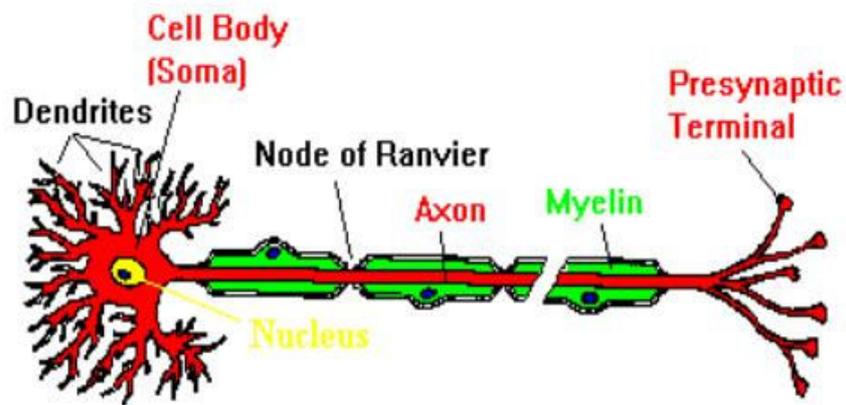
Murakami, 1999

A normális myelinizáció



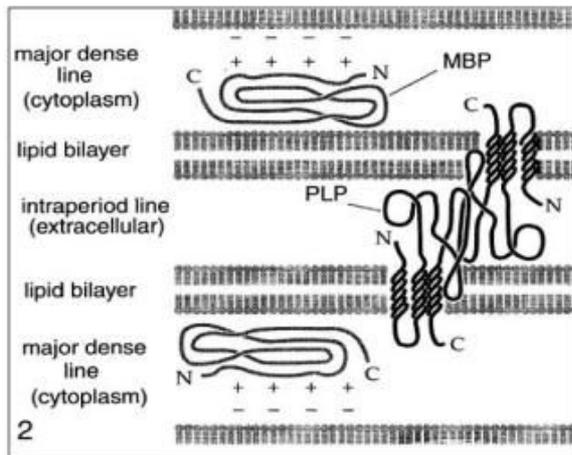
Evans, 1996

A myelin szerkezete



A myelin szerkezete

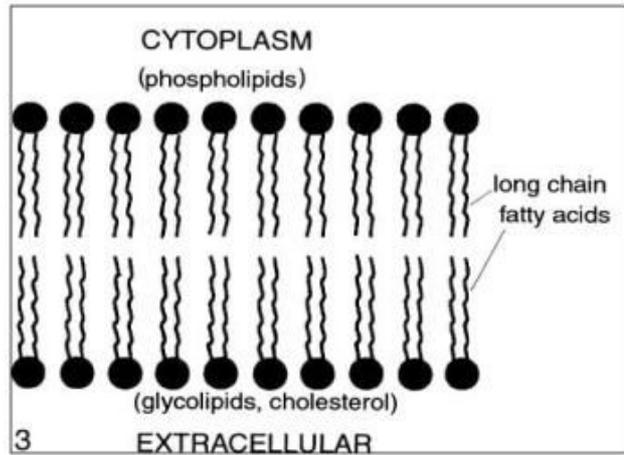
Myelin egység



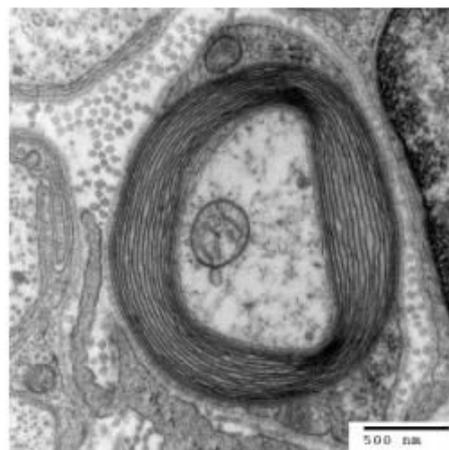
Major period line, myelin basic protein (MBP)

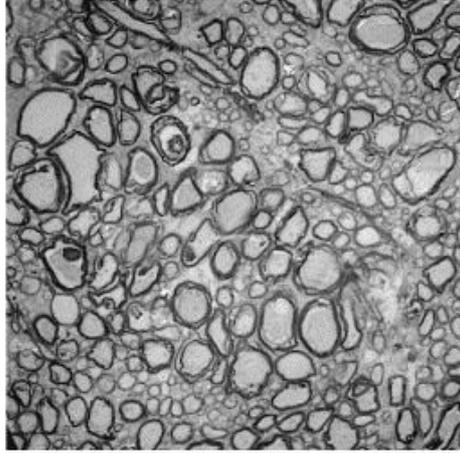
Intraperiod line, proteolipid protein (PLP)

Lipid kettősmembrán

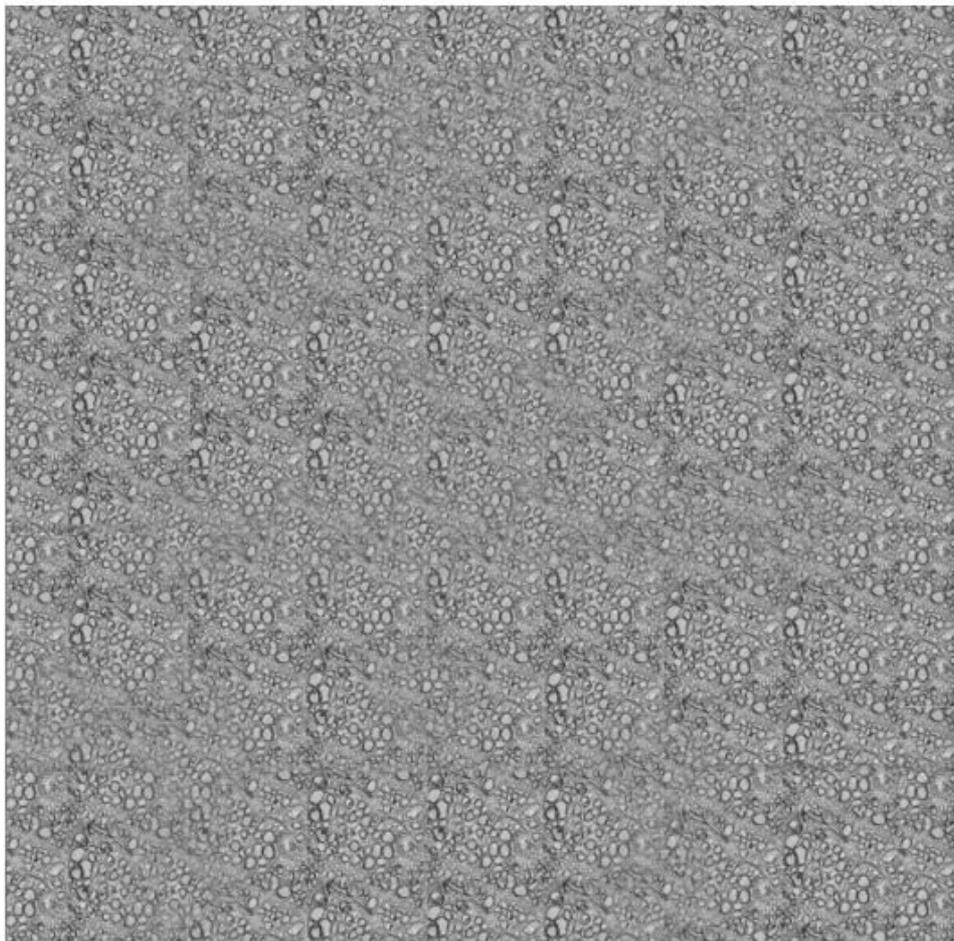


Barkovich 2000



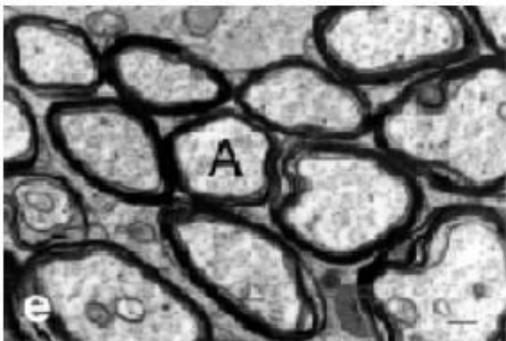
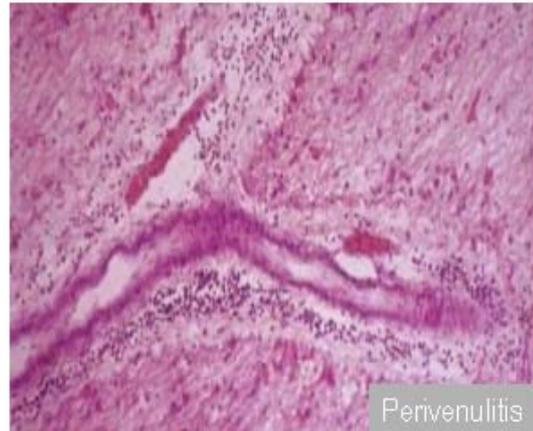
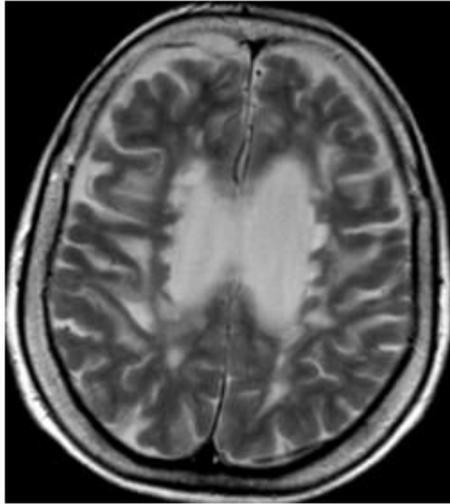


8 μm



800 μm

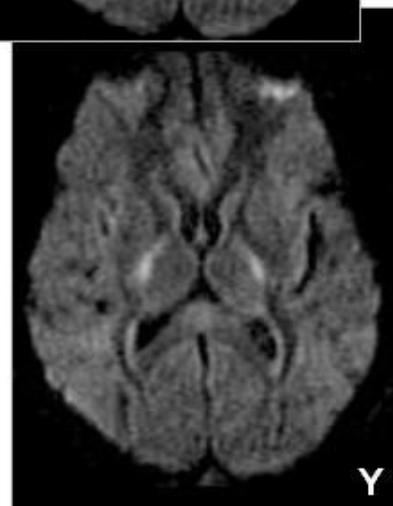
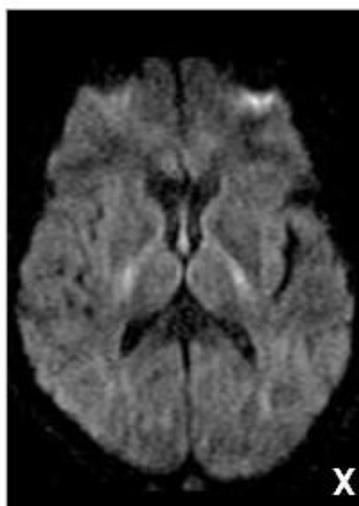
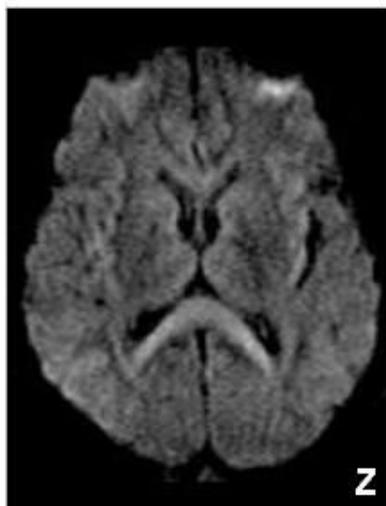
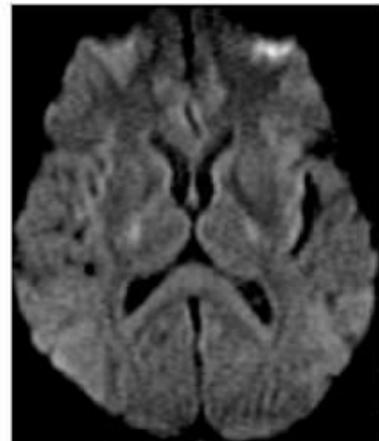
Demyelinizáció



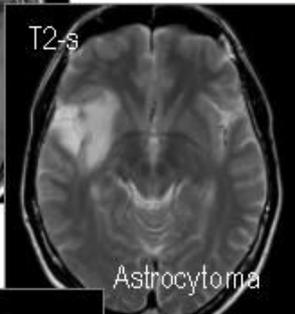
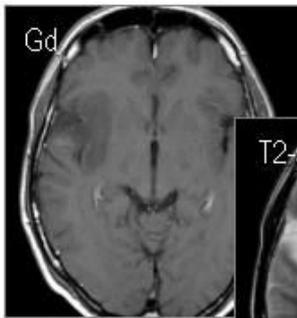
Krsulovic, 1999

Diffúzió-súlyozott MR (DWI)

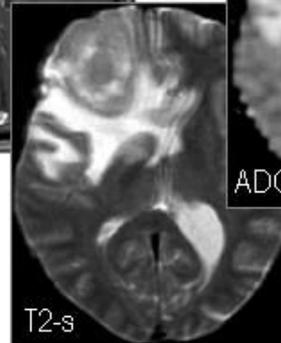
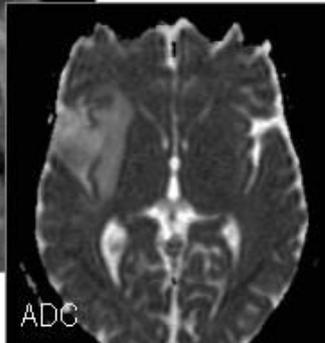
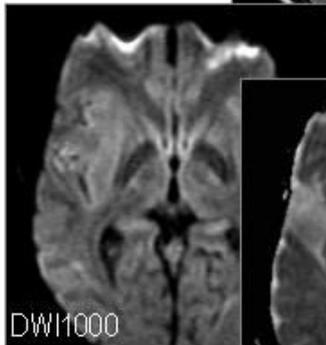
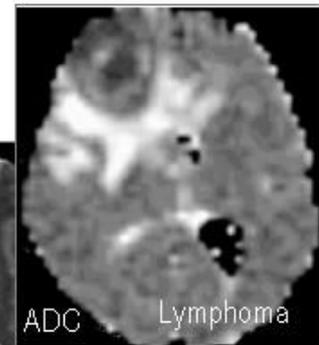
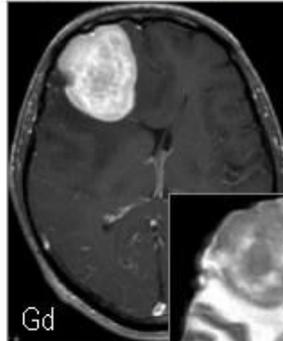
$$\text{Trace (Nyom)} = \sqrt[3]{X*Y*Z}$$



DWI - ADC



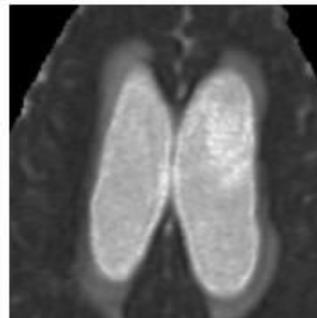
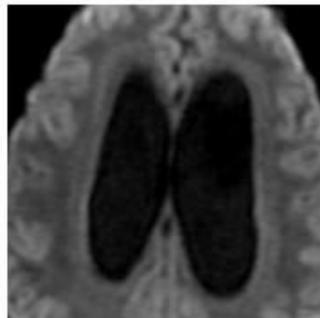
- Az ADC a szürke- és fehérállomány-ban közel egyforma.
- Az astrocytoma területén a DWI gátolt diffúziót mutat, pedig az ADC nagy („T2 shine-through” T2 áttűnés, maradék T2).
- A B-lymphoma nagy cellularitása miatt az ADC kicsi.



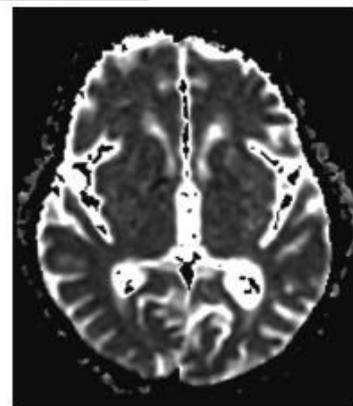
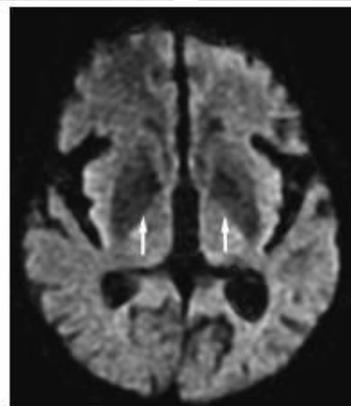
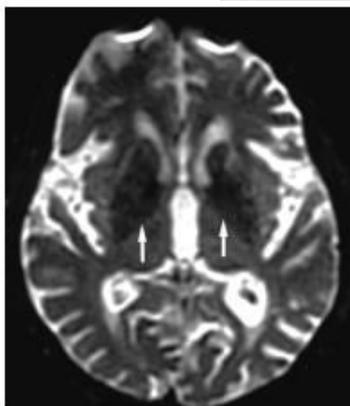
Provenzale, 2006

T2 Washout, T2 Blackout

Obstructiv hydrpcephalus

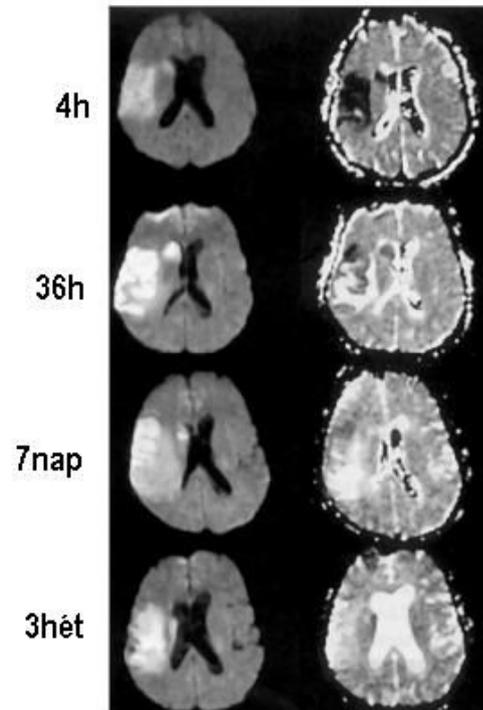
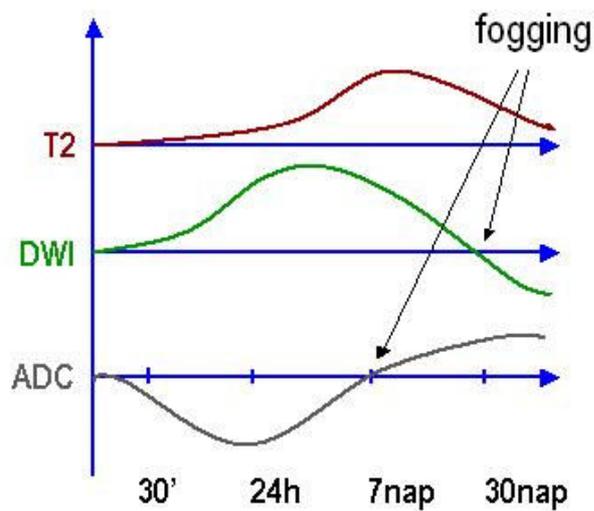


Metal depositio

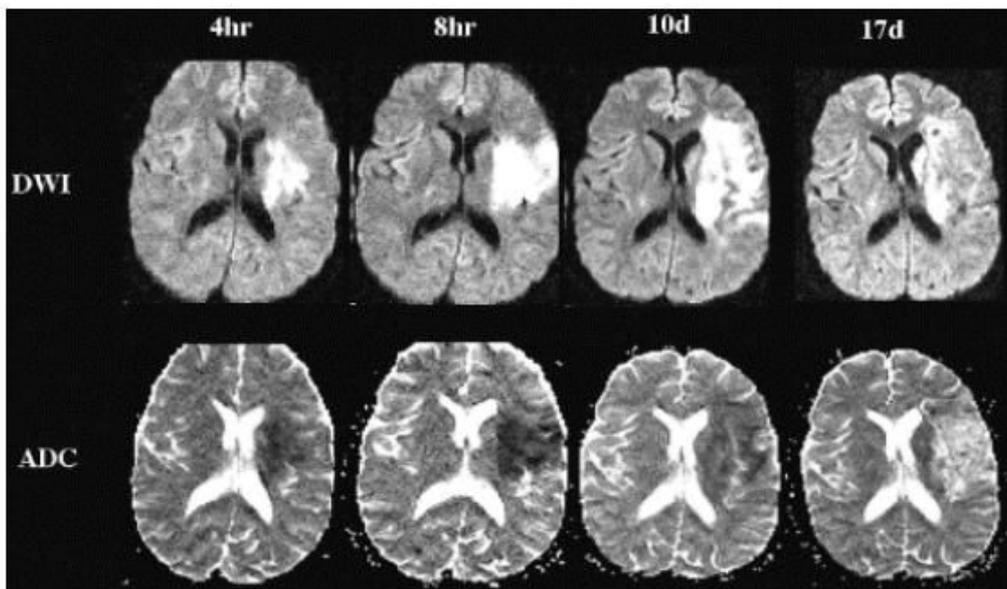


Hiwatashi, 2003

Az ischemias stroke időbeli megjelenése az MR felvételeken



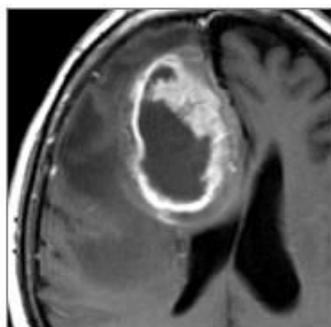
Az ischemias stroke időbeli megjelenése az MR felvételeken



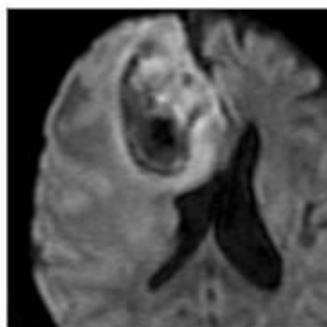
Diffúzió-súlyozott MR alkalmazása

Glioblastoma

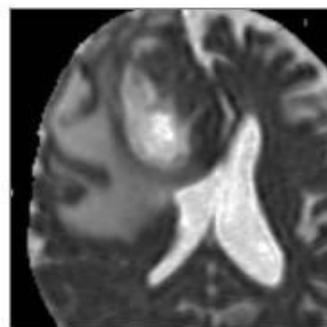
↕
Abszesszus



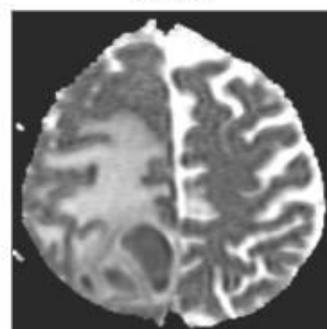
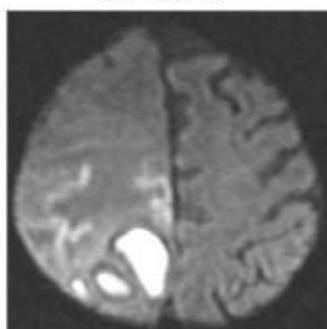
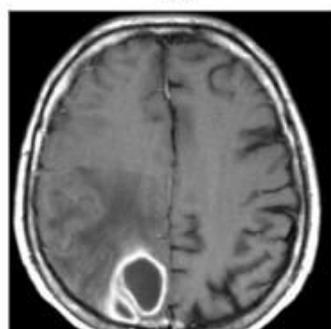
Gd



b=1000



ADC

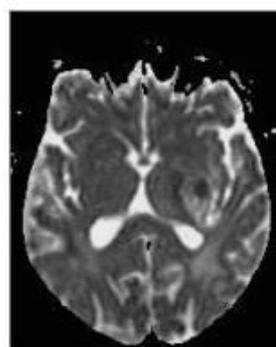
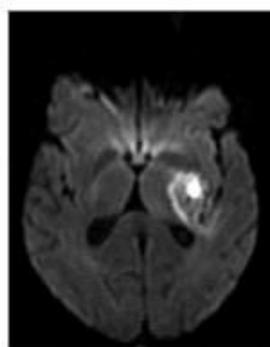
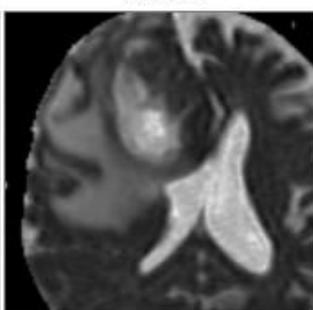
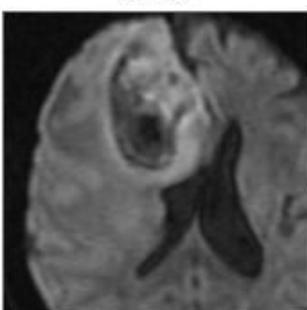
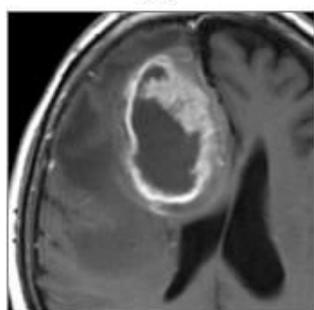


Centrális necrosis

Gd

1000

ADC



Intracerebralis hematóma



Acut



25 nap



65 nap



110 nap

Intracerebrális vérzés

Jelmenetet befolyásoló tényezők

A hemoglobin és lebomlási termékeinek megjelenése:

oxihemoglobin	/ diamágneses
deoxihemoglobin	/ paramágneses
methemoglobin	/ paramágneses
hemosiderin	/ paramágneses
hemochromatinok	/ paramágneses

A vörösvértestek állapota:

- intakt
- lysált

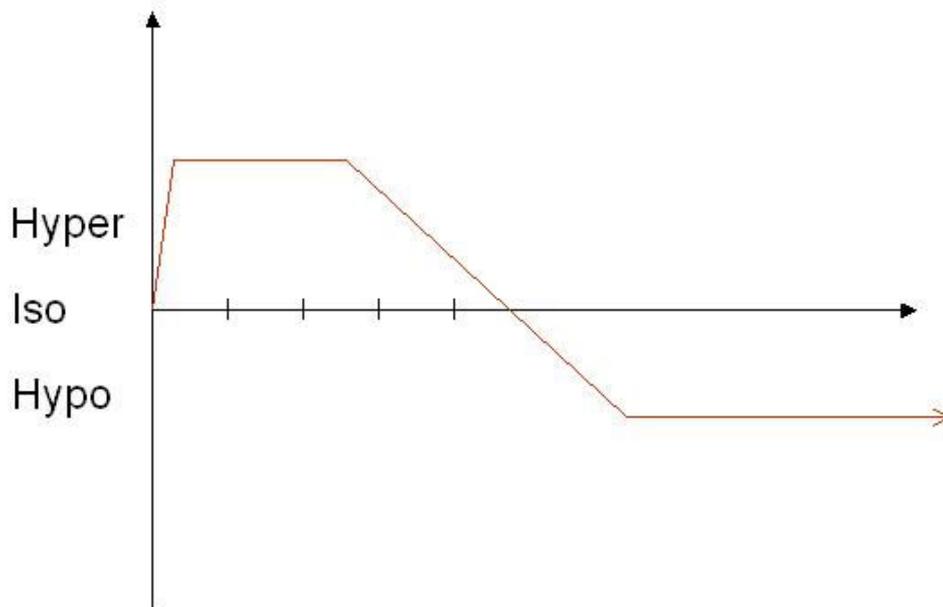
Macrophagok

T1 és T2 relaxációs idő rövidülés

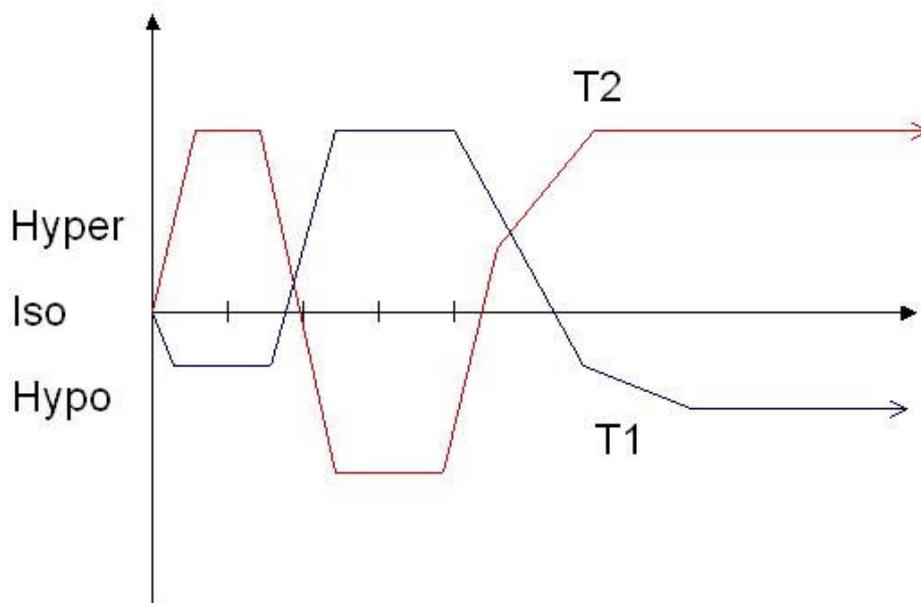
Világosodik

Sötétedik

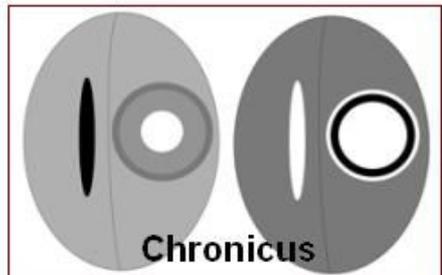
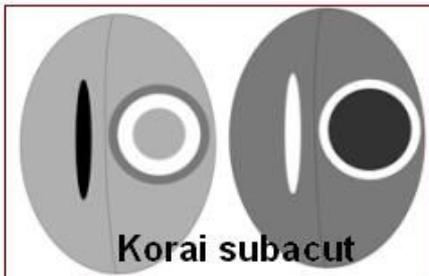
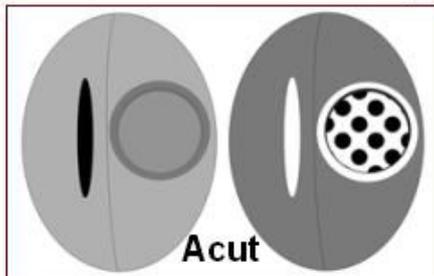
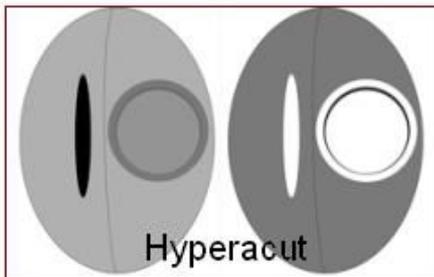
A hematoma CT megjelenésének időbeli változása



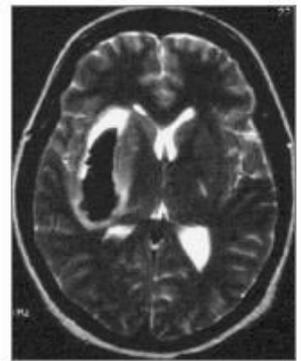
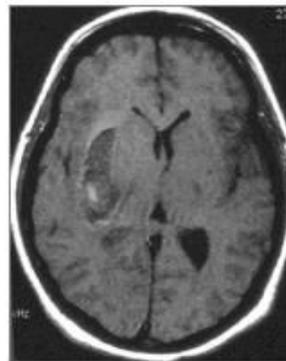
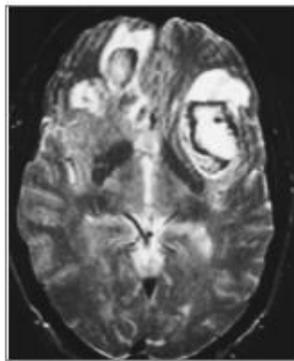
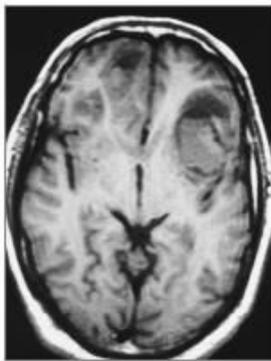
A hematoma MR megjelenésének időbeli változása



A hematoma jelmenet változása

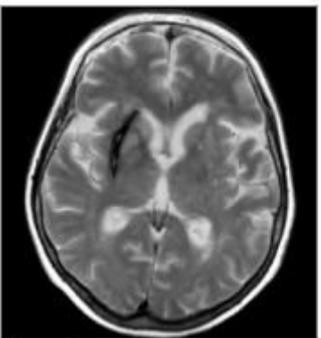
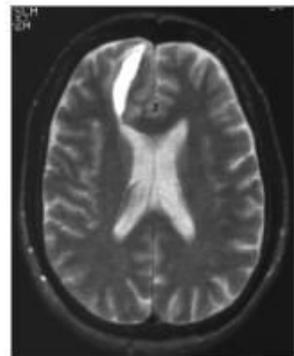
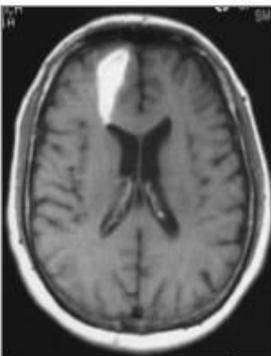


A hematoma jelmenet változása



Hyperacut

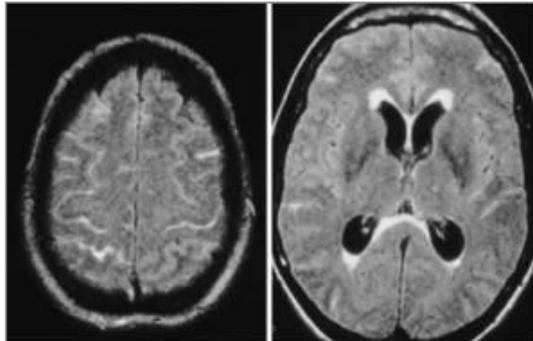
Acut



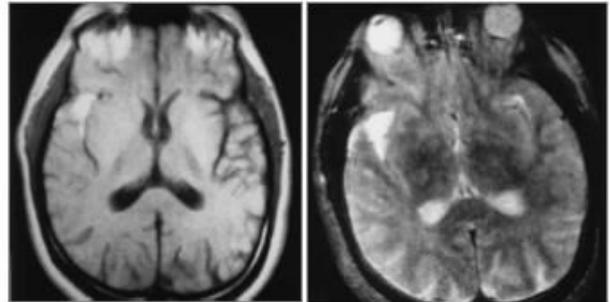
Késői subacut

Késői chronicus

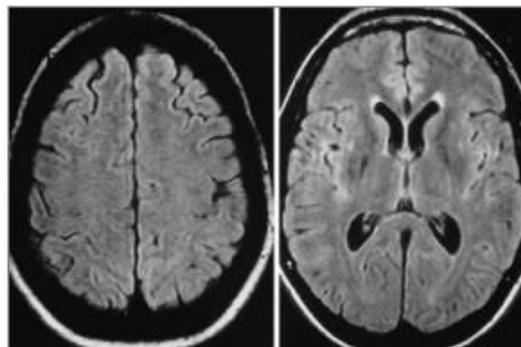
Subarachnoidalis vérzés



Acut



Subacut



FLAIR!

Chronicus

Pialis siderosis



Normál spin-echó

