

# Open MRI ...

# ... more than just a question of comfort



**FUJIFILM**  
Value from Innovation



J. Biederer  
May 2023

# Conflicts of Interests Disclosure

The following conflicts of interest may be discussed in respect to this presentation:

<b>Affiliation/ Financial interest</b>	<b>Commercial Company</b>
Grants/research support:	Siemens, Bayer
Honoraria or consultation fees:	Roche, Boehringer Ingelheim, Fuji
Participation in a company sponsored bureau:	none
Stock shareholder:	none
Spouse/ partner:	none
Other support/ potential conflict of interest:	none

# MRI from a Patient's Perspective...

High tech medicine, but ...

# MRI from a Patient's Perspective...

High tech medicine, but ...

... not at all a pleasant experience!

- a long, loud procedure in a narrow tunnel
- fixated by devices such as head coils etc.
- feeling alone and exposed
- a needle will be placed for contrast injection
- far from really understanding what is happening



- “Comfort” - what patients (like all of us) would want
- Beyond “comfort” – Needs defined by clinical care
- Performance - Specs you would expect from a high end scanner
- Markets and demands – Facts to convince your “paymasters”



**Patient Perspective**

**Clinical Needs**

**Expectations on Performance**

**Economic Perspective**

# What PATIENTS would want ...

- a pleasant setting

# Patient Comfort – A truly open System





# What PATIENTS would want ...

- a pleasant setting
- spacy, open system, “no tunnel”



# Patient Comfort – A truly open System



# What PATIENTS would want ...

- a pleasant setting
- spacy, open system, “no tunnel”
- comfortable positioning

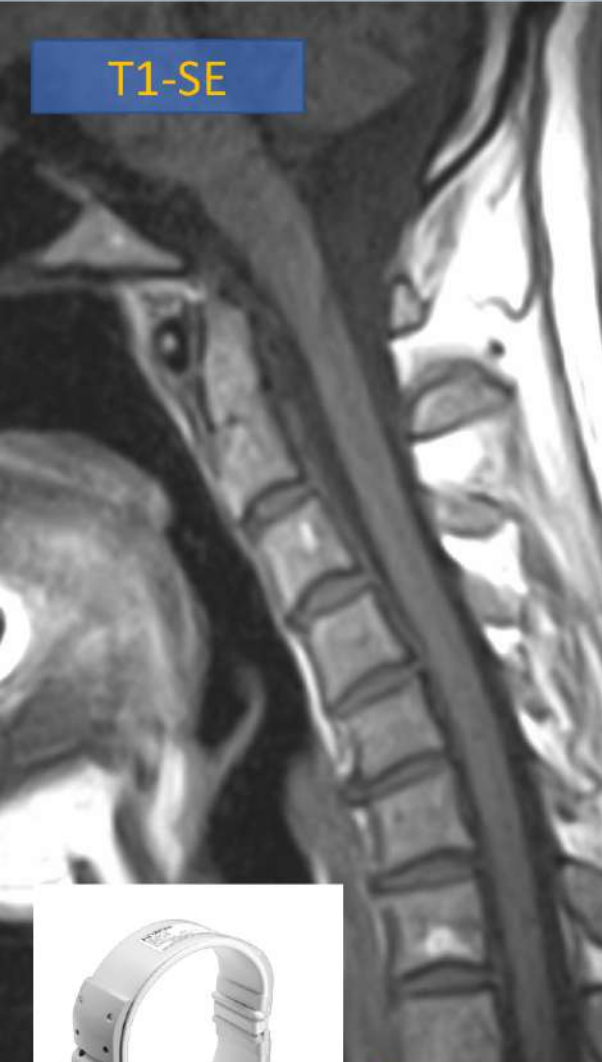


# Patient Comfort – A truly open System



# Cervical Spine – Solenoid Coil/lateral Position

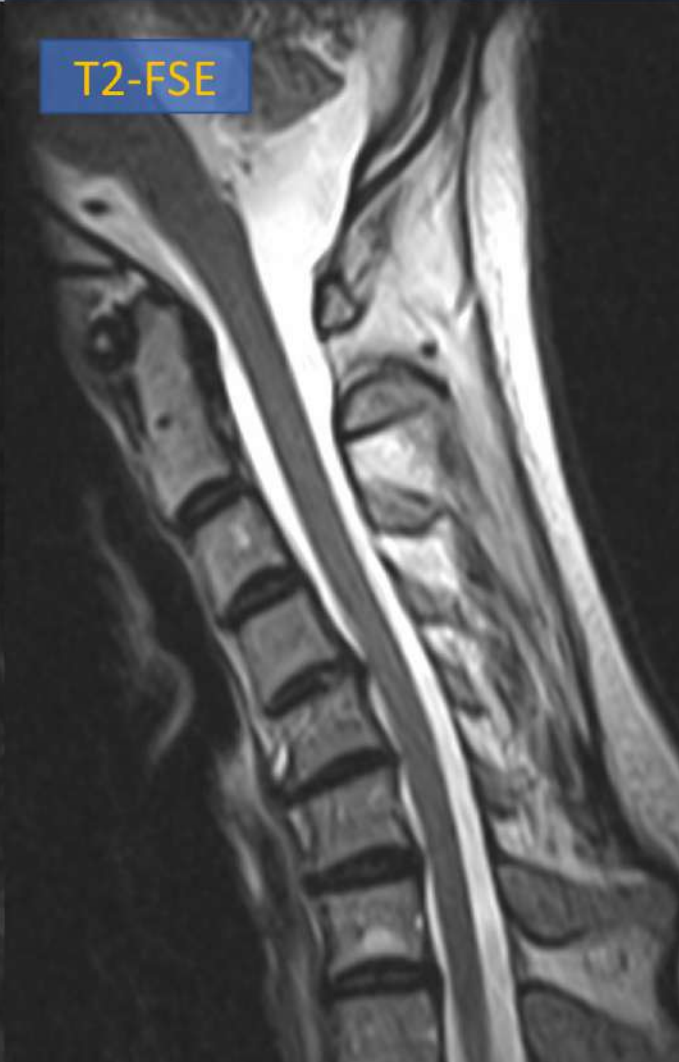
T1-SE



STIR



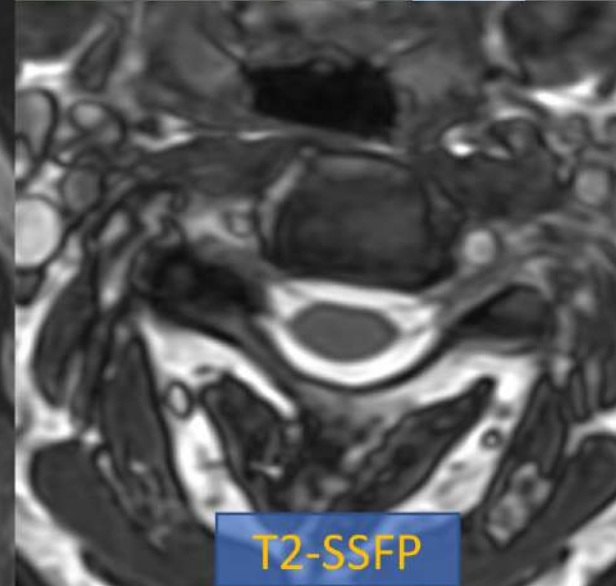
T2-FSE



multi-purpose solenoid coil

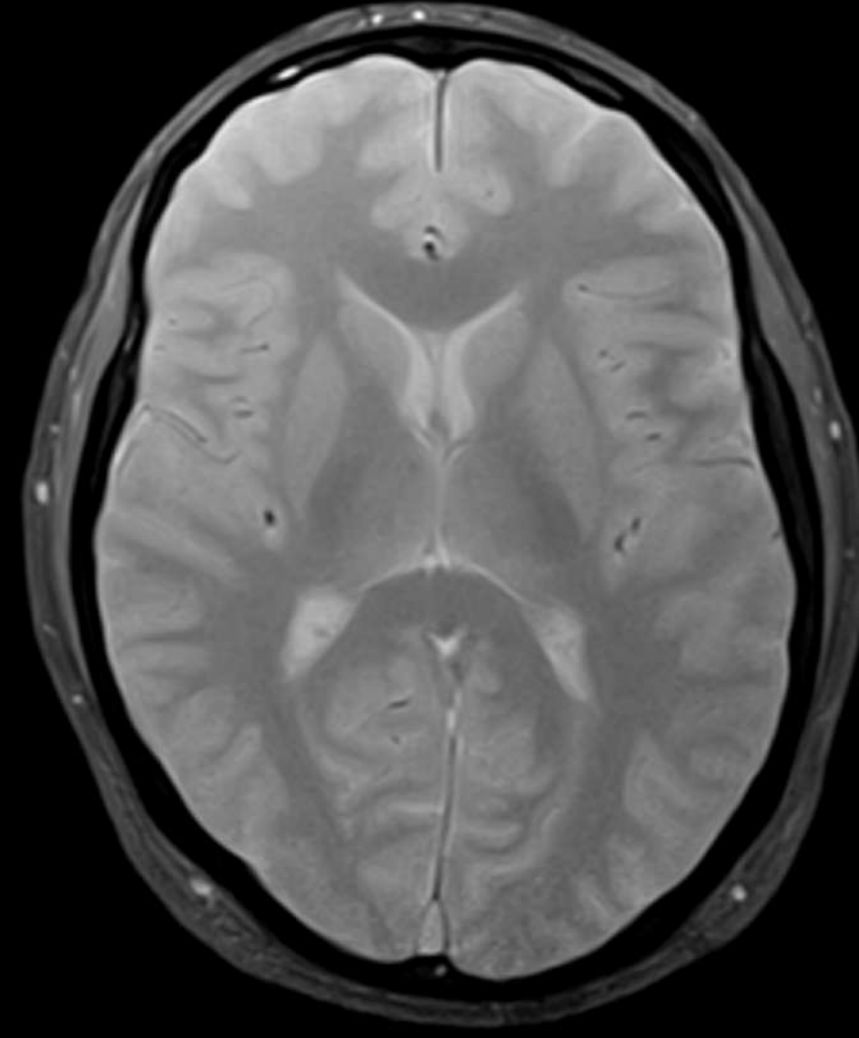
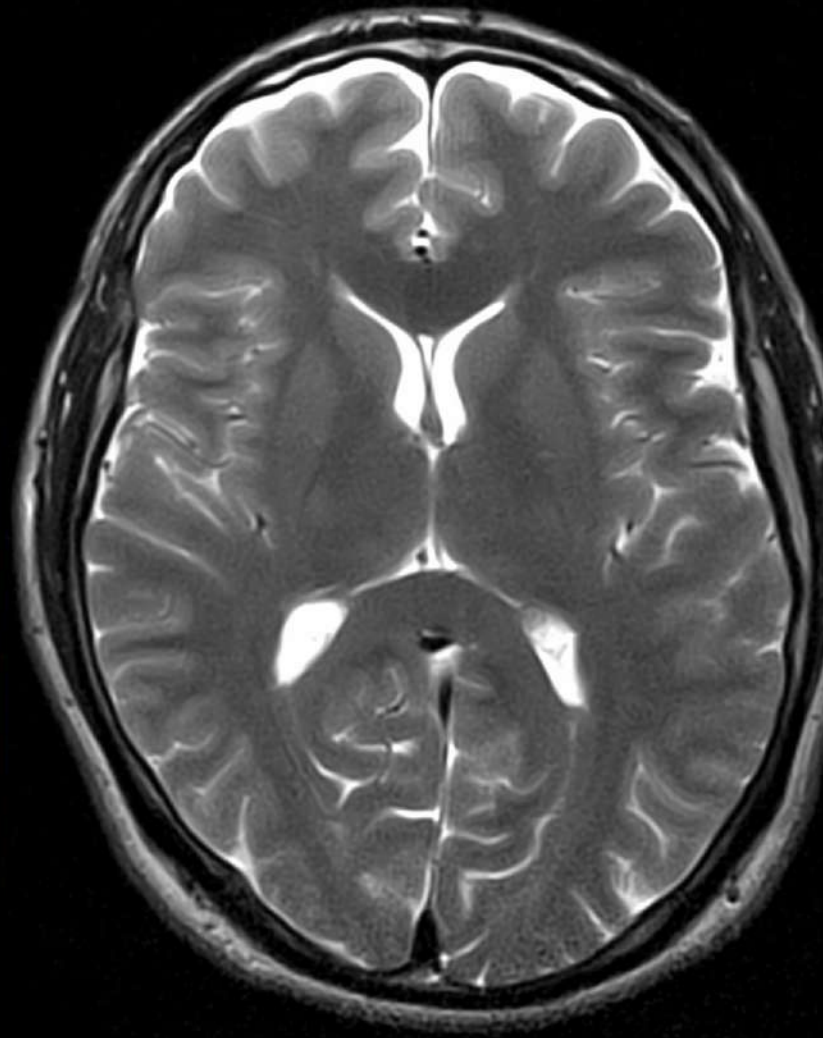


T2-SSFP

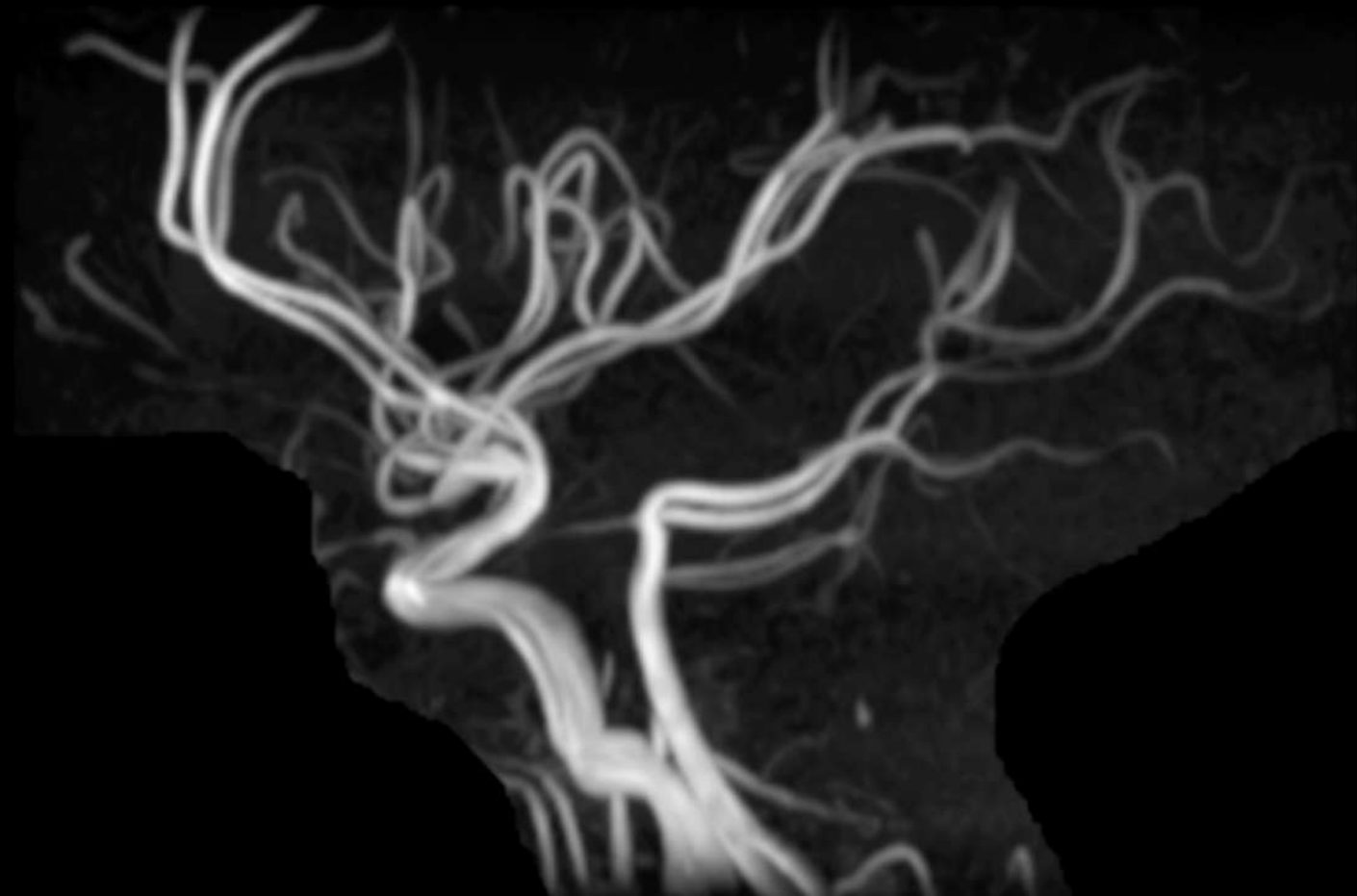
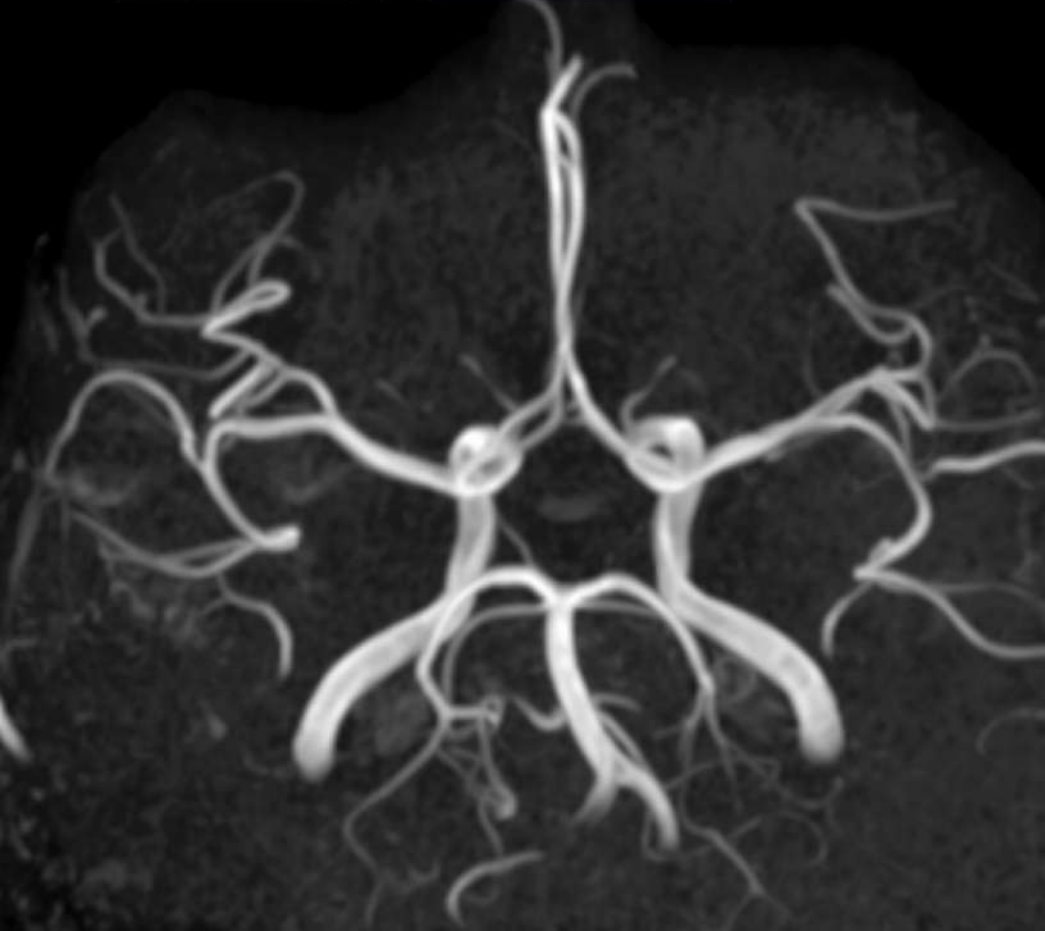


# Brain MRI – lateral Position

solenoid coil



# Brain TOF MRA – Solenoid Coil/lateral Position



# What PATIENTS would want ...

- a pleasant setting
- spacy, open system, “no tunnel”
- comfortable positioning
- less noise



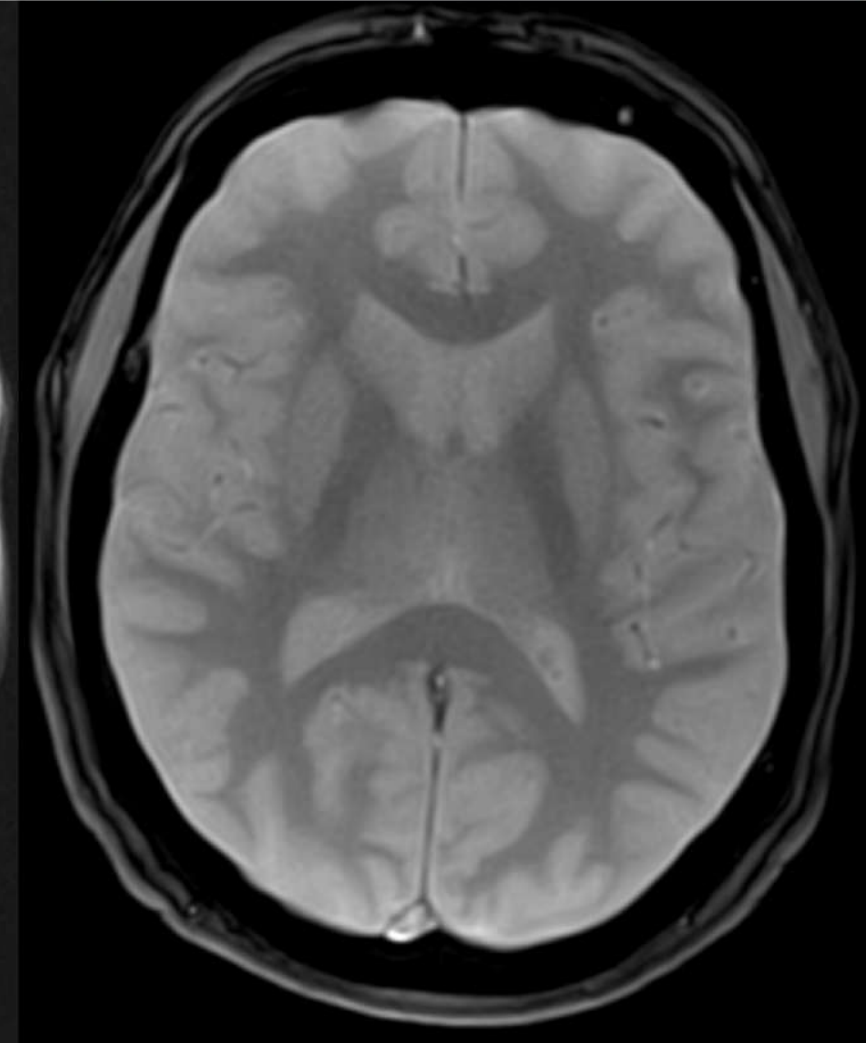
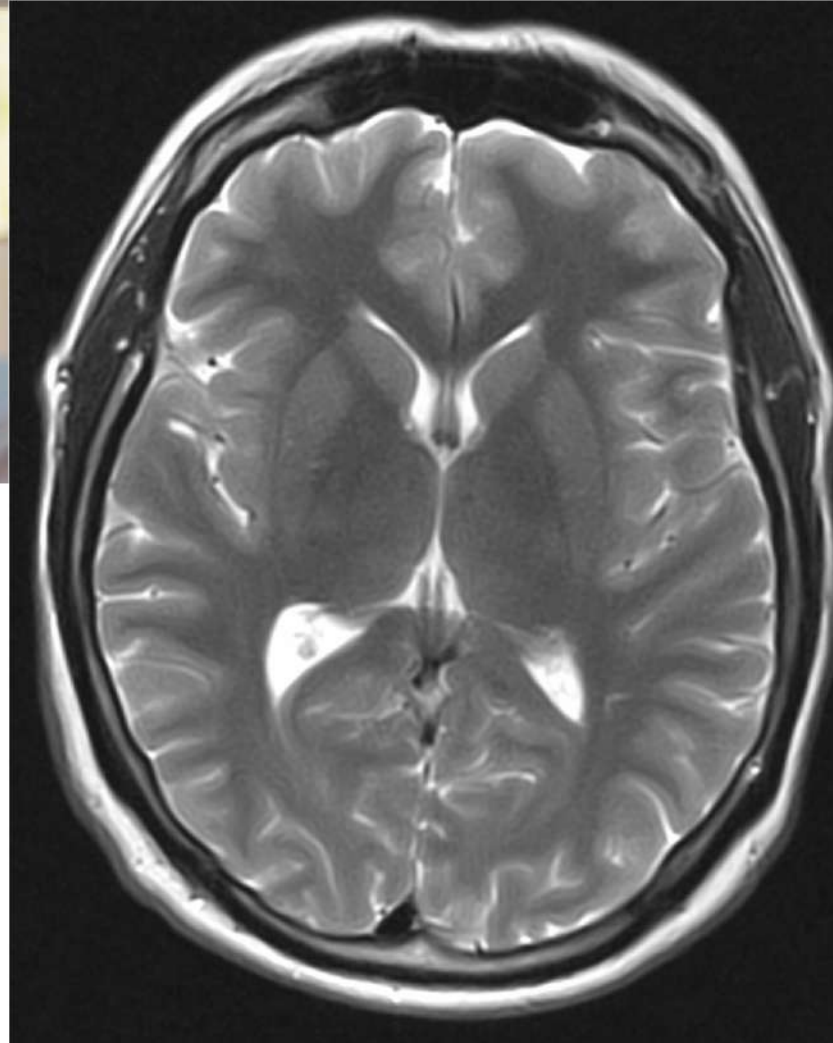


# Brain MRI – Noise Reduction

head coil



noise reduced scan



# What PATIENTS would want ...

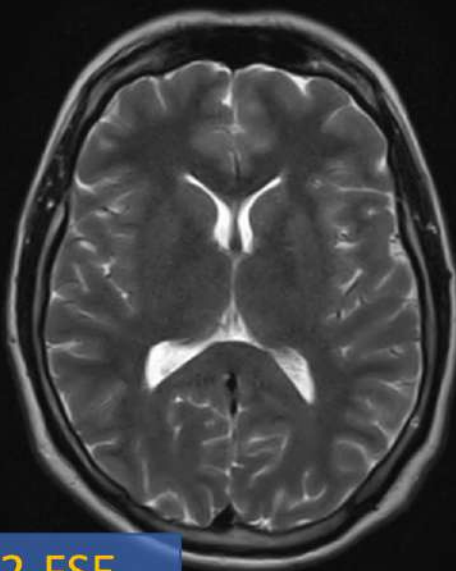
- a pleasant setting
- spacy, open system, “no tunnel”
- comfortable positioning
- less noise
- short procedure



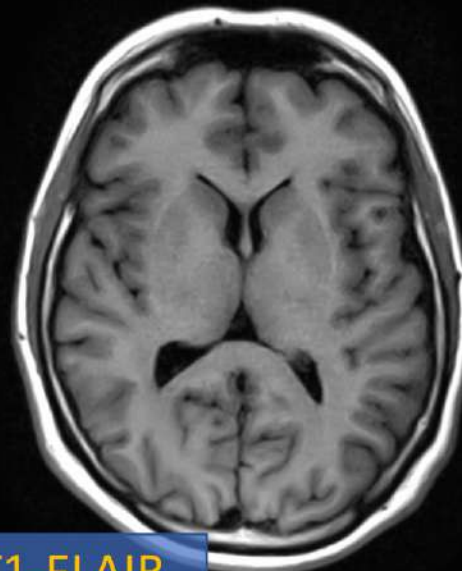
# Brain MRI –Fast Scanning

head coil

fast scanning  
(IP RAPID)



T2-FSE

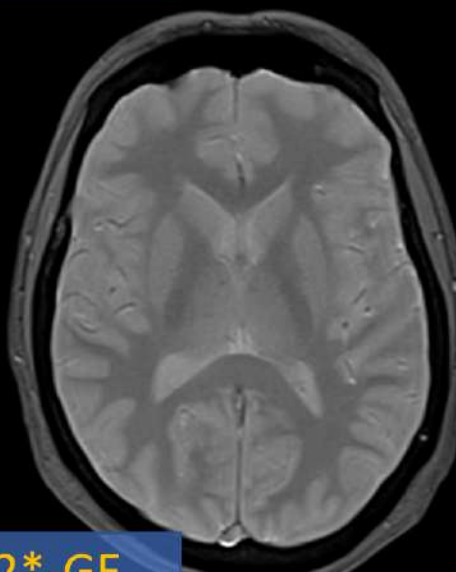


T1-FLAIR

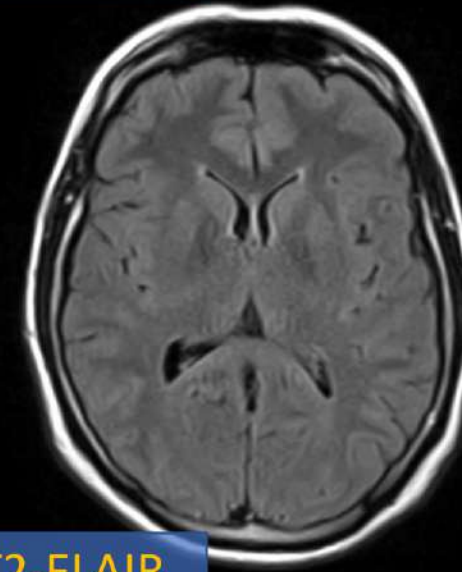
“have it all”  
in 9:38 min.



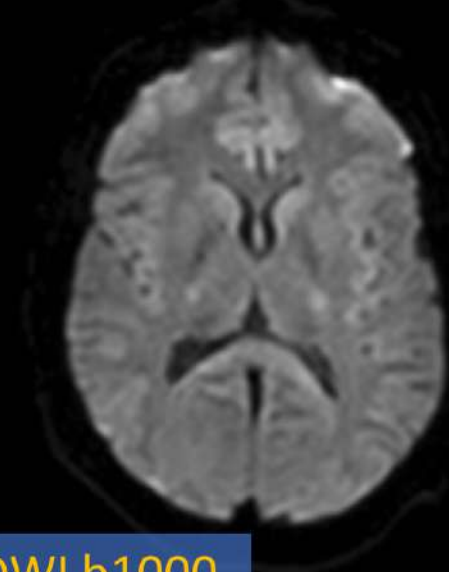
3D-TOF



T2\*-GE



T2-FLAIR



DWI b1000

# What PATIENTS would want ...

- a pleasant setting
- spacy, open system, “no tunnel”
- comfortable positioning
- less noise
- short procedure
- no injection



# Non-CE MRA with Arterial Spin Labeling (ASL)



# Beyond “Comfort” – clinical Needs...

- a solution for claustrophobic\* patients

open design

no “tunnel experience”

a person at the patient’s side



\*including dementia!

# Beyond “Comfort” – clinical Needs...

- accommodation of “large patients”

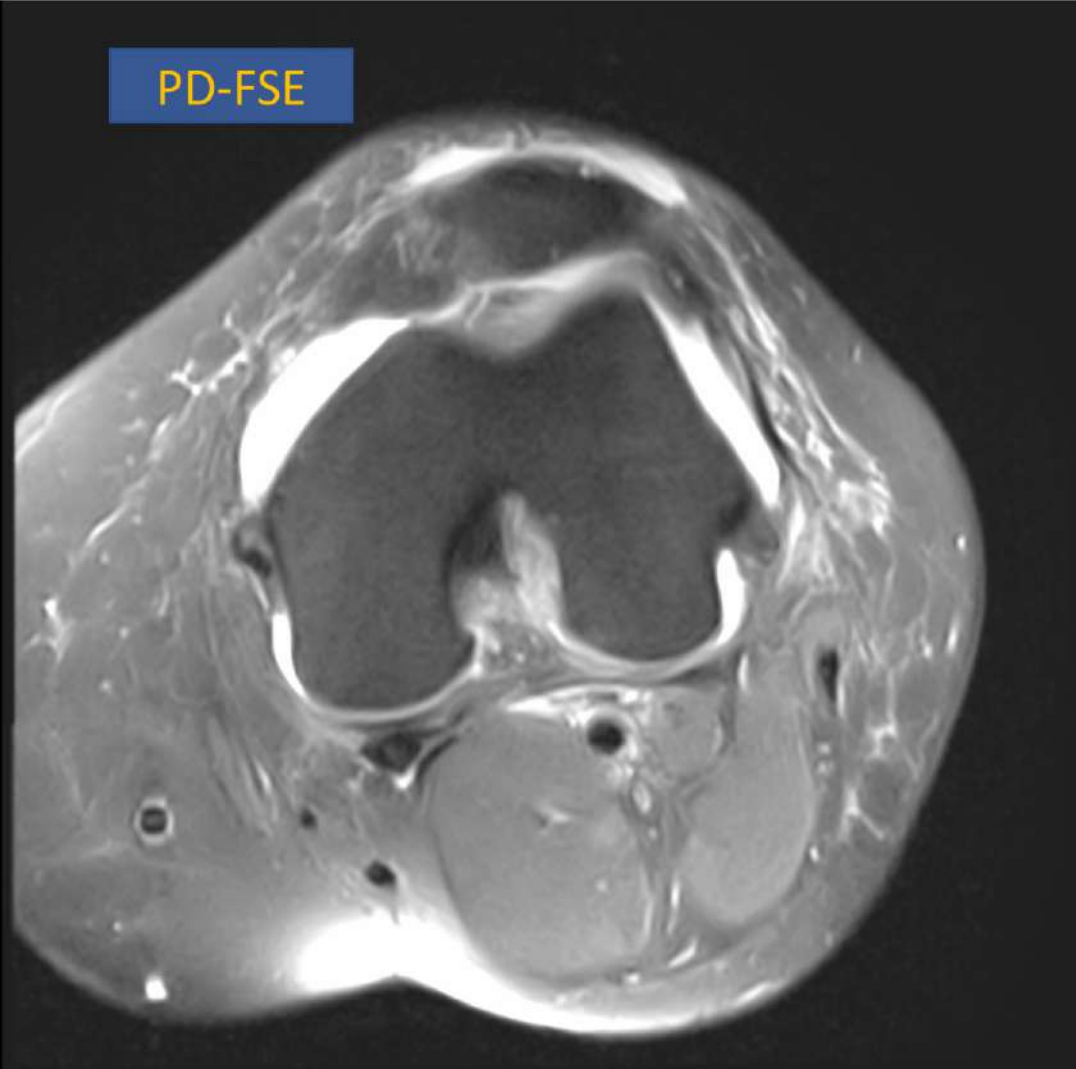
Your open scanner will attract patients who are not easy to handle ...



# Beyond "Comfort" – clinical Needs...

Left ACL tear in an XXL patient

PD-FSE



PD-FSE



blanket coil

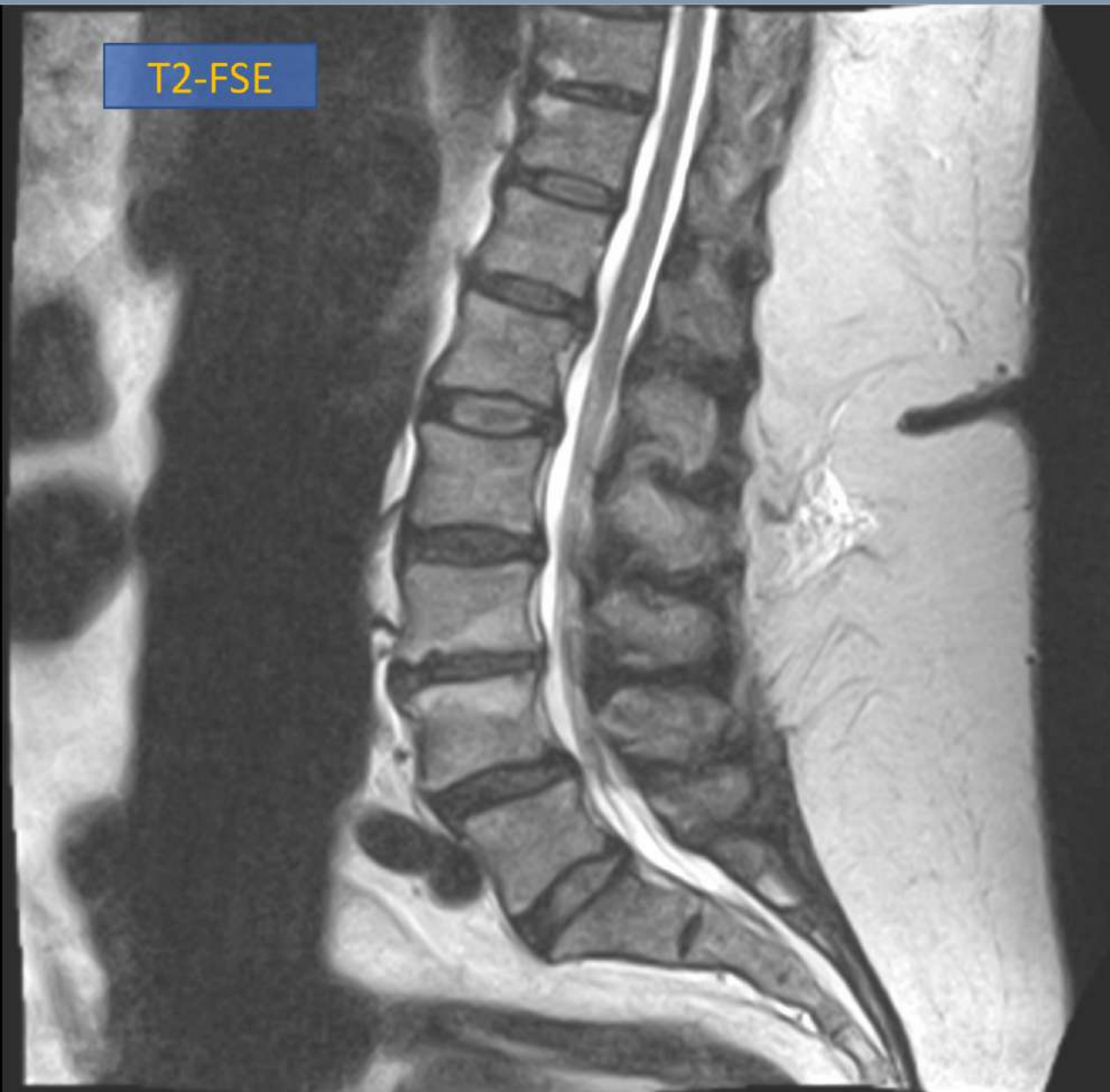


knee coil



# Beyond “Comfort” – clinical Needs...

T2-FSE



T2-FSE

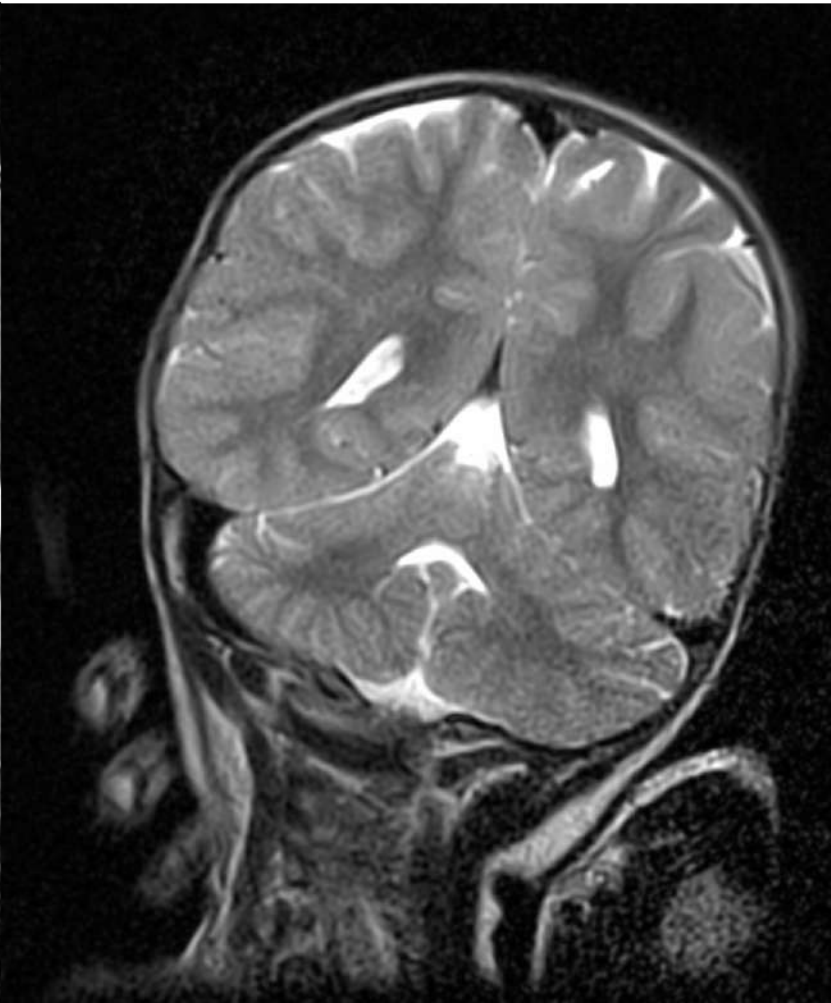
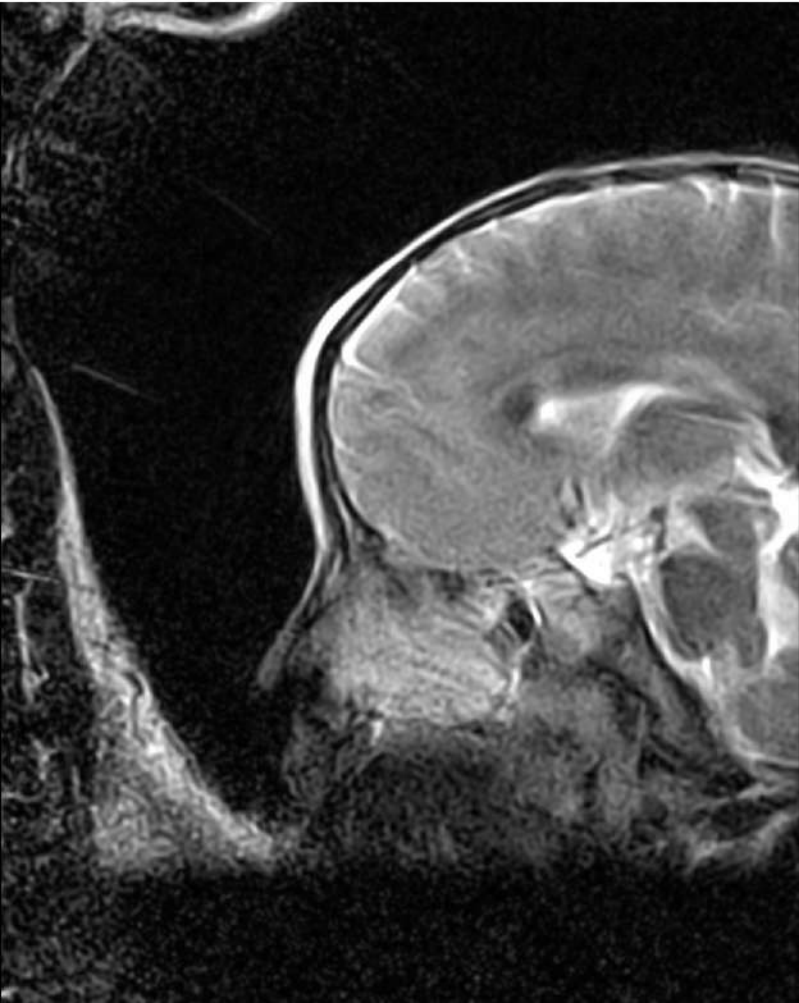


lumbar stenosis in an XXL patient

# Beyond “Comfort” – clinical Needs...

- options for pediatric patients

... some situations need creativity 😊

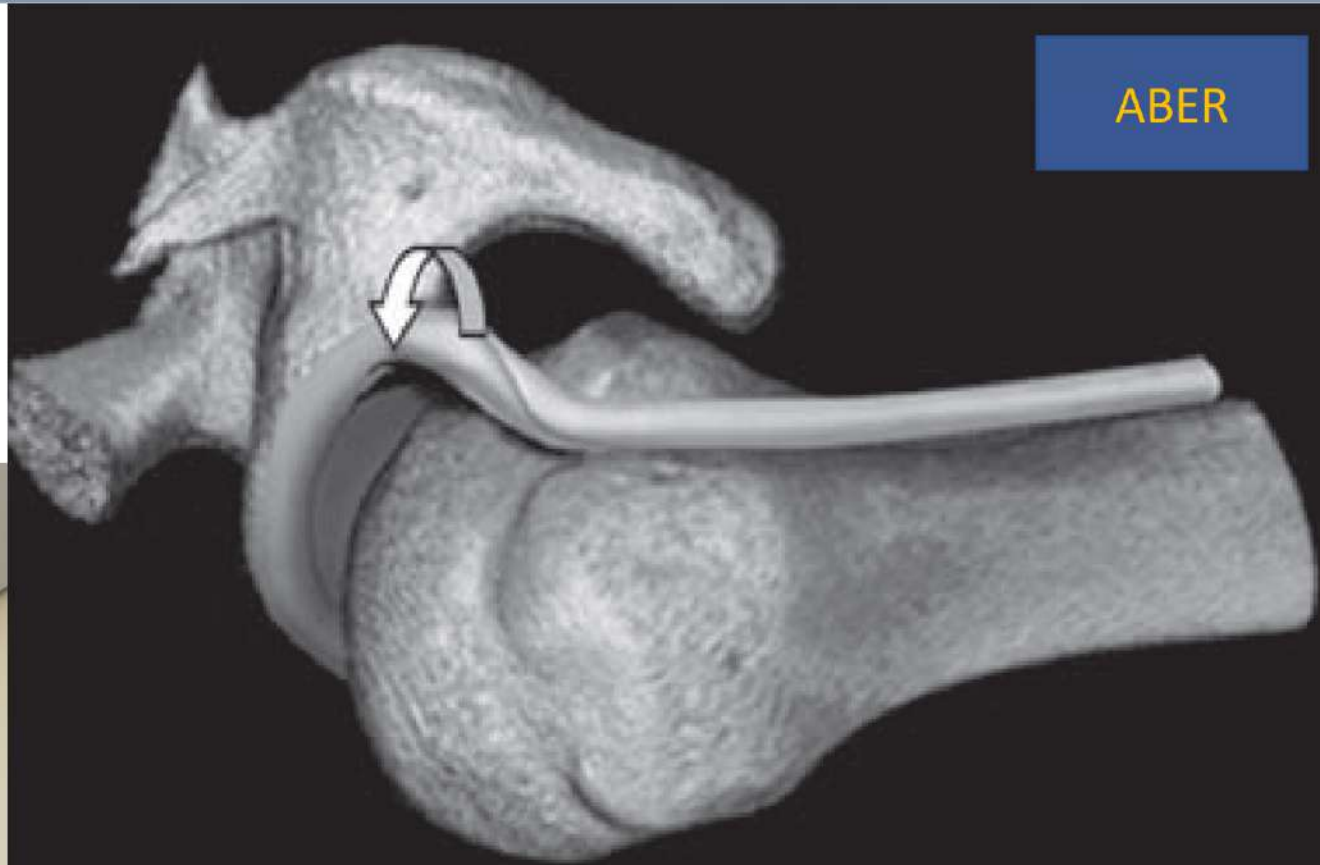


# Beyond “Comfort” – clinical Needs...

- positioning options

MSK – shoulder in **AB**duction

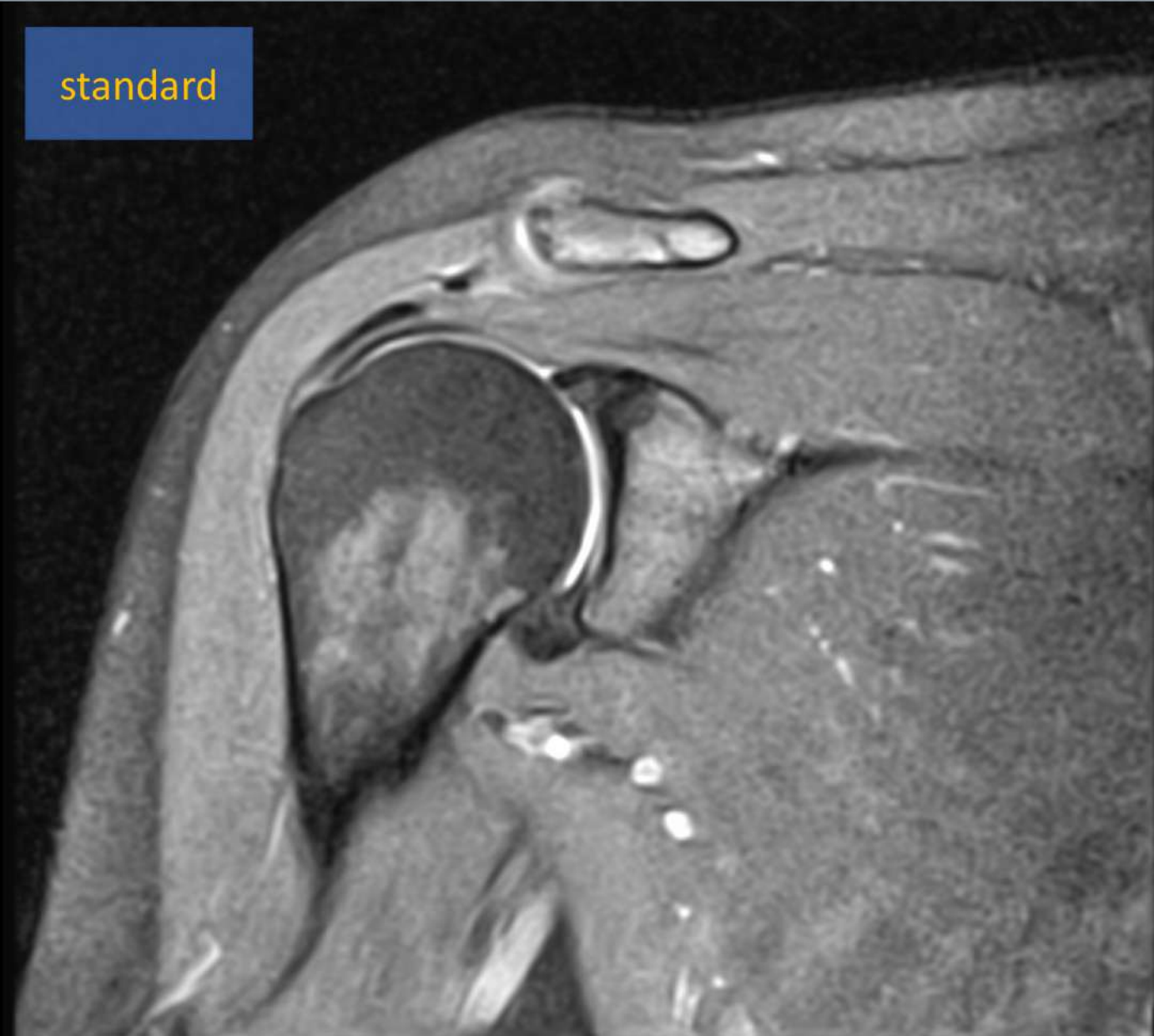
**E**xternal **R**otation position (ABER)



torsion of bicipital anchor in ABER  
“peel-back” of superior labral a.p.- tear

# MSK – Shoulder/ABER Position

standard



ABER



# MSK – Shoulder/ABER Position

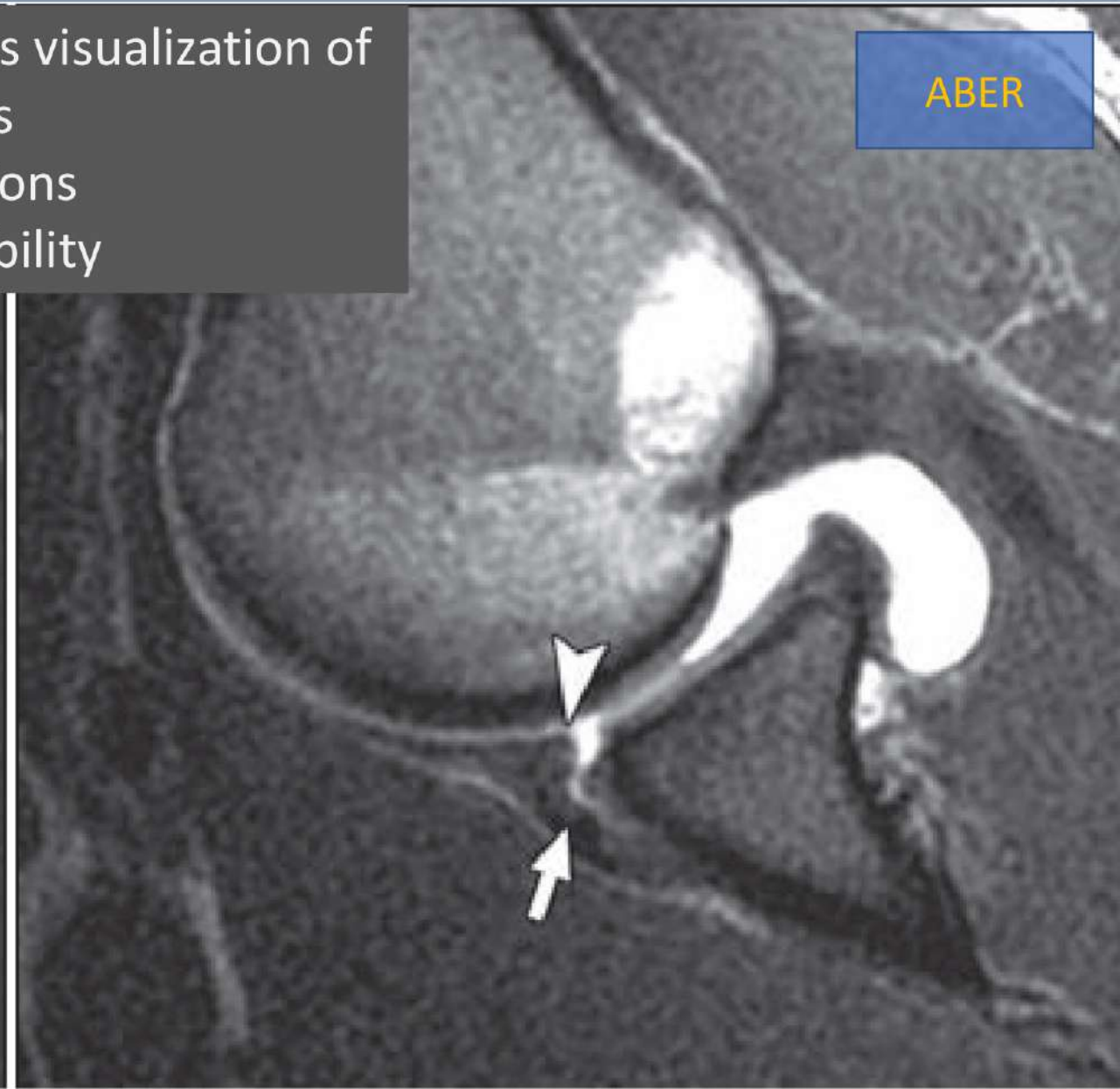
standard



ABER improves visualization of

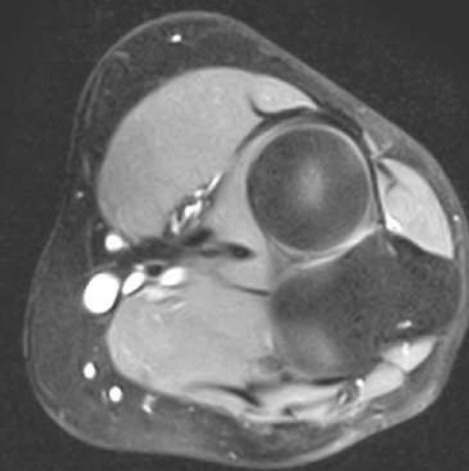
- SLAP-lesions
- Perthes-lesions
- Micro-Instability

ABER

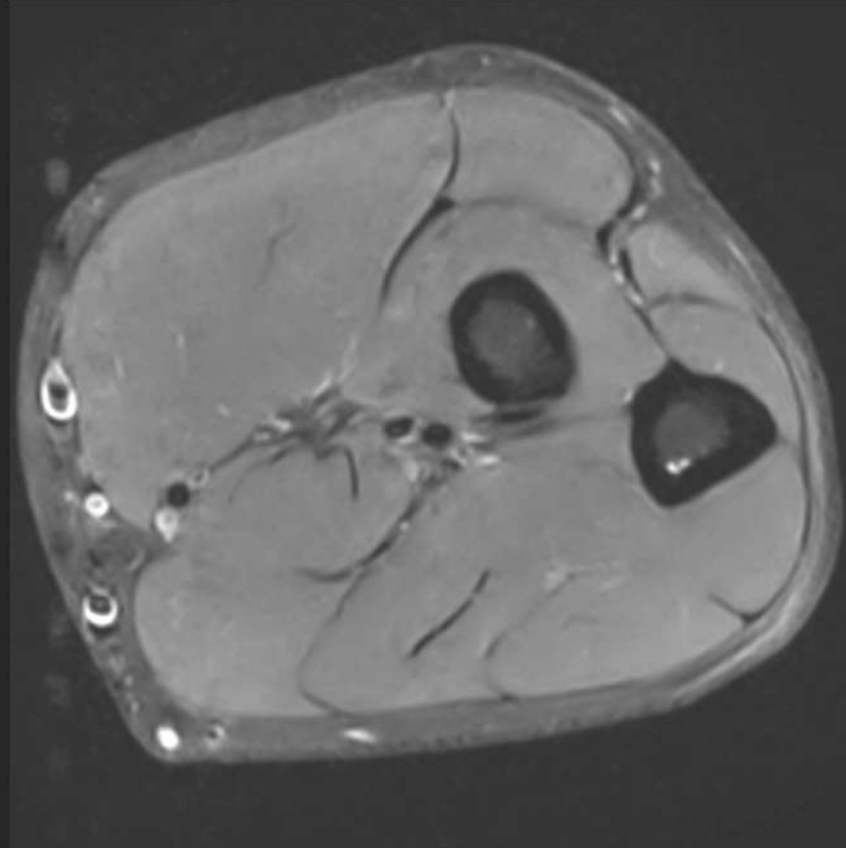
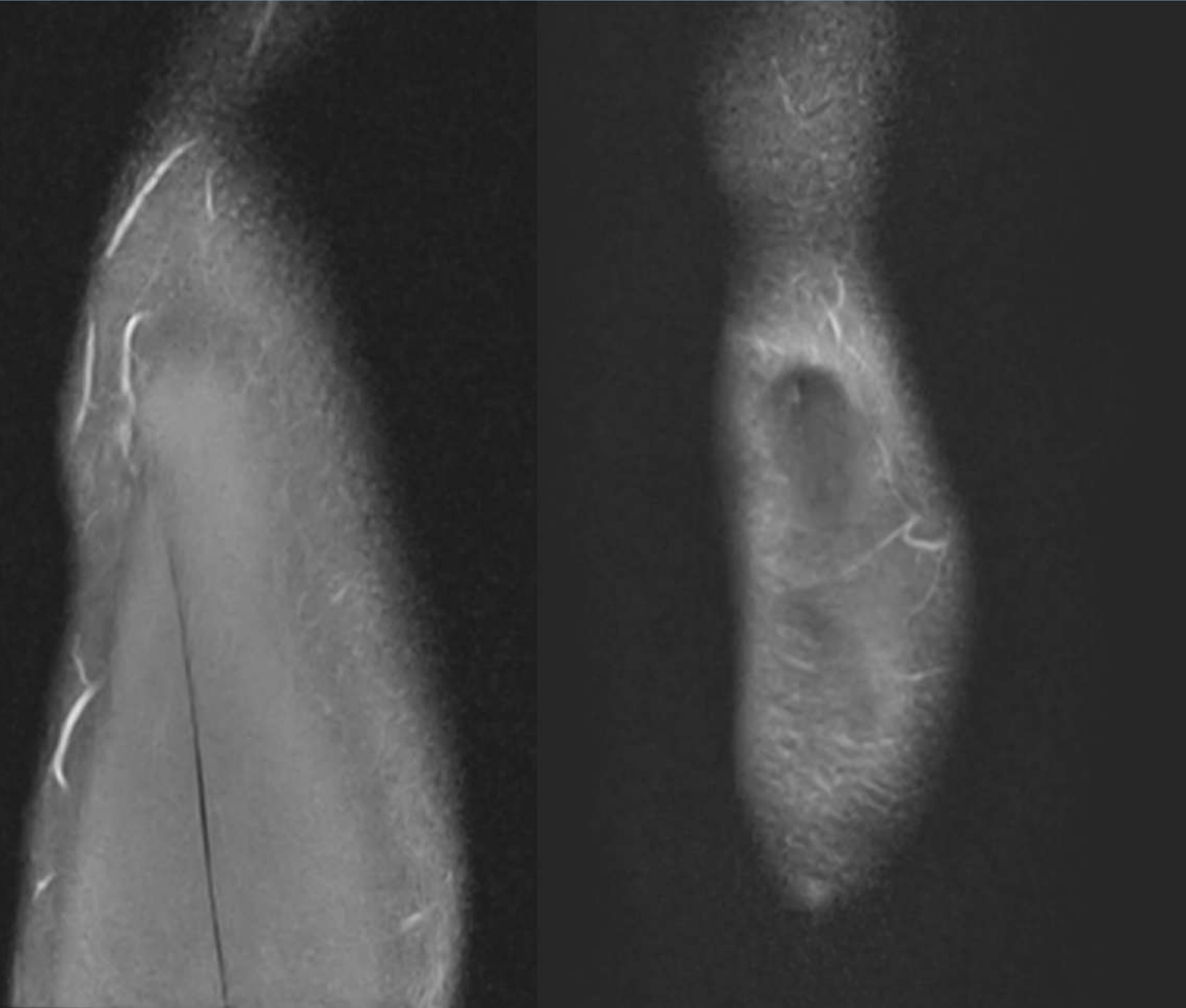


# MSK – Wrist, Elbow etc. in Isocenter

lateral table shift to isocenter



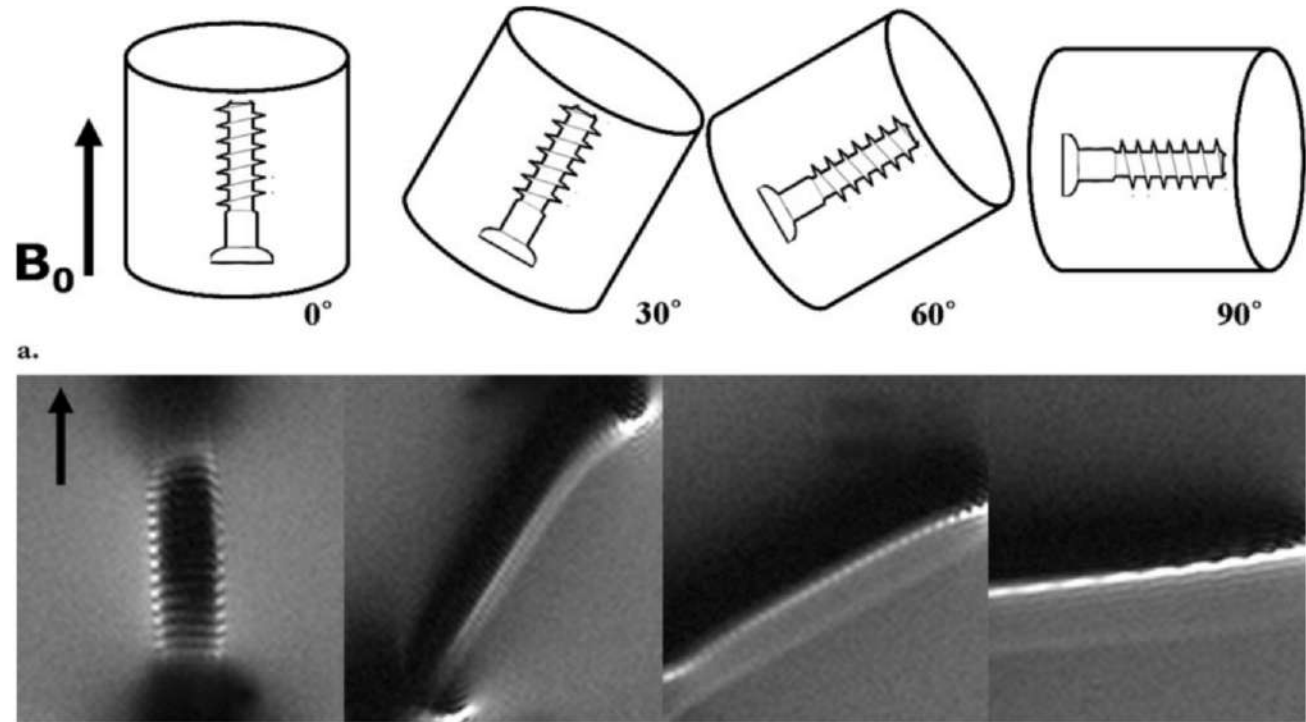
- Epicondylitis humeri rad.



PD FSE fs., isocenter

# Beyond Comfort– Effects on Metal Artifacts

- Size and shape change with angle to direction of  $B_0$
- minimal size, if parallel
- increase with angle



> many materials favourably oriented in the vertical field

> open Scanner facilitates optimum patient positioning

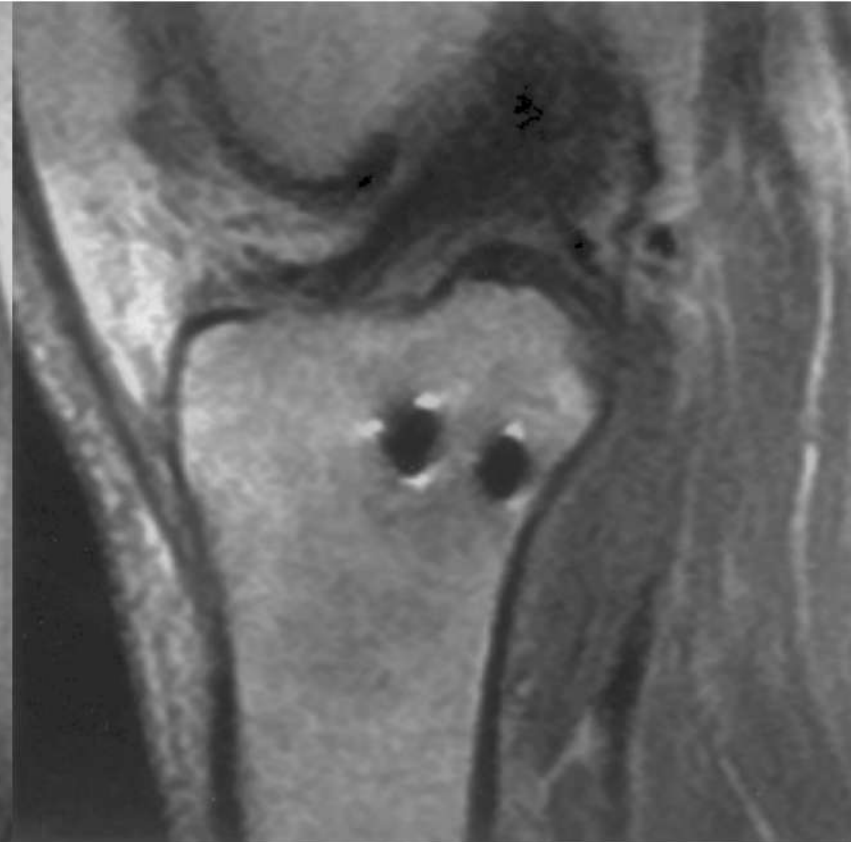
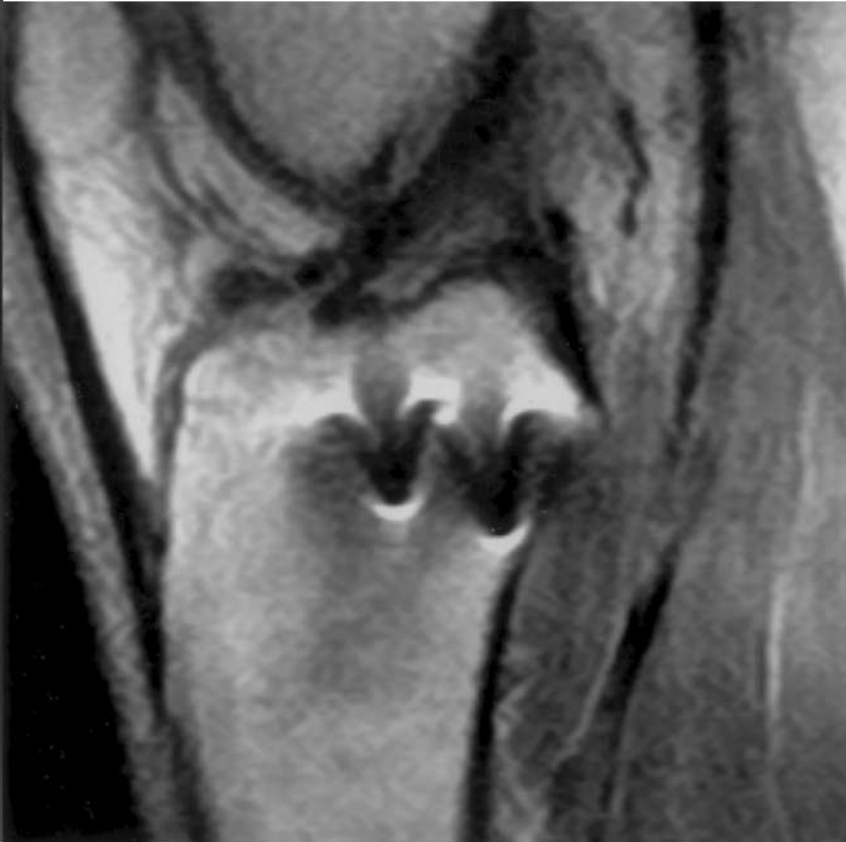


# Vertical Field – Effects on Metal Artifacts



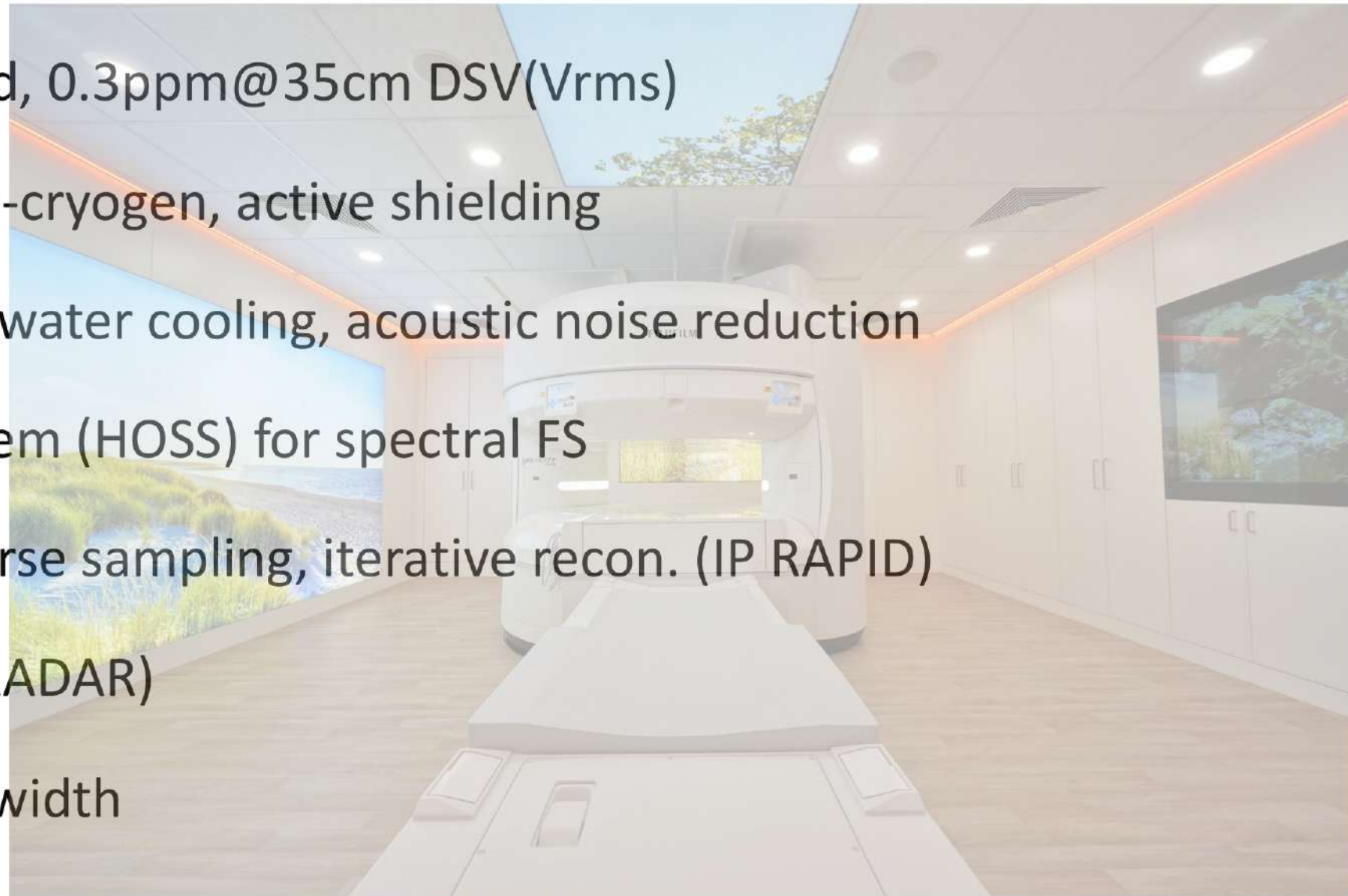
# Vertical Field – Effects on Metal Artifacts

0.2 T scanner, screws not aligned with  $B_0$  (left) and after external rotation of the foot to improve alignment



# Expectations on Performance

- 1.2 Tesla vertical field, 0.3ppm@35cm DSV(Vrms)
- superconducting, He-cryogen, active shielding
- 33mT/m, 100T/m/s, water cooling, acoustic noise reduction
- high order shim system (HOSS) for spectral FS
- parallel imaging, sparse sampling, iterative recon. (IP RAPID)
- motion correction (RADAR)
- 300 kg, 83 cm table width
- ...

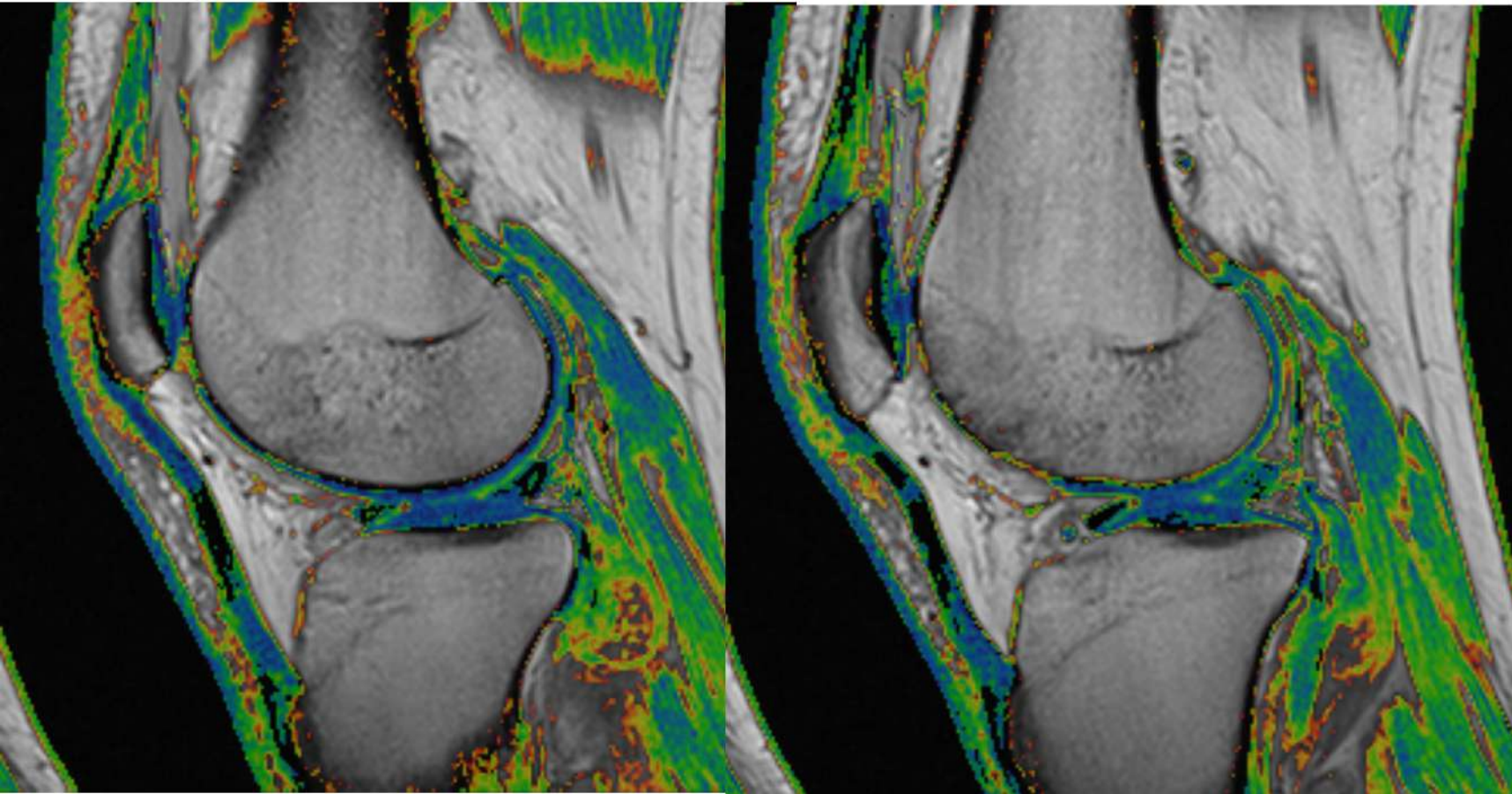


# Expectations on Performance

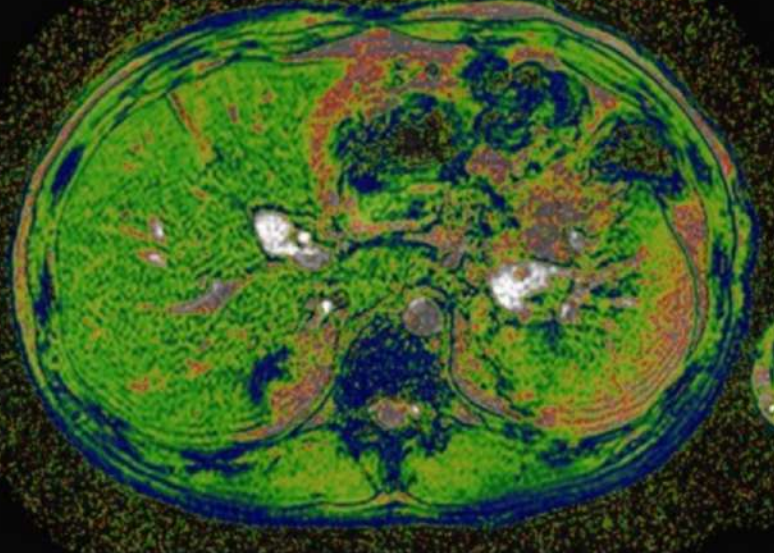
- quantitative imaging

T2\*-mapping of liver fat

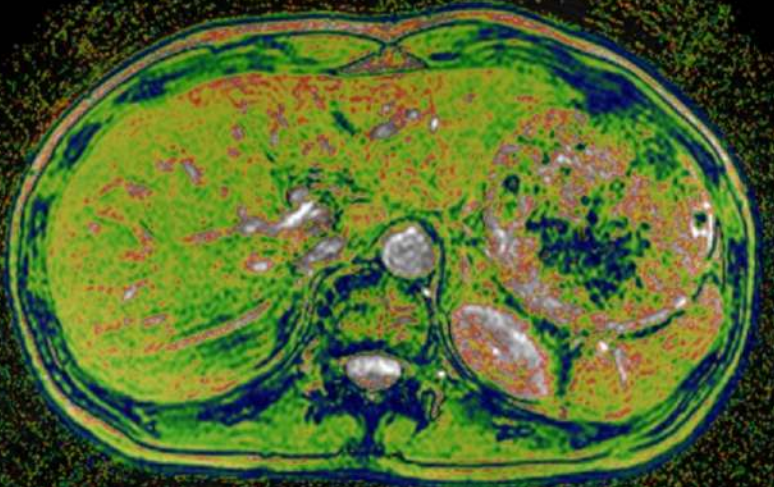
T2-mapping of cartilage



healthy liver: T2\* 29.2ms



steatosis: T2\* 22.3ms

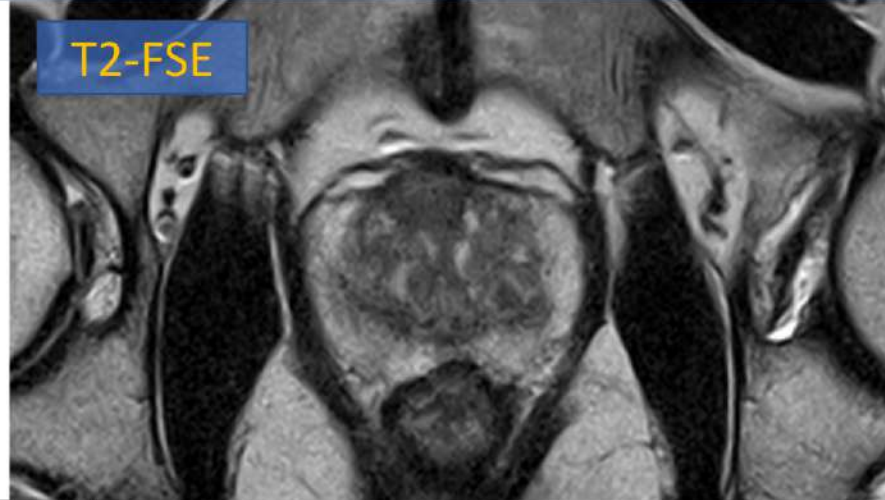


# Expectations on Performance

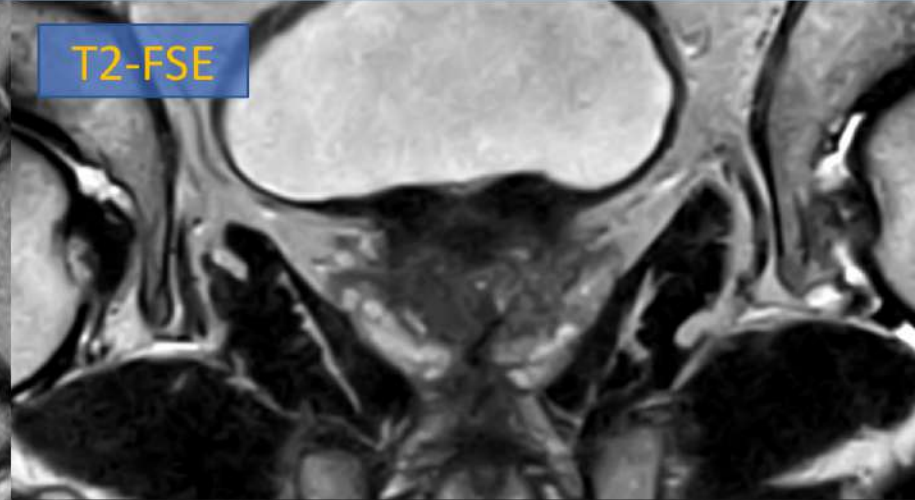
- Prostate mpi

full coverage of PIRADS criteria

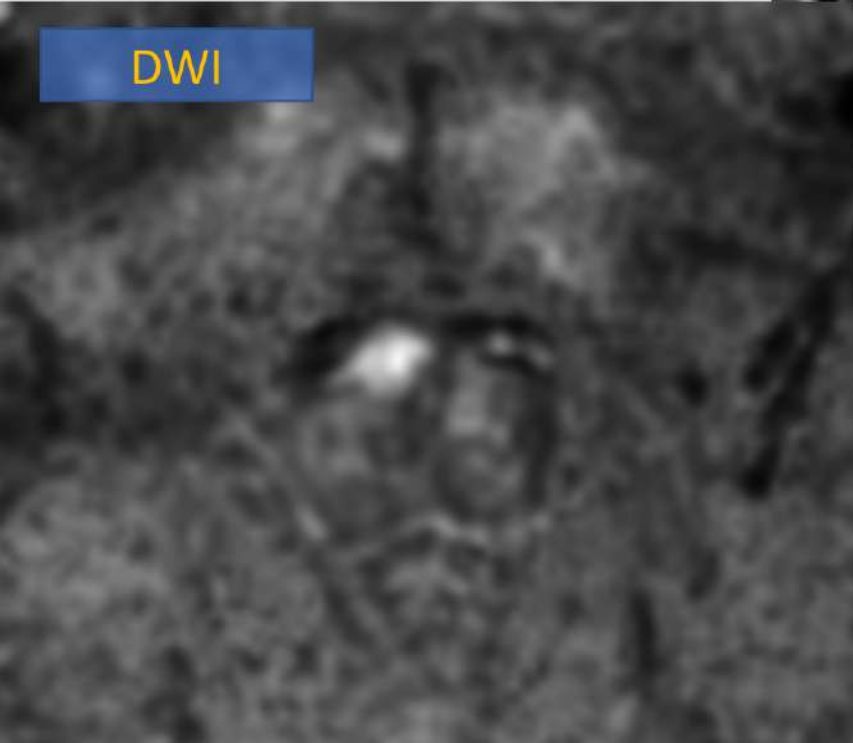
T2-FSE



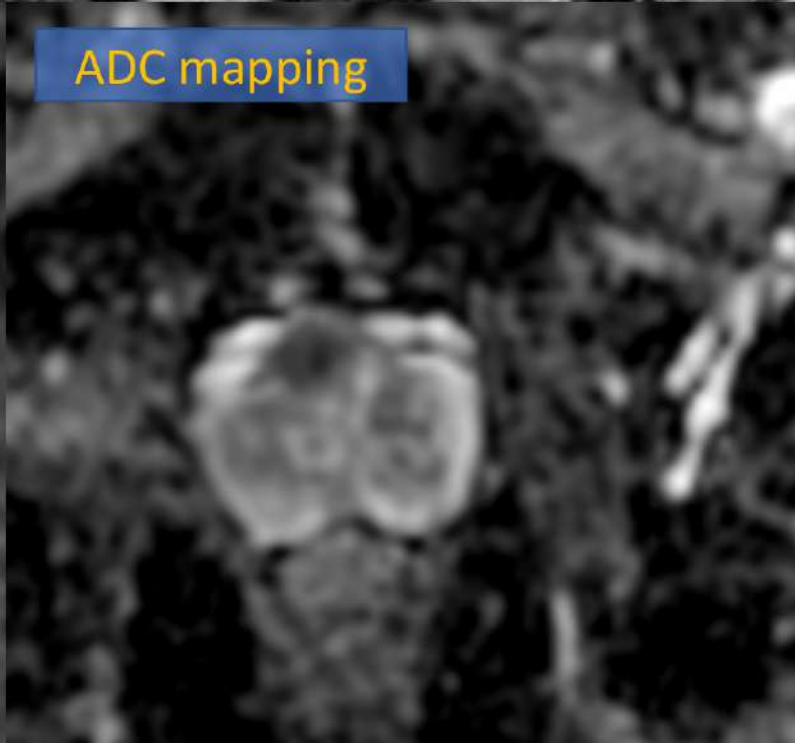
T2-FSE



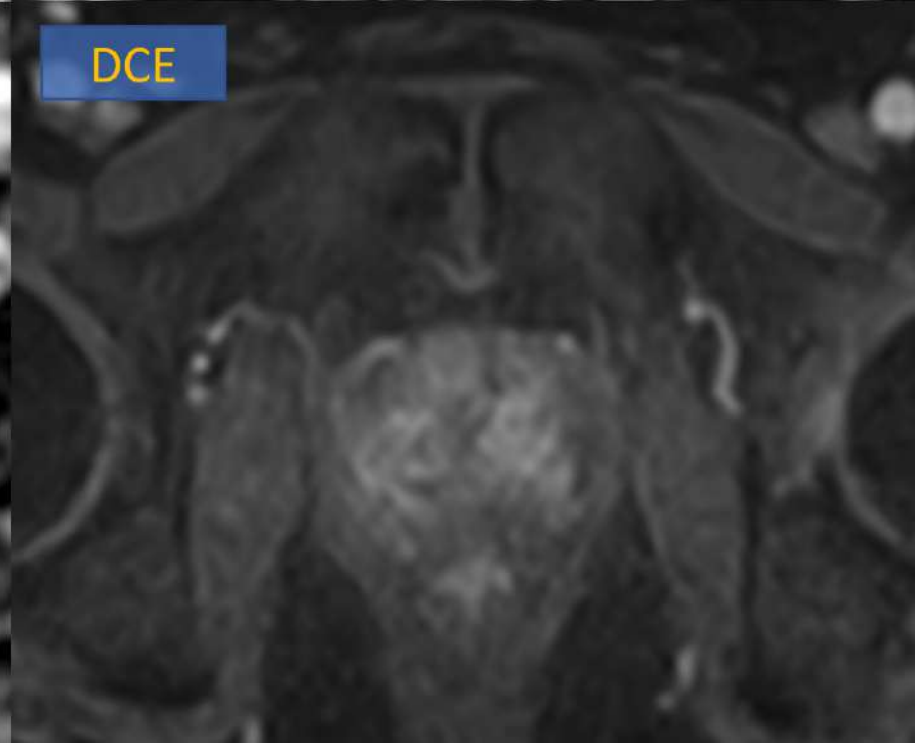
DWI



ADC mapping

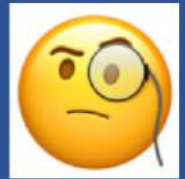


DCE



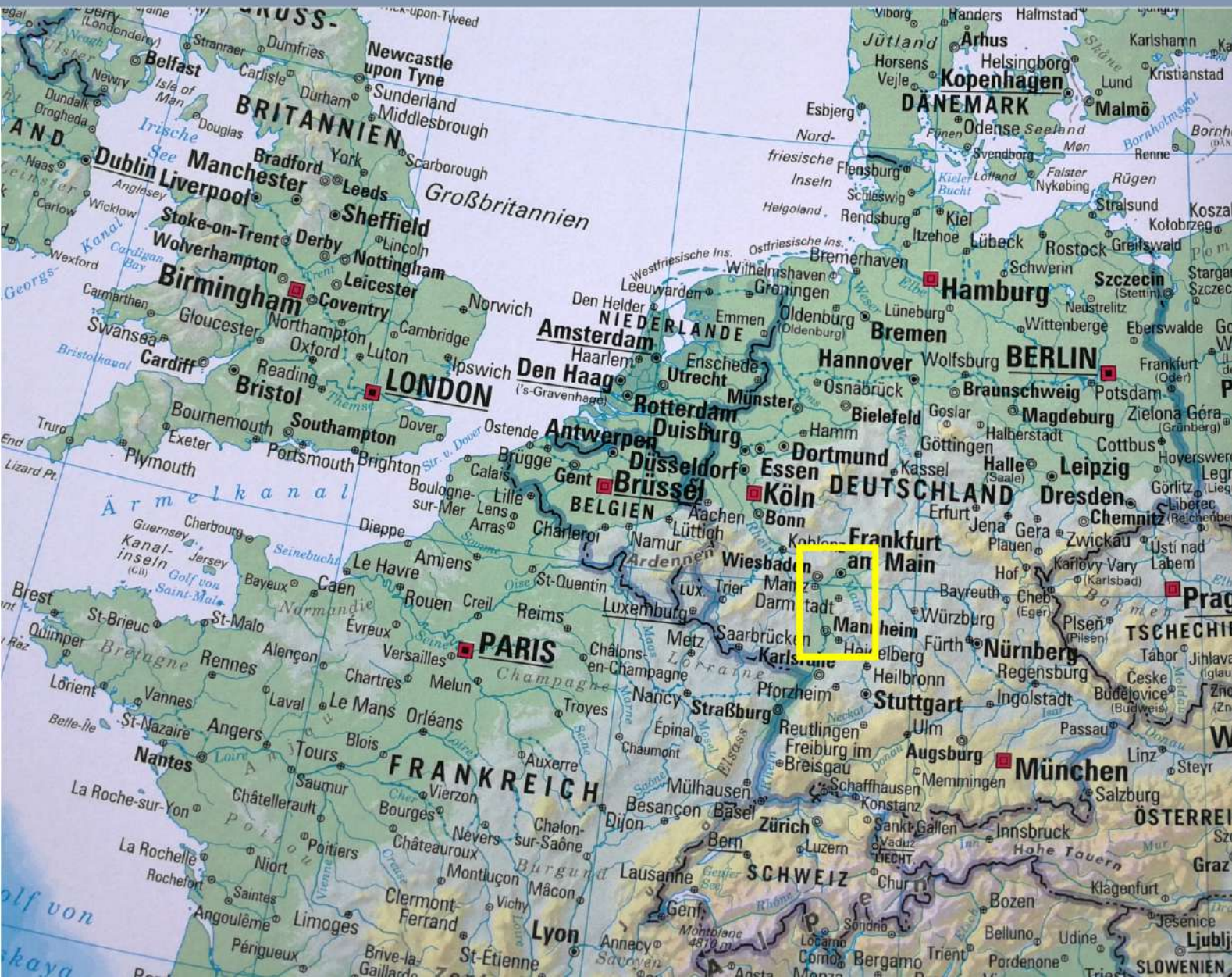
# Economic Aspects I

Nice! ... but how about finances???



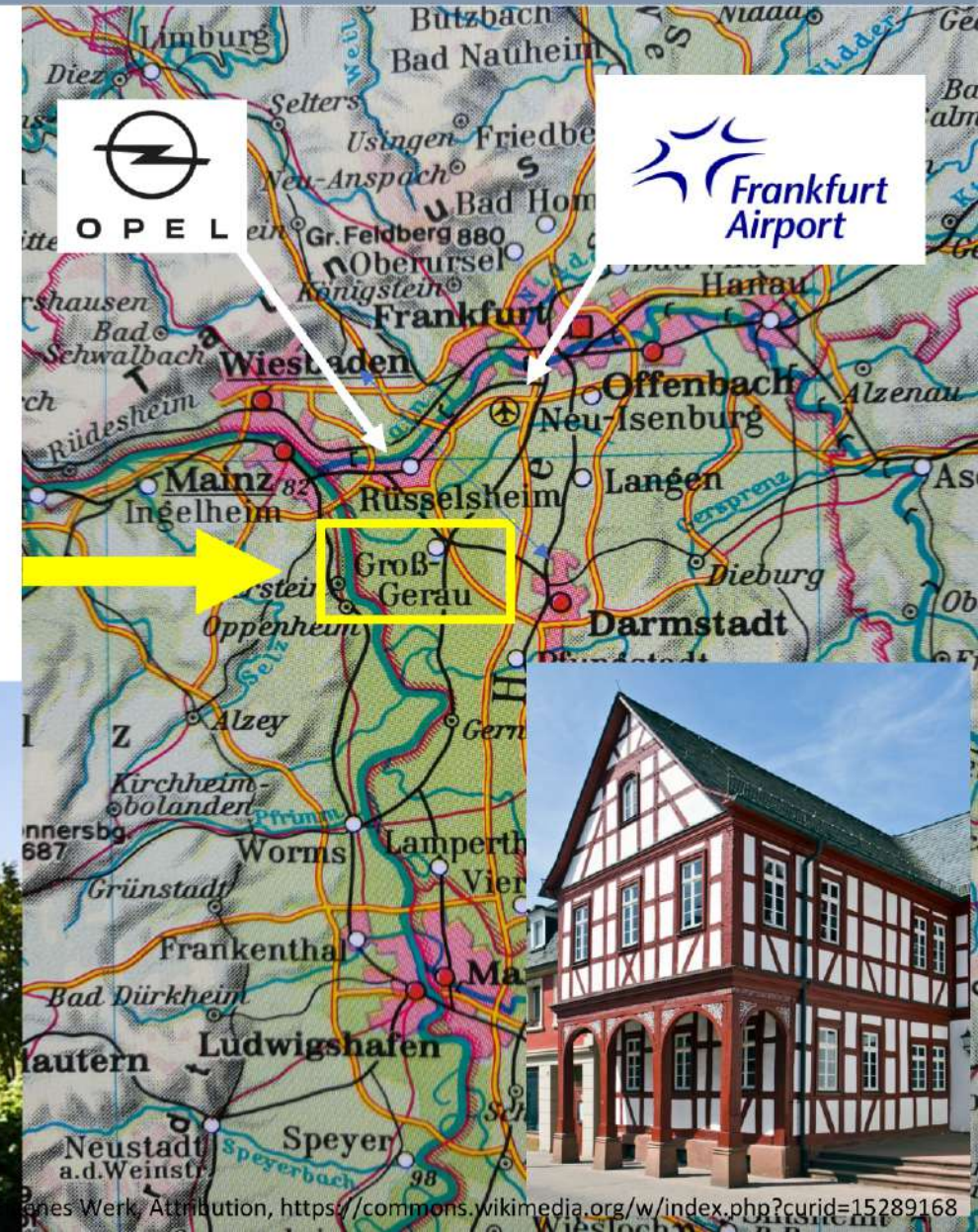
# A typical "Use Case" – Gross-Gerau County H.

- Probably most of you have already seen Gross-Gerau ...



# A typical “Use Case” – Gross-Gerau County H.

- County capital
- dates back to a roman “castellum”
- Population 26.000, young, growing
- Rhein-Main-Neckar metropolitan regions
- Frankfurt Airport
- **County hospital**





- the hospital: a small fish among many big fish
- new MR-system needed
- “enough“ high-end scanners in the region (?)
- something unique wanted
- additional external patients to make it more profitable



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- new MR-system needed
- “enough“ high-end scanners in the region (?)
- something unique wanted
- additional external patients to make it more profitable



**The solution: A system that the PATIENTS would want ...**

## **Patient Perspective**

pleasant setting  
spacy, open system  
“no tunnel”  
comfortable positioning  
less noise  
no injection

## **Expectations on Performance**

high field + strong gradients  
all options for advanced procedures  
(current and future applications)

## **Clinical Needs**

claustrophobic patients  
large patients  
paediatric patients  
positioning options

## **Economic Perspective**

less examinations aborted  
procedure times shortened  
opportunity costs reduced  
new patients attracted



# The last big Obstacle (not only in Germany ...)

County hospital = public procurement procedures are obligatory



# The last big Obstacle (not only in Germany ...)

County hospital = public procurement procedures are obligatory

- performance and price as main criteria
- higher price for a specific system configuration must be justified
- “soft criteria“ (social, psychologic or ecologic) usually not accepted ...
- ... unless additional income and/or savings can be realized
  - additional income from attracting new patients
  - reduced opportunity costs

# Value-based vs. Price-oriented Procurement

- extended cost controlling beyond machine purchase and service
- savings for the hospital
  - less cancellations/ abortions of examinations
- additional income for the hospital
  - extra fees for handling “large“ patients
  - extra-budgetary fees for handling claustrophobic patients
  - attraction of “private“ patients (comfort, setting)



Prof. Dr. Erika Raab

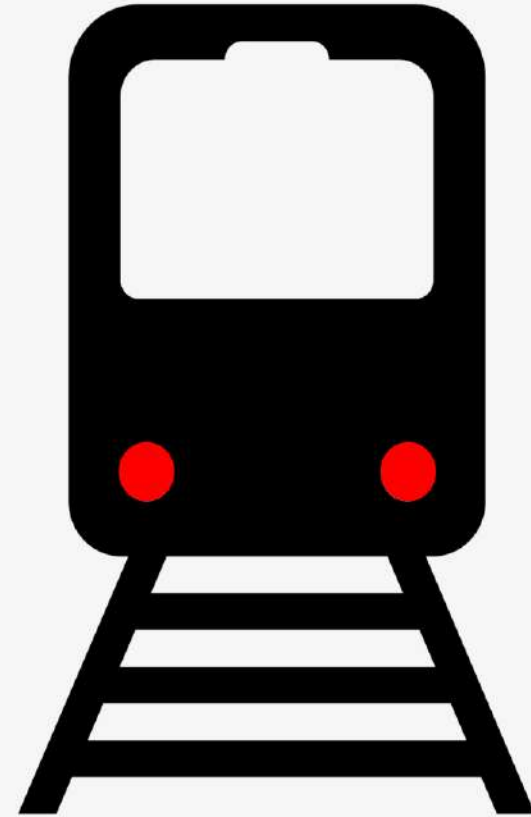
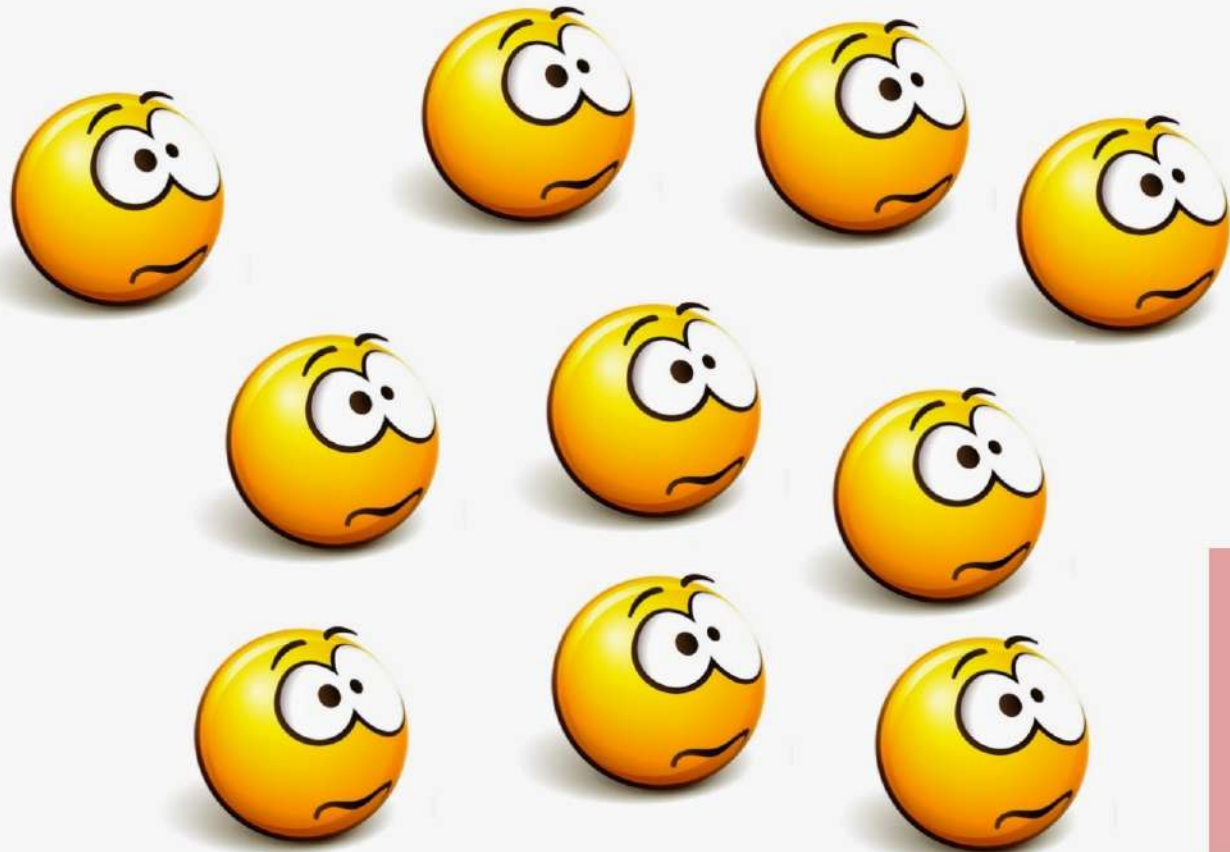
- Example: road accident victim, spine fractures, MRI required, examination 2 times aborted for panic and pain, transfer to hospital with “open” scanner

- Example: road accident victim, spine fractures, MRI required, examination 2 times aborted for panic and pain, transfer to hospital with “open” scanner
  - costs of 1 day without treatment - 460 €
  - costs of aborted MRI scan - 650 €
  - shortened flat rate bc. transfer to other hospital - 530 €
  - revenue for the hospital from this case (flat A 1700€ - costs) 60 €
  - lost profit compared to full flat (flat B 7600€ - flat A) - 5900 €
  - opportunity costs (“missed chances”) - 5840 €



# Concept of “Opportunity Costs”

- opportunity costs = missed chances
- almost equal to profit



10 passengers left behind at the stop  
10 tickets 2.50 € each not sold  
25 € “opportunity costs”

# The Result

- 112 of the first 250 patients claustrophobic
- not a single examination aborted
- drastic reduction of related opportunity costs
- additional external patients attracted
- 98% recommendation rate after 3 months



... you are in a smaller place and looking for an economic solution?

... you are in a smaller place and looking for an economic solution?

***Let's ask him:***

***Mihály Aradi MD. PhD., radiologist***

County Hospital Of Zala (Hungary)

Integrity Hungary Private Diagnostic Center Zalaegerszeg

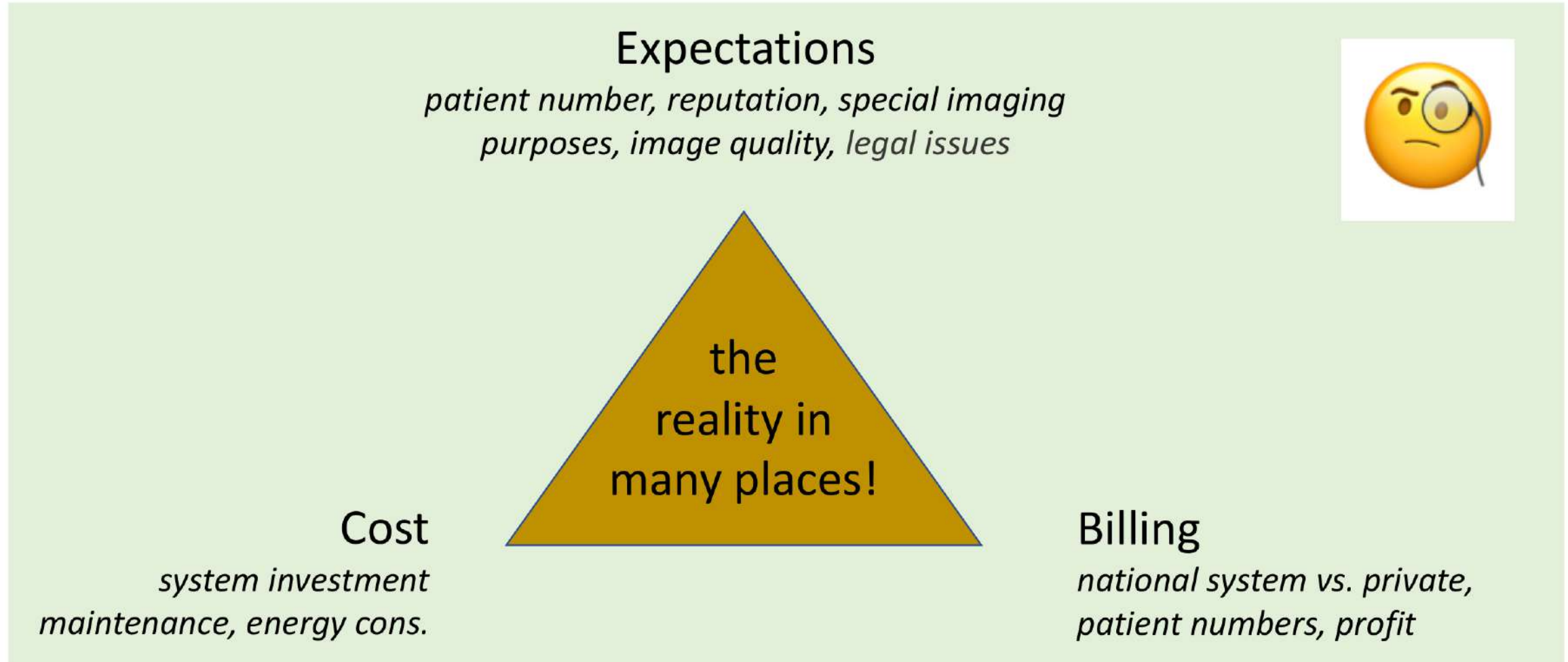
Operator level experience with 0.3T-9.4T MR machines

using 0.4 T (Aperto Lucent), 1.5 T and 3 T



- Advanced medicine needs advanced diagnostic procedures!

- Advanced medicine needs advanced diagnostic procedures, but ...



# Economic Aspects II – What if ...

... so wouldn't it be great if this beauty had a "little sister"?



# Economic Aspects II – What if ...

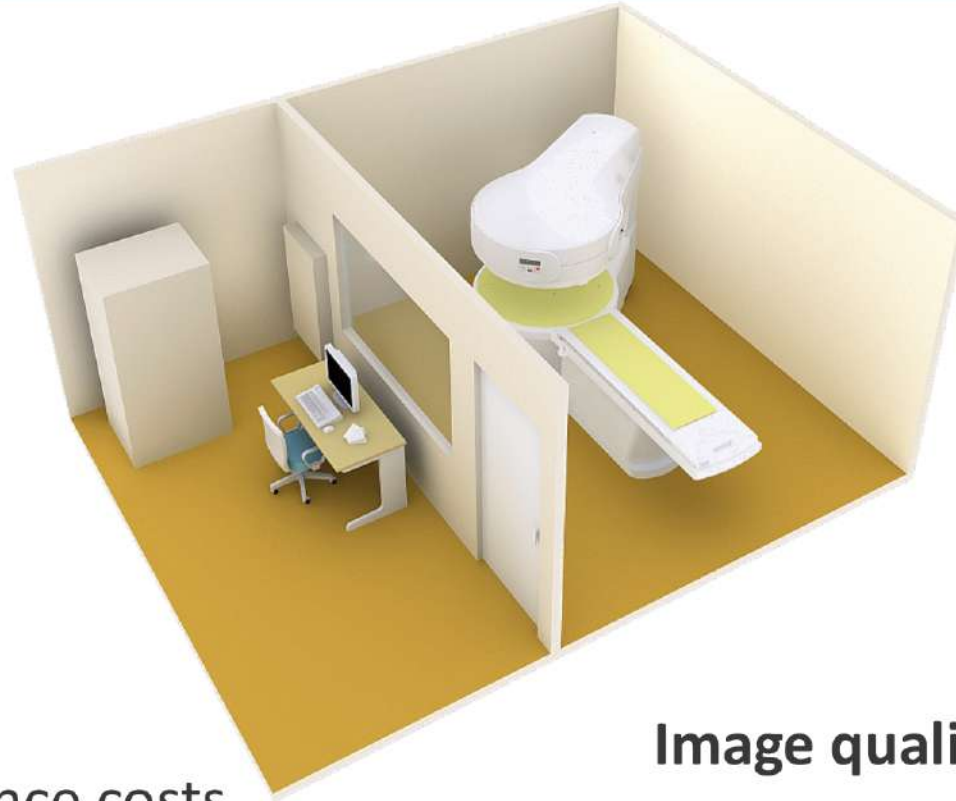
Yes! It does have a “little sister“!



Aperto Lucent



# Comfort–Cost-Quality in an open 0.4 T System



## Cost

permanent magnet

*no helium , no water cooling*

low installation/maintenance costs

low power consumption

*1/10 of a superconductive system (Fuji)*

## Comfort

320° open single pillar gantry

low noise

motorized patient table

## Image quality

advanced signal processing

dedicated coils

IP-RAPID (Lucent Plus)

*faster measurements, improved signal processing*

# Pros and Cons of low Field MRI

**pro:**

**less chemical shift artefact**

**lower SAR, lower RF power**

**lower susceptibility artefact**

**better T1 contrast (w/wo. c.agent)**

less blurring in frequency encoding direction

better EMF safety, cheaper system

less image distortion around implants

improved diagnostic value



# Pros and Cons of low Field MRI

## pro:

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## con:

**less T2 contrast**

**lower raw SNR**

**no spectroscopy/DTI/fMRI**

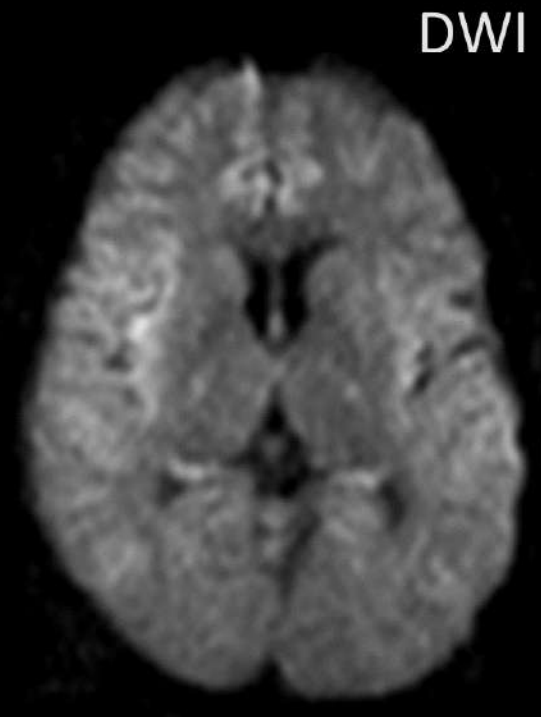
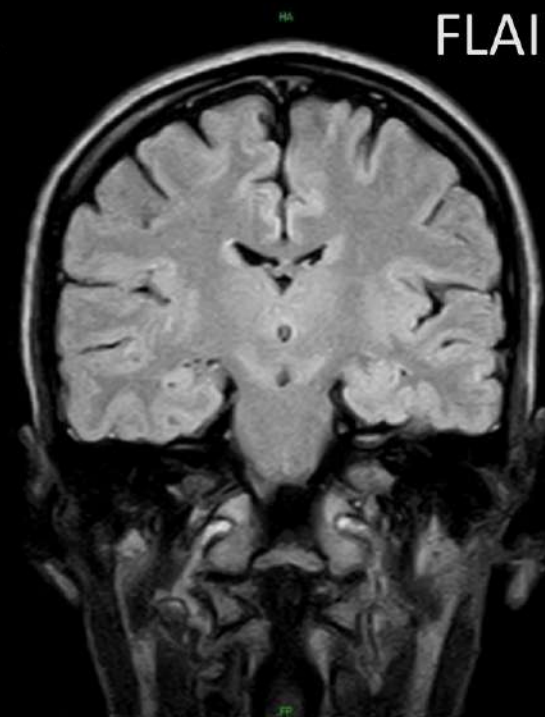
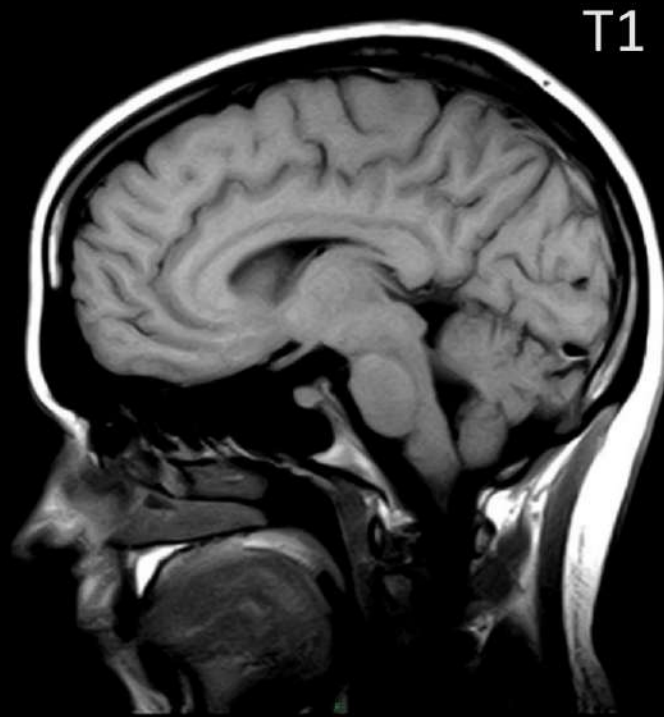
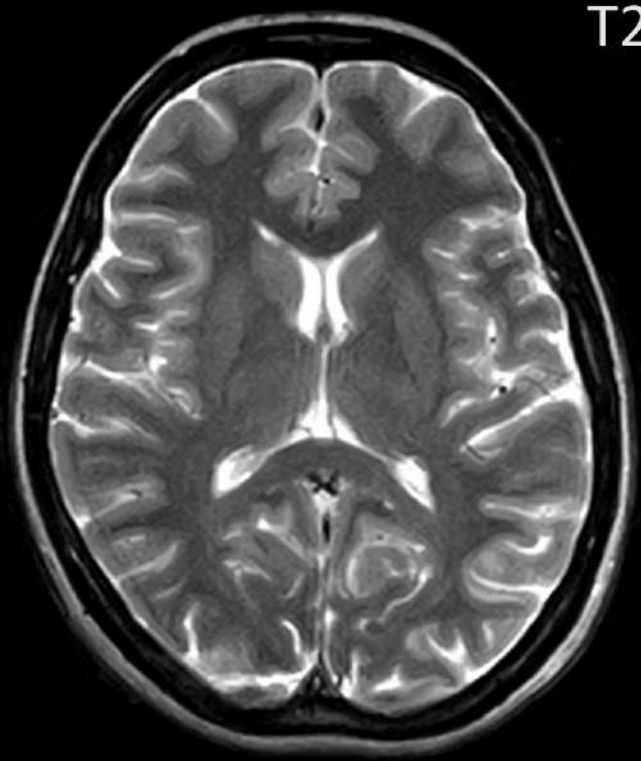
dedicated coils needed

longer measurement times, less forgiving

a system for routine imaging



# Practical Experience with an open 0.4 T System



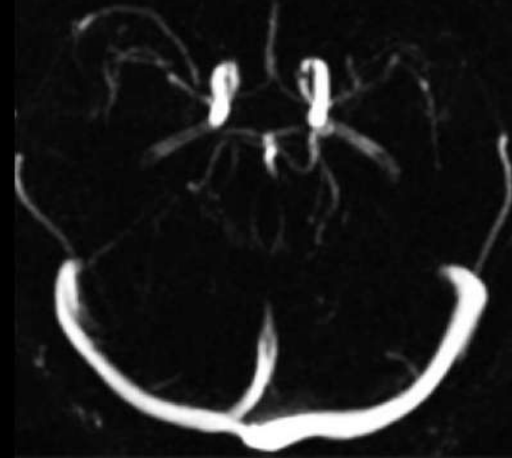
0.4T Aperto Lucent



TOF



PC



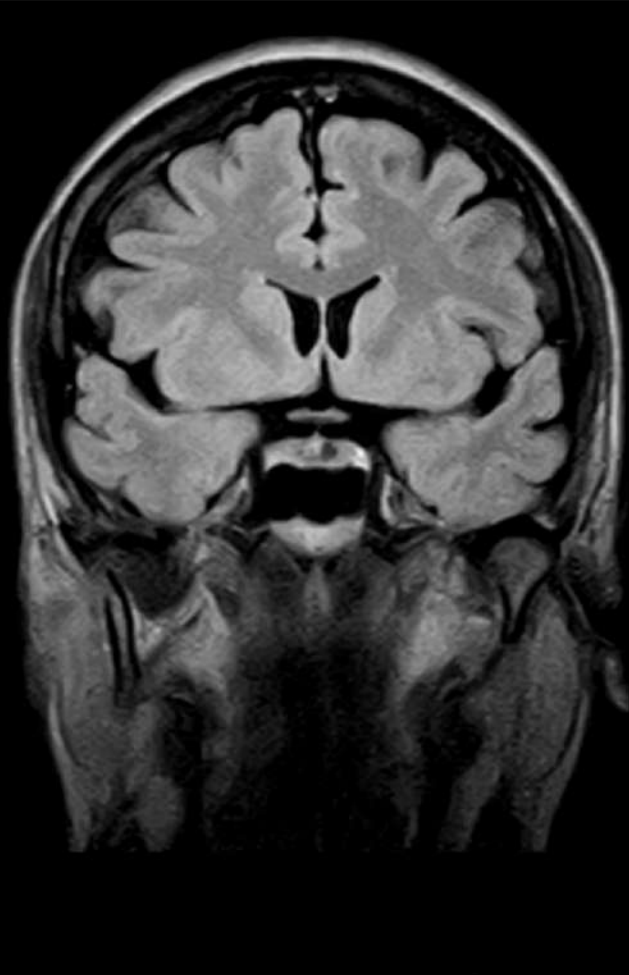
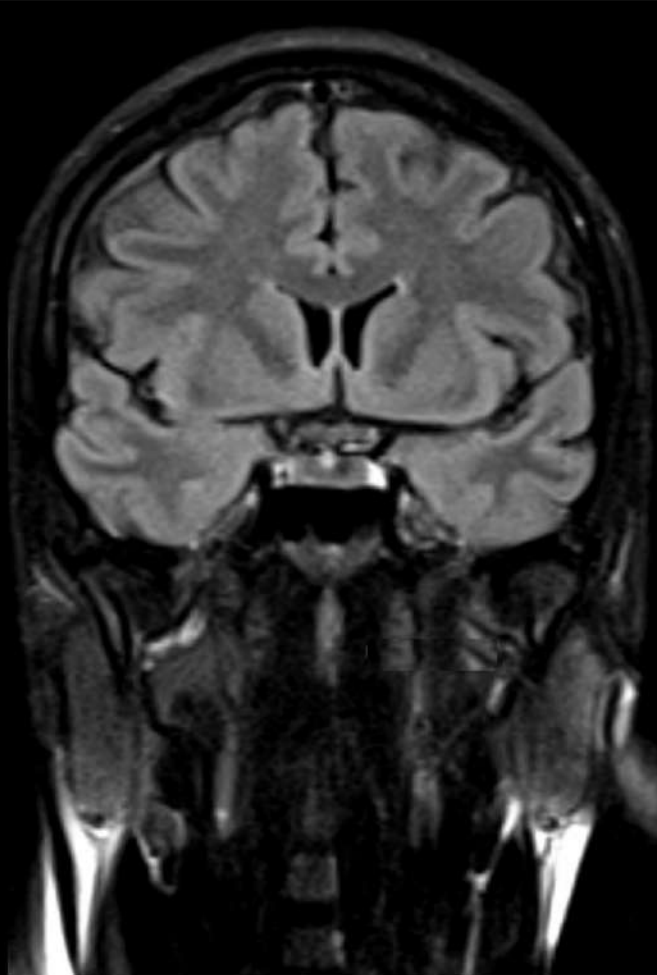
# Practical Experience with an open 0.4 T System

1.5T

0.4 T

1.5T

0.4 T

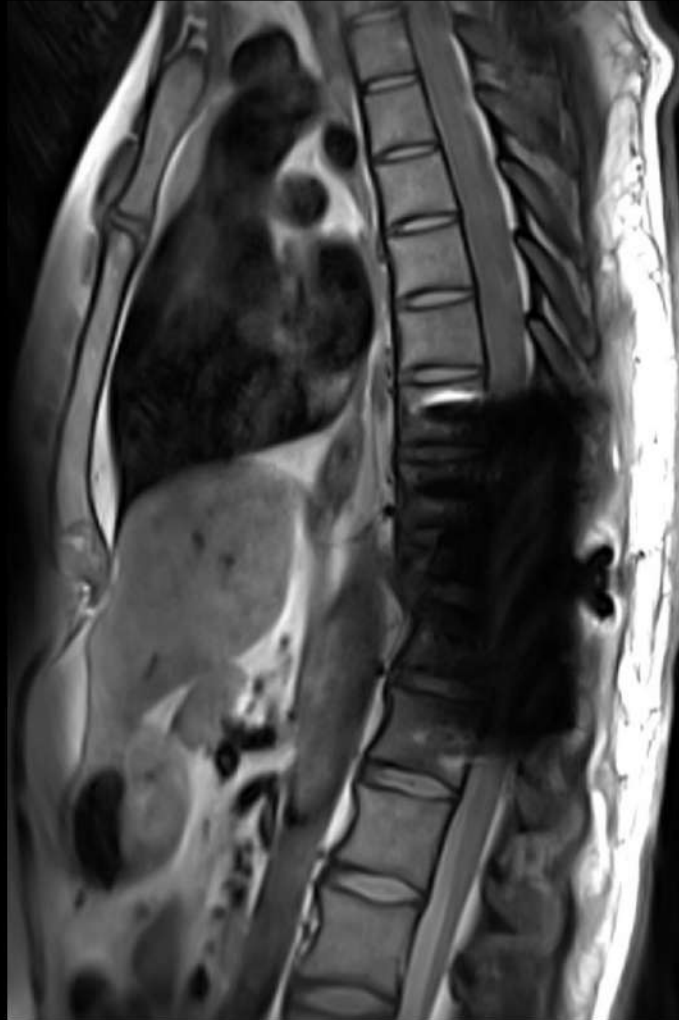


# Practical Experience with an open 0.4 T System

**FUJIFILM**  
Value from Innovation

3T

0.4T Aperto Lucent



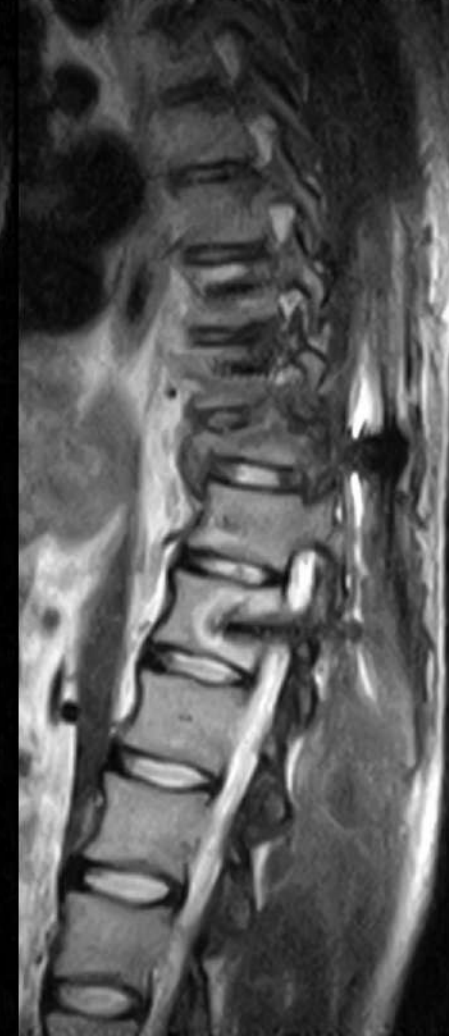
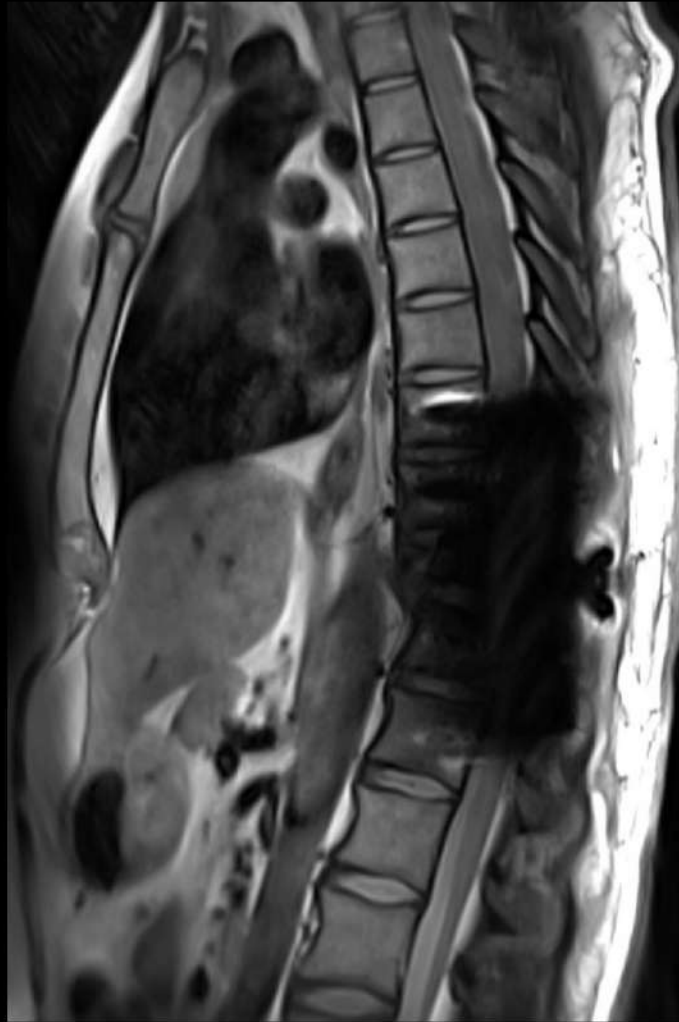
# Practical Experience with an open 0.4 T System

**FUJIFILM**  
Value from Innovation

3T

0.4T

0.4T Aperto Lucent

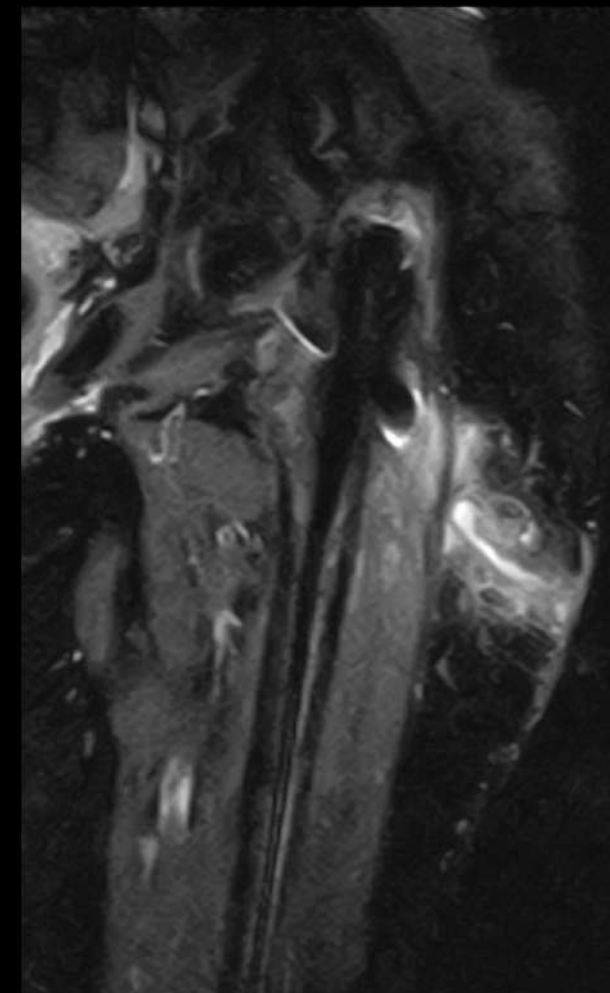
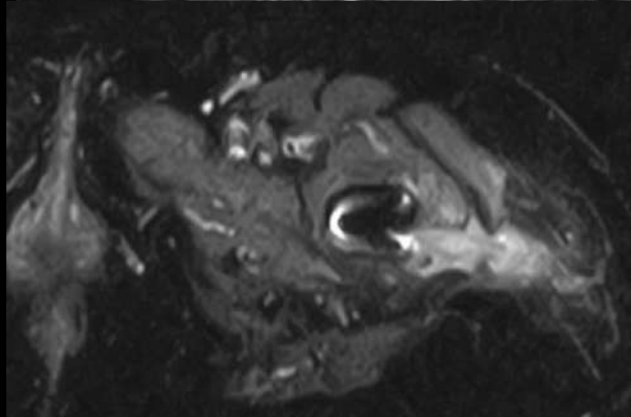
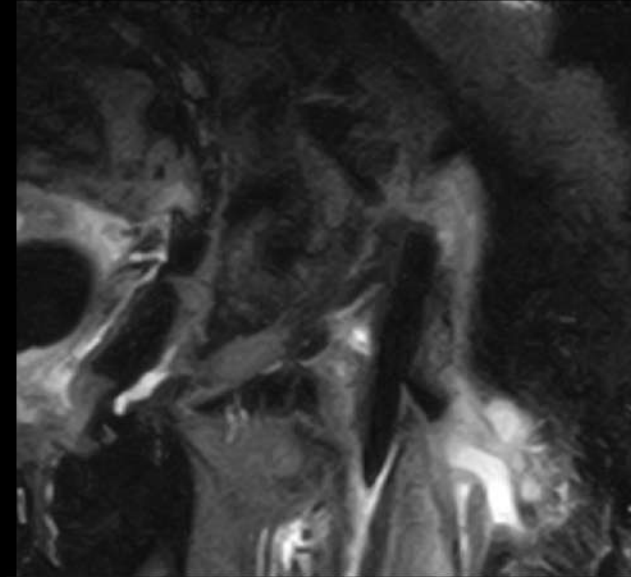


images: Dr. Aradi, Integrity Hungary Private Clinic

# Practical Experience with an open 0.4 T System

T2

STIR



0.4T Aperto Lucent



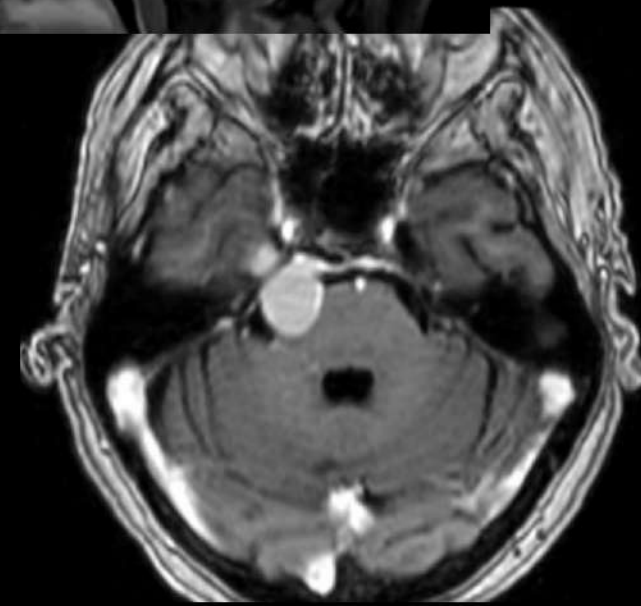
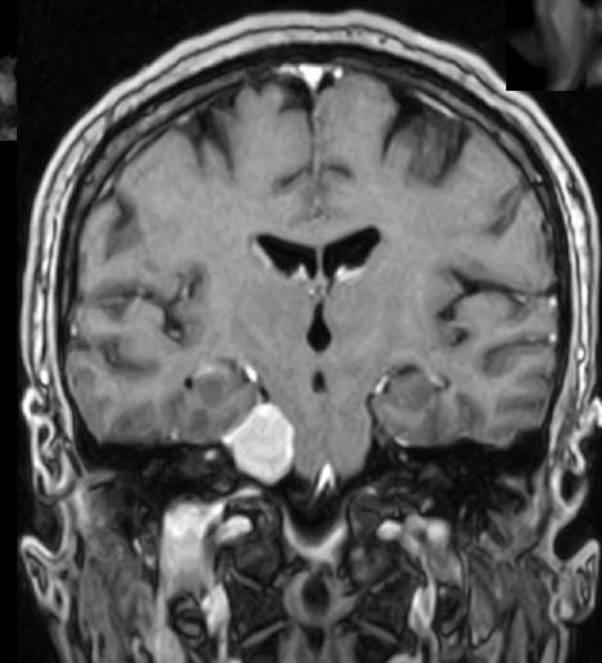
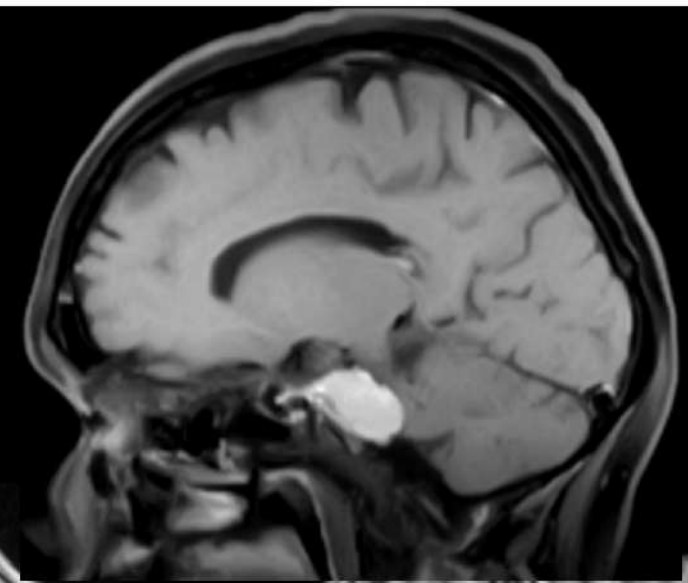
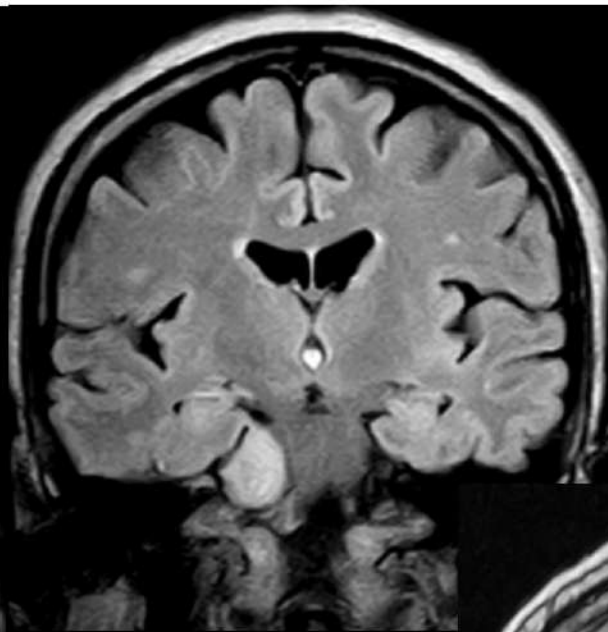


# Practical Experience with an open 0.4 T System

T2

FLAIR

3D T1 ce (cor)



0.4T Aperto Lucent



meningeoma

# Practical Experience with an open 0.4 T System

FLAIR

T2

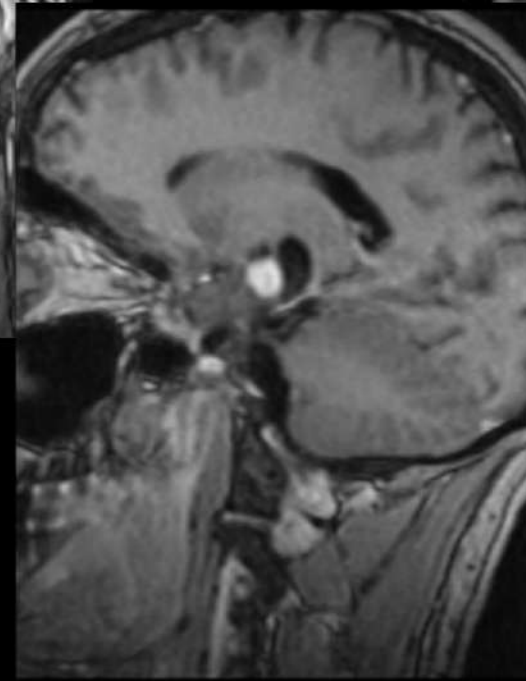
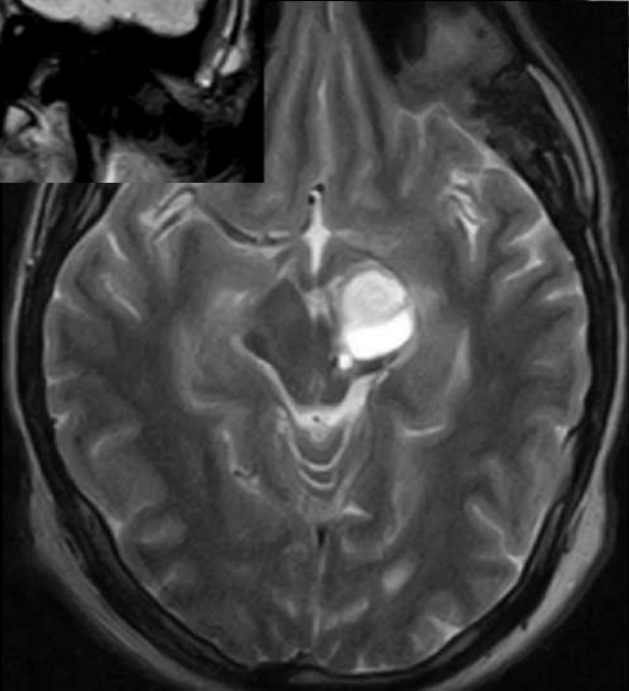
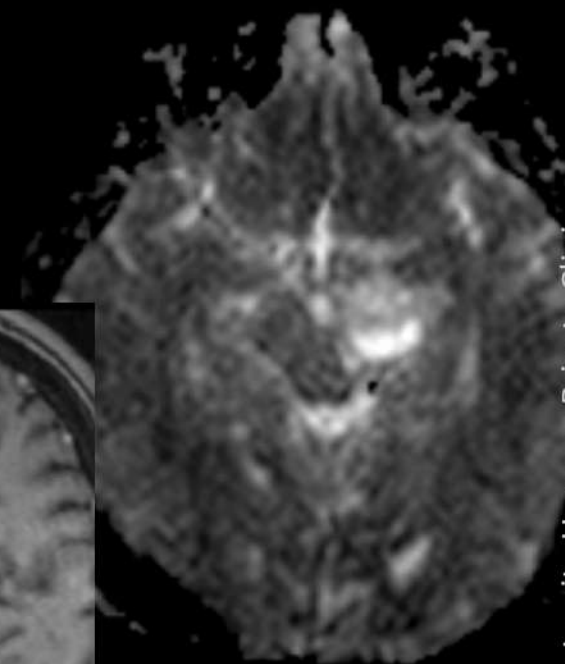
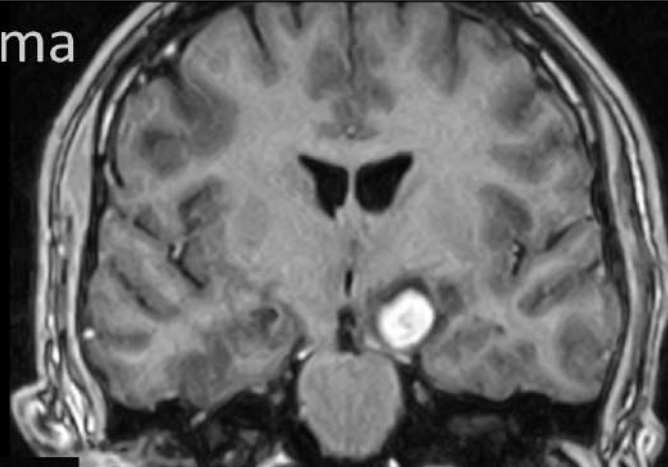
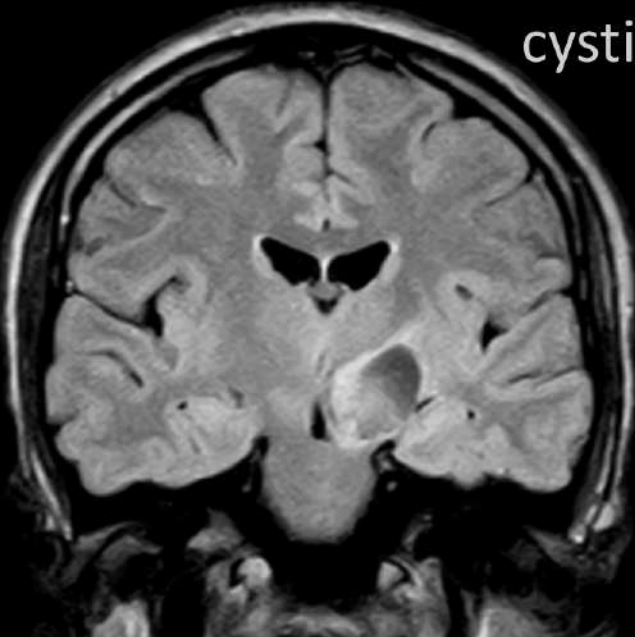
3D T1 ce (cor)

0.4T Aperto Lucent



cystic astrocytoma

DWI



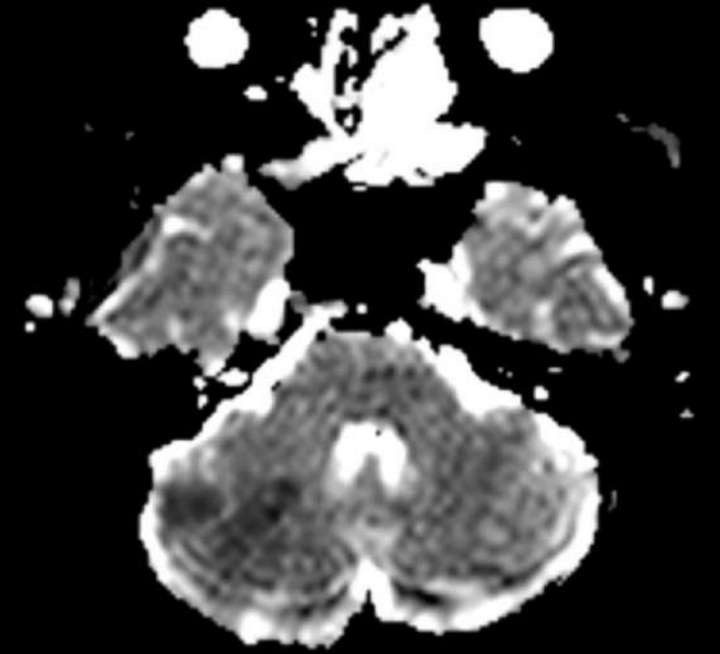
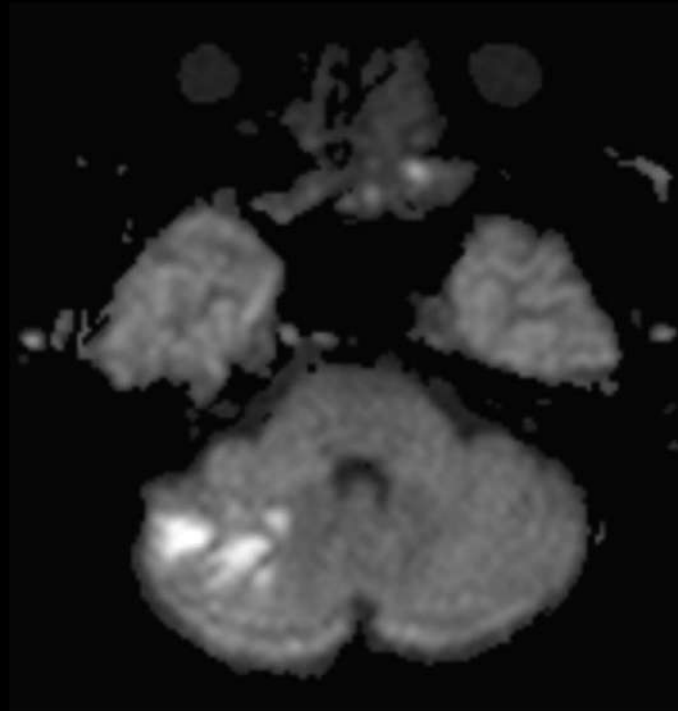
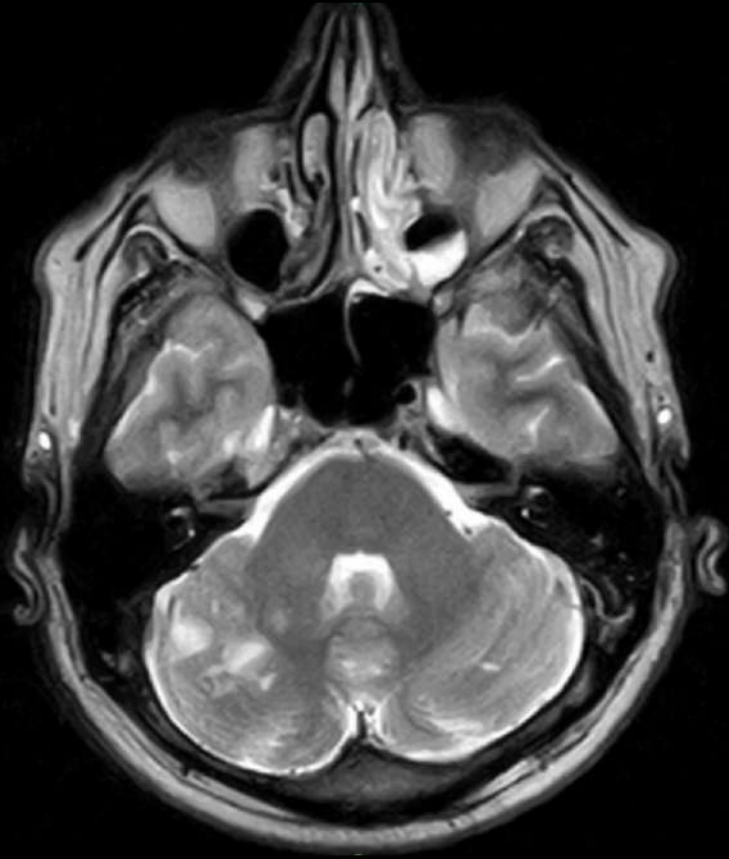
# Practical Experience with an open 0.4 T System

T2

DWI/ADC



0.4T Aperto Lucent



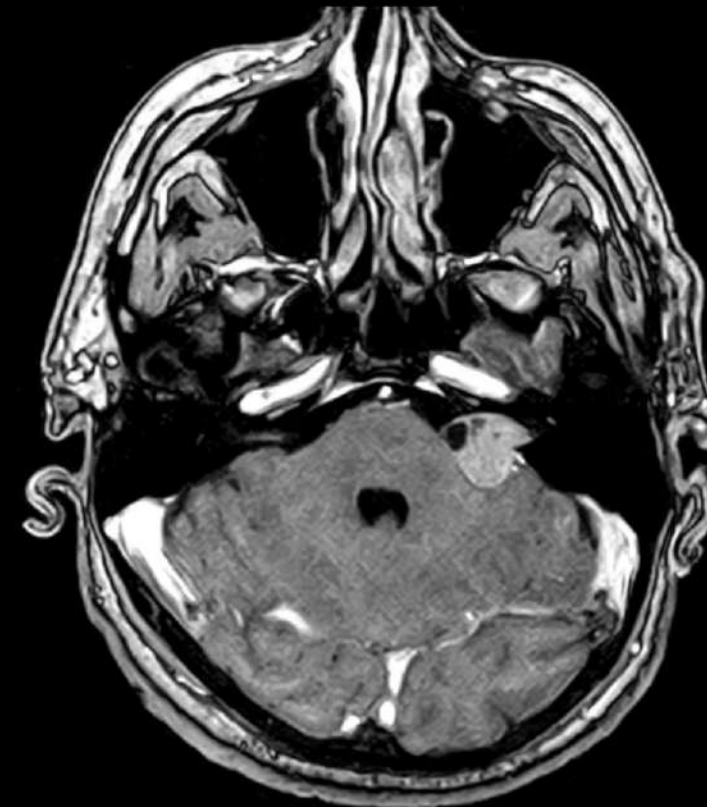
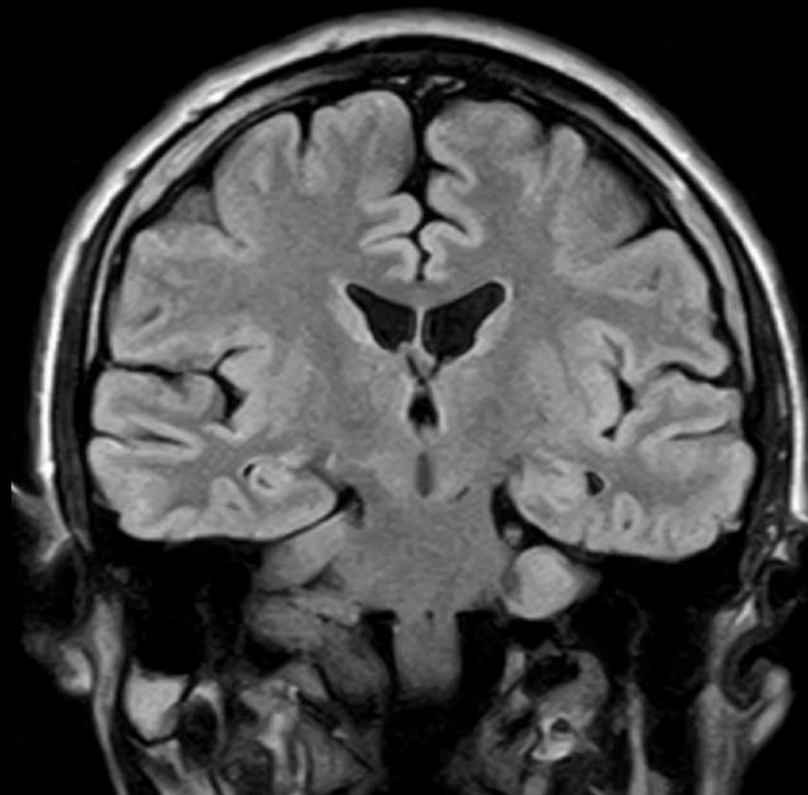
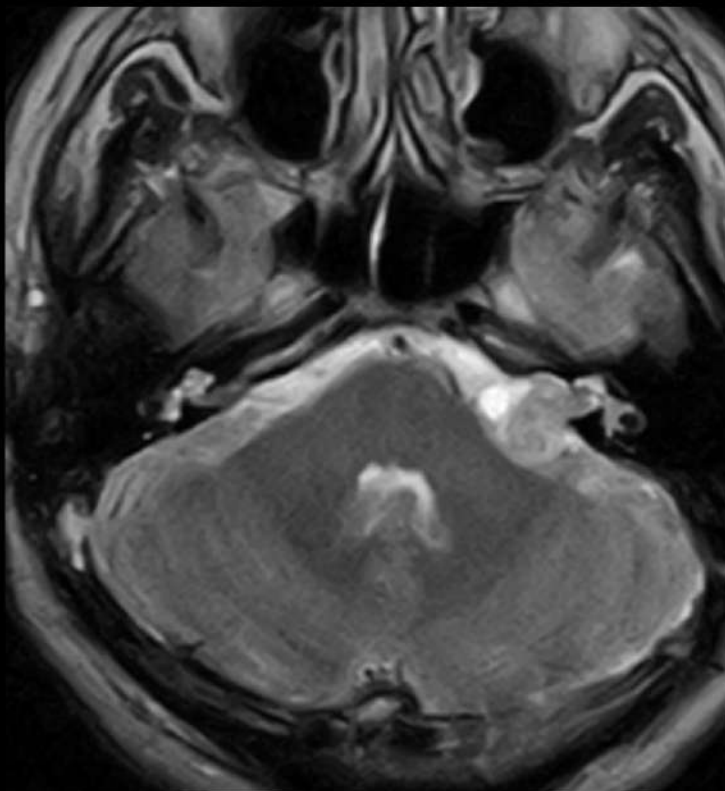
acute ischaemia

# Practical Experience with an open 0.4 T System

T2

FLAIR

3D T1 ce



acoustic schwannoma



0.4T Aperto Lucent

images: Dr. Aradi, Integrity Hungary Private Clinic

# Practical Experience with an open 0.4 T System

T2w -RADAR

STIR-RADAR

/DWI



retropharygeal  
abscess



0.4T Aperto Lucent

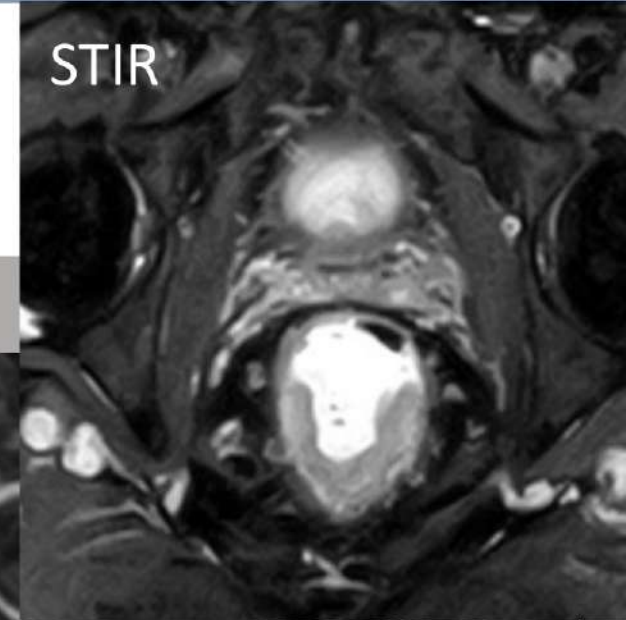
# Practical Experience with an open 0.4 T System

Rectal cancer staging  
w/gel distension

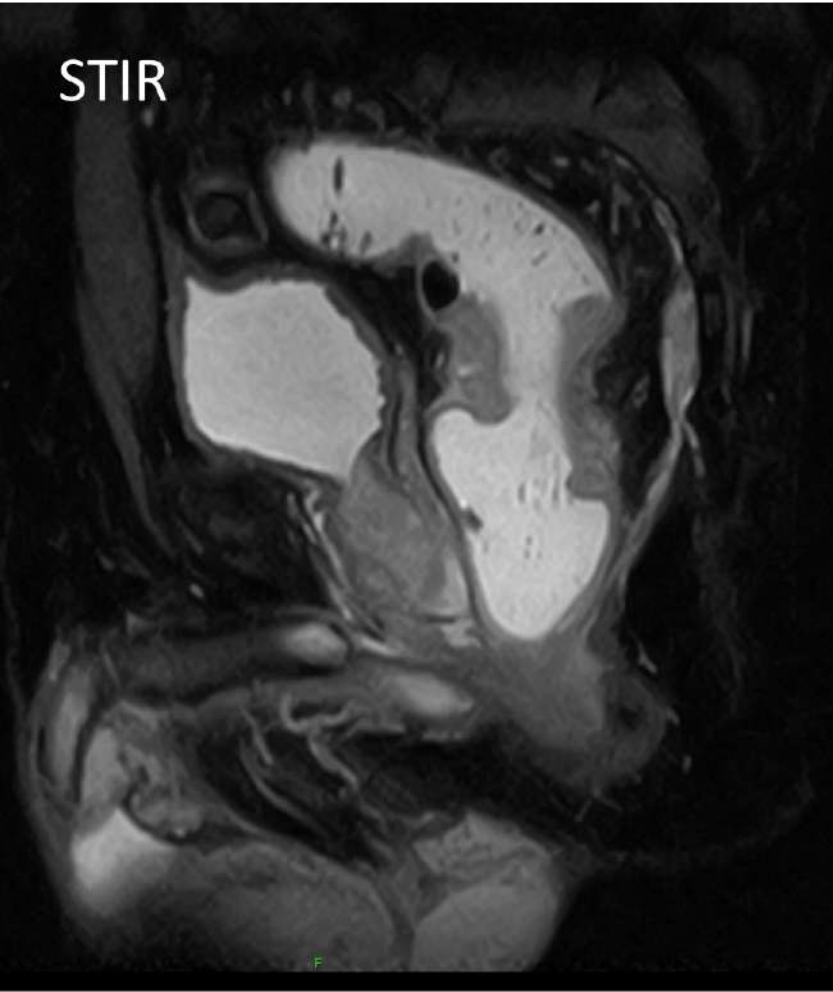
0.4T Aperto Lucent



STIR



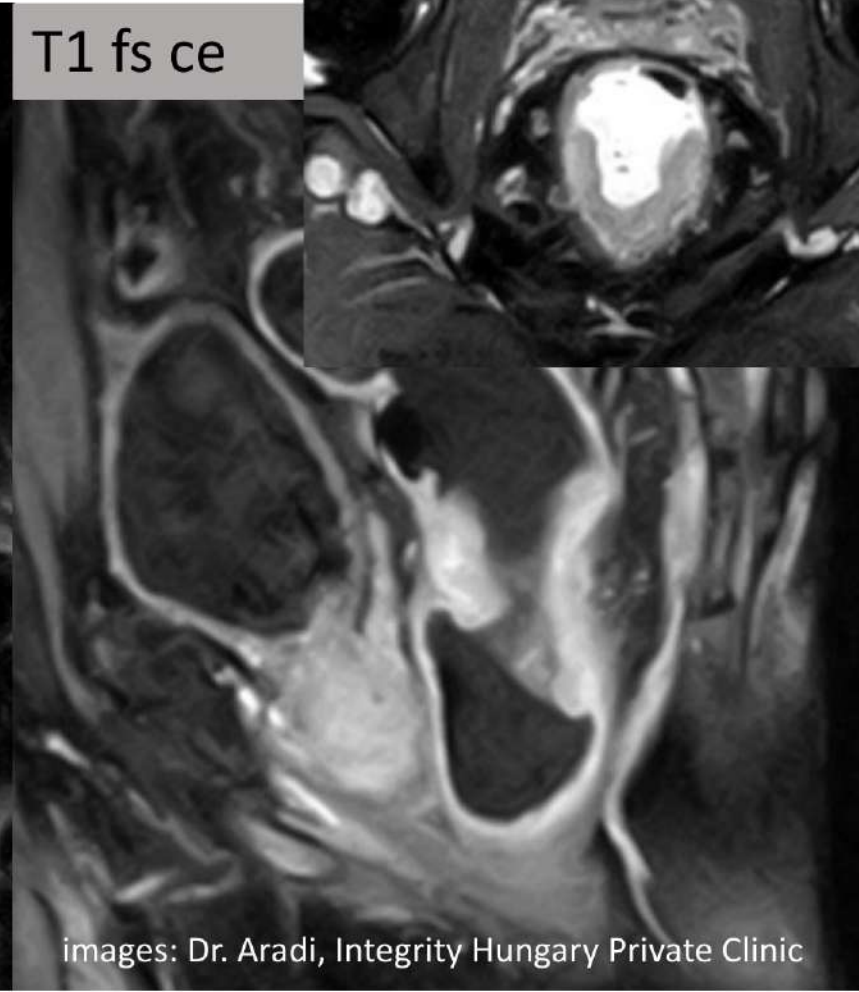
STIR



T2



T1 fs ce

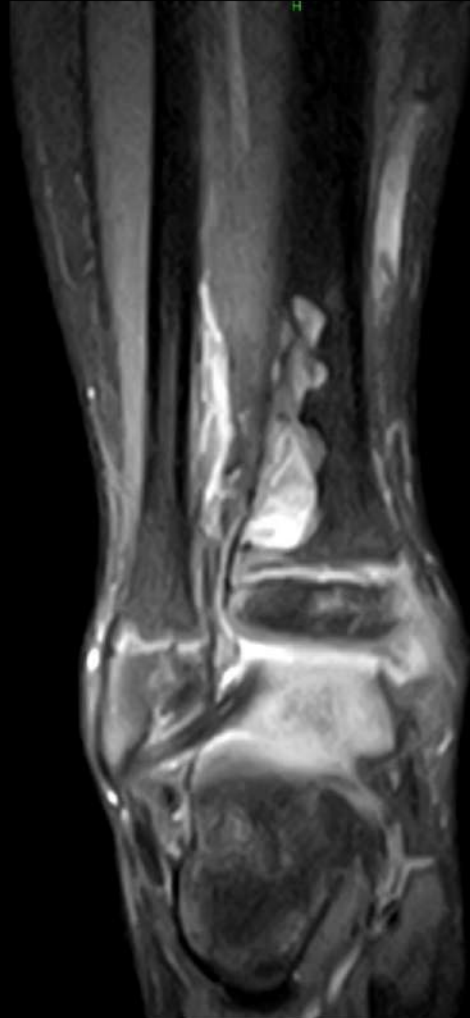


# Practical Experience with an open 0.4 T System

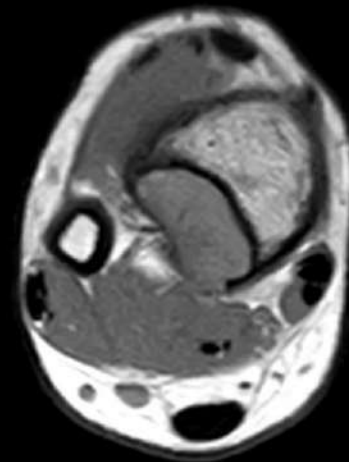
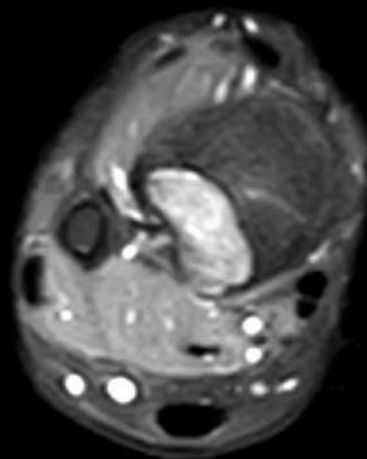
T1



T1



STIR/T1



0.4T Aperto Lucent

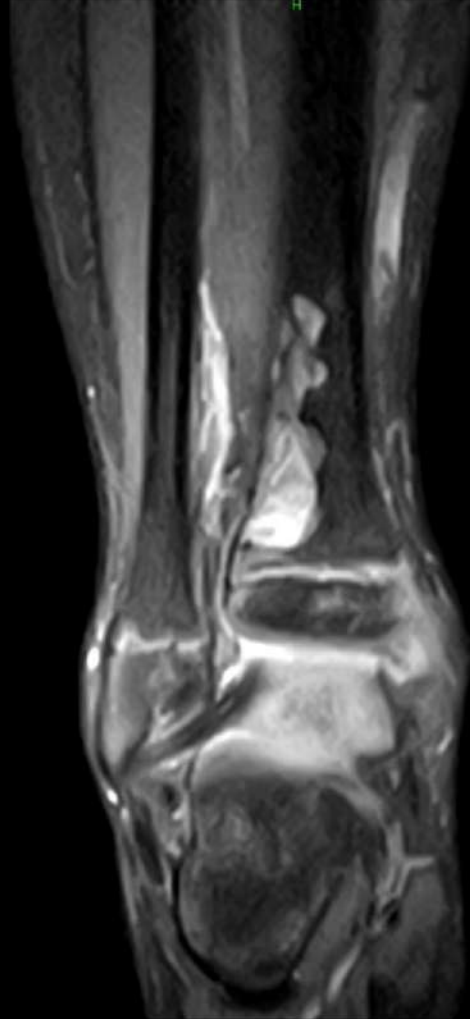
NOF (9 y., m.)

# Practical Experience with an open 0.4 T System

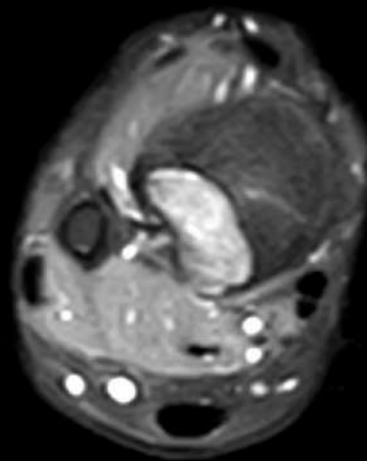
T1



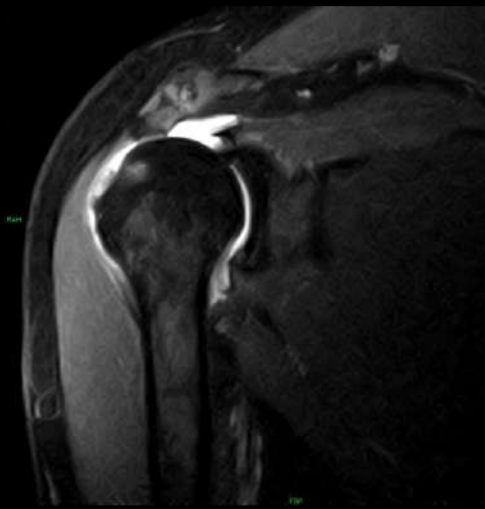
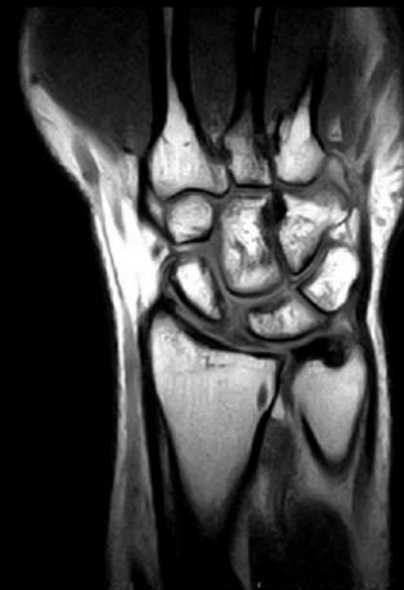
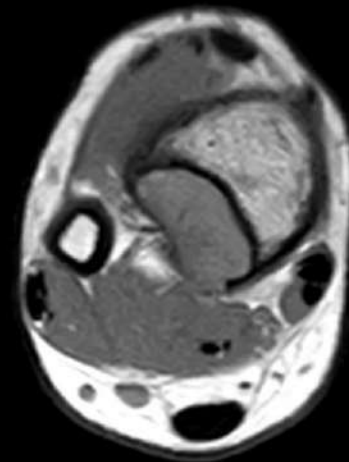
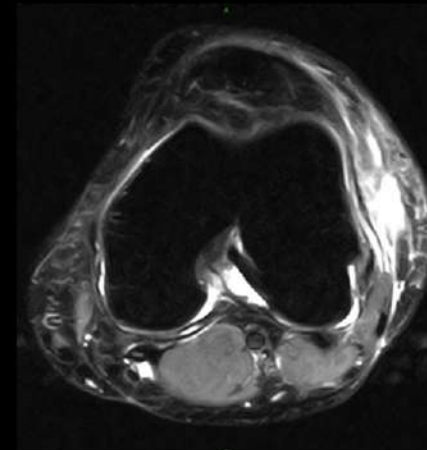
T1



STIR/T1



... more joint imaging



0.4T Aperto Lucent

NOF (9 y., m.)



# The whole Family of open MRI ...



OASIS  
Velocity

AIRIS Vento Plus



APERTO Lucent



AIRIS Vento

APERTO Lucent Plus



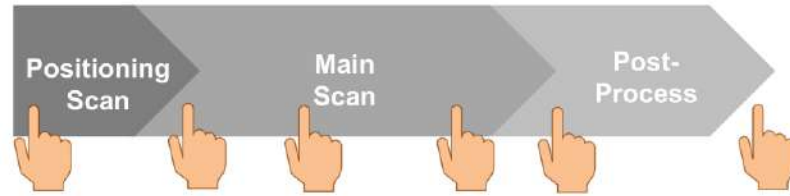
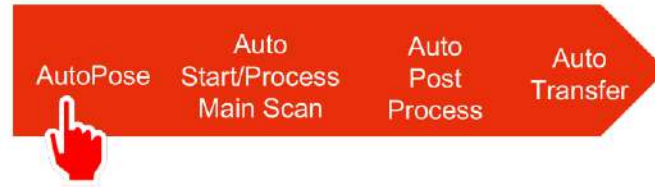
**Synergy Drive:** Speeding up standard examinations at all levels

- **AutoExam**      automated workflow from positioning to transfer

# AutoExam – Single Click Brain Study

## AutoExam

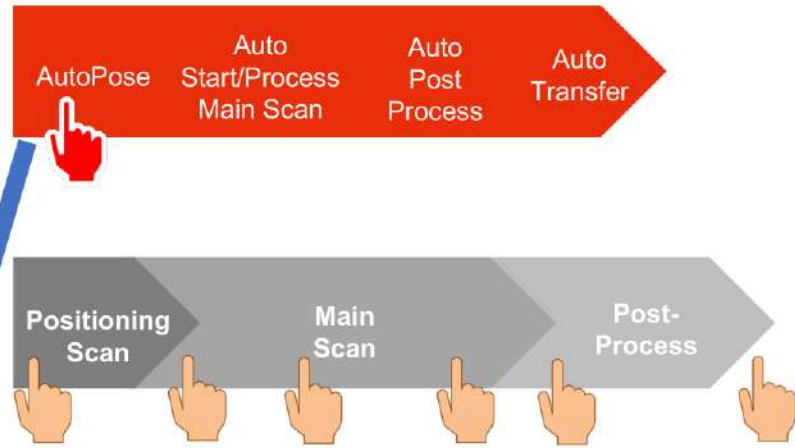
**Auto Exam**



# AutoExam – Single Click Brain Study

## AutoExam

**Auto Exam**



AutoPose Brain  
multiplane setting, up to 5 different planes can be preset

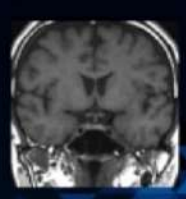
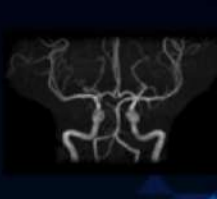
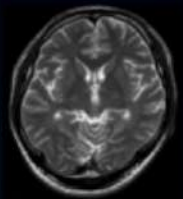
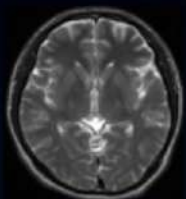
AC-PC line

OM line

For MRA

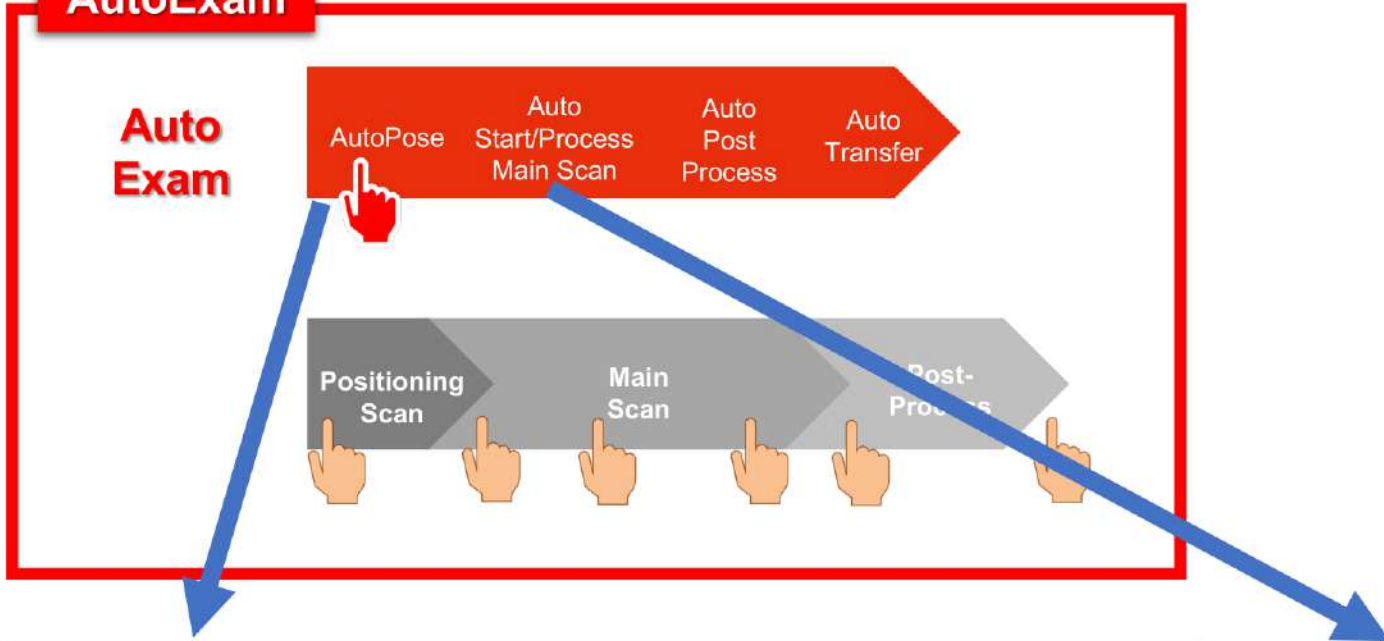
For hippocampus

For pituitary gland



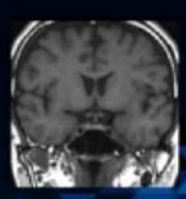
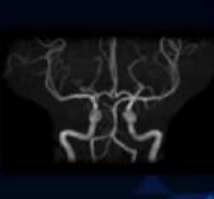
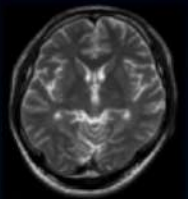
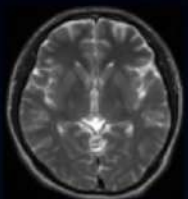
# AutoExam – Single Click Brain Study

## AutoExam

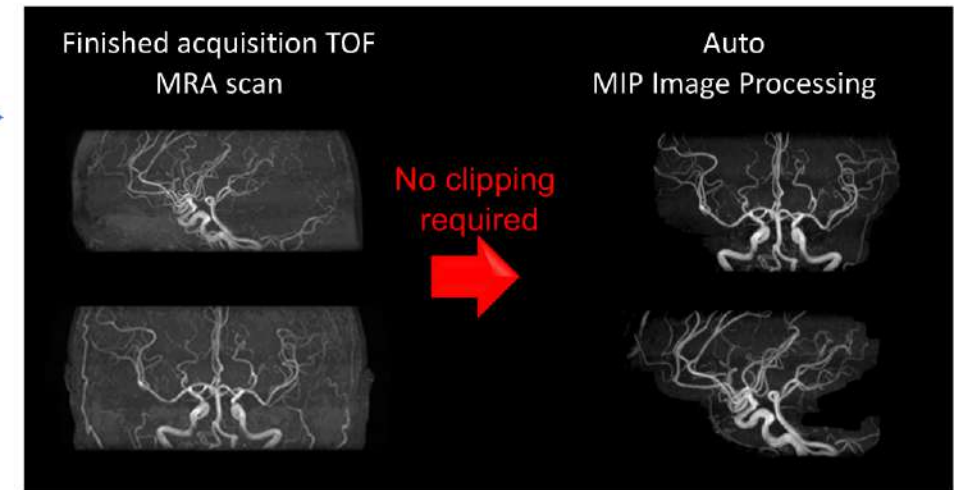
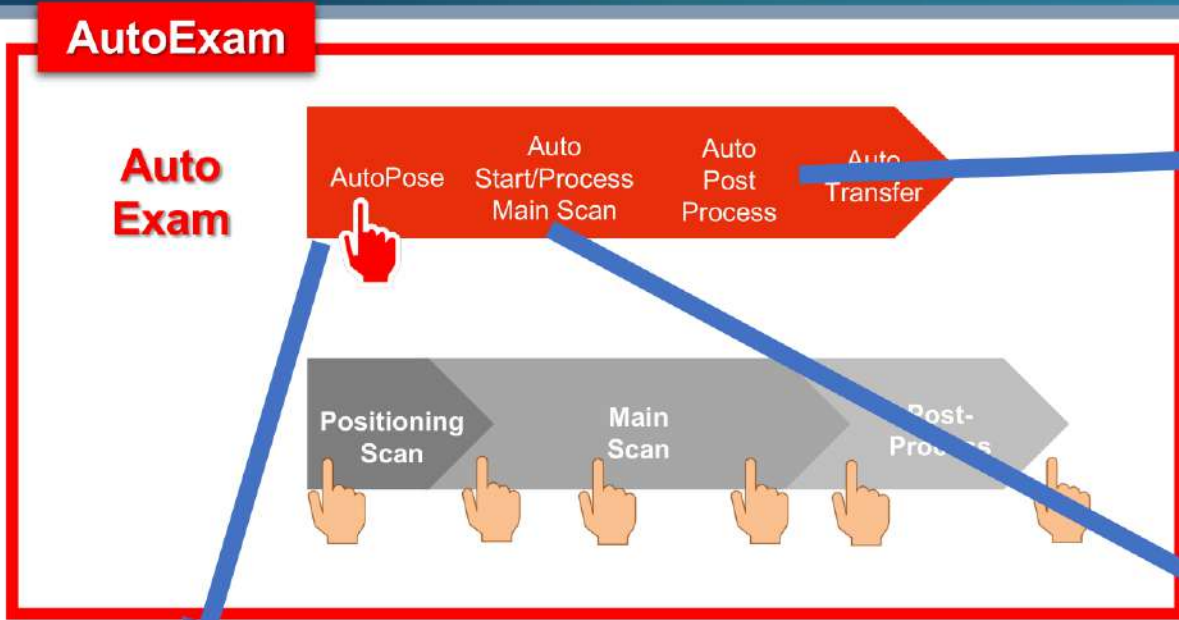


AutoPose Brain  
multiplane setting, up to 5 different planes can be preset

AC-PC line    OM line    For MRA    For hippocampus    For pituitary gland



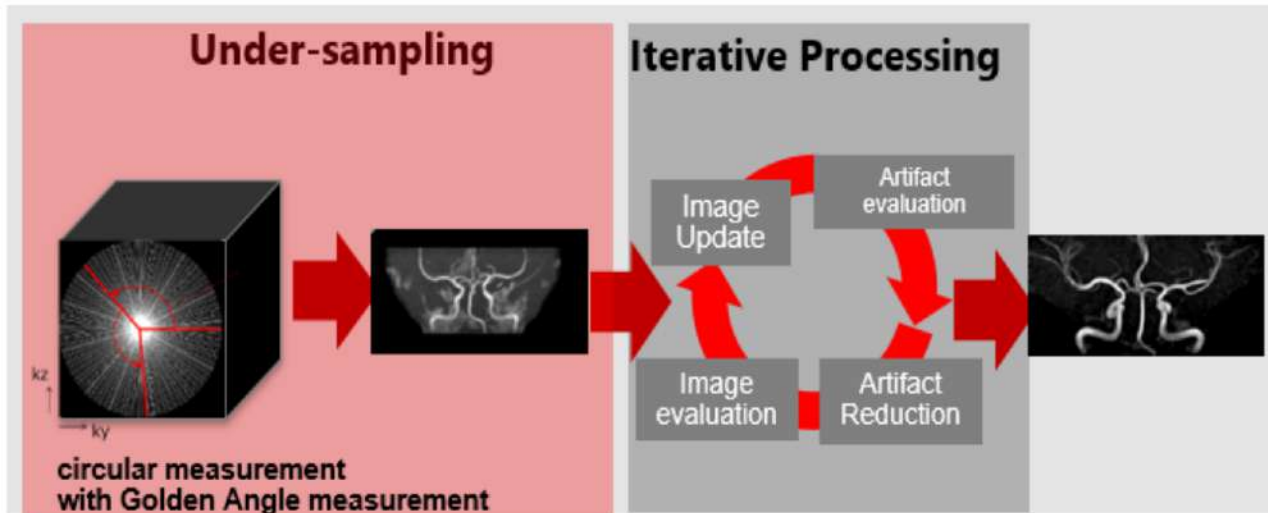
# AutoExam – Single Click Brain Study



**Synergy Drive:** Speeding up standard examinations at all levels

- **AutoExam**      automated workflow from positioning to transfer
- **IP RAPID**      faster/higher quality image acquisition

## IP RAPID Scan

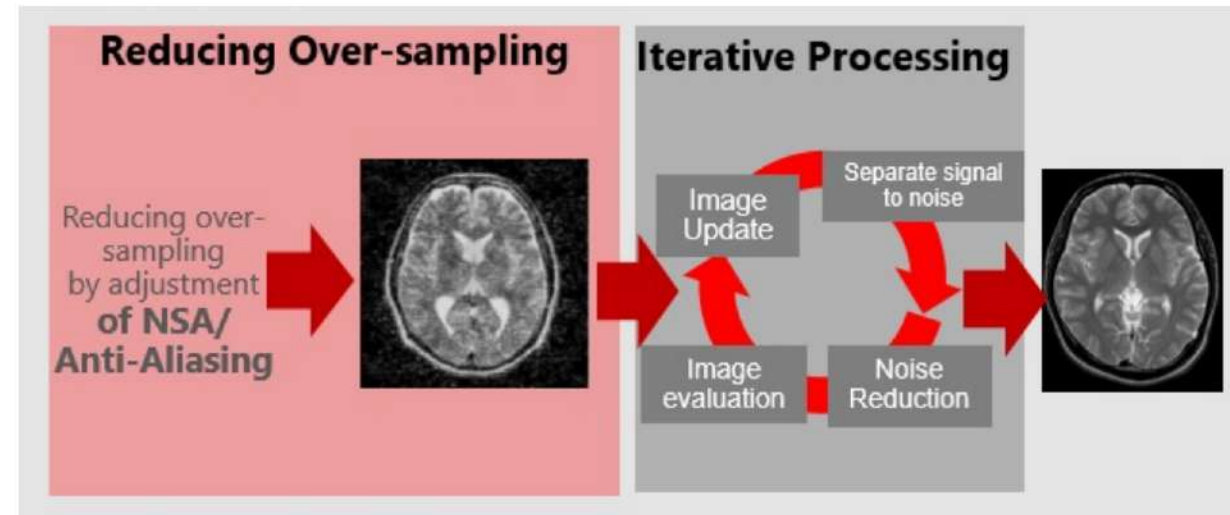


for 3D TOF sequence

data under-sampling using circular and Golden Angle measurement

iterative Reconstruction (Artifact reduction)

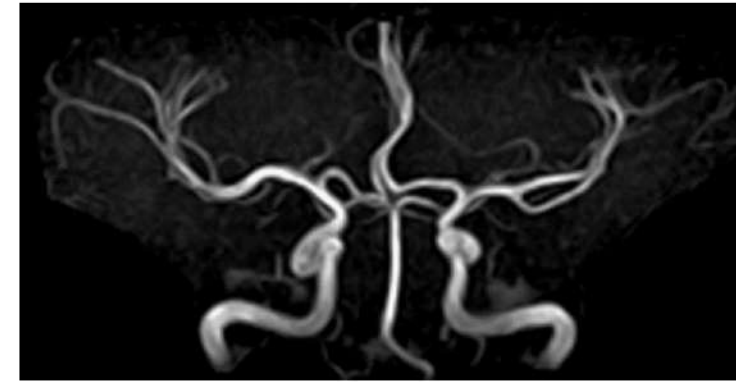
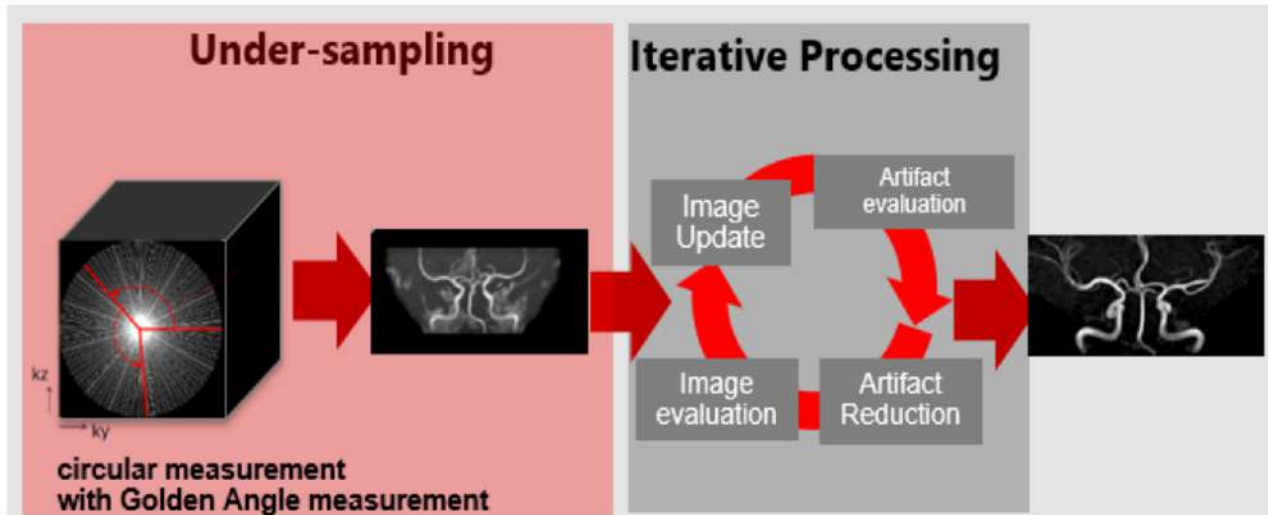
## IP RAPID Recon for 2D sequences



reducing data over-sampling, NSA, anti-aliasing  
iterative reconstruction (noise reduction)



## IP RAPID Scan



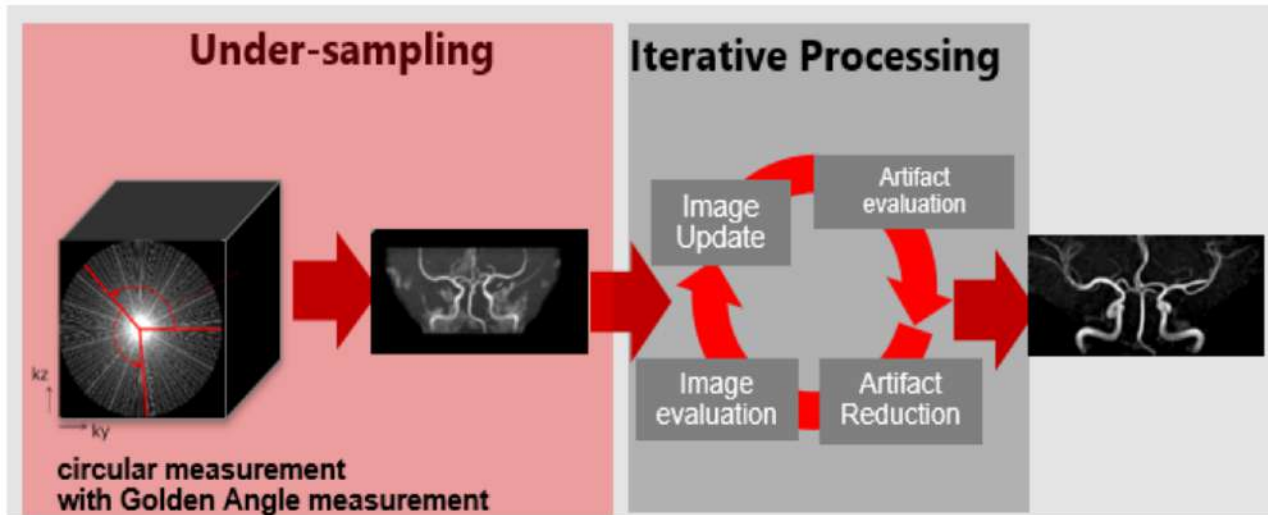
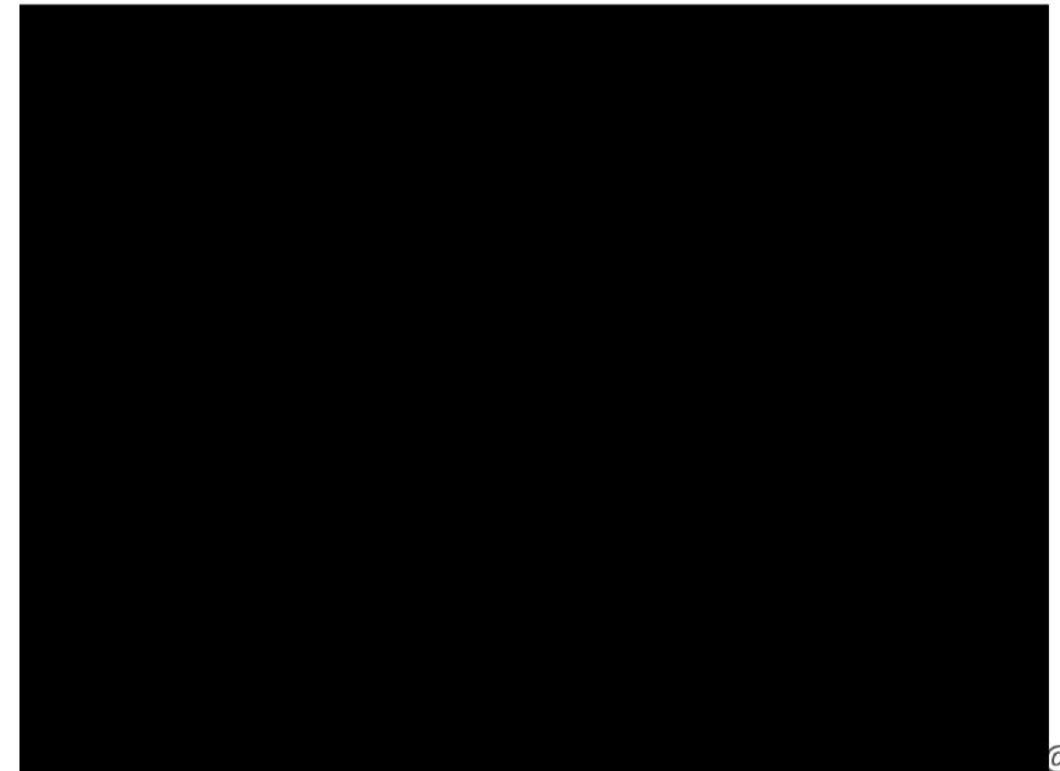
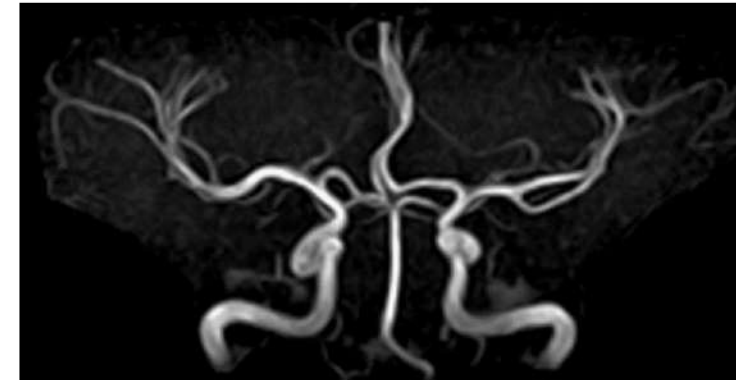
standard TOF-MRA 9:53 min.

for 3D TOF sequence

data under-sampling using circular and Golden Angle measurement

iterative Reconstruction (Artifact reduction)

## IP RAPID Scan



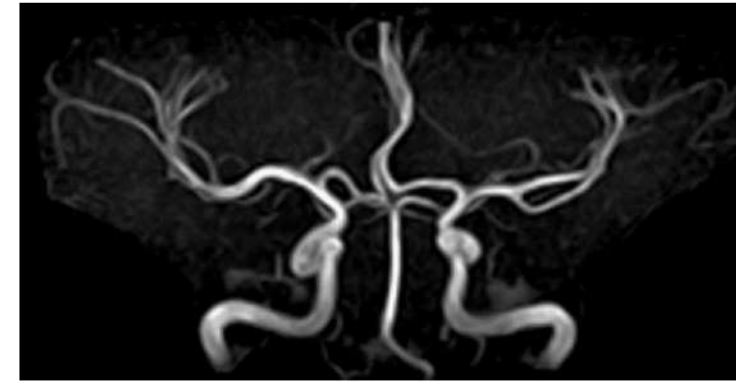
for 3D TOF sequence

data under-sampling using circular and Golden Angle measurement

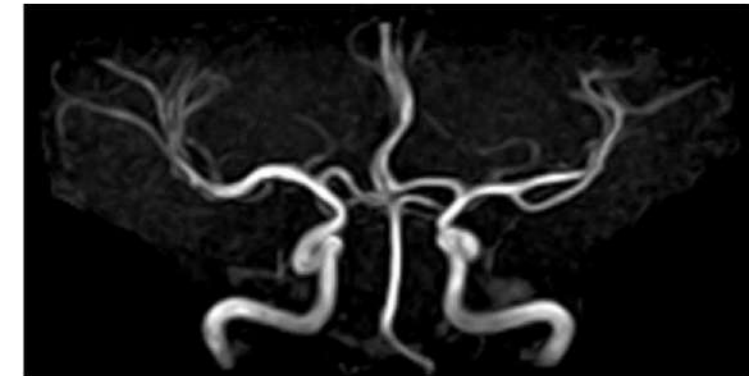
iterative Reconstruction (Artifact reduction)

# IP RAPID: Saving Time with iterative Processing

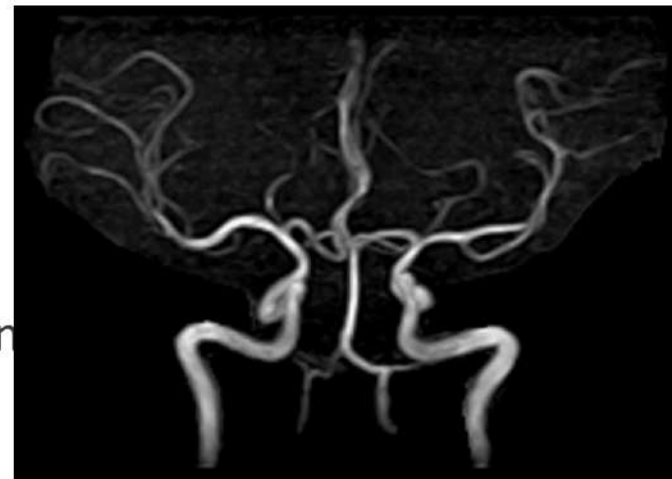
## IP RAPID Scan



standard TOF-MRA 9:53 min.



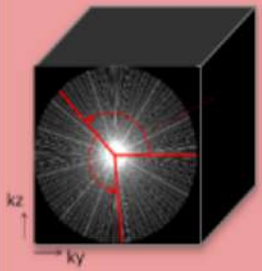
IP RAPID MRA 5:58 min.



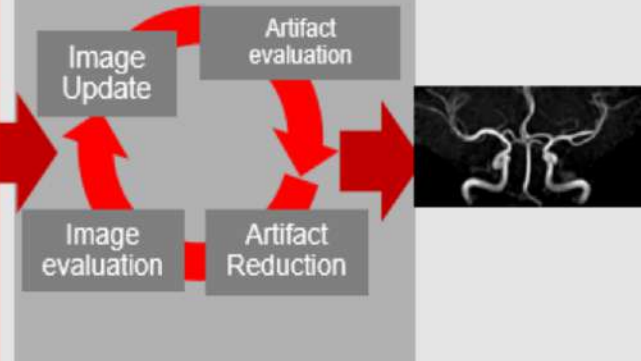
IP-RAPID wide range scan  
9:40 min.

### Under-sampling

### Iterative Processing



circular measurement  
with Golden Angle measurement

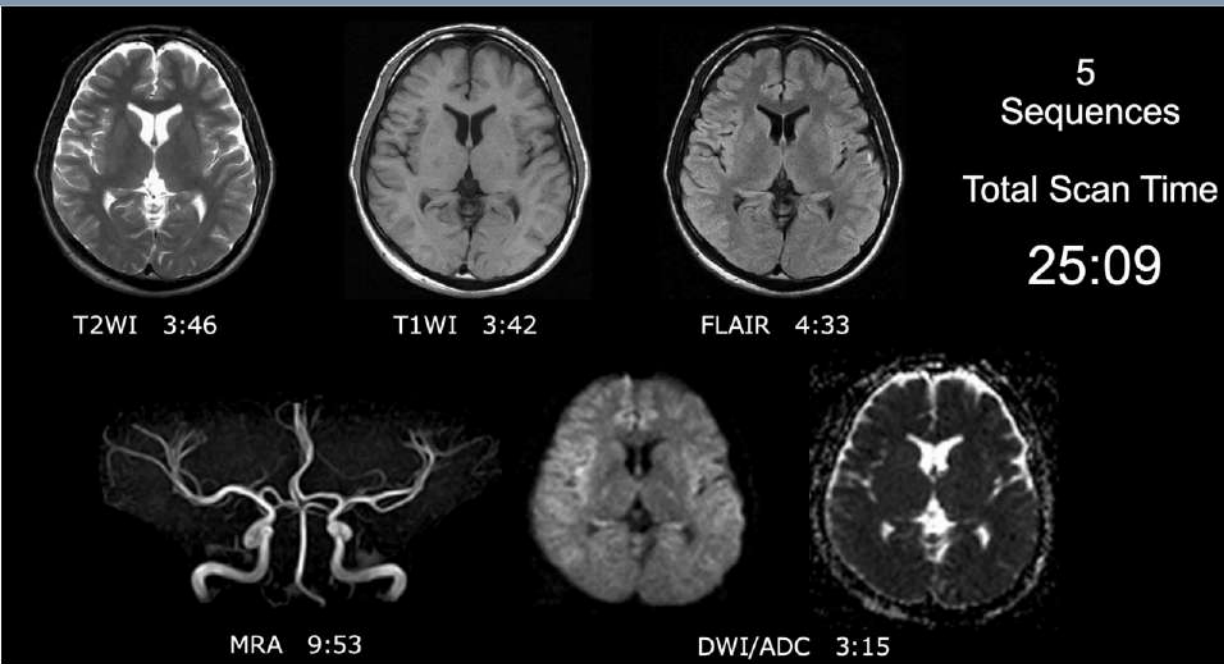


for 3D TOF sequence

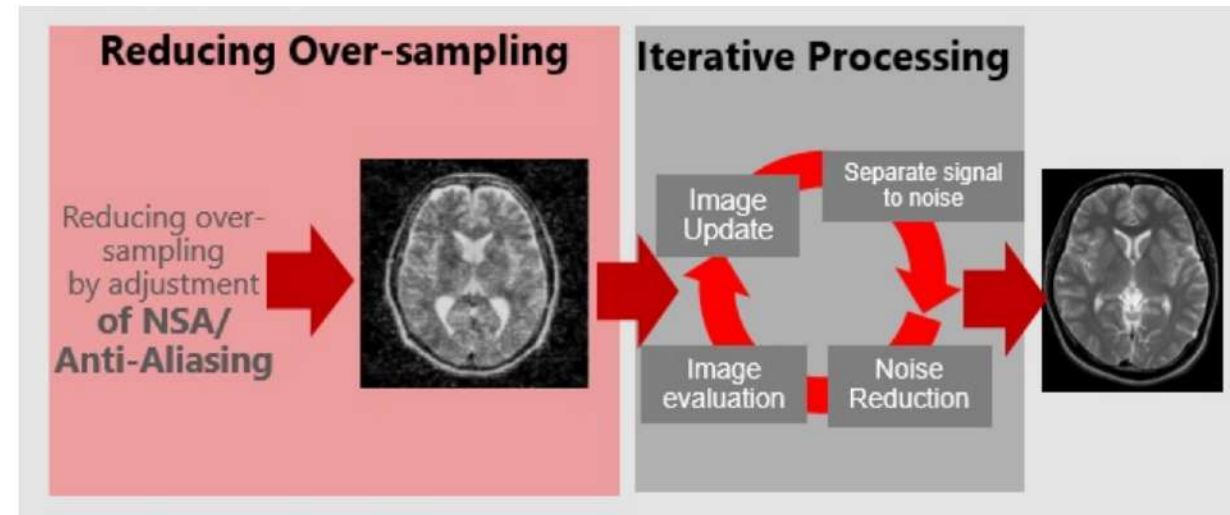
data under-sampling using circular and  
Golden Angle measurement

iterative Reconstruction (Artifact reduction)

# IP RAPID: Saving Time with iterative Processing

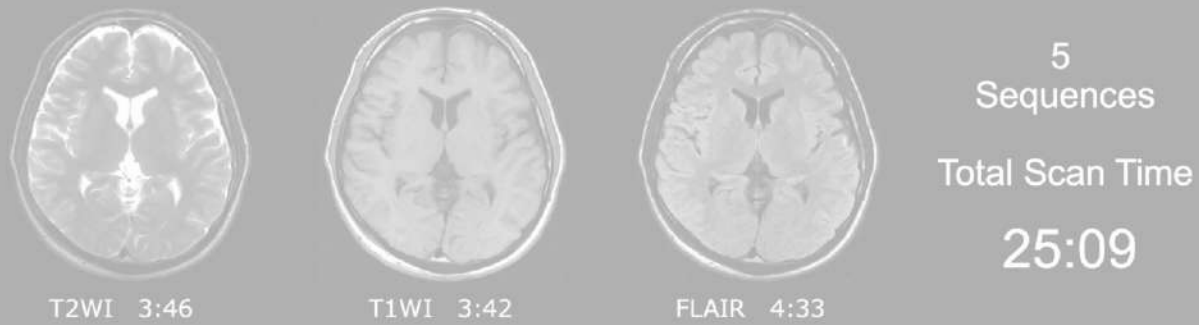


## IP RAPID Recon for 2D sequences



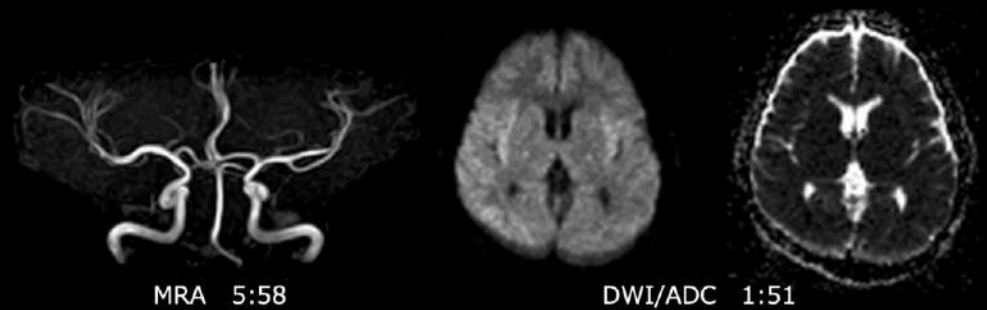
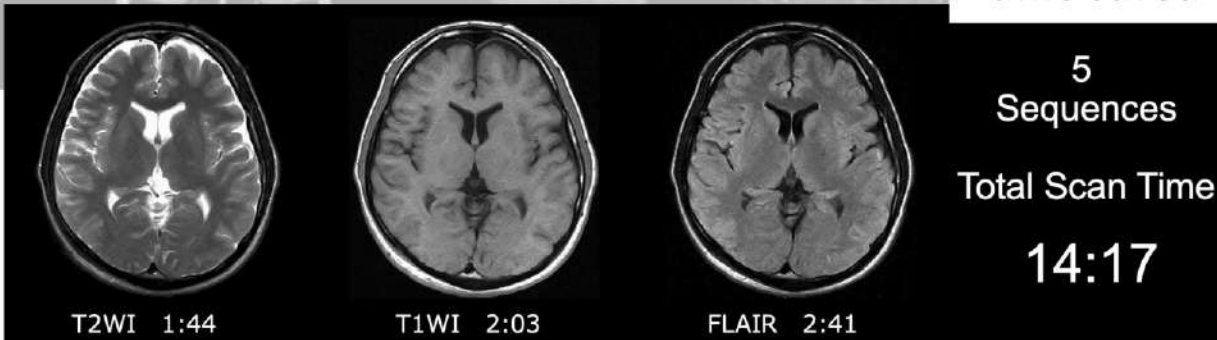
reducing data over-sampling, NSA, anti-aliasing  
iterative reconstruction (noise reduction)

# IP RAPID: Saving Time with iterative Processing

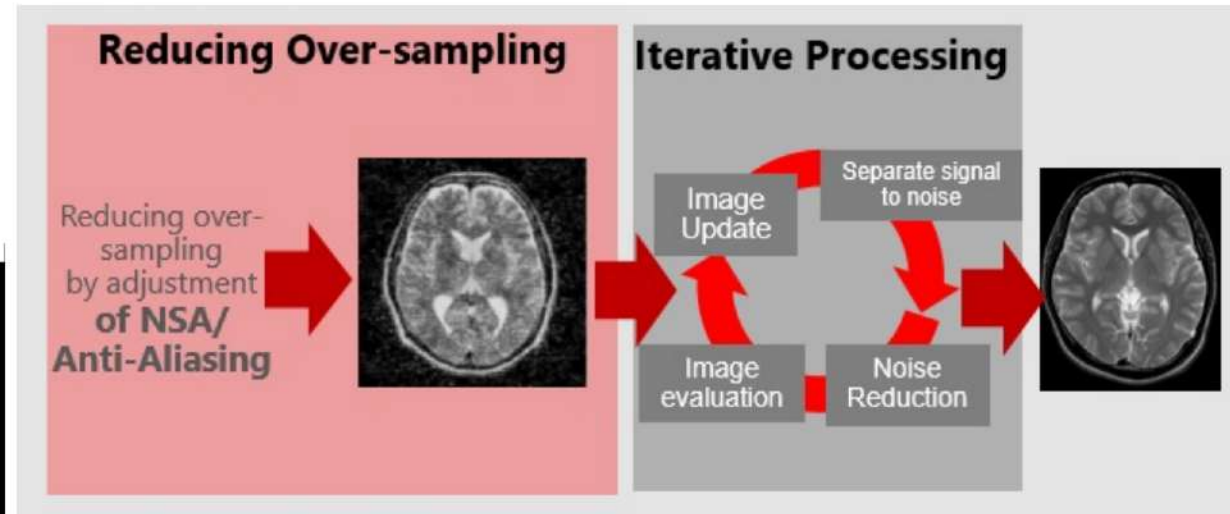


**43%**

time saved



## IP RAPID Recon for 2D sequences



reducing data over-sampling, NSA, anti-aliasing  
iterative reconstruction (noise reduction)

# IP RAPID: Saving Time with iterative Processing

## ROUTINE BRAIN SCAN

with  
IP-RAPID



  
**3 cases**  
per hour

without  
IP-RAPID



  
**2 cases**  
per hour

Faster scanning ...

# IP RAPID: Saving Time with iterative Processing

## ROUTINE BRAIN SCAN

with  
IP-RAPID



  
**3 cases**  
per hour

without  
IP-RAPID



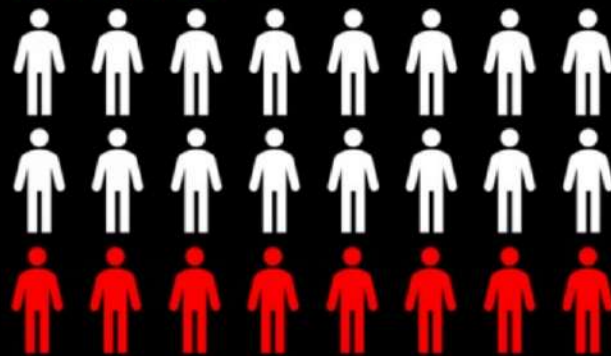
  
**2 cases**  
per hour

Faster scanning ...

... translated into more  
patients per day

### PATIENTS PER DAY

with IP-RAPID



**24 cases**

20 min per case for 8 working hours

### PATIENTS PER DAY

without IP-RAPID



**16 cases**

30 min per case for 8 working hours

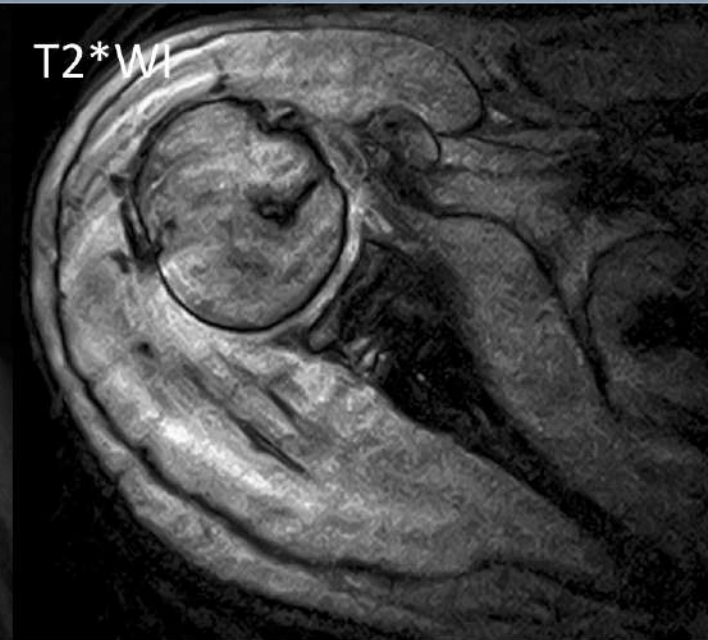
**Synergy Drive:** Speeding up standard examinations at all levels

- **AutoExam**      automated workflow from positioning to transfer
- **IP RAPID**      faster/higher quality image acquisition
- **All AroundRADAR**      smart motion correction with RADAR



# All Around RADAR

standard Scan



# All Around RADAR

standard Scan

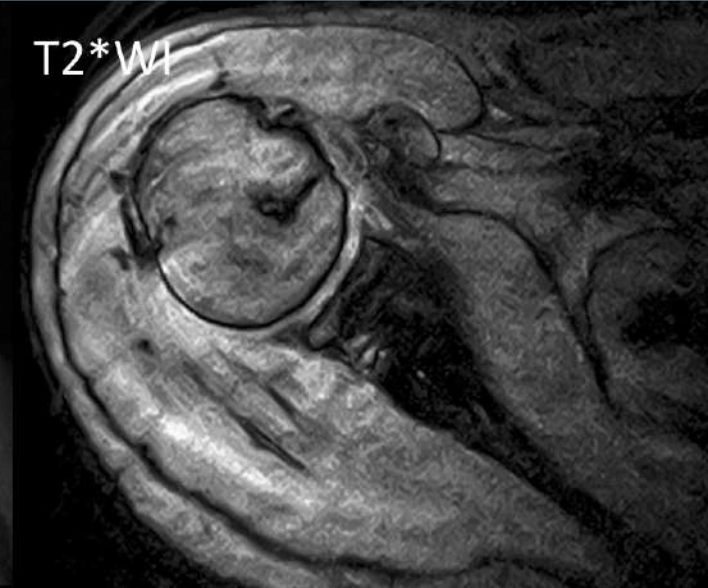
T2WI



T1WI



T2\*WI



motion robust Scan  
with **RADAR**

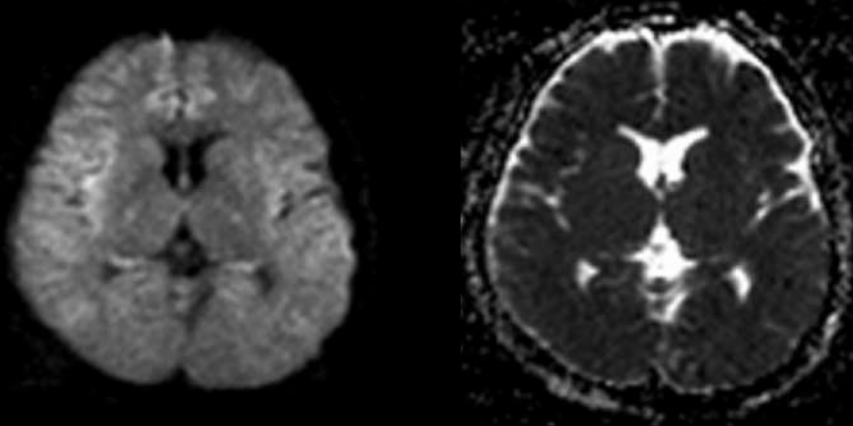


- Synergy Drive:** Speeding up standard examinations at all levels
- **AutoExam** automated workflow from positioning to transfer
  - **IP RAPID** faster/higher quality image acquisition
  - **All AroundRADAR** smart motion correction with RADAR
  - **Single Shot DWI** fast – robust – no gating required

# Single Shot DWI – without Gating

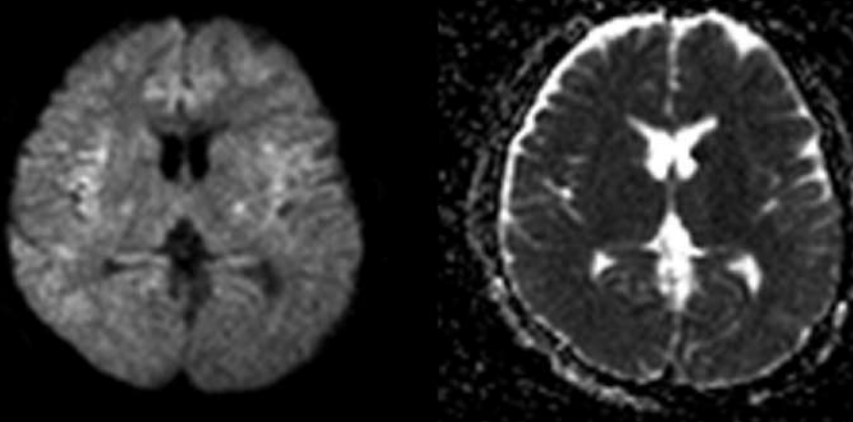


Lucent



DWI/ADC 3:15

Vento



DWI/ADC 3:15

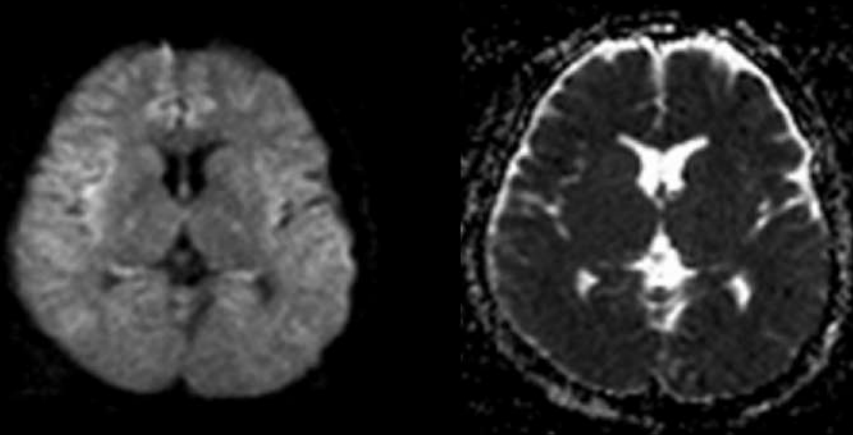
Current MRP Multi Shot



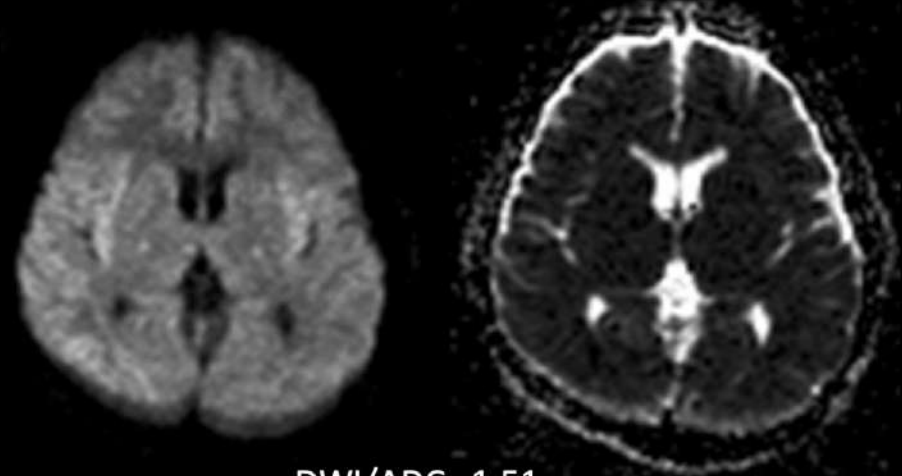
# Single Shot DWI – without Gating



Lucent

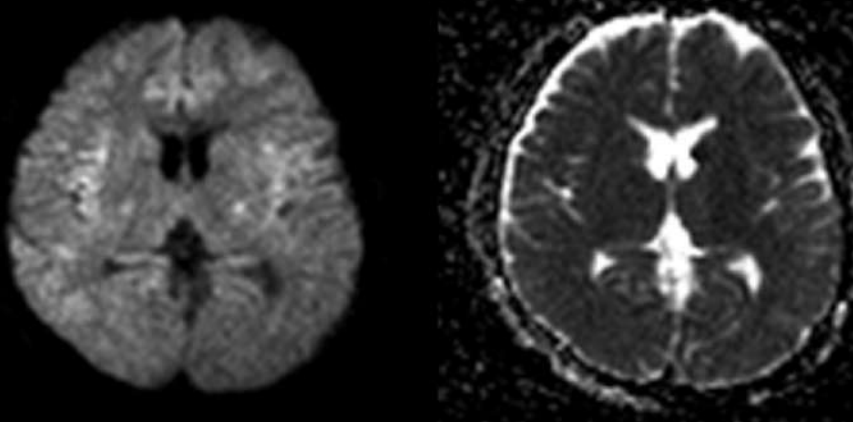


DWI/ADC 3:15

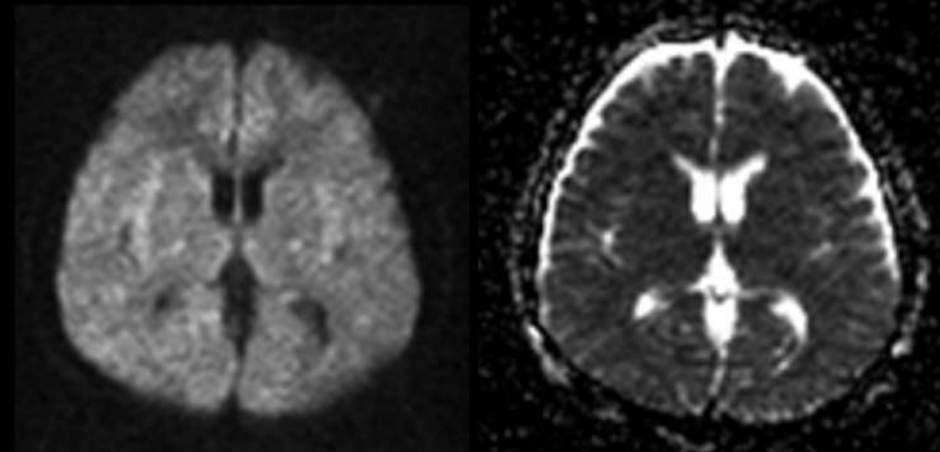


DWI/ADC 1:51

Vento



DWI/ADC 3:15



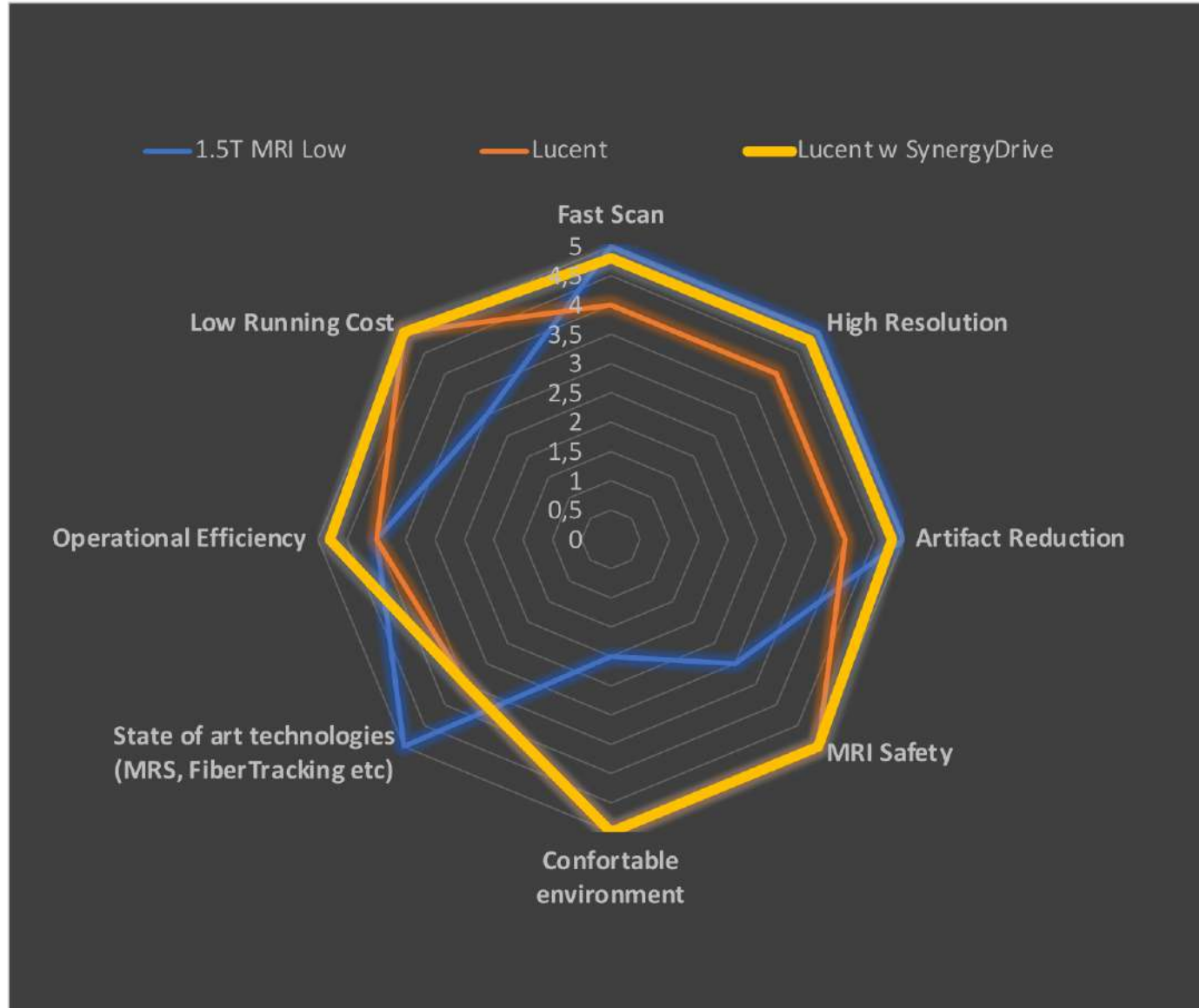
DWI/ADC 1:51

Current MRP Multi Shot

Single Shot



# Synergy Drive ... a clear **Plus!** for your System



## A Total Workflow Solution

### shorter Scan Time

#### High-speed Scan

IP-RAPID (IP-Scan, IP-Recon)  
Single-shot DWI

### simplified Operation

#### Operation Automation

AutoExam Brain  
AutoPose Brain  
AutoClip

#### Operation Support

Parameter suggestion  
AutoVoice

### less Exam Process

#### easy Setting

Non-gating with Single-shot DWI

## **Economic Perspective**

limited investment  
low running costs  
new patients attracted  
less examinations aborted

## **Clinical Needs**

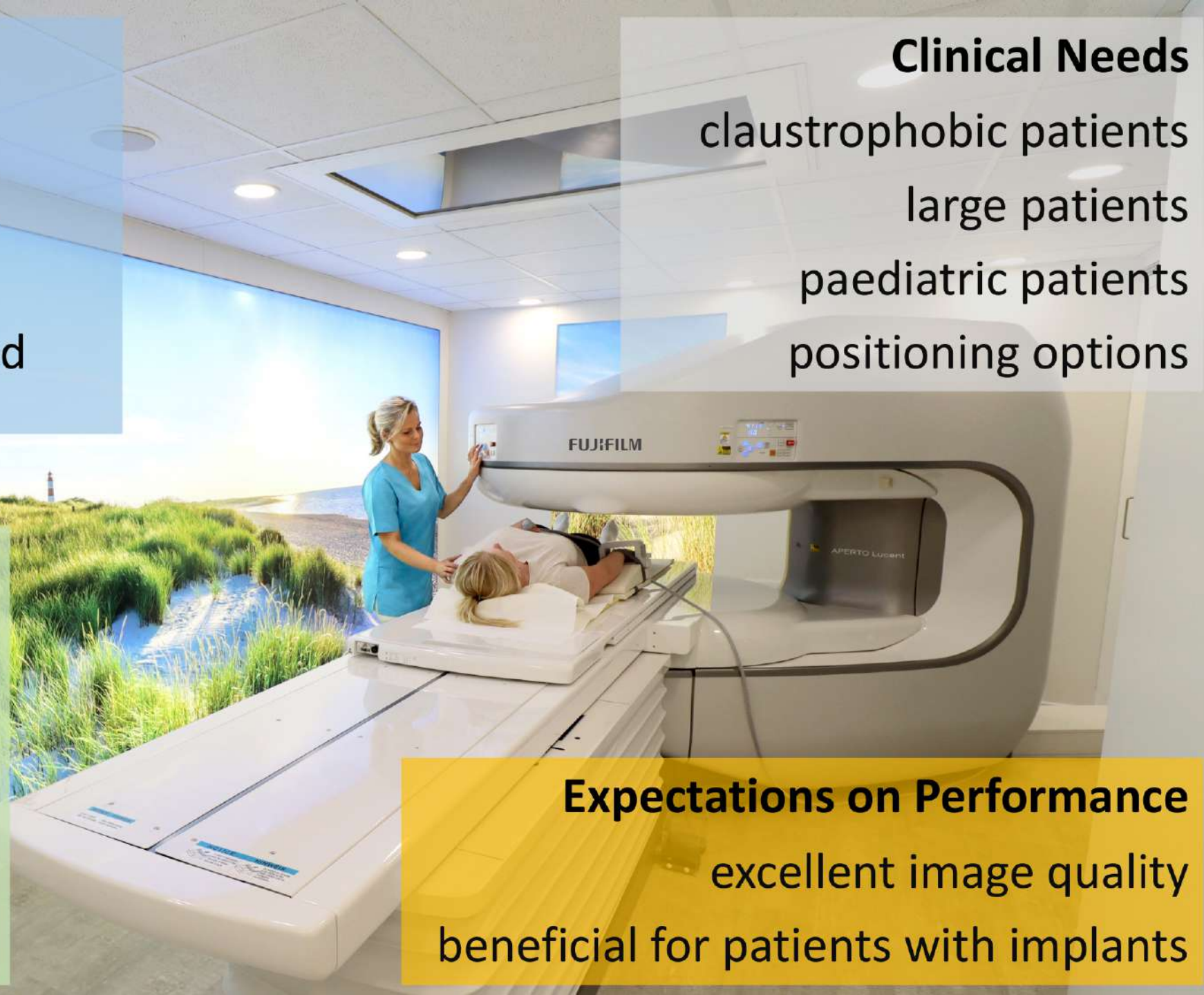
claustrophobic patients  
large patients  
paediatric patients  
positioning options

## **Patient Perspective**

pleasant setting  
spacy, open system  
“no tunnel”  
comfortable positioning  
less noise

## **Expectations on Performance**

excellent image quality  
beneficial for patients with implants





Obrigado pela vossa atenção!