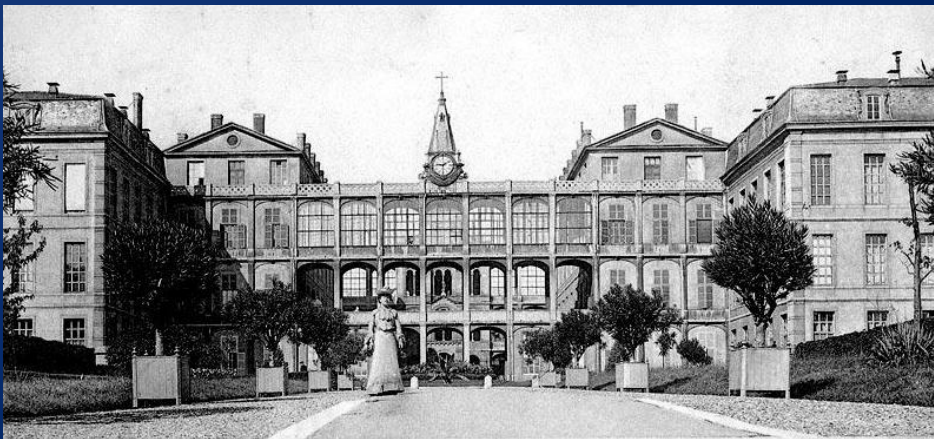


# Algorithmes de réduction des artefacts métalliques en TDM (OMAR / Philips) et en IRM (SEMAC / Siemens)

*Dr Fabien Craighero, PH hopital de la Croix Rousse  
Remerciements au Pr Loïc Bousset, au Dr Sebastien Chomel (clinique Protestante) et à Philips*



# IRM

Algorithme SEMAC  
(SIEMENS)



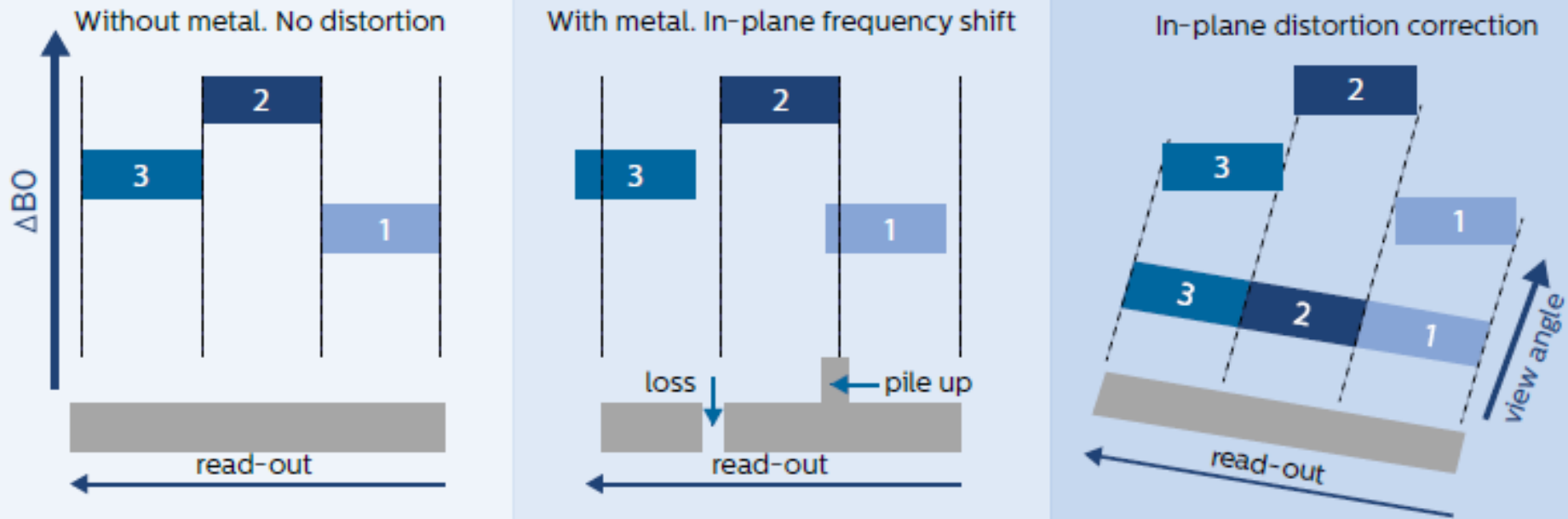
# Les contraintes du métal dans l'IRM

- ◎ **Distorsion du champ magnétique** (fonction du type d'implants, de l'épaisseur du métal et de la distance à la zone d'intérêt explorée)
- ◎ **La problématique**
  - **Vide de signal par déplacement intra-voxel**
  - **Et inhomogénéité de champ**
    - Distorsion dans le plan : déplacement du pixel
    - Distorsion à travers le plan : obtention de coupes curvilignes par déviation du signal
    - **Saturation de graisse inefficace** de même que bandes de saturation

# Les solutions techniques

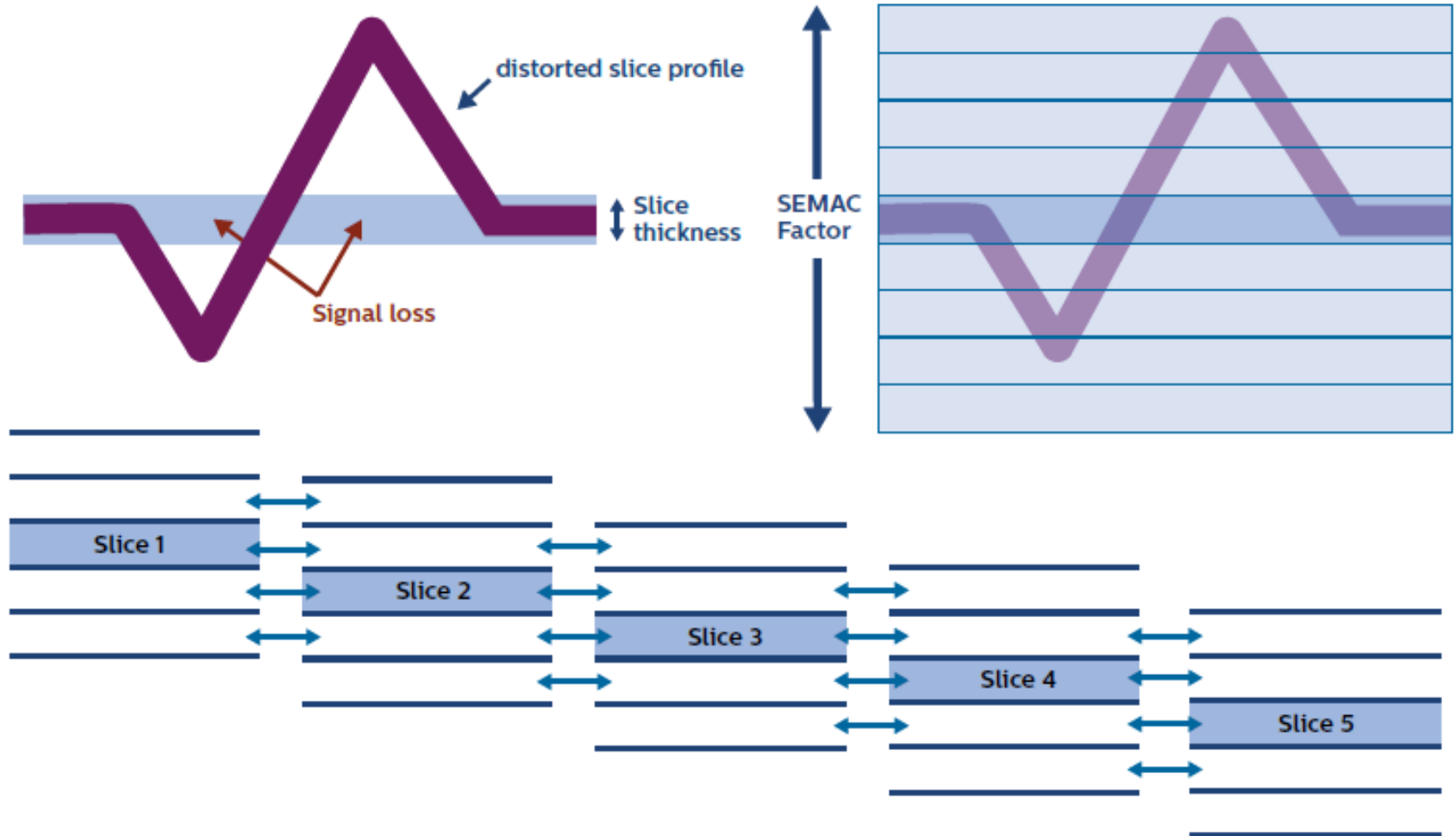
- **1.5 T > 3T**
- Séquences **Spin Echo** ou **Turbo Spin Echo**
- Séquences **en IR (STIR ++)** et non en FAT SAT
- **Nouvelles séquences (associables)**
  - ✓ **WARP**
    - VAT (view angle TILT) = réduction des artefacts dans le plan
    - Augmentation de la bande passante
  - ✓ **SEMAC** (MAVRIC) Slice encoding for metal artifact correction =réduction des artefacts dans le plan et à travers le plan (encodage de phase de chaque coupe dans les 3 plans de l'espace)

# WARP: View angle tilting



**Figure 2:** View Angle Tilting principle. In the presence of metal implants frequency shifts occur, resulting in in-plane signal loss or pile up. By tilting the readout direction using a gradient on the slice select axis during readout that is of the same amplitude as the slice select gradient, the received signals can be projected into the correct pixel of the image matrix. Although in-plane spatial distortion is considerably reduced, blurring can be introduced into the MR image.

# SEMAC



**Figure 3:** SEMAC principle: For each slice, a 3D image is formed to capture the through-plane distorted signal and map it back to its original slice location. The SEMAC factor is the number of z-phase encoding steps. Prior to the image reconstruction, data of the phase encoding steps of the different slices are processed and combined, resulting in an image corrected for through-plane distortion. Maximum through-plane correction can be obtained if the SEMAC factor is equal or larger than the number of scanned slices.

# Les contraintes d'utilisation

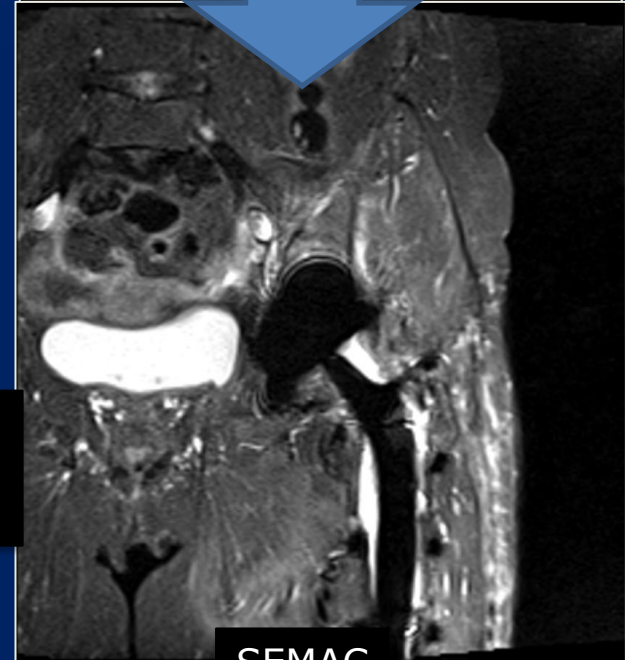
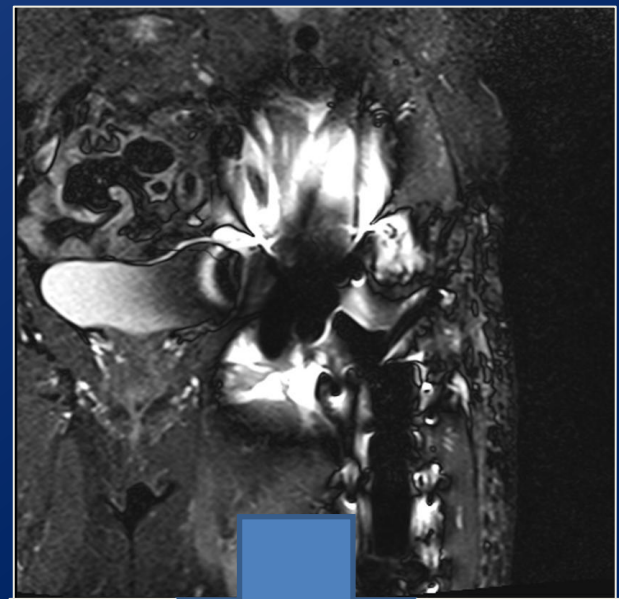
- Séquences optionnelles : coût +++
- Très longues en acquisition ( 6 à 8 minutes contre 2 à 3 sur des séquences standards)
  - Temps **X 2** voir **X 3!!** (45-60 min pour une prothèse)
- Validation par le constructeur de la compatibilité machine de sa prothèse
- Respect de **l'intervalle d'intégration tissulaire** de 6 à 8 semaines (moins si titane)



# AVANT



Artefacts métalliques sur imageurs et séquences non dédiées  
« PETAL FLOWERS »  
INEXPLOITABLE

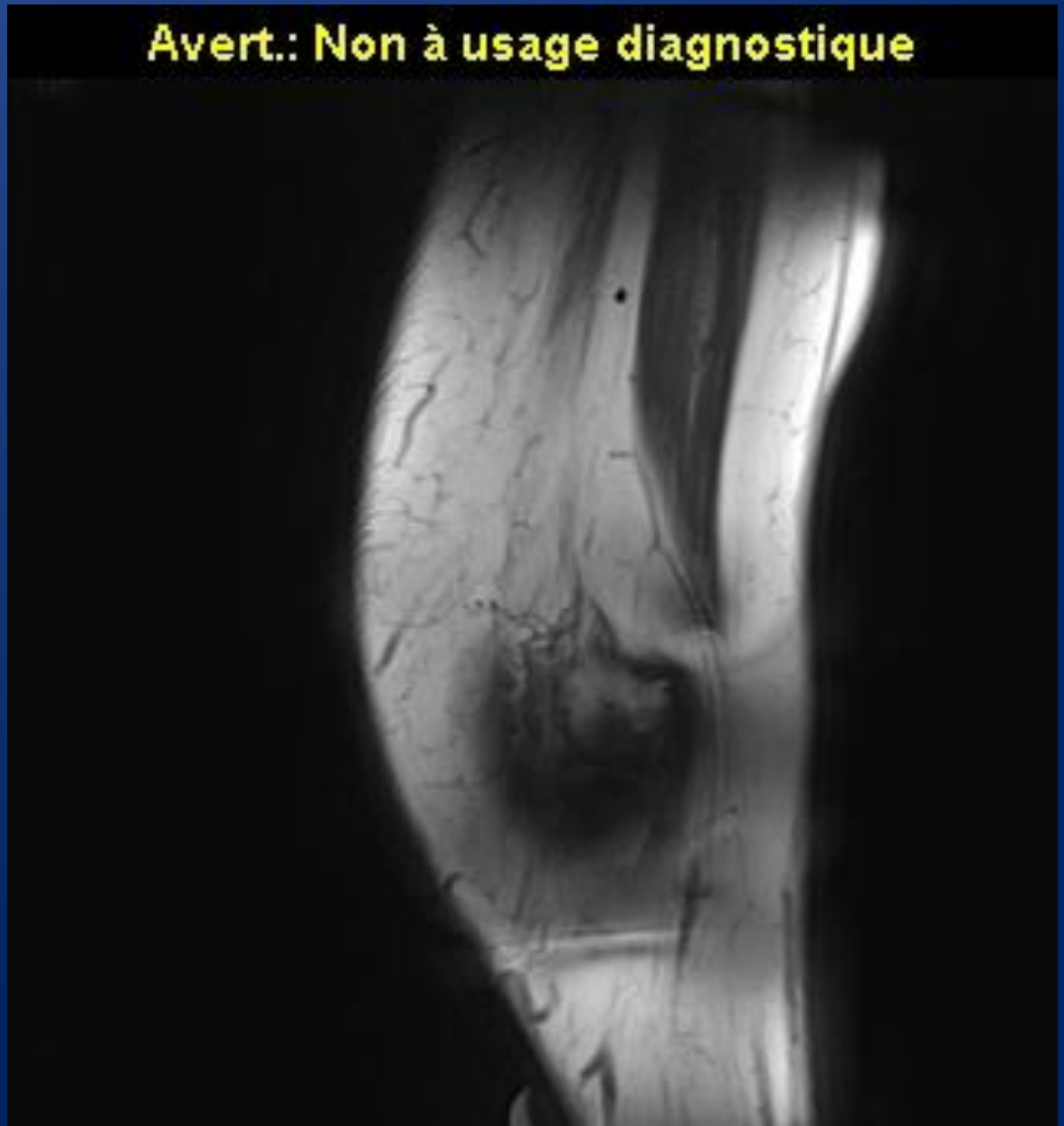


SEMAC

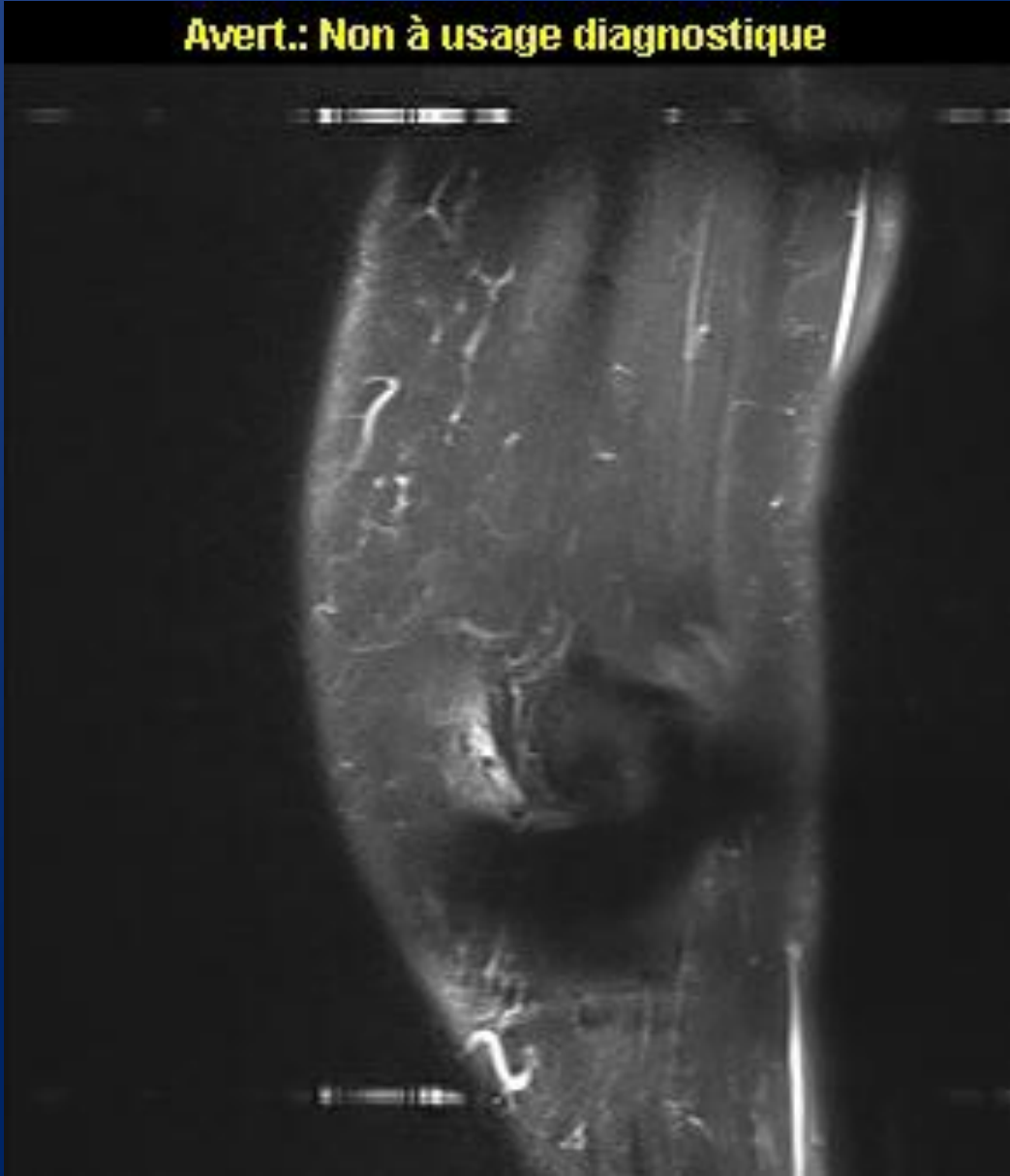


**Avert.: Non à usage diagnostique**

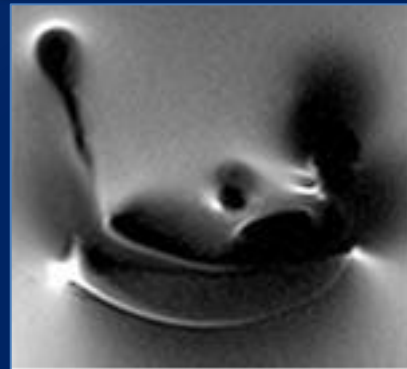
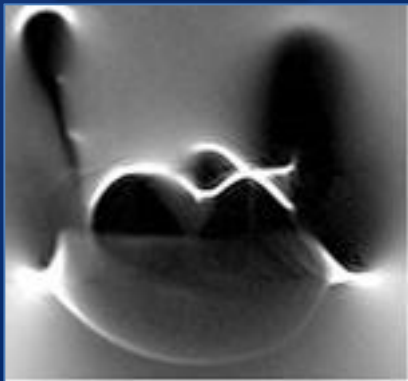
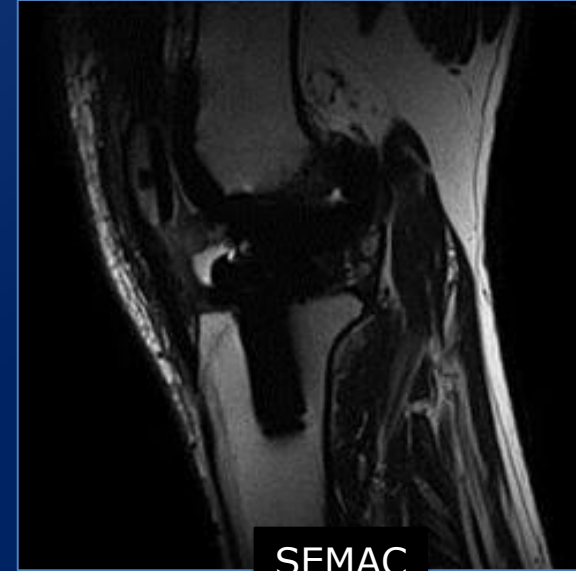
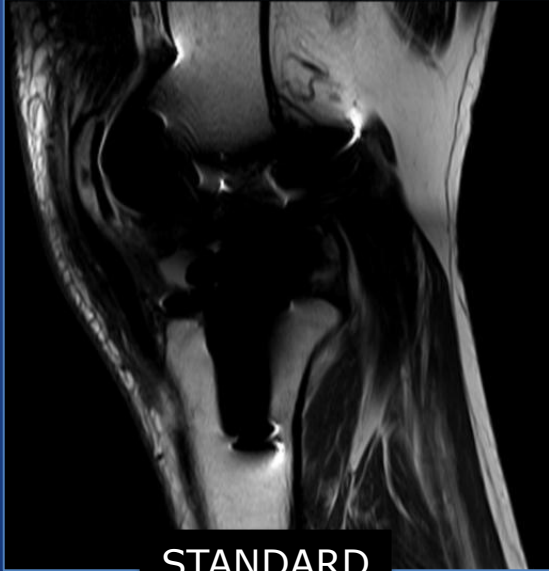
T1 SEMAC



# STIR SEMAC



# COMPARATIF

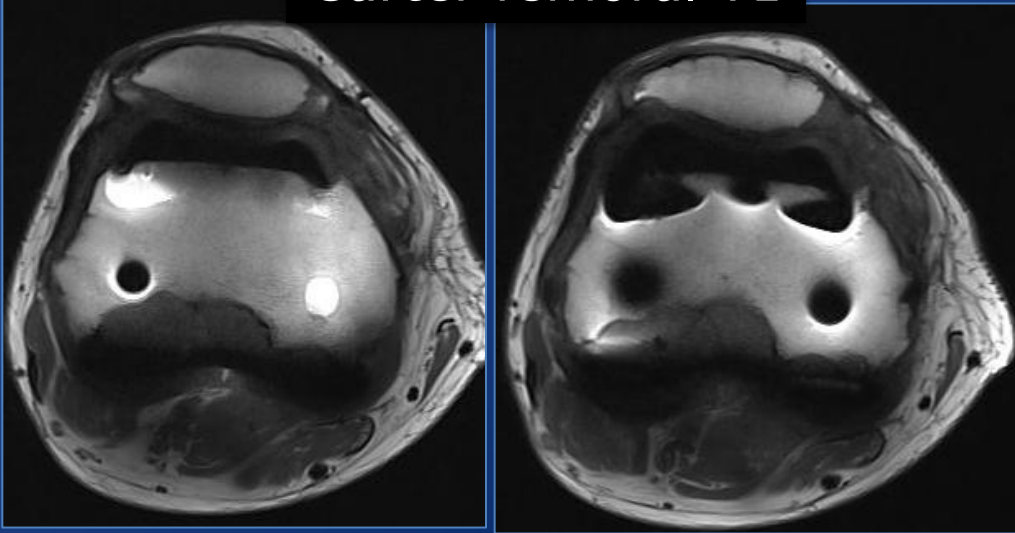


Correction du bruit métallique des séquences classiques à SEMAC  
Images SIEMENS

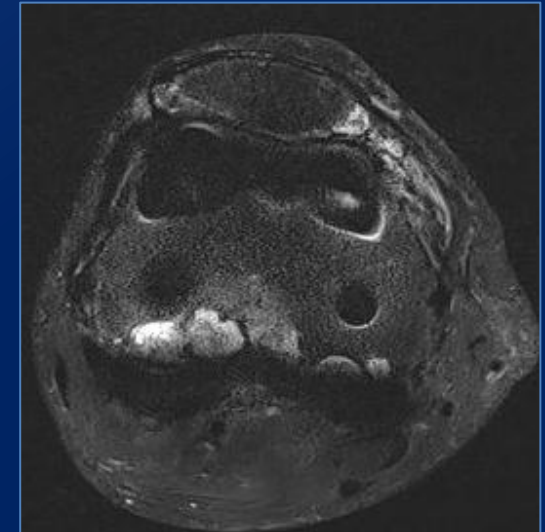
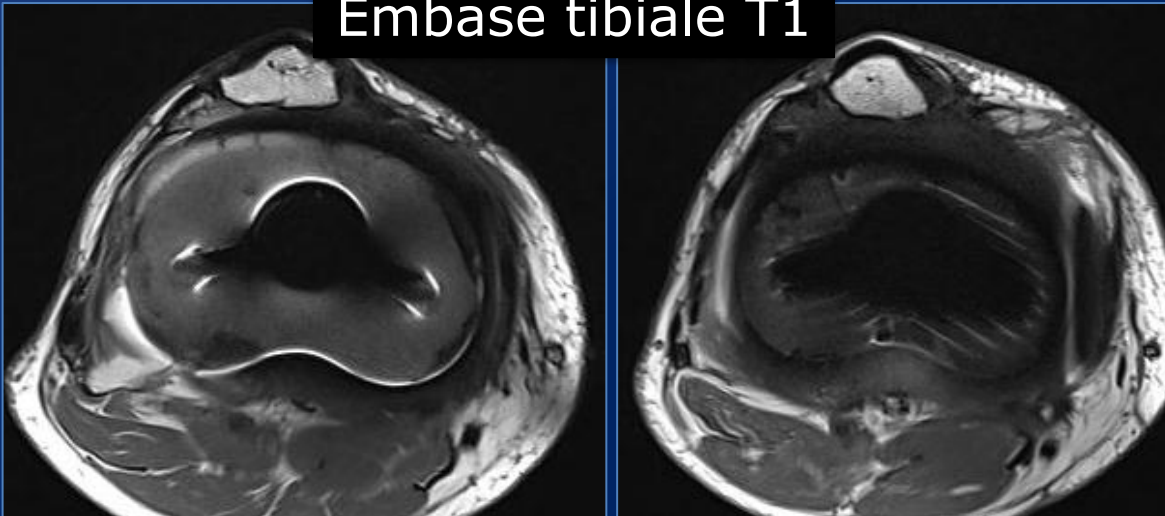
MAINTENANT

Nouvel aimant 1,5T  
Nouvelles séquences VAT WARP SEMAC

Carter fémoral T1

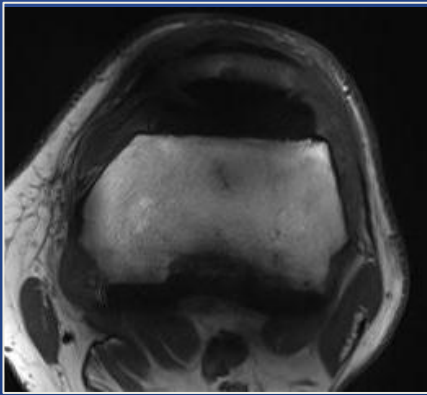


Embase tibiale T1

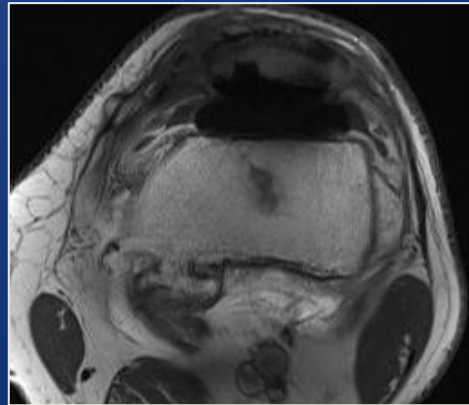


T2 STIR  
Effet scintigraphique

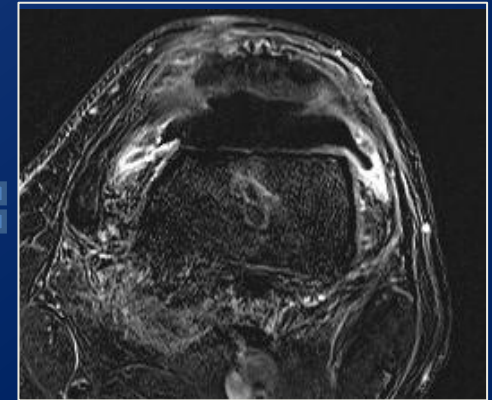
# Prise de contraste en T1



Séquence T1



Séquence T1  
Gd +



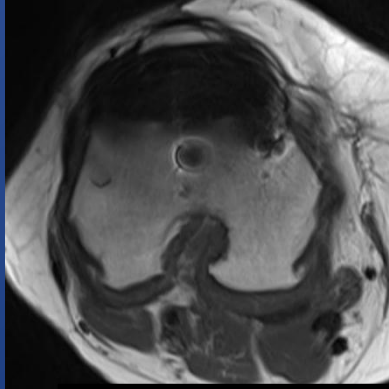
Soustraction

Technique du masque + soustraction

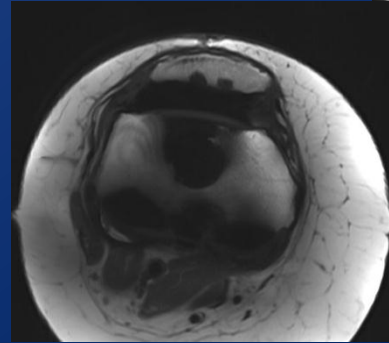
Pas de technique d'effacement de graisse  
Trop d'artefacts



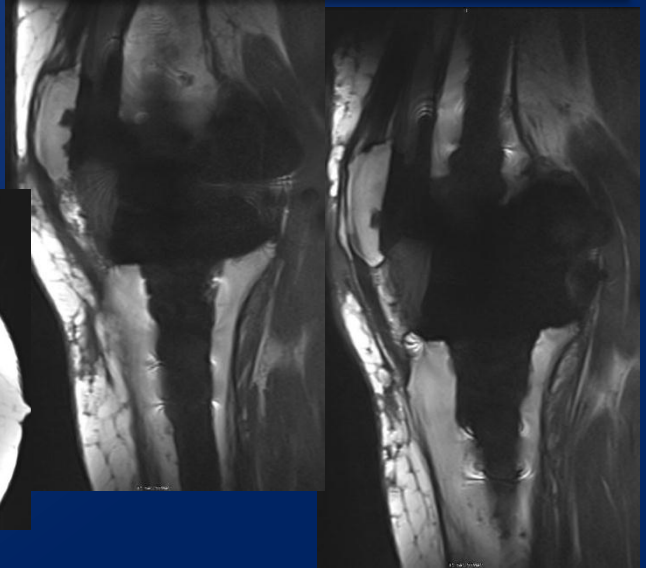
# TOUT TYPE DE PROTHESE



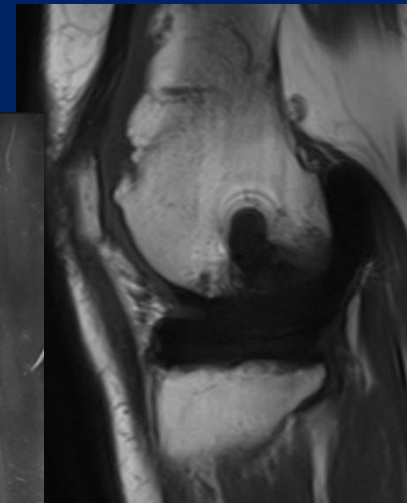
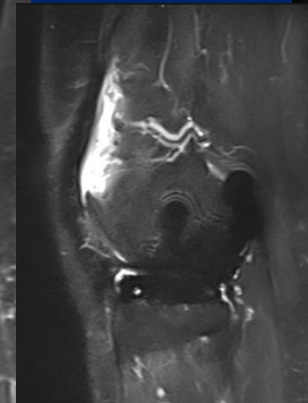
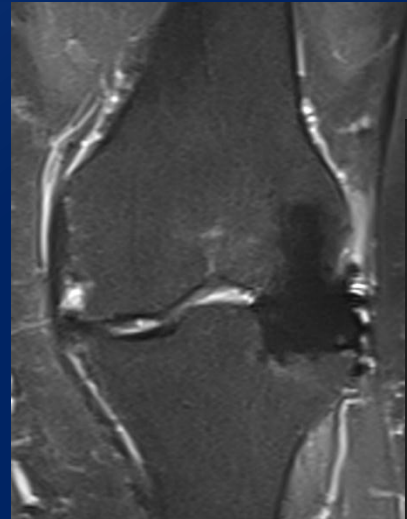
Prothèse Fémoro-patellaire



PTG tri-compartimentale  
Quilles longues

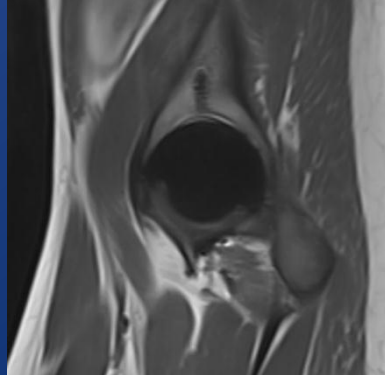
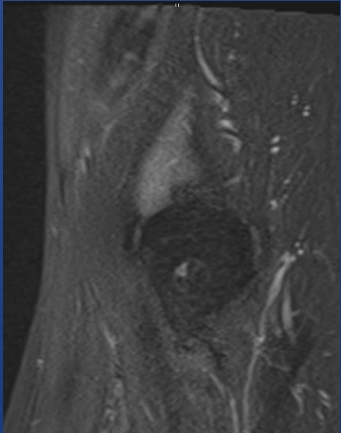


## GENOU

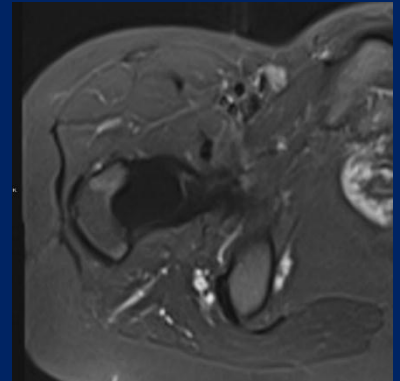
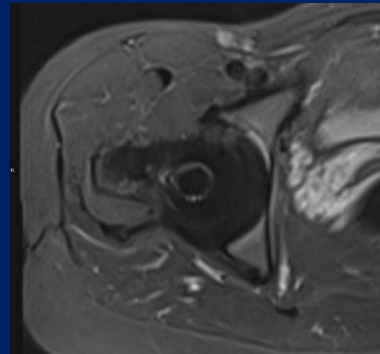
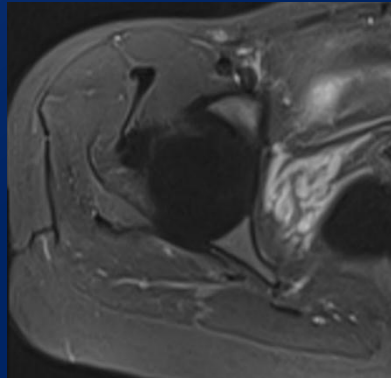
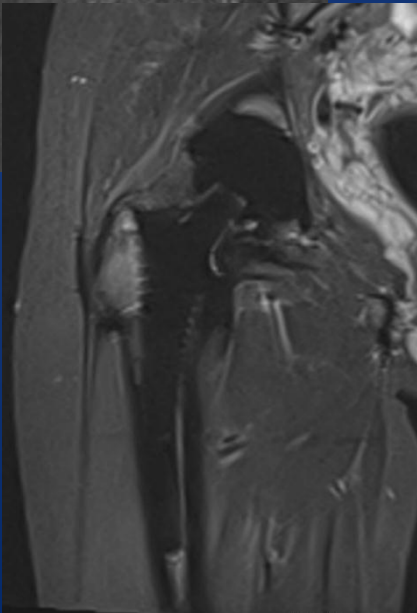


PUC latérale

# TOUT TYPE DE PROTHESE

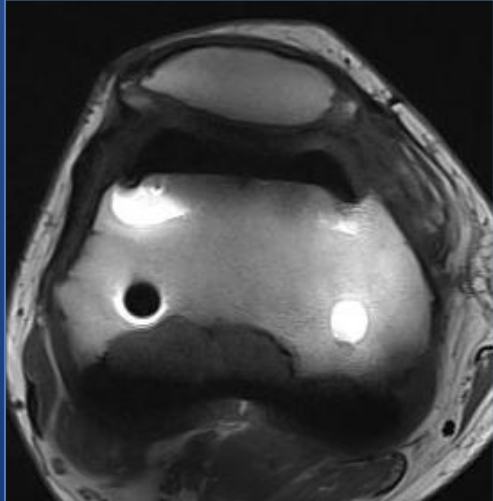


PTH

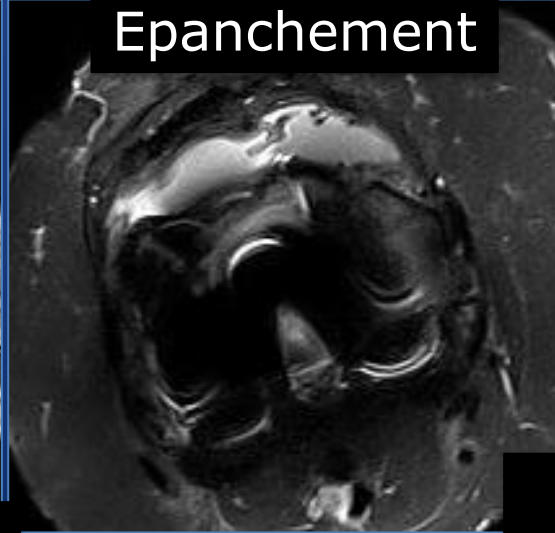




MAINTENANT



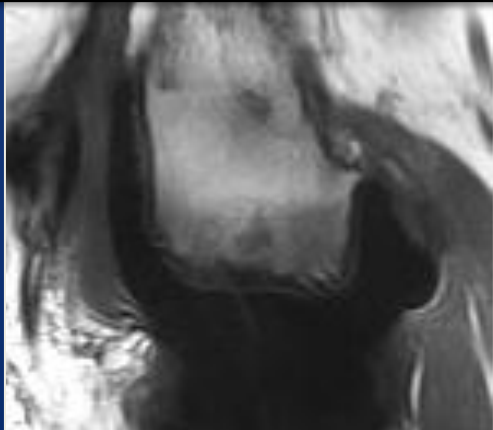
Interface os-prothèse



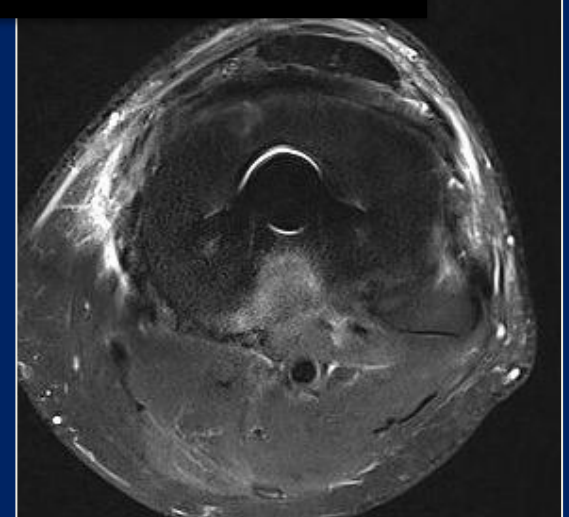
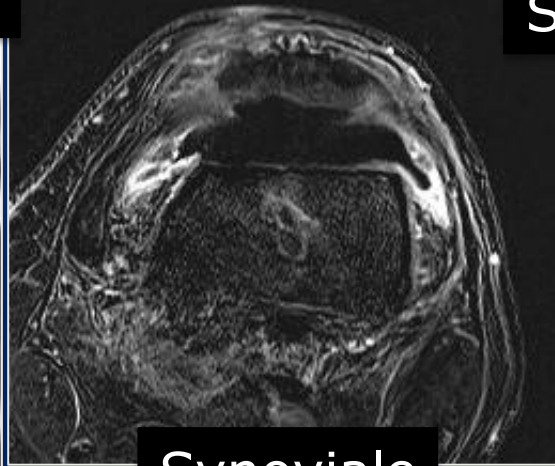
Epanchement



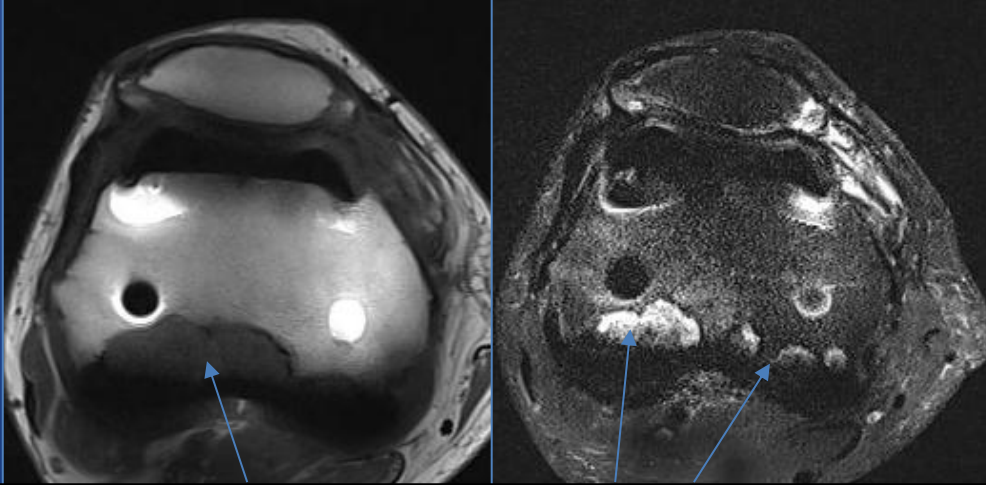
Tendons  
Système extenseur



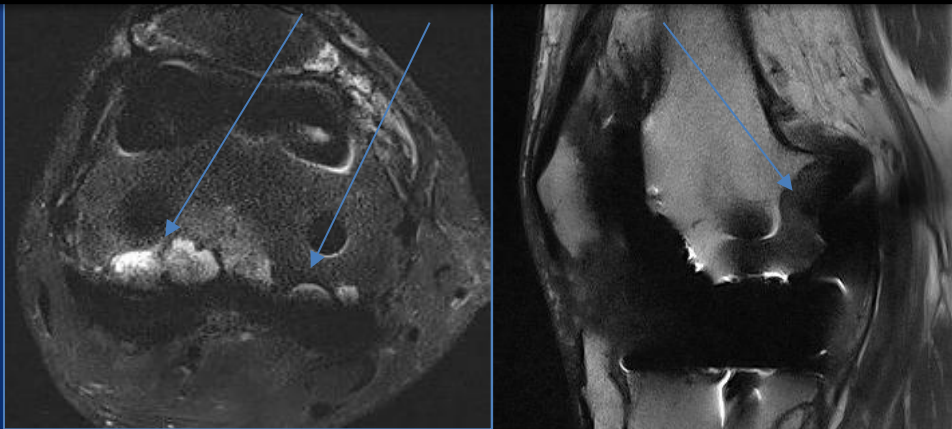
Synoviale



# Cas 1



Ostéolyse granulomateuse fémorale

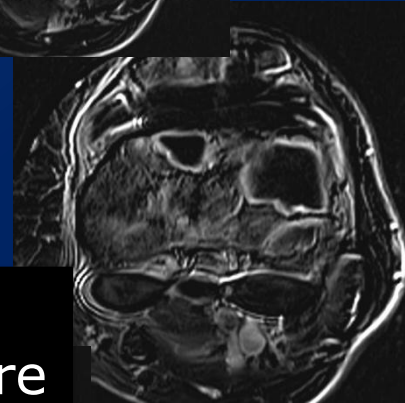
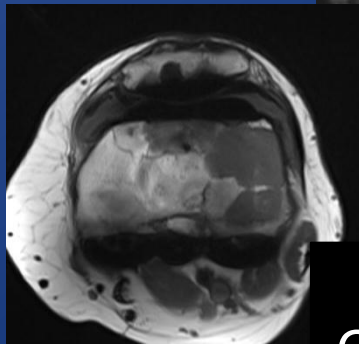
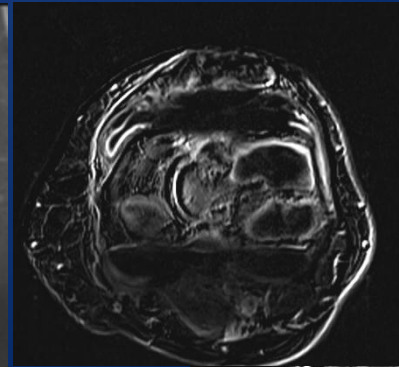
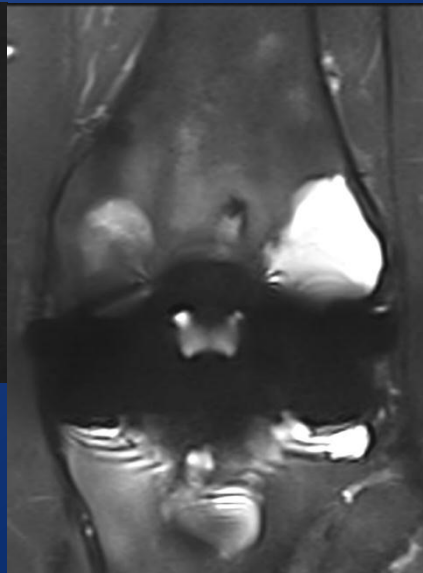
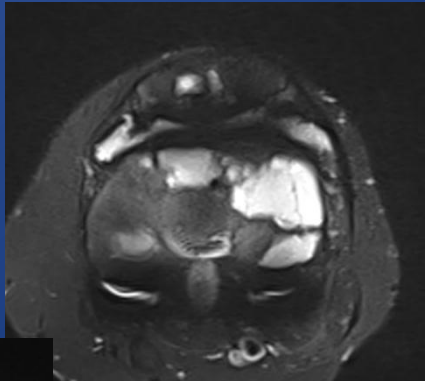


PE non visible entre les pièces métalliques

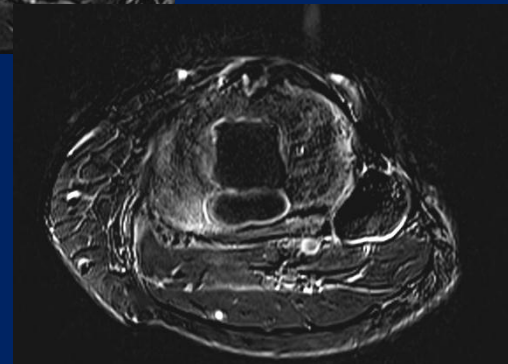
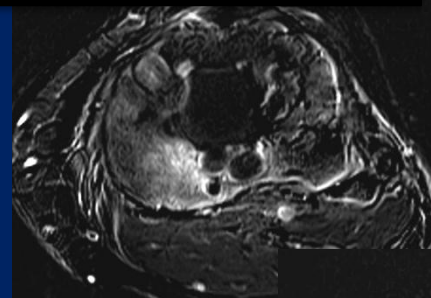
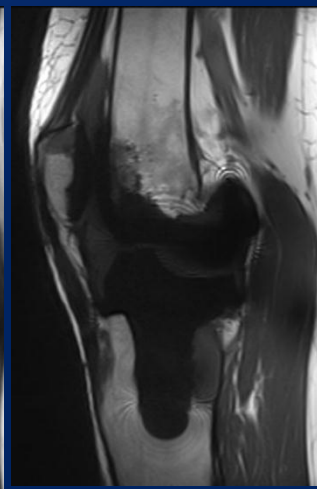
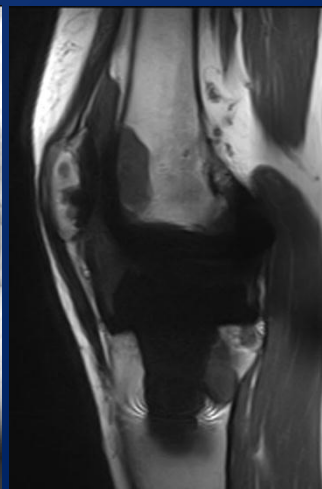
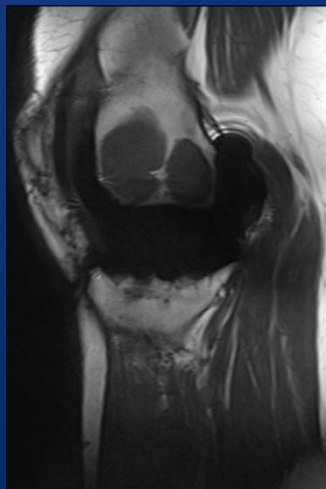


Ossification du tendon patellaire

# Cas 2

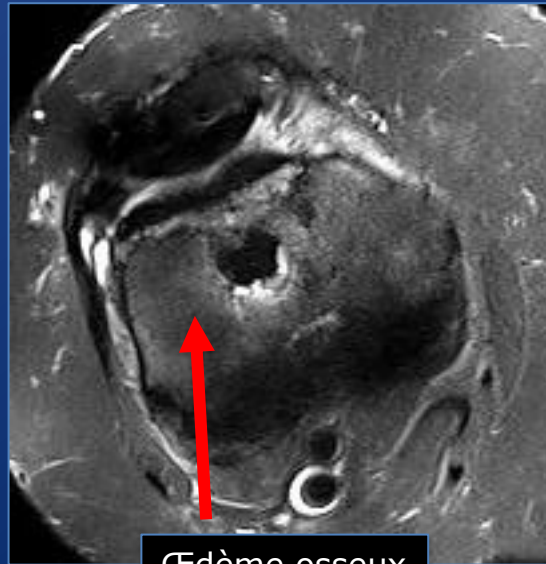
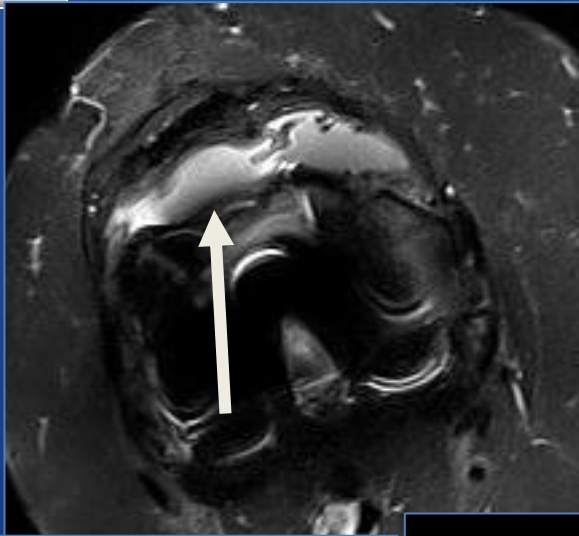


Descellement  
Ostéolyse granulomateuse multipolaire

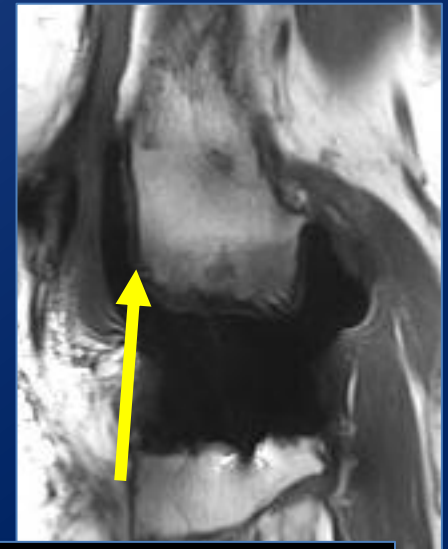




# Cas 3

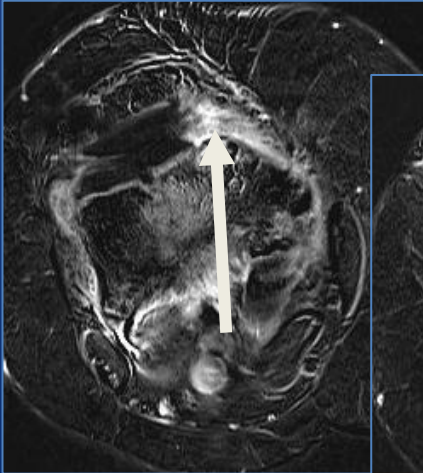


Œdème osseux

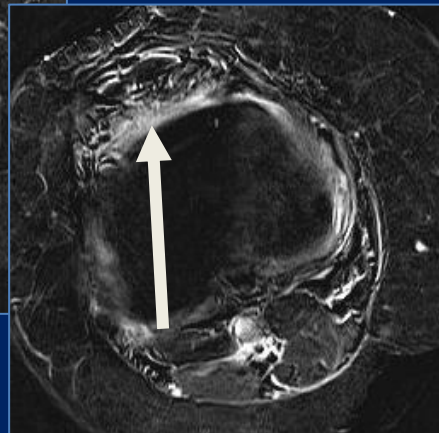
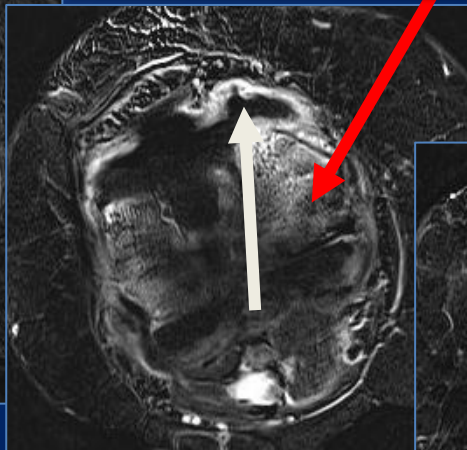


Liseré de descellement

## Descellement implant fémoral

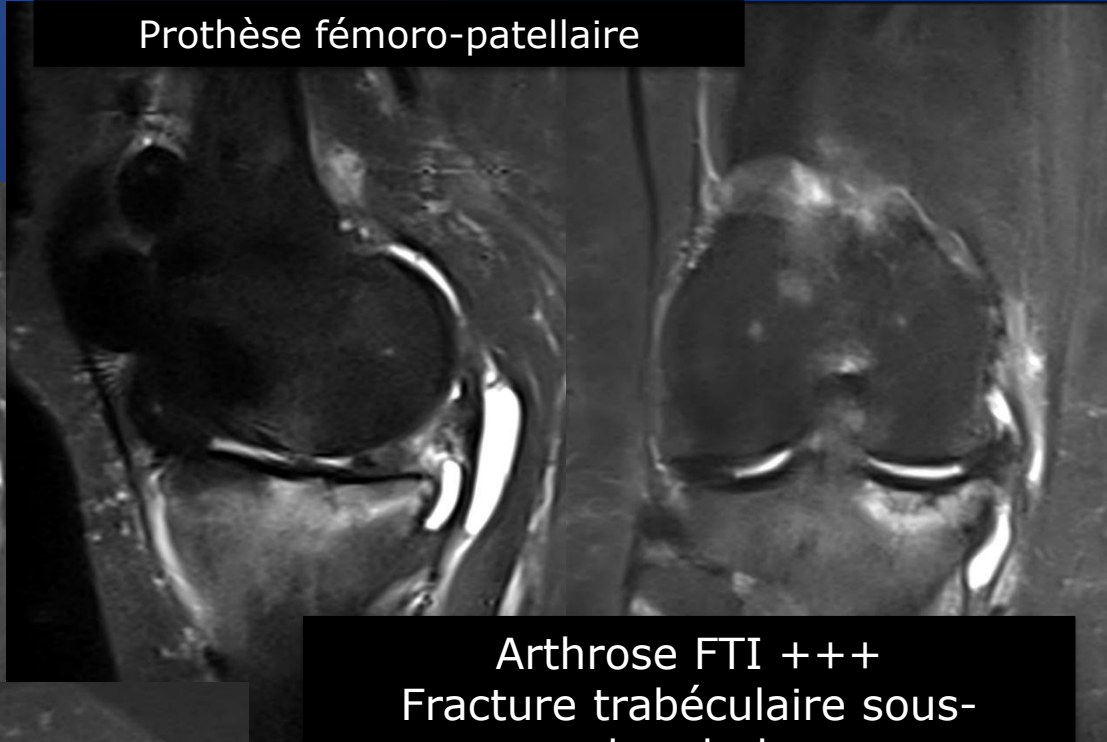
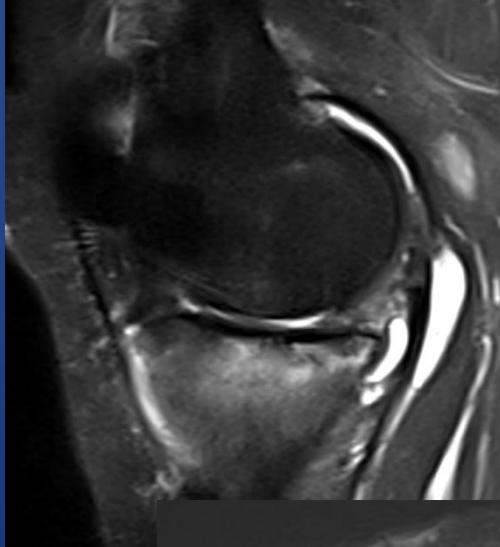


Epanchement et synovite

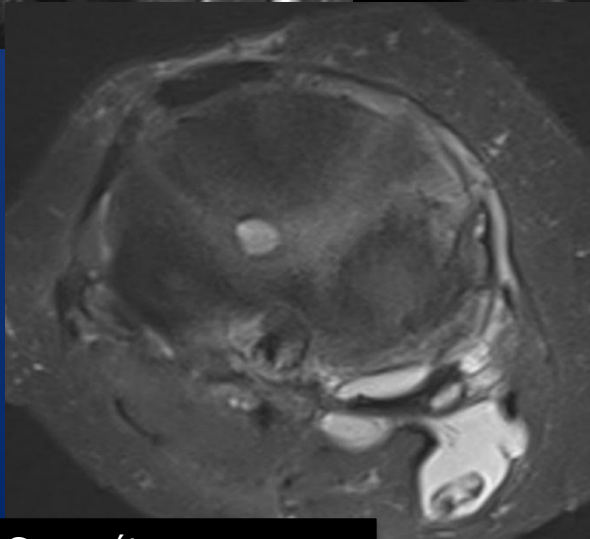


# Cas 4

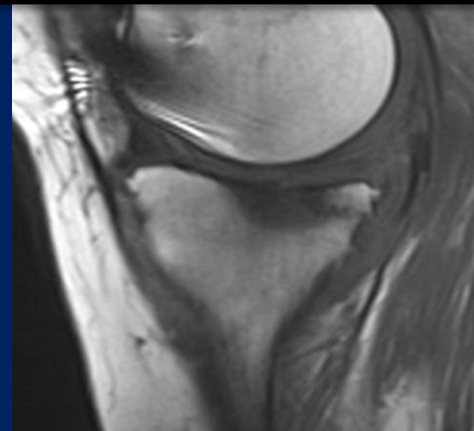
Prothèse fémoro-patellaire



Arthrose FTI +++  
Fracture trabéculaire sous-  
chondrale

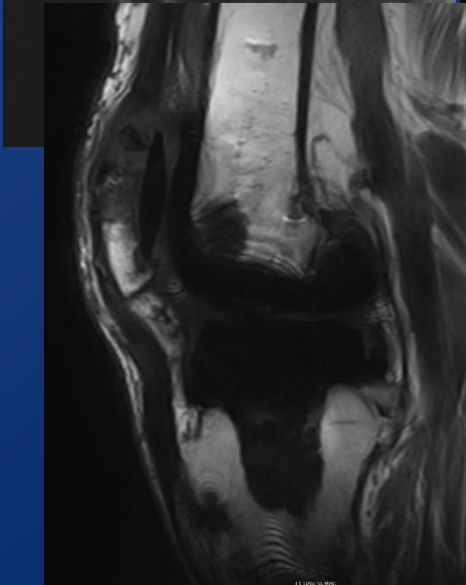
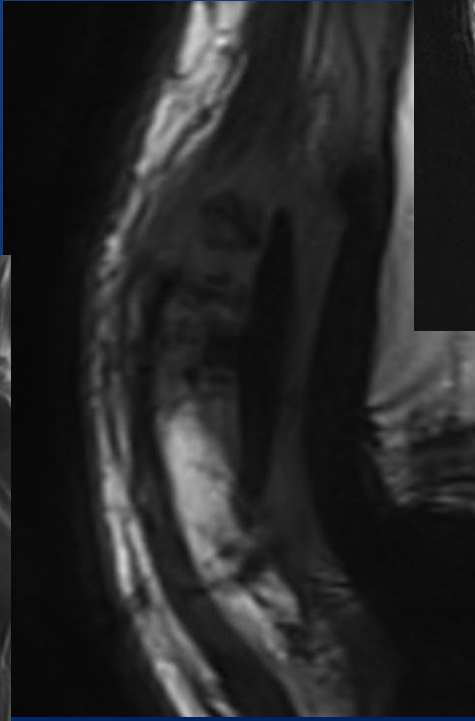
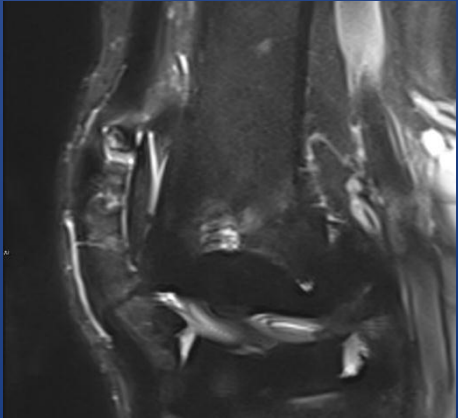
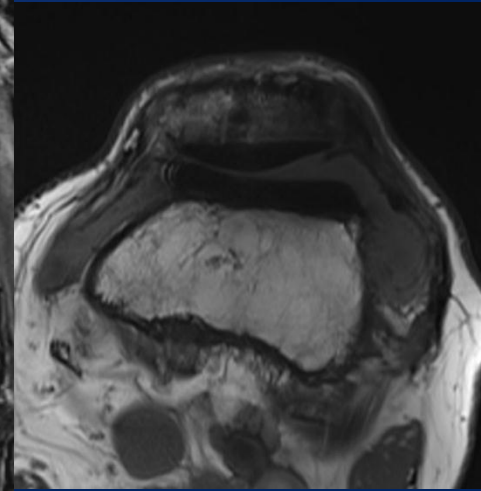
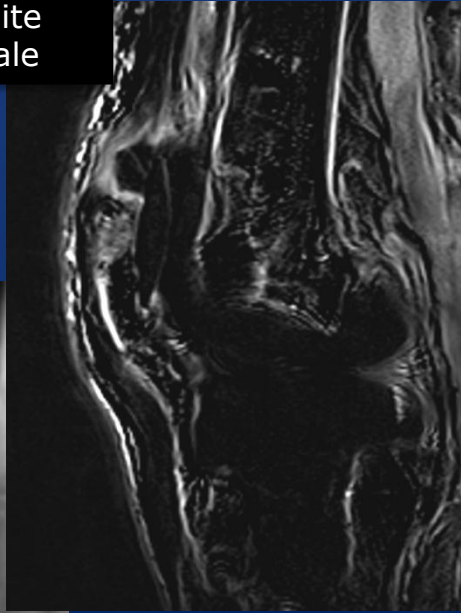


Corps étranger  
au sein d'un kyste poplité

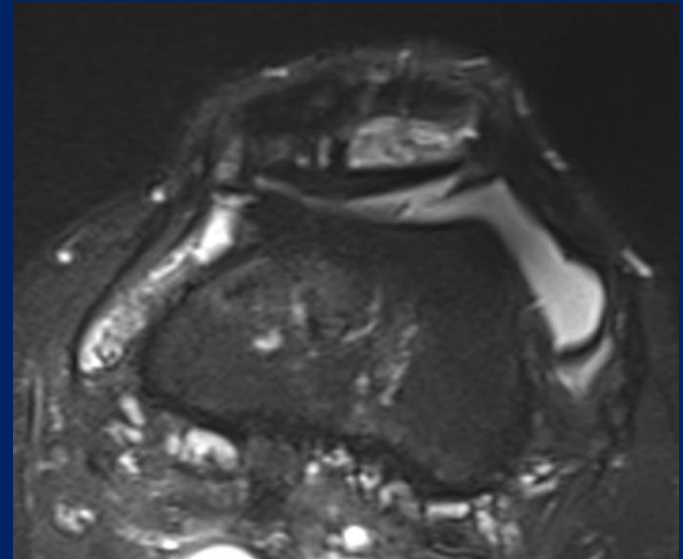


# Cas 5

Réhaussement  
inflammatoire satellite  
Enthèse quadricipitale

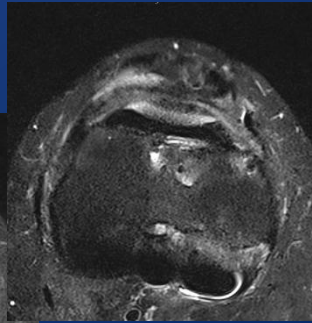
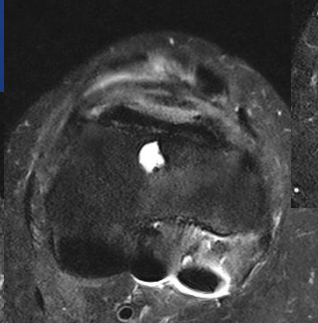
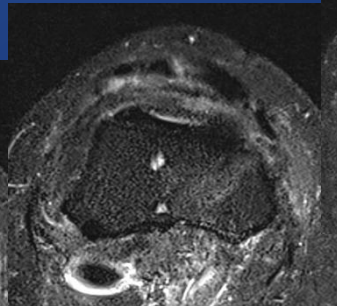
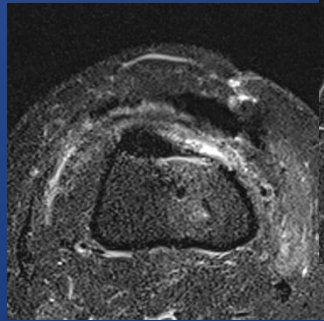


Fracture parcellaire  
patellaire supéro-  
latérale

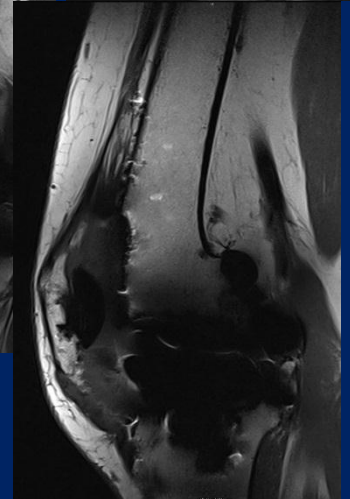
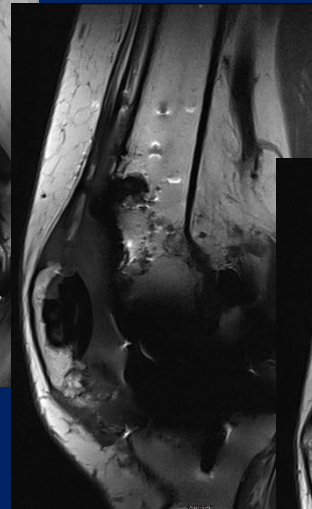
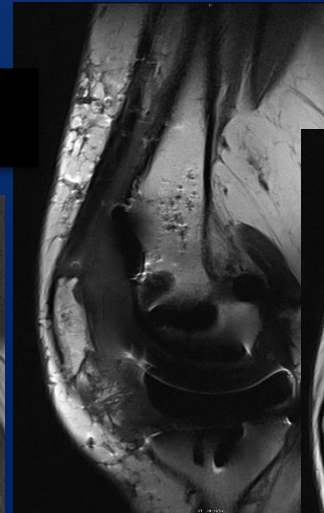
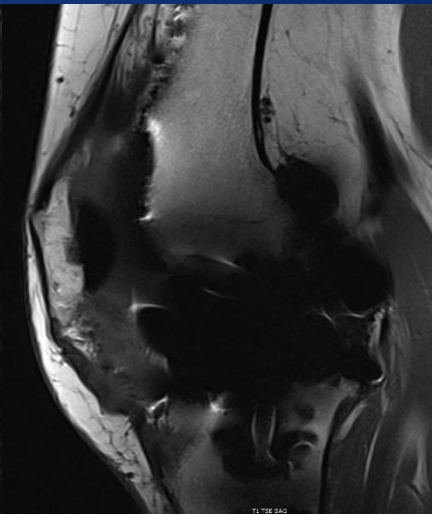
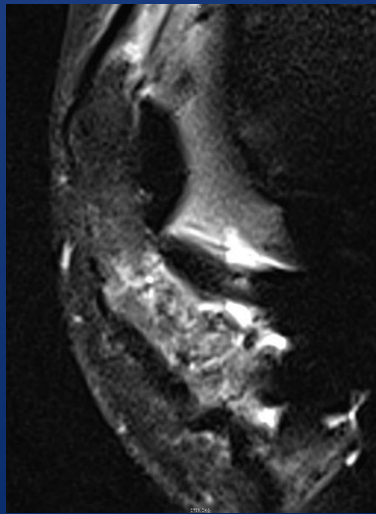




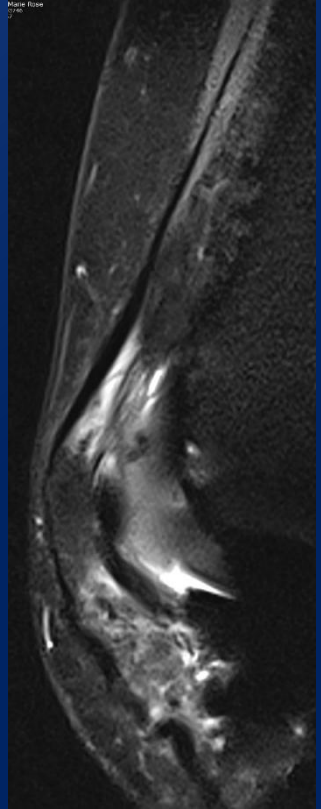
# Cas 6



Rupture partielle large  
Tendon quadricipital



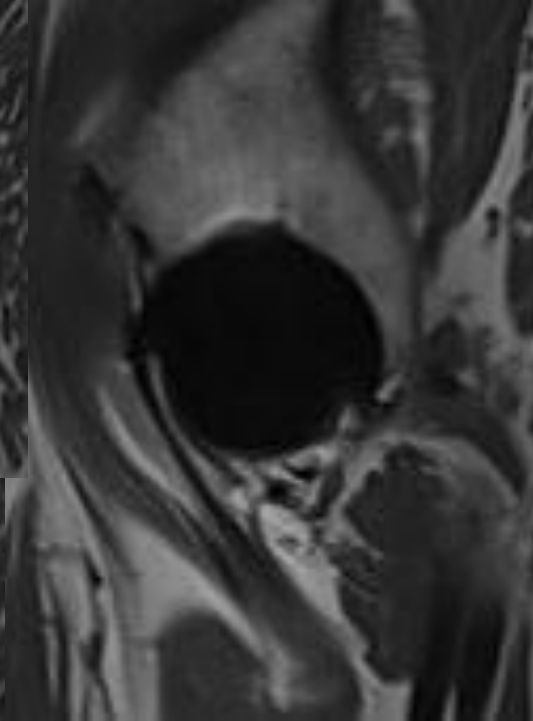
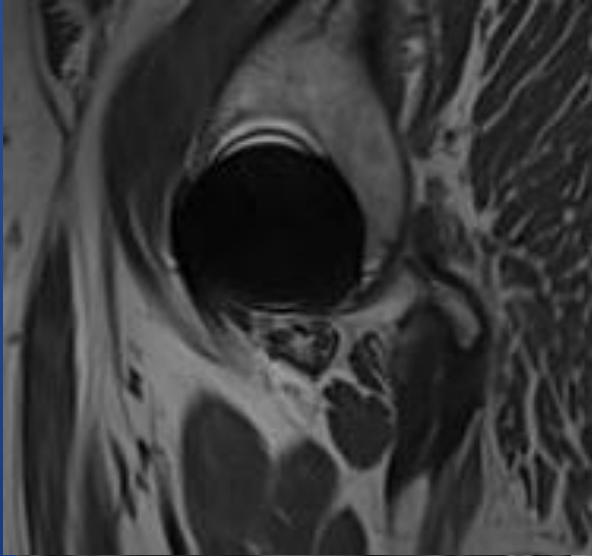
Rotule abaissée  
Aspect détendu tendon patellaire





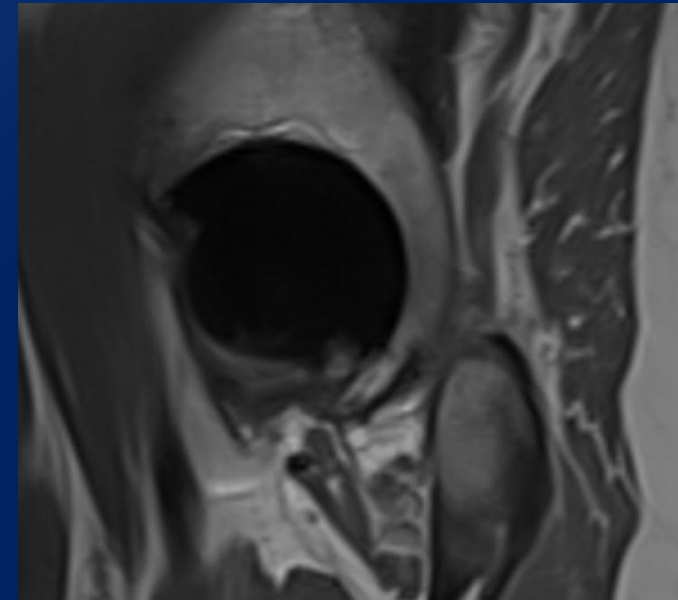
# Cas 7

## Coté gauche



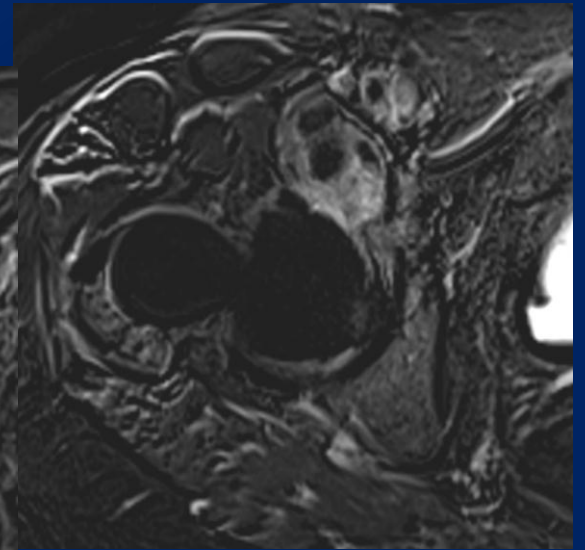
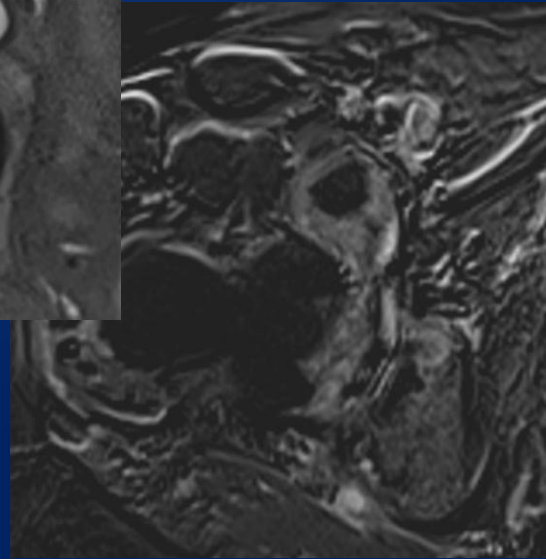
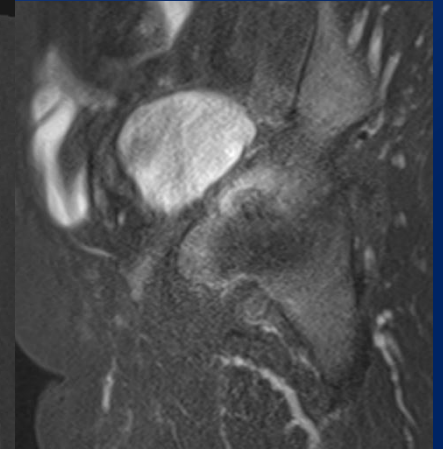
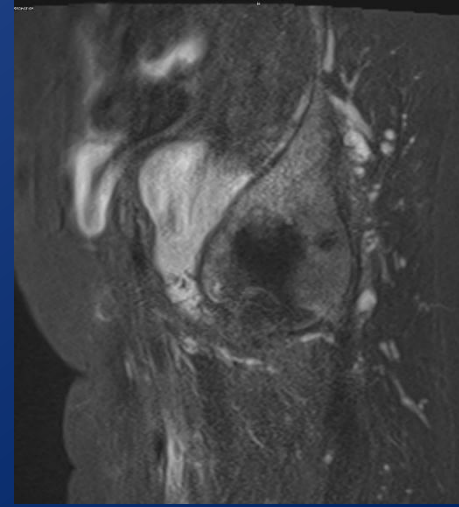
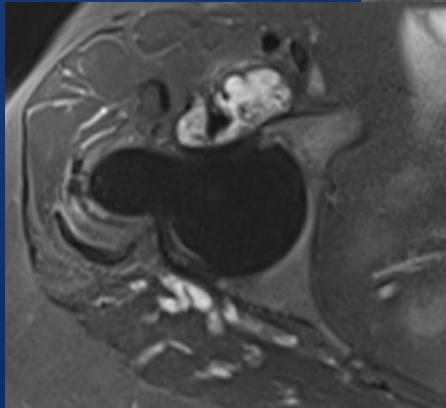
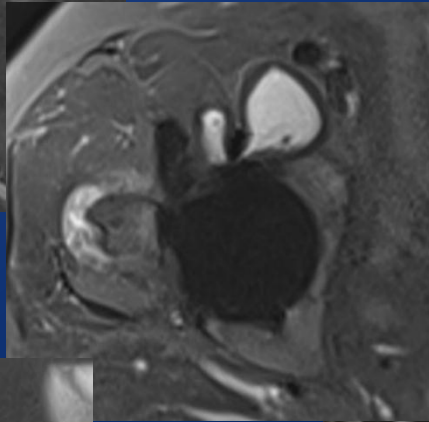
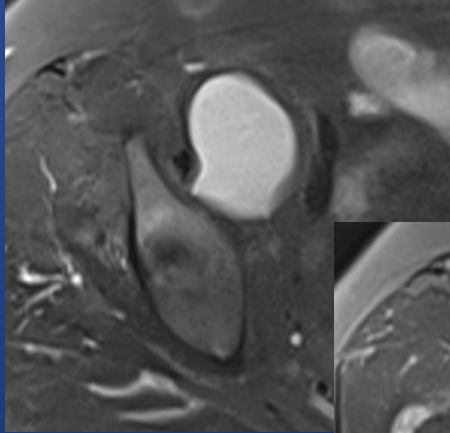
Cupule débordante horizontalisée  
Conflit PTH-psoas

## Coté droit



Cupule non débordante  
Pas de débord

# Cas 8



Volumineuse bursite inflammatoire du psoas  
Bursopathie para-trochantérienne

# TDM

Algorithme OMAR

(Philips)



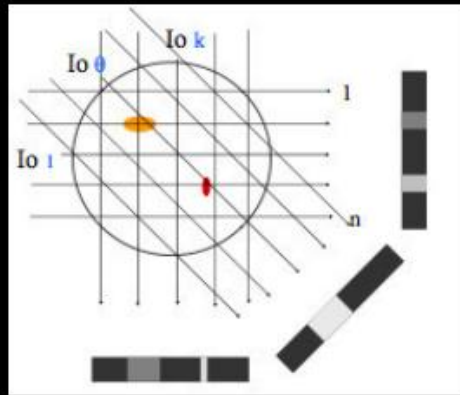
# Rétroprojection filtrée (Filtered Back Projection : FBP)

- Algorithme de reconstruction « standard » utilisé depuis les débuts du scanner (1976)
- Basée sur la transformée de Radon inversée d'un modèle théorique
- Méthode analytique adoptée par tous les constructeurs
- Simple, rapide et fiable
- Mais :
  - basée sur un modèle « idéal » du faisceau
  - n'utilise pas toutes les informations
    - taille réelle du foyer et des détecteurs
    - Bruit
    - Valeur des voxels adjacents
  - méthode « très bruitée »

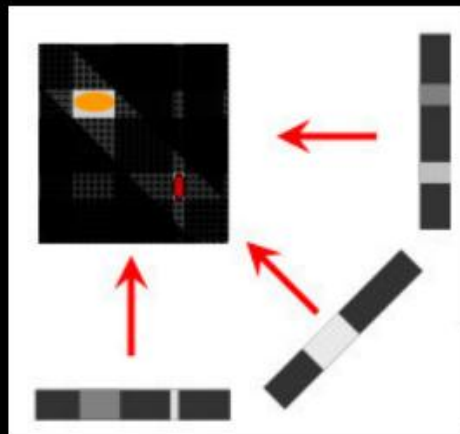
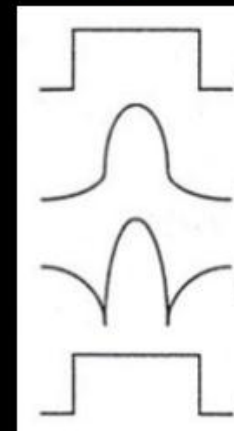
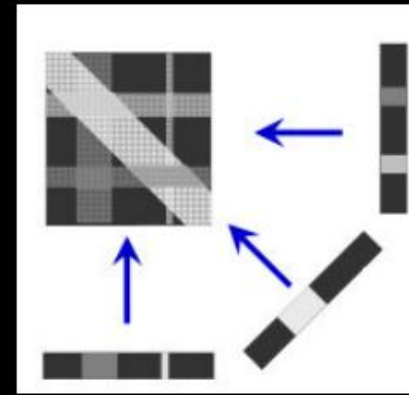
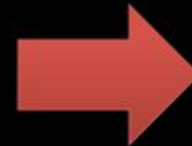


# FBP

Raw-data



Rétroprojection = «épandage»

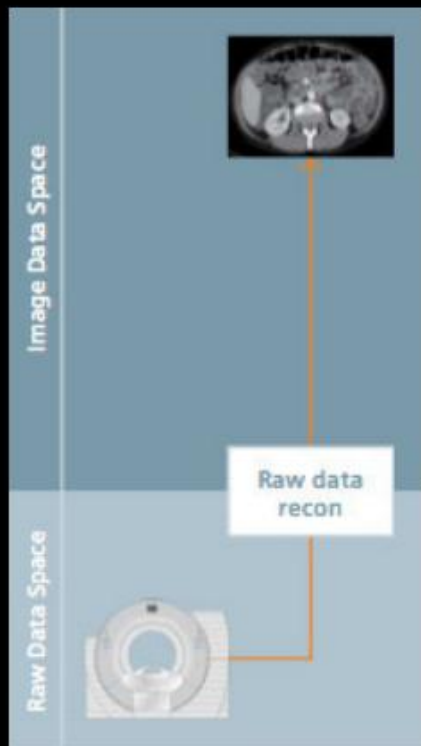


image

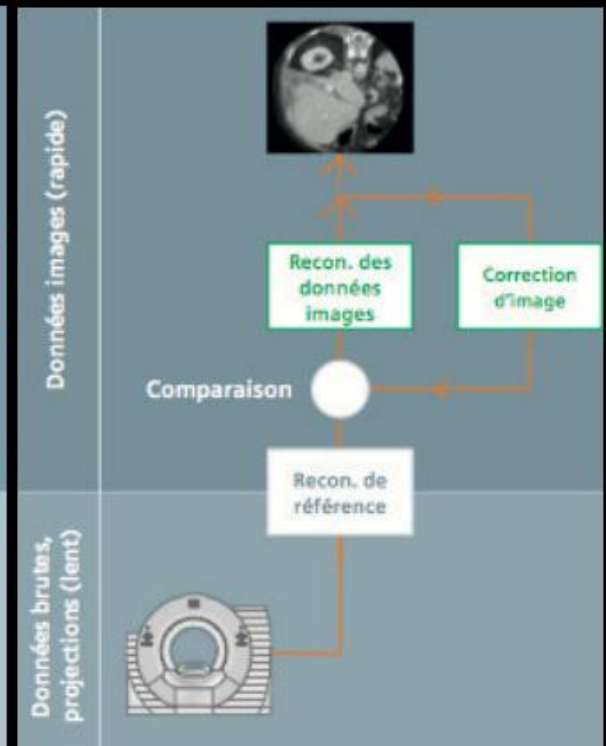
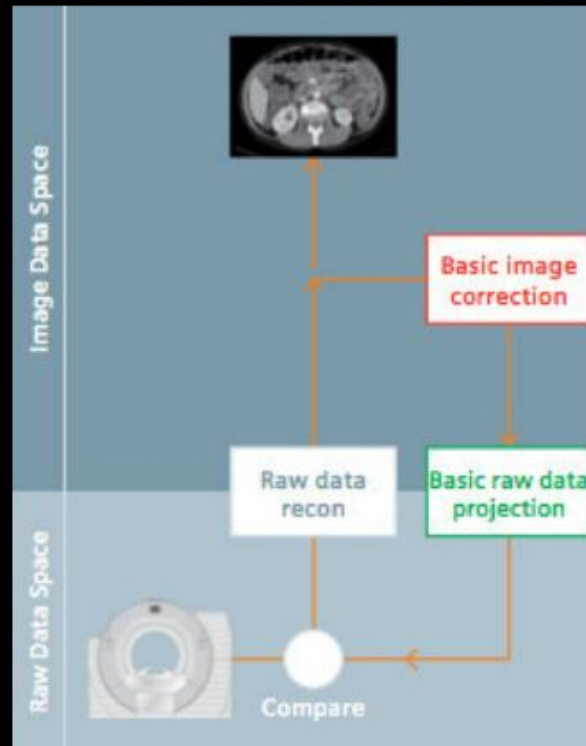
filtrage



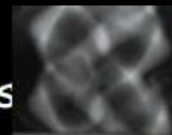
# FBP



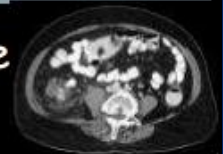
# Reconstructions itératives



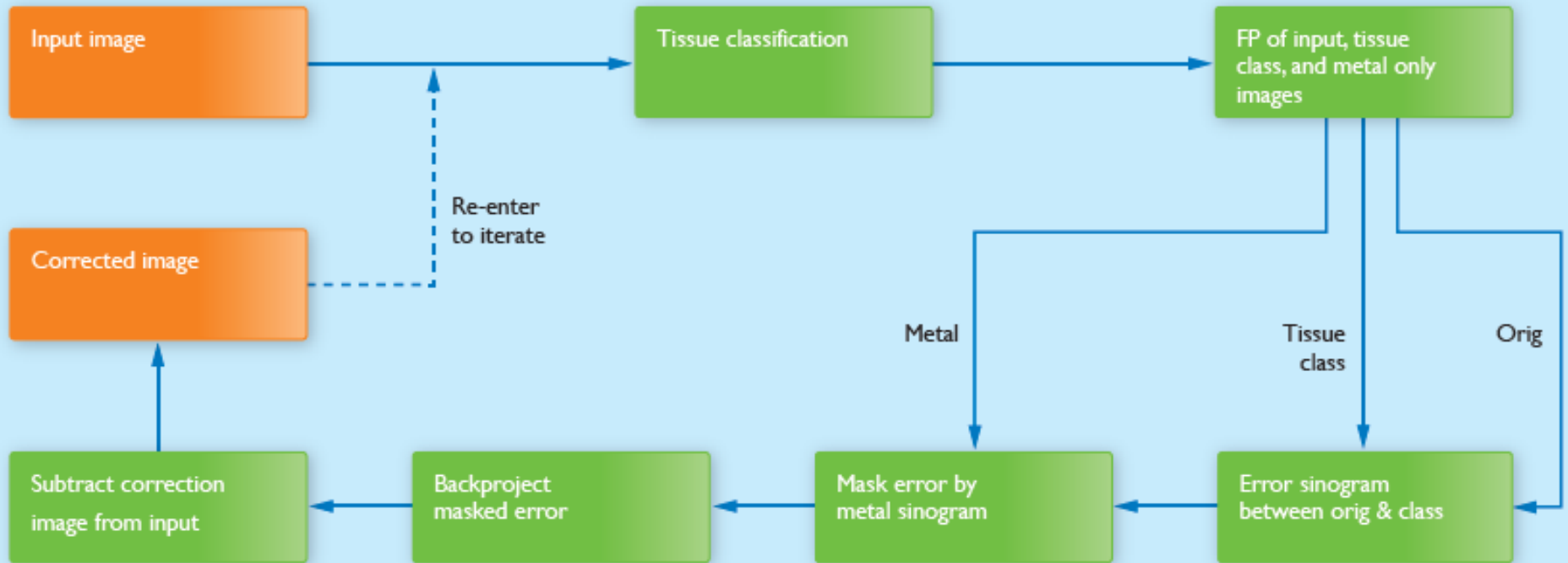
Domaine des données brutes



Domaine image



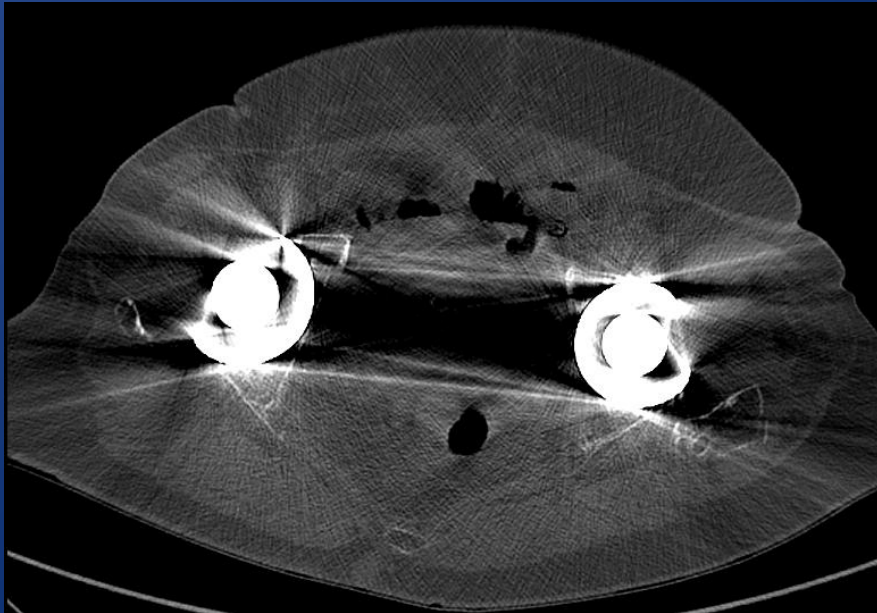
# OMAR





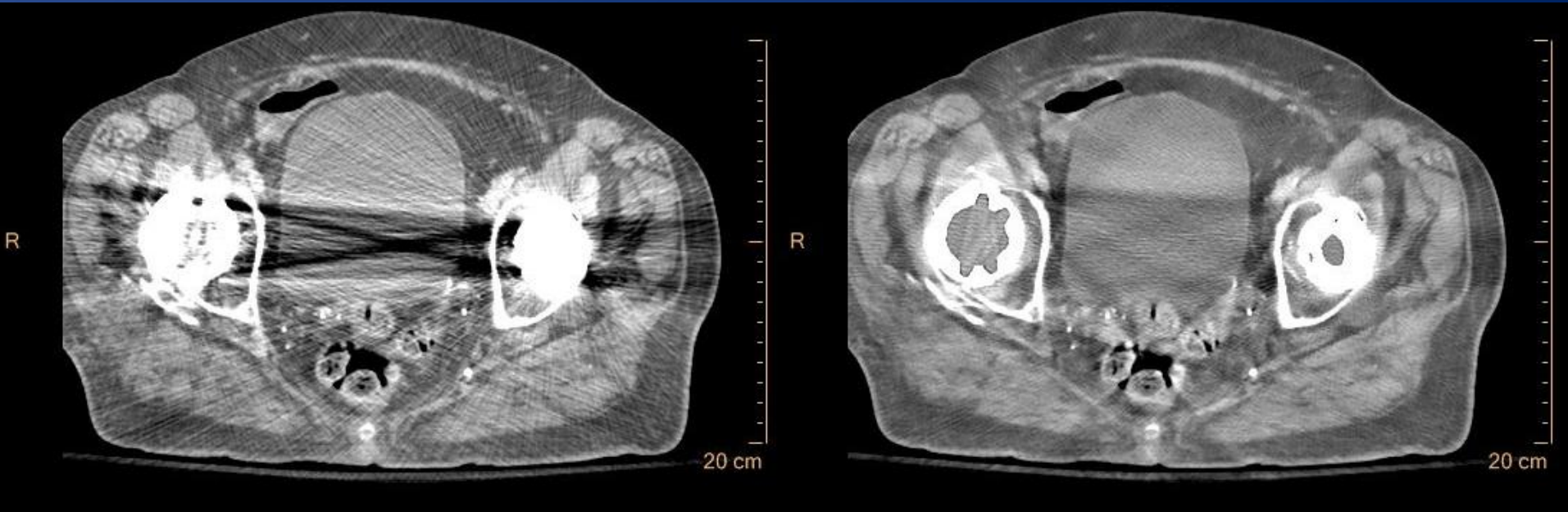
# COMPARATIF

Natif



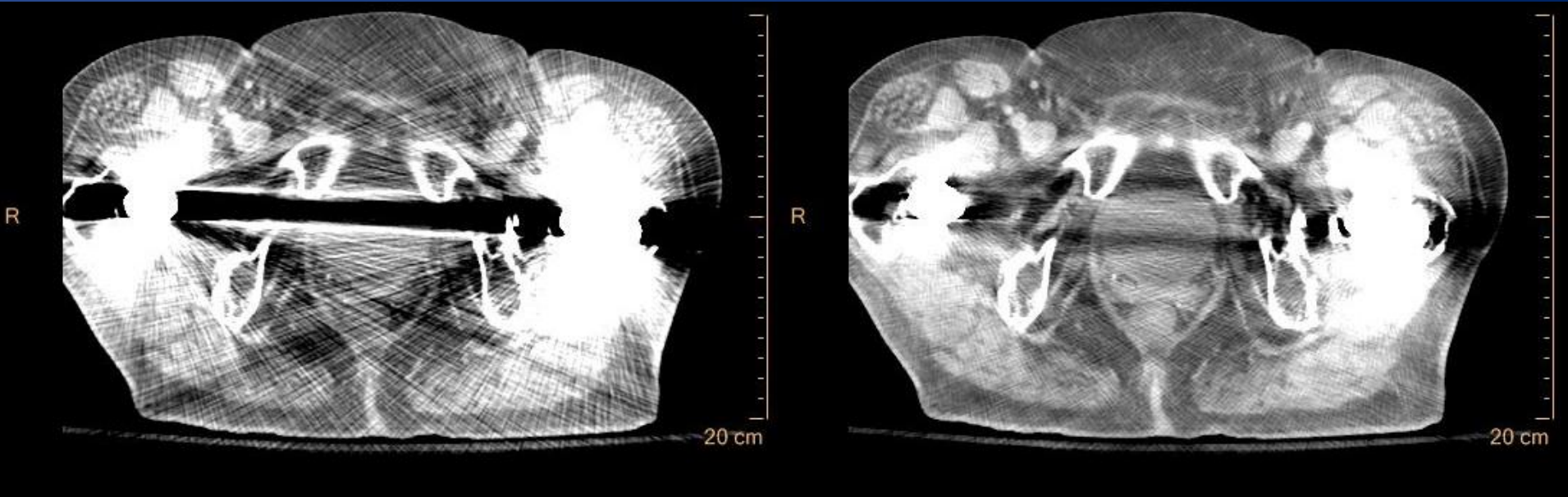
OMAR





Standard Reconstruction and iDose<sup>4</sup> Level 3 with OMAR





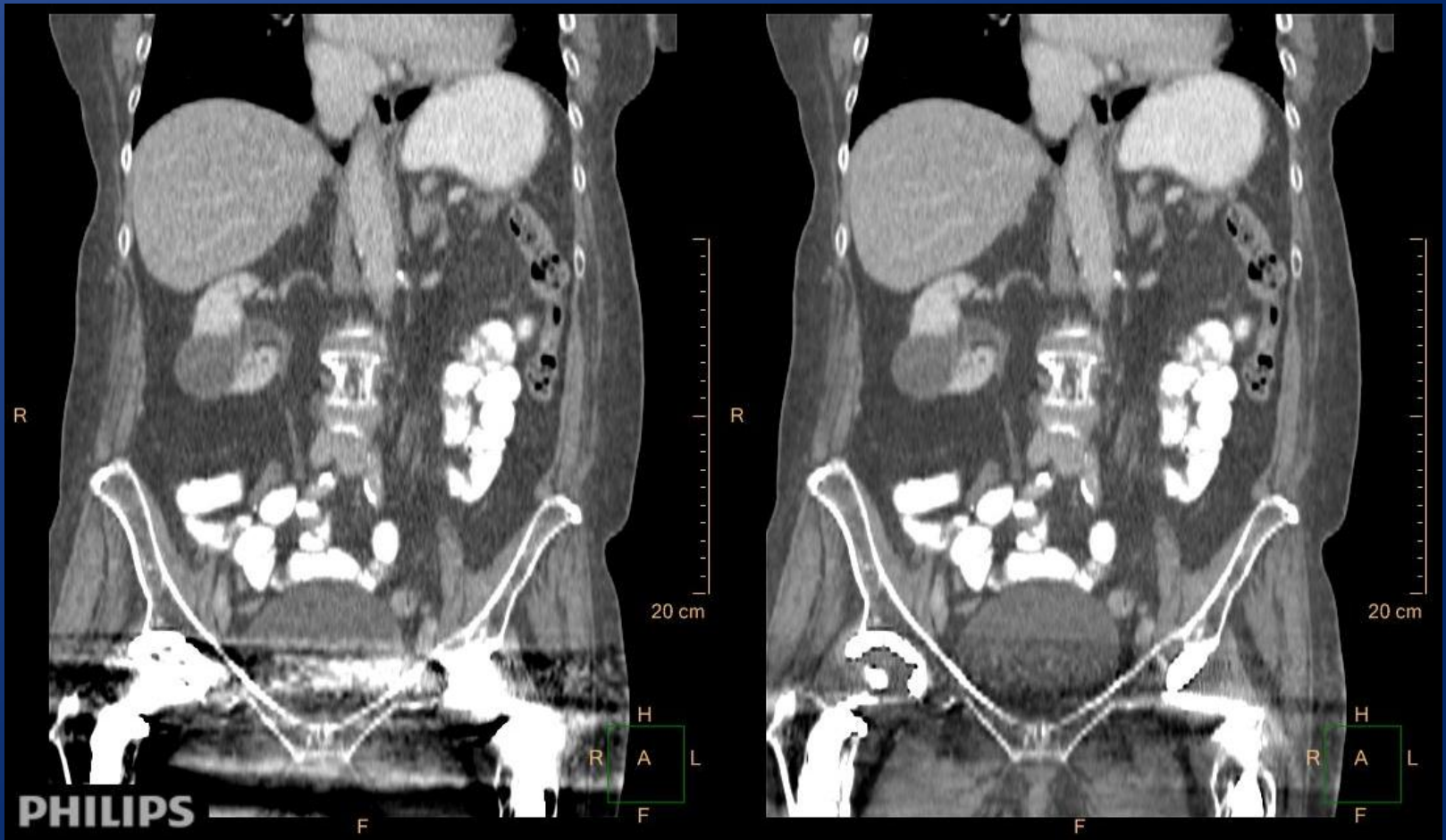
Standard Reconstruction and iDose<sup>4</sup> Level 3 with OMAR





Standard Reconstruction and iDose<sup>4</sup> Level 3 with OMAR





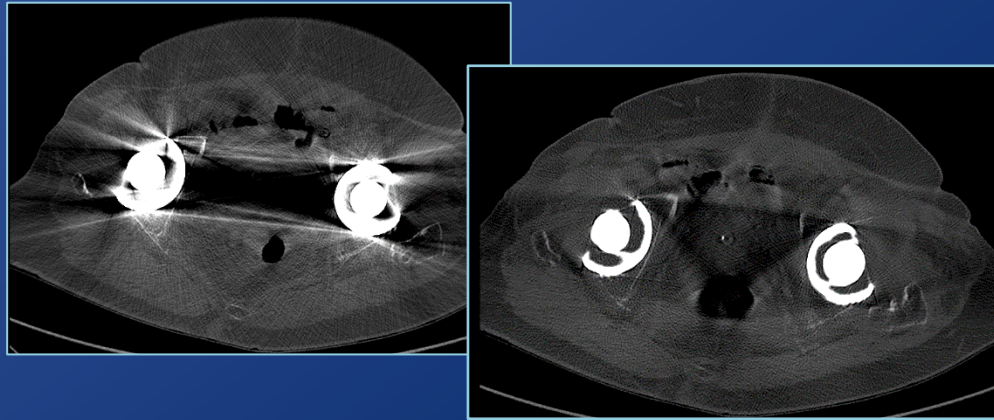
Standard Reconstruction and iDose<sup>4</sup> Level 3 with OMAR

# Place de l'imagerie / prothèse et implants

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- **Sepsis**
  - **Ostéite, descellement septique**
  - **Epanchement/ synovite, collections para-articulaires, fistules**
  - **Séquestres**
- **Descellement et ostéolyse non septiques (liseré et granulome)**
- **Tout matériel d'arthrodèse ou d'ostéosynthèse (membres et rachis compris)**
- **Fragmentation du PE et synovite avec CE**
  - PE non explorable directement (effet cage du métal)
- **Système extenseur et bouton patellaire**
- **Conflit, interruption du système extenseur, arthro-fibrose**
- **Evaluation des compartiments articulaires non implantés quand PUC ou ostéotomie**
- **Conflit tendon-prothèse : PTG-patte d'oie, PTH-psoas**

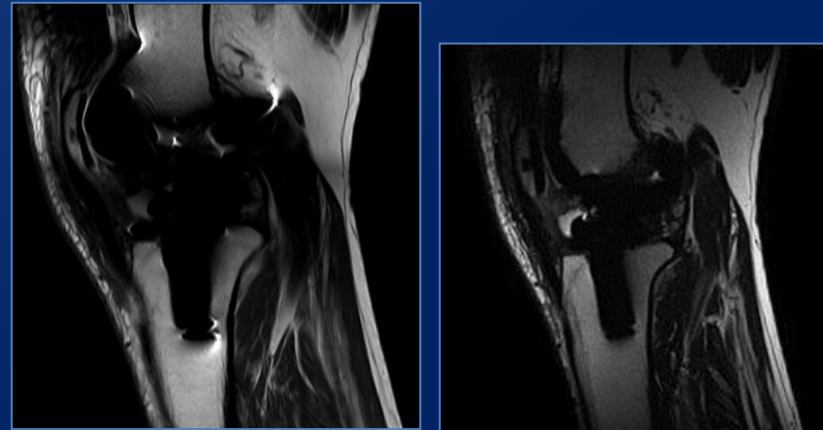
# Réduction artefacts



TDM (OMAR)

- **Coût** n'équipent pas toutes les machines
- Allongement de la **durée** de l'examen en IRM

IRM (SEMAC)



- Analyse de l'**interface os- prothèse**
- Epanchement / synovite
- Abscès / fistule
- Tendons

**DIAGNOSTIC +++**