Orthopedic Management of Skeletal Metastases

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General

- Approximately 1.4 million new cancer patients diagnosed each year
- Incidence of skeletal metastases varies: 12-70%
- Bone---3rd most common organ involved by mets, behind lung and liver (In breast cancer it is the second most common site)
- Autopsy studies of breast cancer patients have demonstrated skeletal metastases in 90% of patients
- The quality of life of patients with skeletal metastases is compromised by pain, forced immobilization and pathological fractures

General

- Most skeletal mets involve the axial skeleton and lower extremities (More heavily vascularized parts of skeleton)
  - Thoracolumbar spine
  - Pelvis
  - Proximal femur/lower limb
  - Skull
  - Upper extremities 10-15 % of skeletal metastases

General

- 7-10% of patients with skeletal metastases develop pathological fractures
- Pathological fracture may be the first sign of disease
- When the primary site is unknown the most likely origin of the metastasis is from the lung or kidney
- The primary site is not discovered in 3-4% of patients who present with a pathological fracture

Most Common Metastases to Bone

- Myeloma
- Breast
- Lung
- Prostate
- Kidney
- Lymphoma
- Thyroid
- GI tract
- Melanoma

Presentation

- Pain, usually localized and intermittent at first; progressive increase in intensity over time
  - (Mechanical Pain and Biological Pain from cytokines and chemical mediators)
- Pain at Night
- Rotator cuff symptoms or frozen shoulder with shoulder girdle mets
- Referred pain, motor weakness, sensory deficits or bowel and bladder dysfunction from spine mets

Evaluation

- Laboratory Studies
  - CBC—anemia, bone marrow suppression, neutropenia
  - Chemistries—hypercalcemia, elevated alkaline phosphatase
  - PT/PTT, LFTs
  - Serum Protein Electrophoresis (SPEP)
  - Urinalysis
  - PSA, CEA (GI Cancer), CA129 (breast)
- Radiological Studies
  - Plain Radiographs
  - Bone Scan
  - MRI/CT Scan
  - PET Scan

Radiographic Studies

- Identify site of disease and extent of local disease
- Amount of bone involved
- Multiple lesions in a bone
- Presence of soft tissue component
- Other sites of disease (precautions during surgery)
- Important to determine optimal surgical approach, amount of tumor to be removed and method of reconstruction

X-Ray

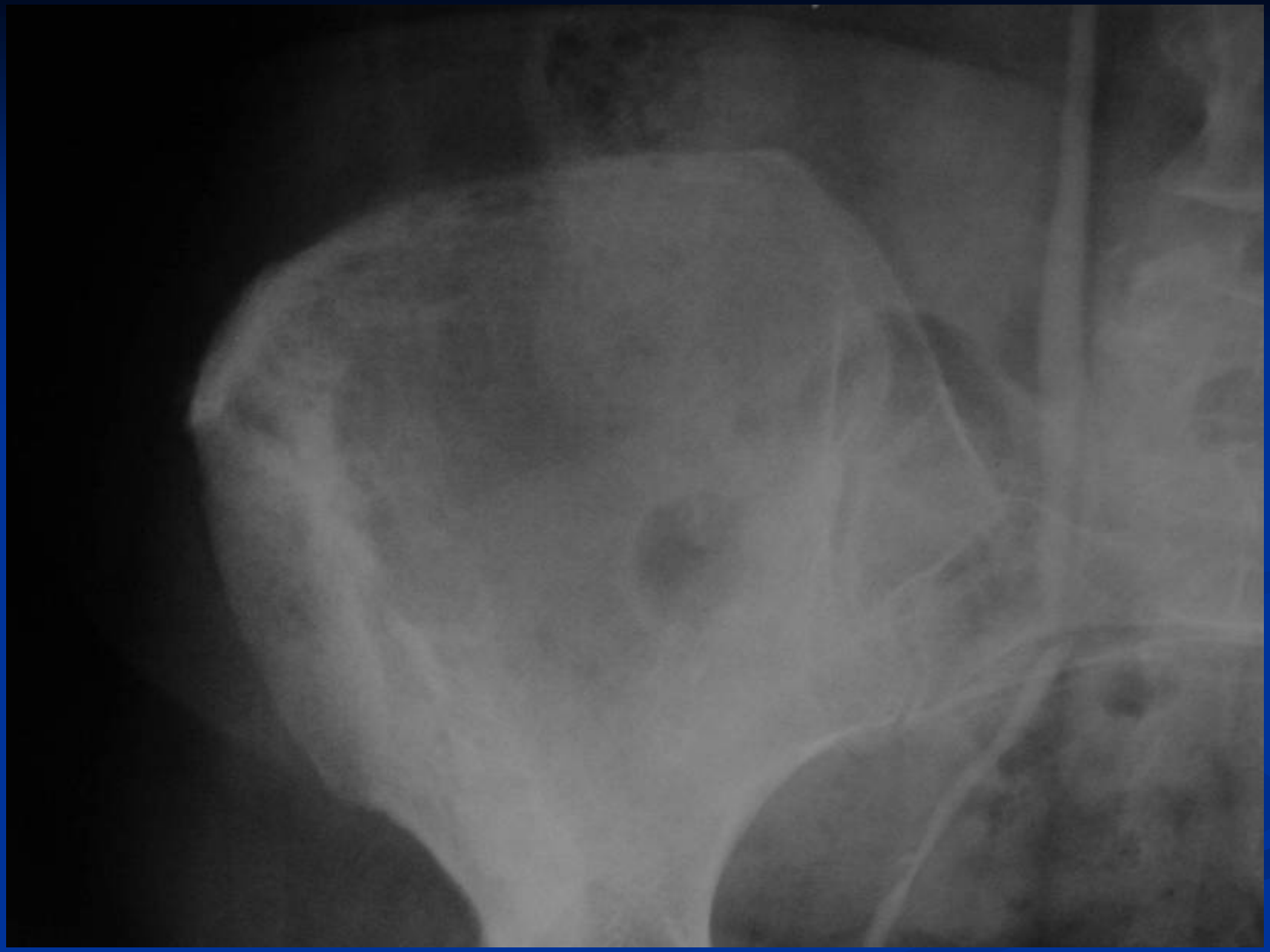
- First test ordered for evaluating bone pain
- Usually permeative, sometimes geographic or well circumscribed
- Lytic, Blastic, Mixed
- Prostate Mets---blastic
- Breast Mets---usually mixed
- Lung Mets---usually lytic
- Renal cell and Thyroid---lytic, expansile

X-Ray

- Evaluate overall bony quality, structure
- Entire bone is radiographed so that all lesions can be identified and addressed during the same surgery
- Monitoring response to treatment, disease progression and local recurrence
- Skeletal survey for tumors that may not be detected on bone scan (multiple myeloma, renal cell carcinoma)
- 30% of bone must be destroyed in order for a lytic lesion to be evident on a plain x-ray

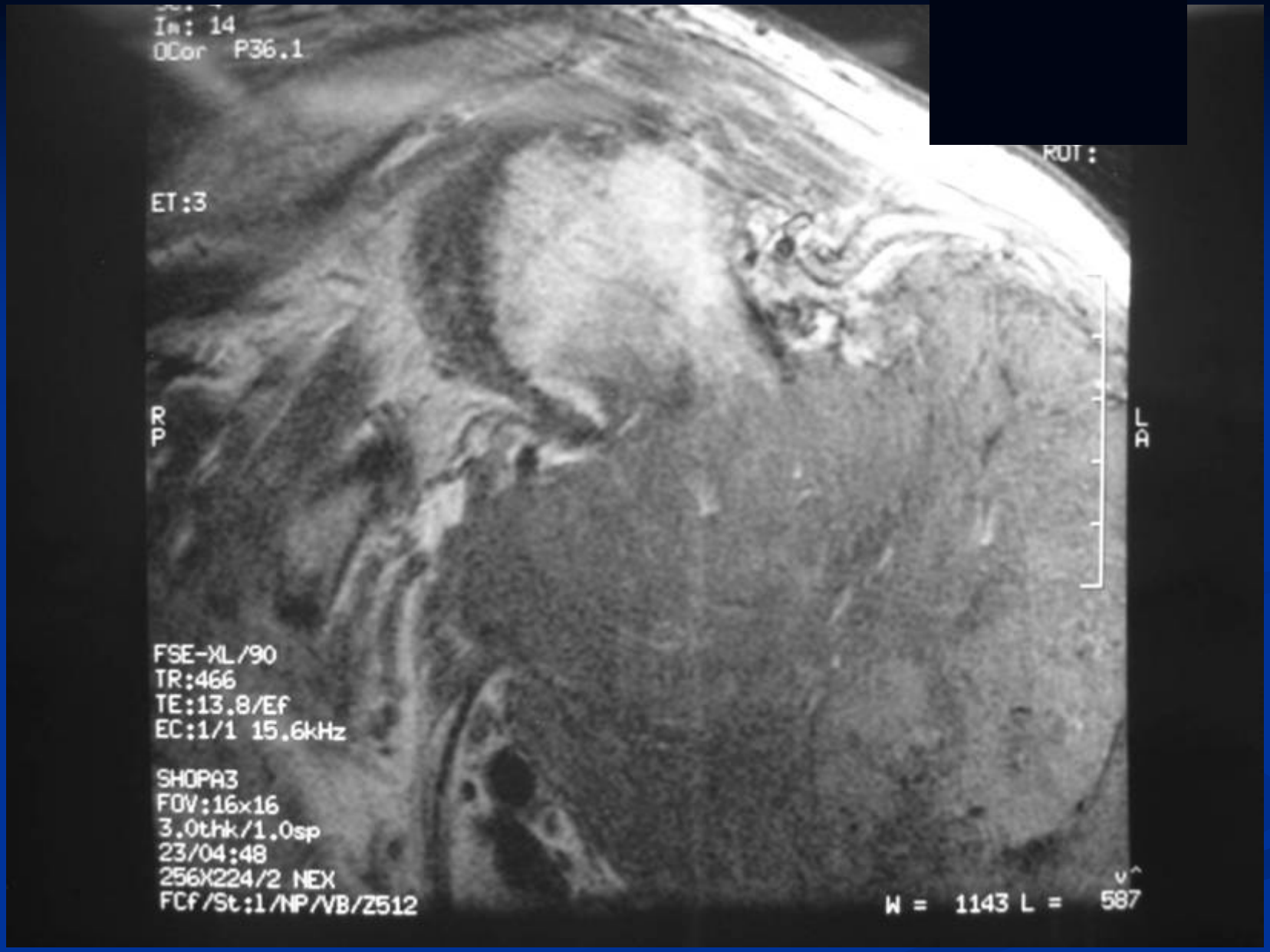
Breast --Mixed

Breast---Mixed



Renal Cell—Permeative, Lytic

Renal Cell—Expansile, Geographic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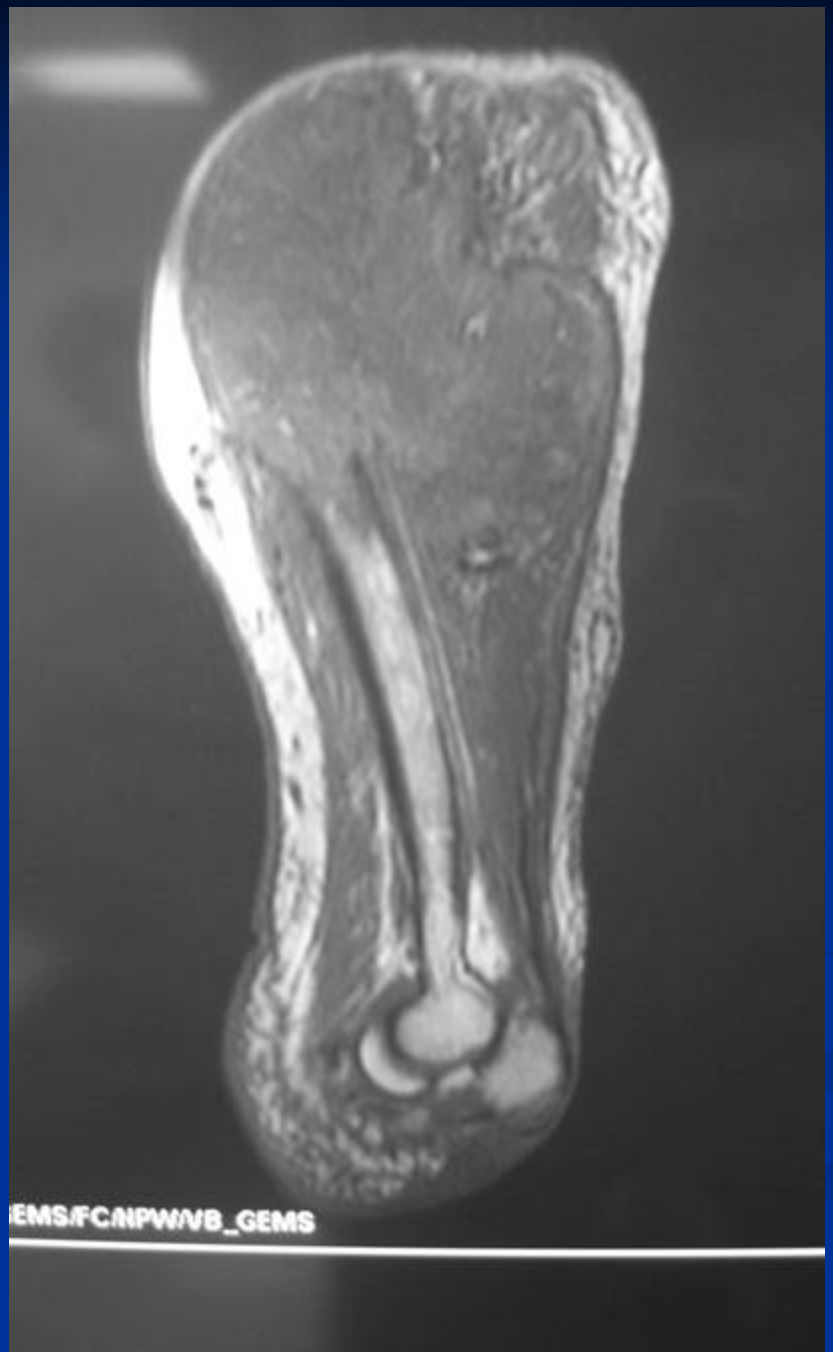
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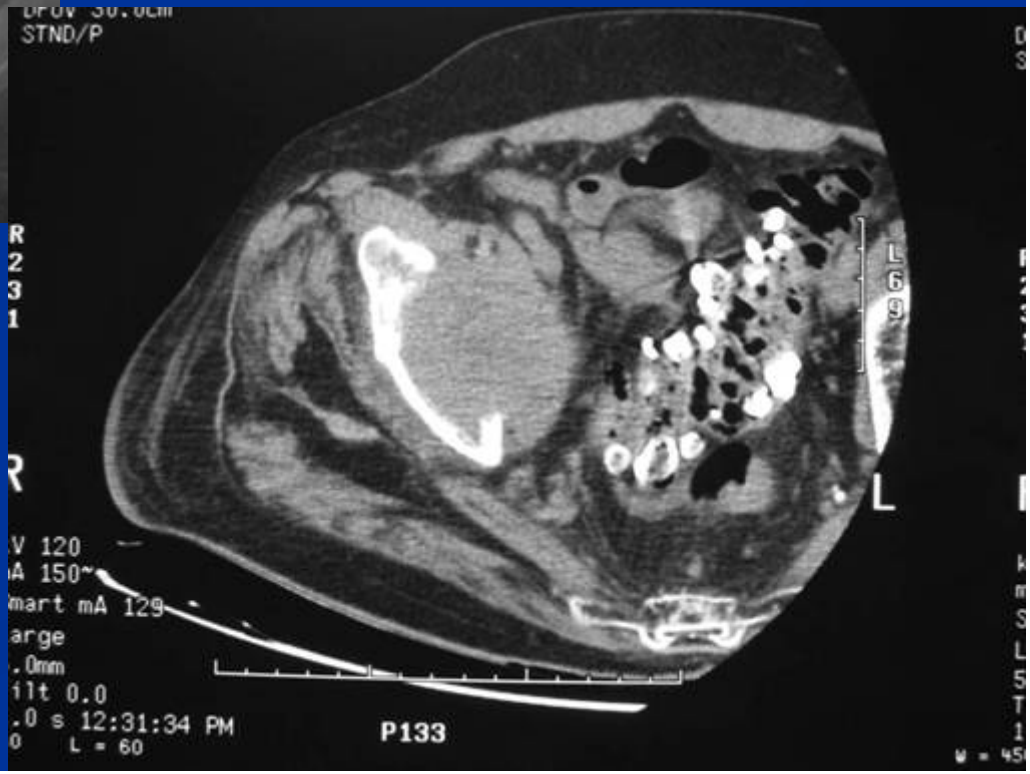
Lung--Lytic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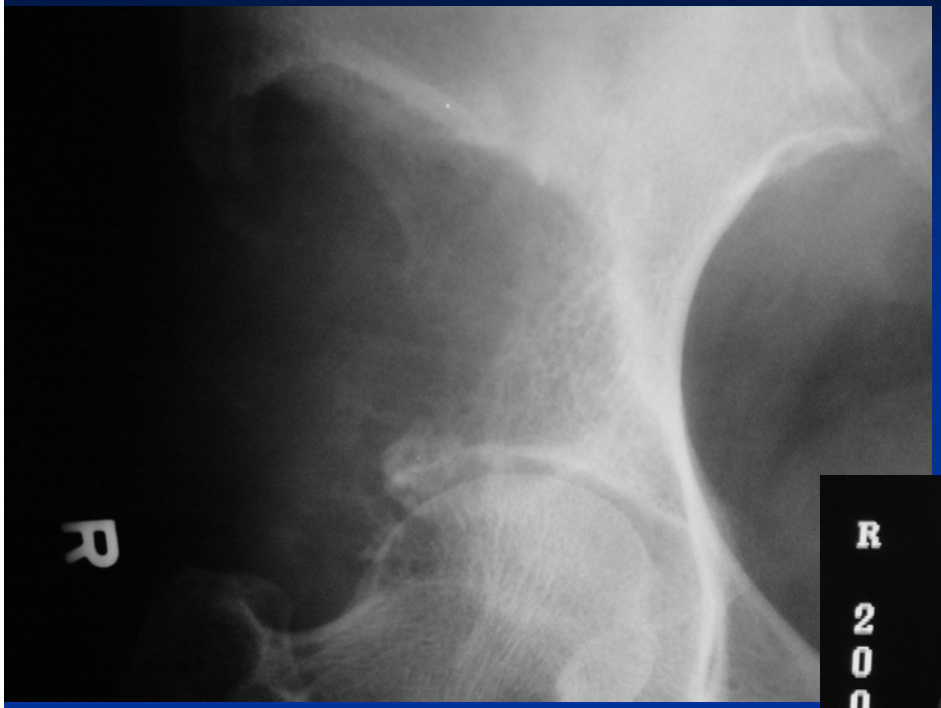
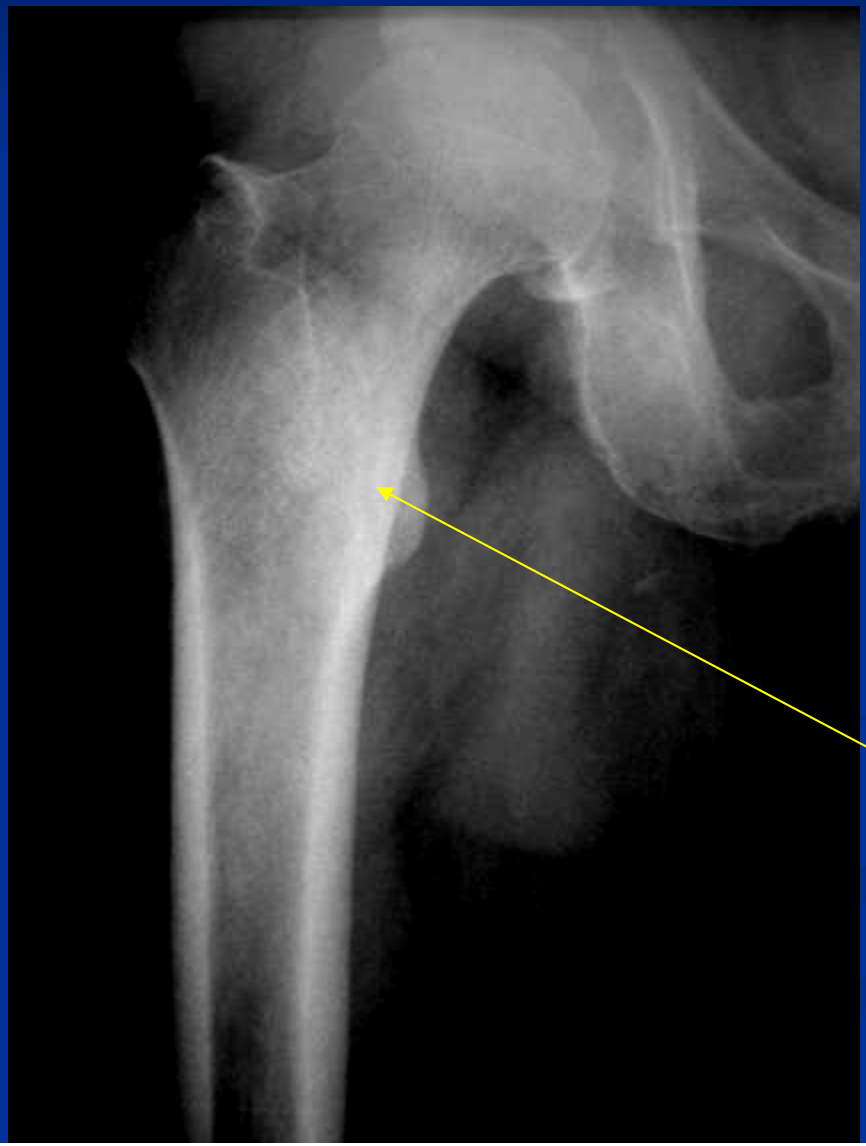
Thyroid—Lytic, Geographic, Blown Out



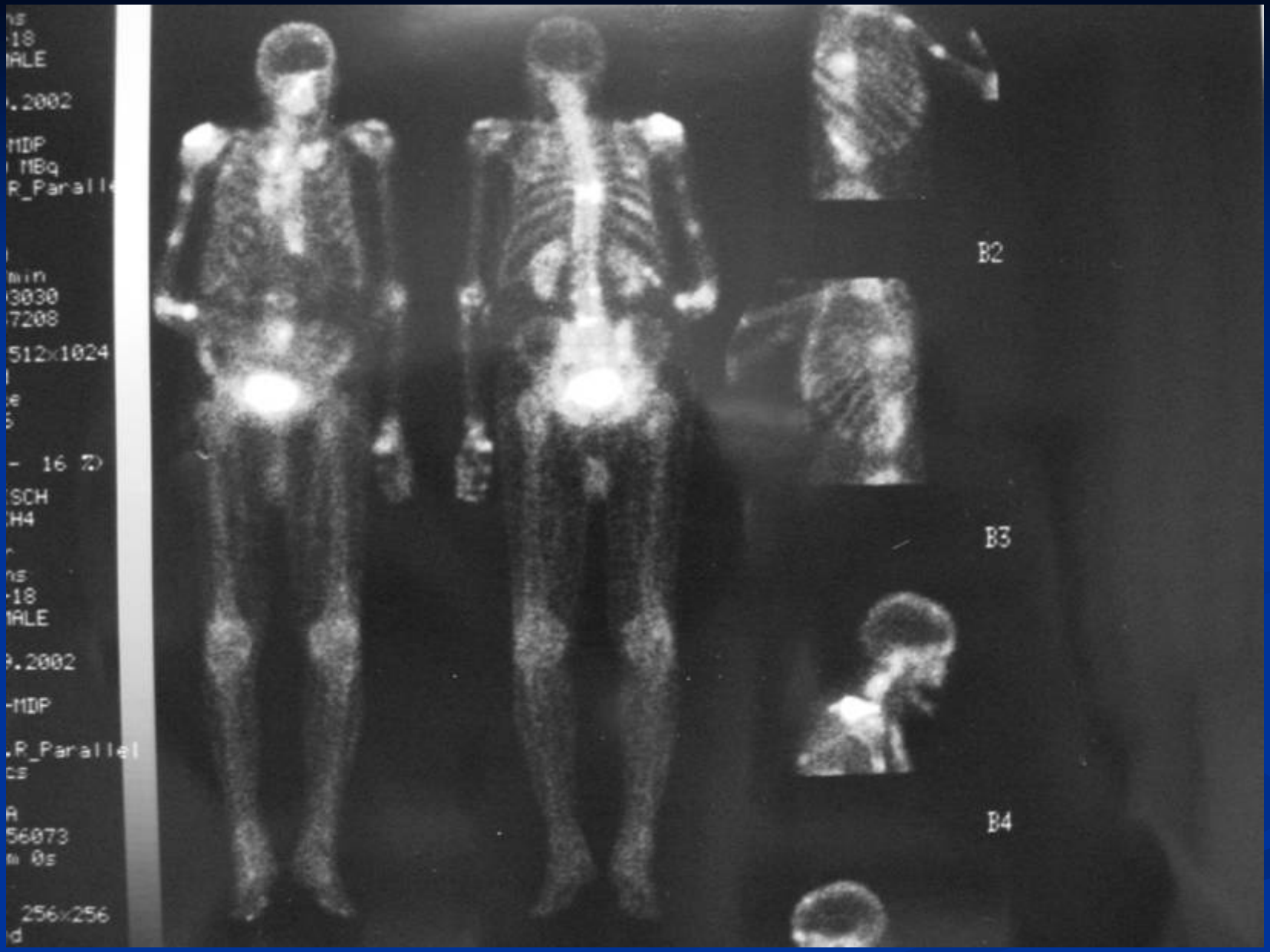
Prostate---Blastic



Myeloma

Bone Scan

- Demonstrates skeletal involvement much earlier than plain radiographs
- Occult bone lesions and metastatic disease
- Does not tell anything about the specific anatomic characteristics of a lesion (bony integrity)
- Monitoring response to treatment and disease progression
- Flare phenomenon occurs in 15% of patients
  - Initial increase in radioisotope uptake with treatment
  - Reflects new bone formation in response to treatment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CT Scan

- Confirm presence of metastatic disease especially when a patient presents with a pathological fracture as the initial presentation (r/o pseudopathologic fracture)
- Bony integrity/ cortical details
- Evaluating pelvis, shoulder girdle and spine that are often not well visualized on x-rays


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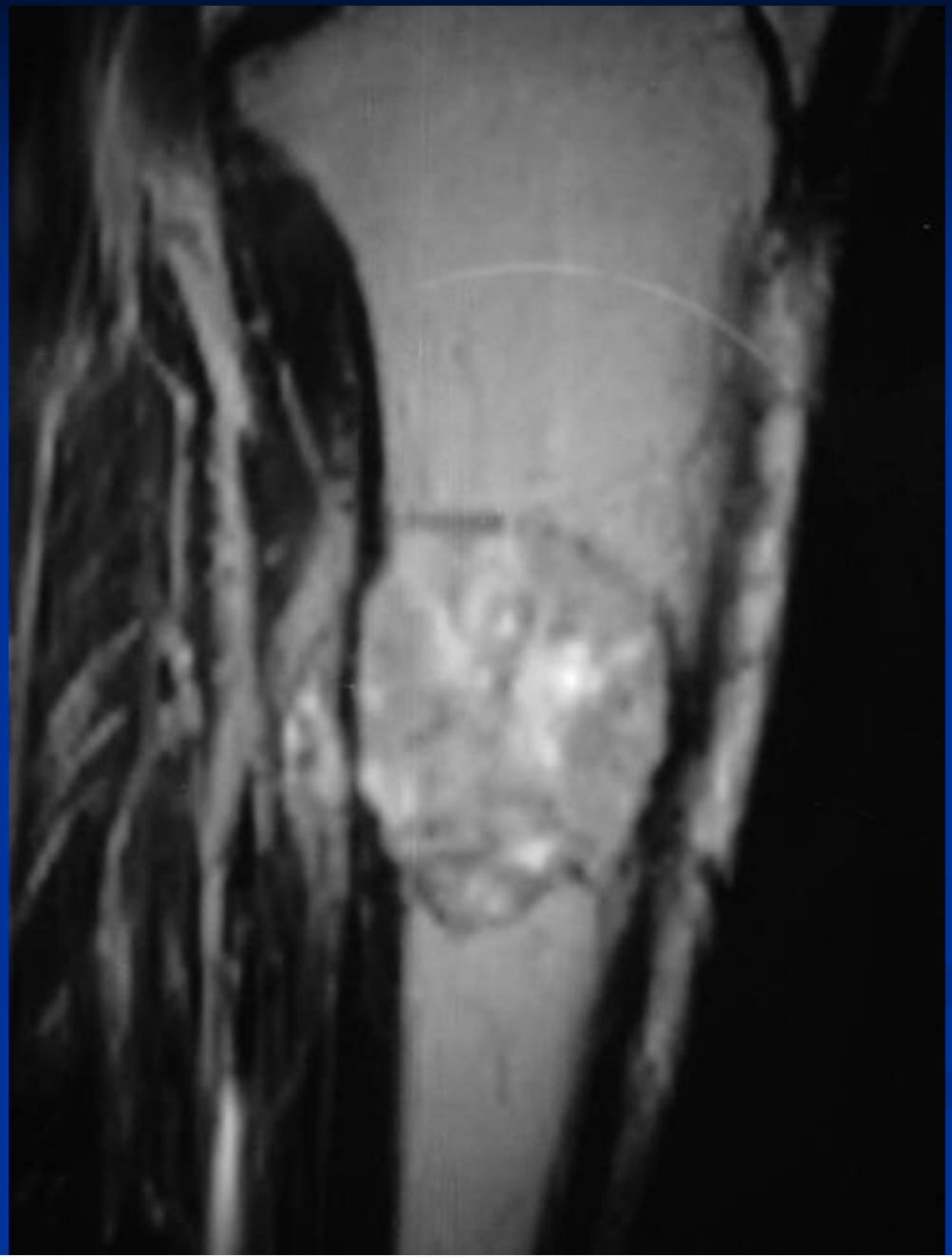

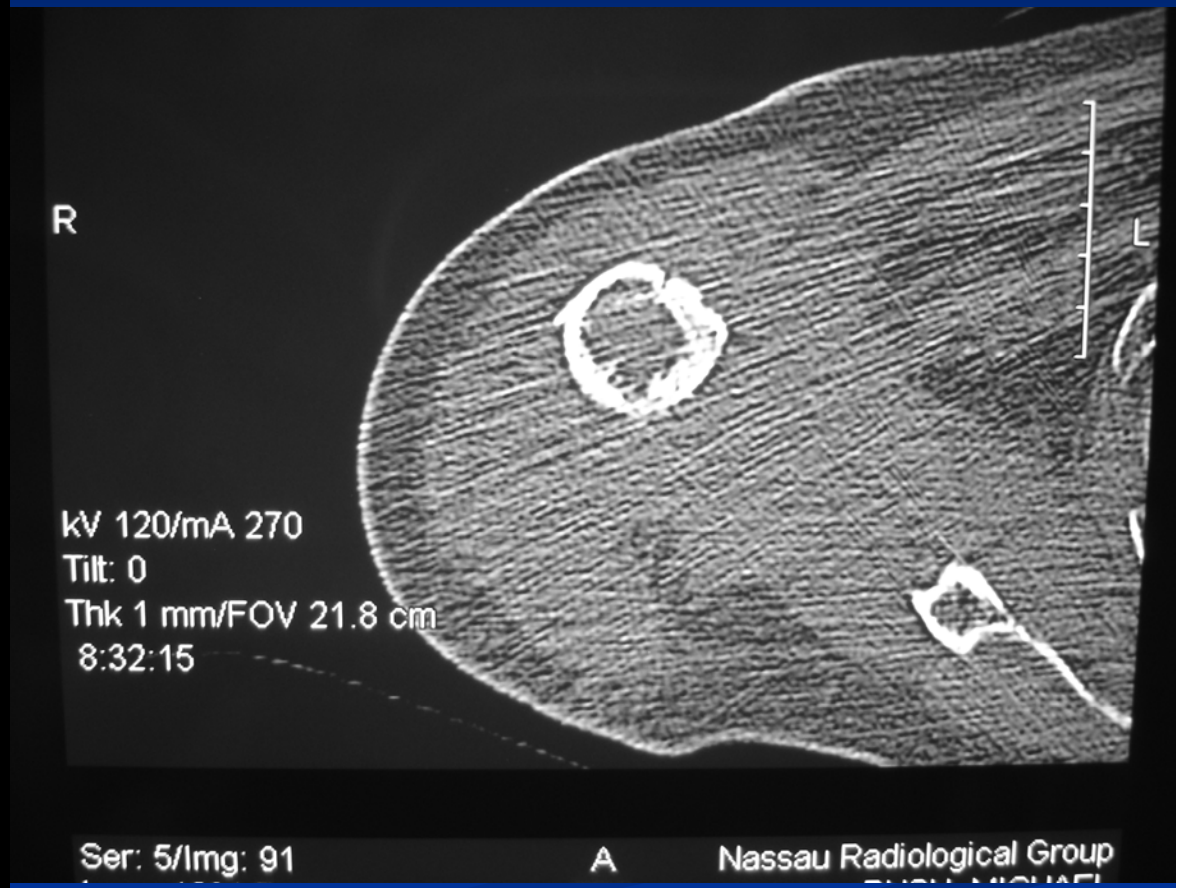
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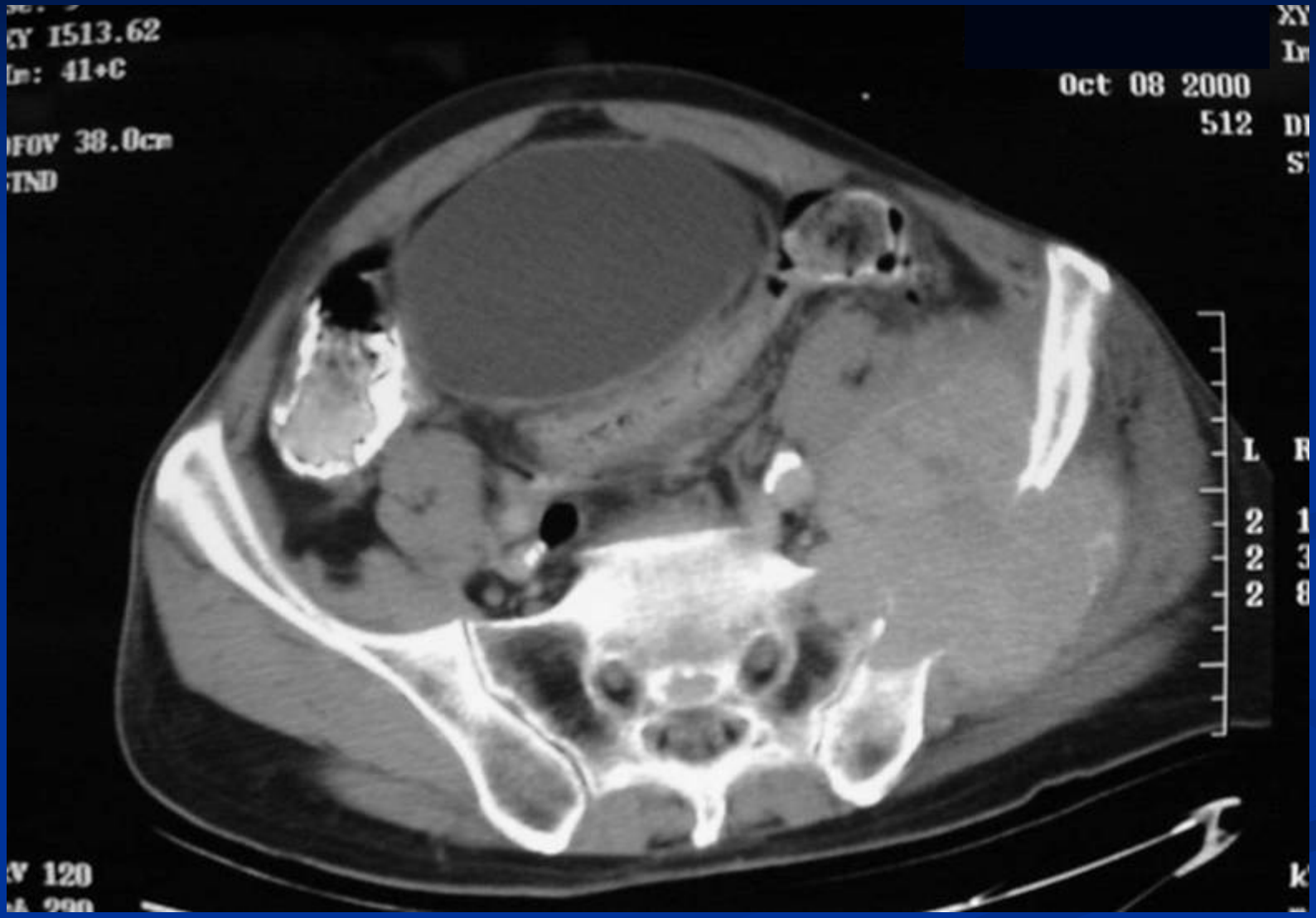
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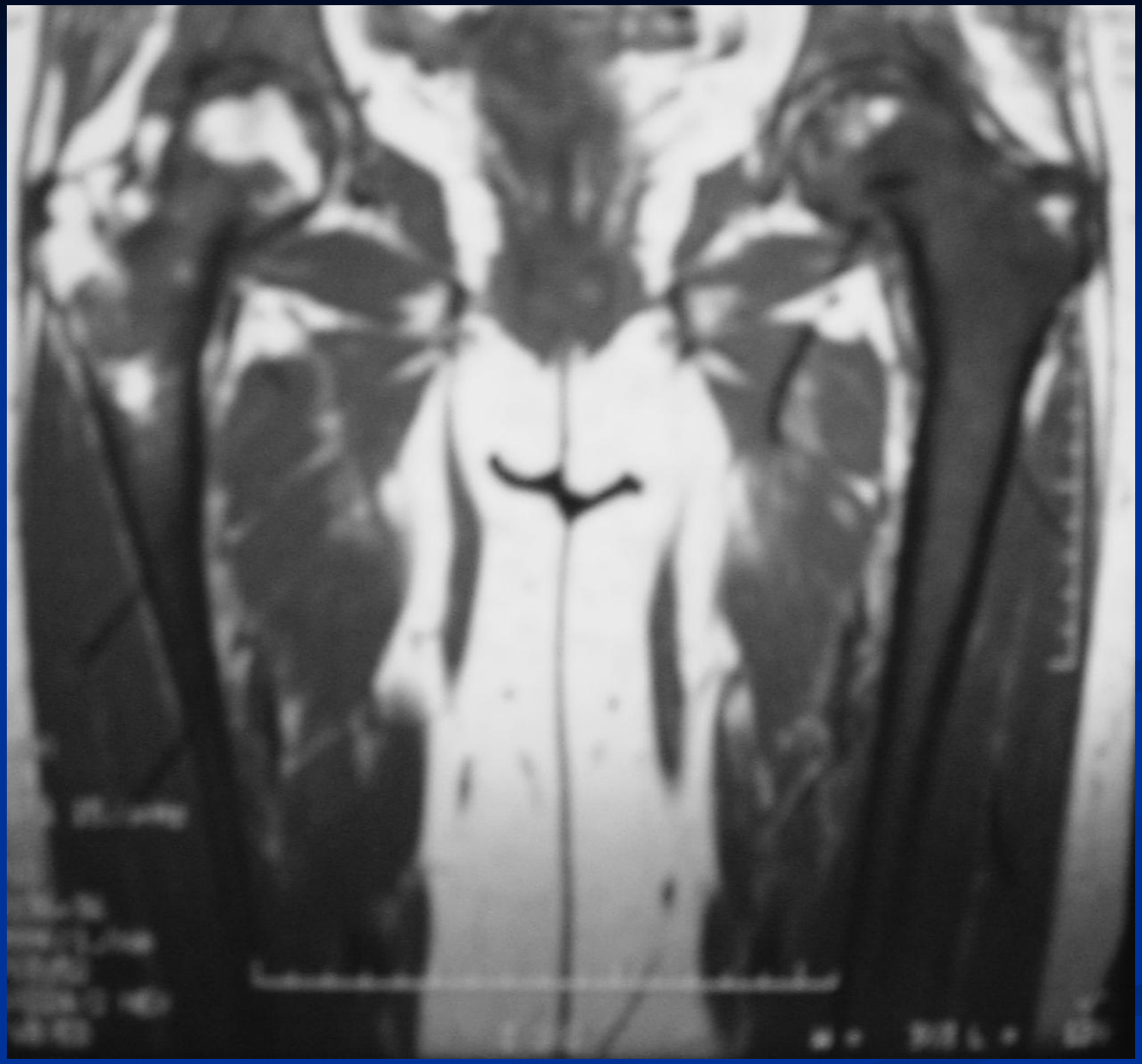
MRI

- Extent of intramedullary amd marrow involvement
- Extraosseous component
- Spine involvement and epidural extension, spinal cord compression
- Pathological fracture through neoplasm vs. osteoportic bone vs. infection
- Evaluating adjacent joints/ other pathology causing pain

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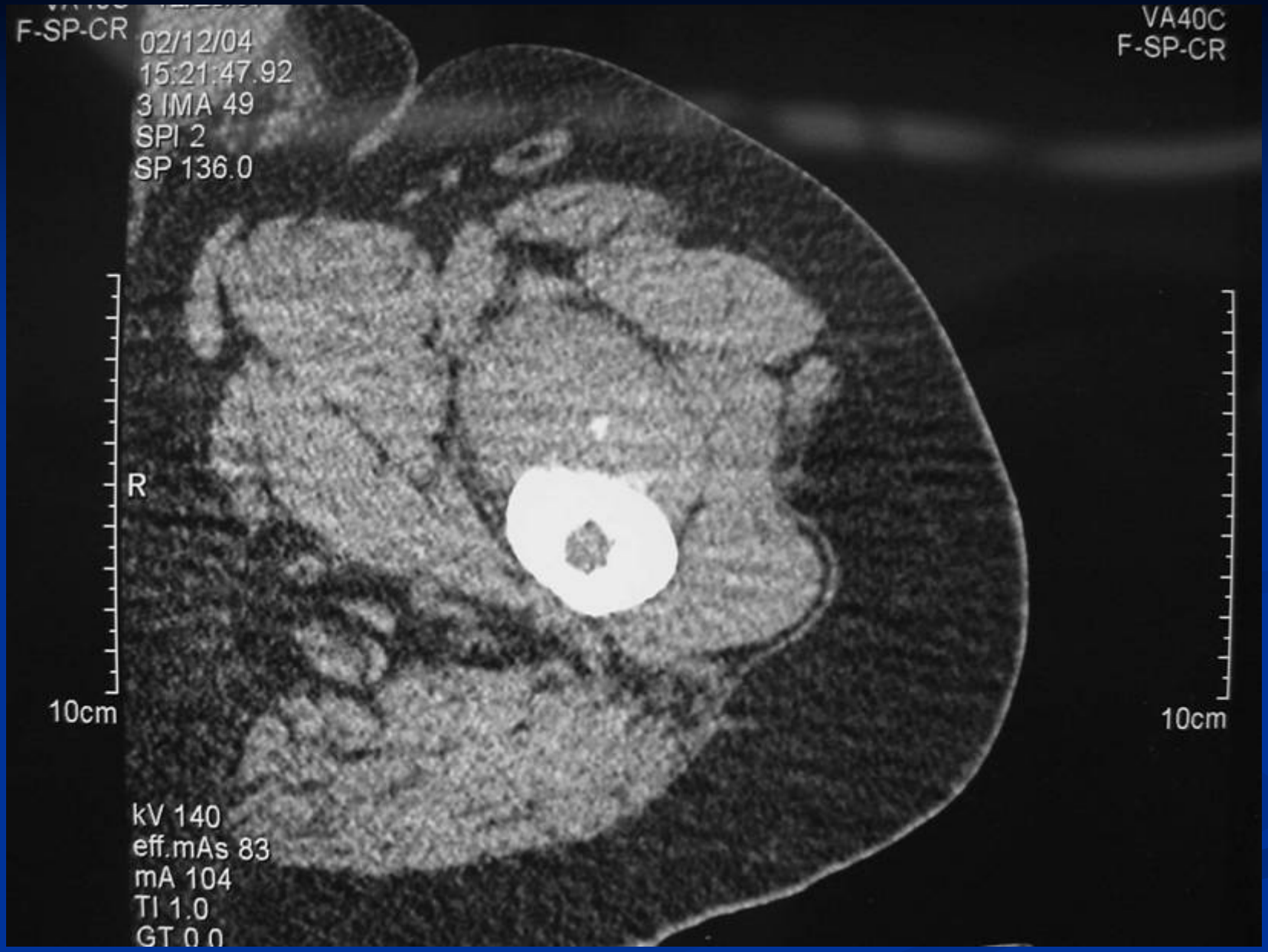
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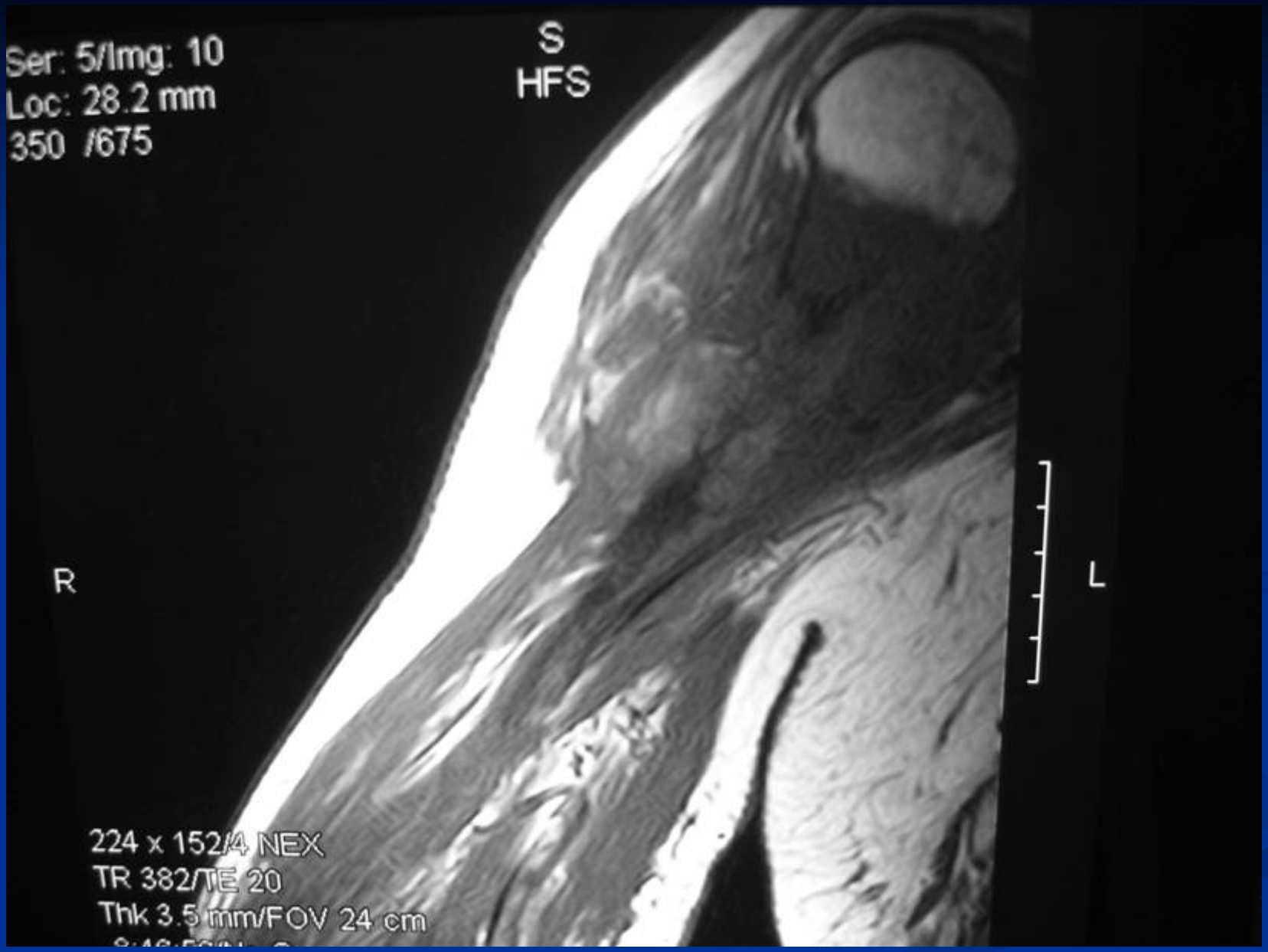
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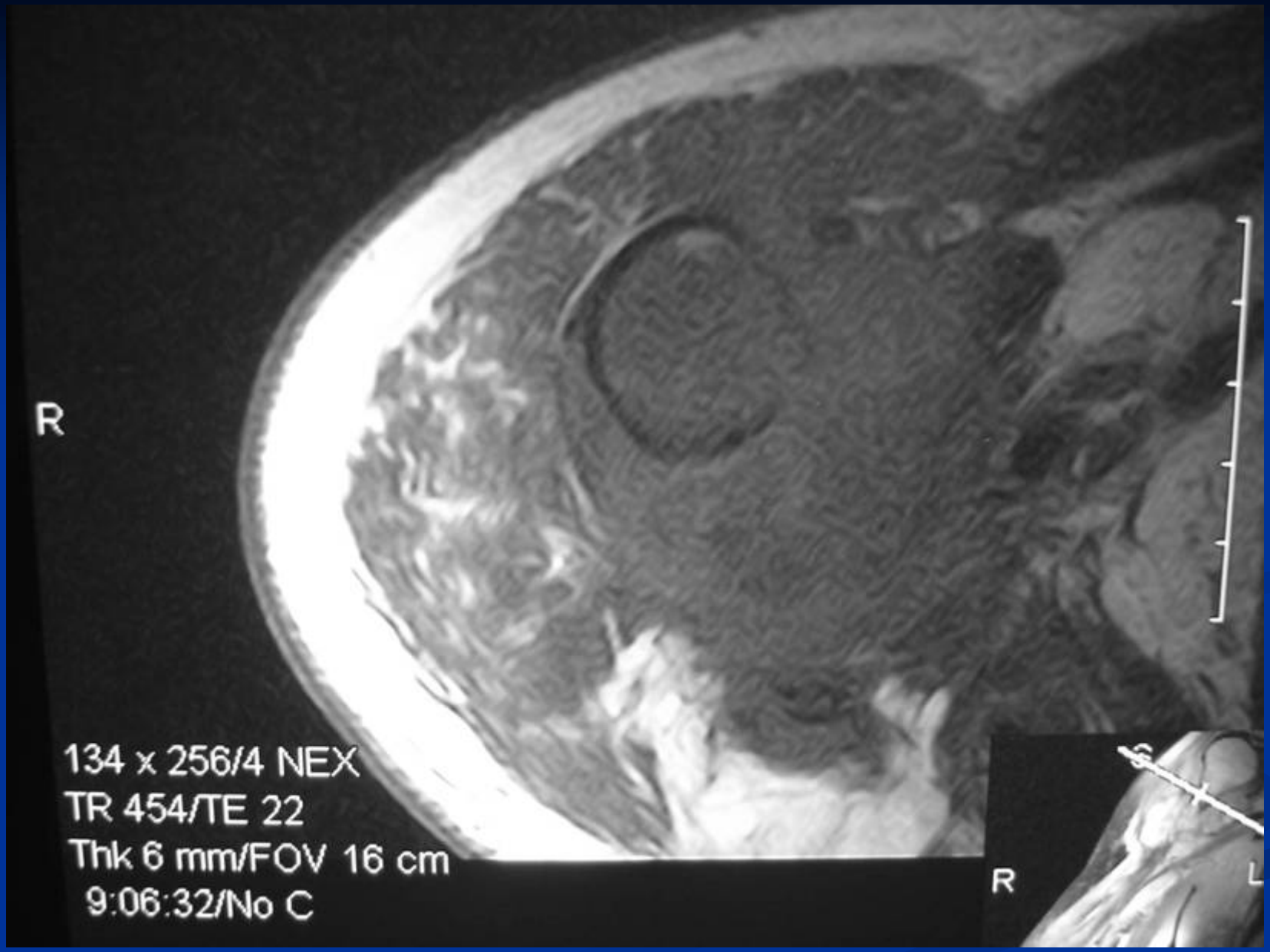
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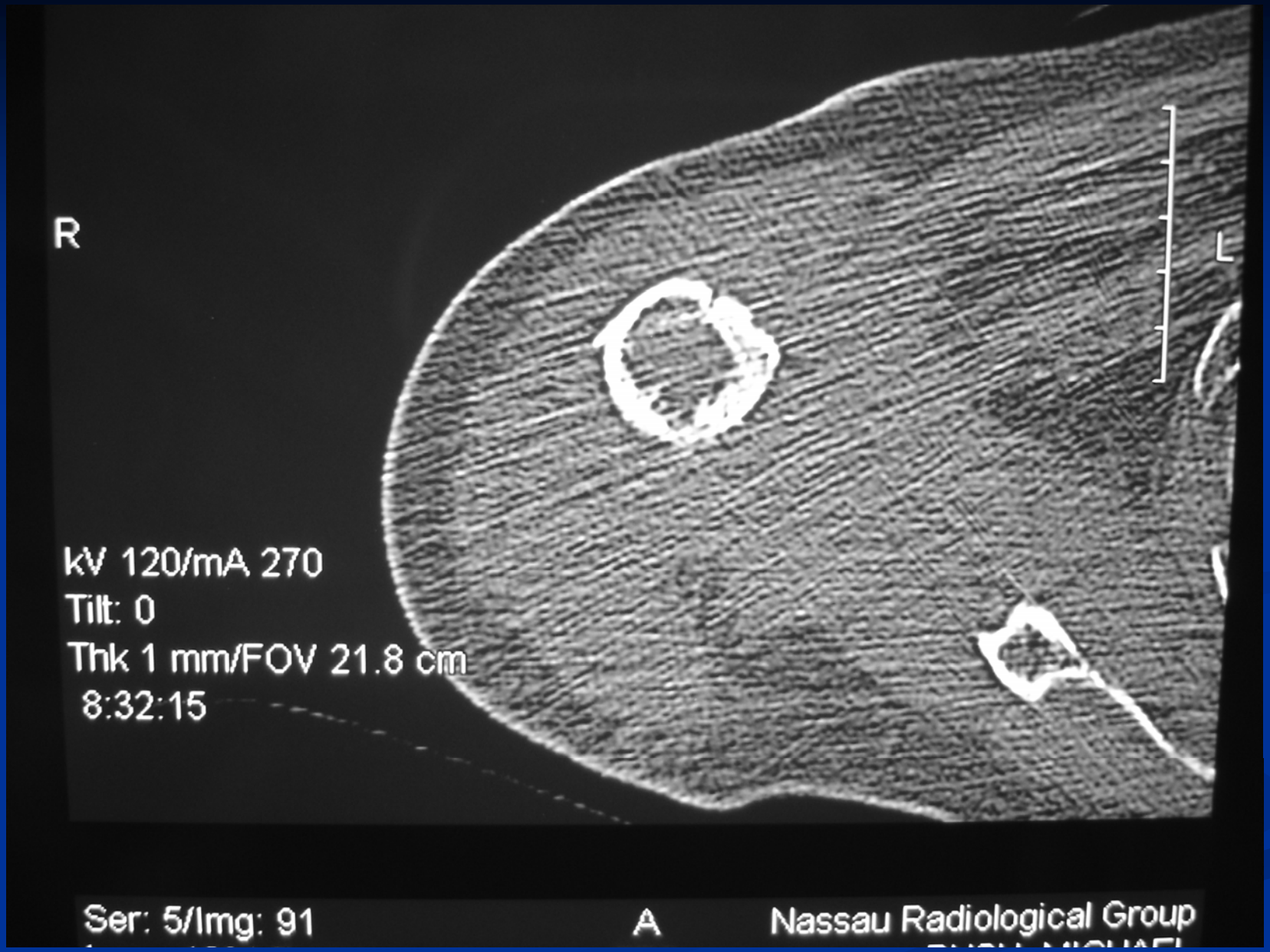
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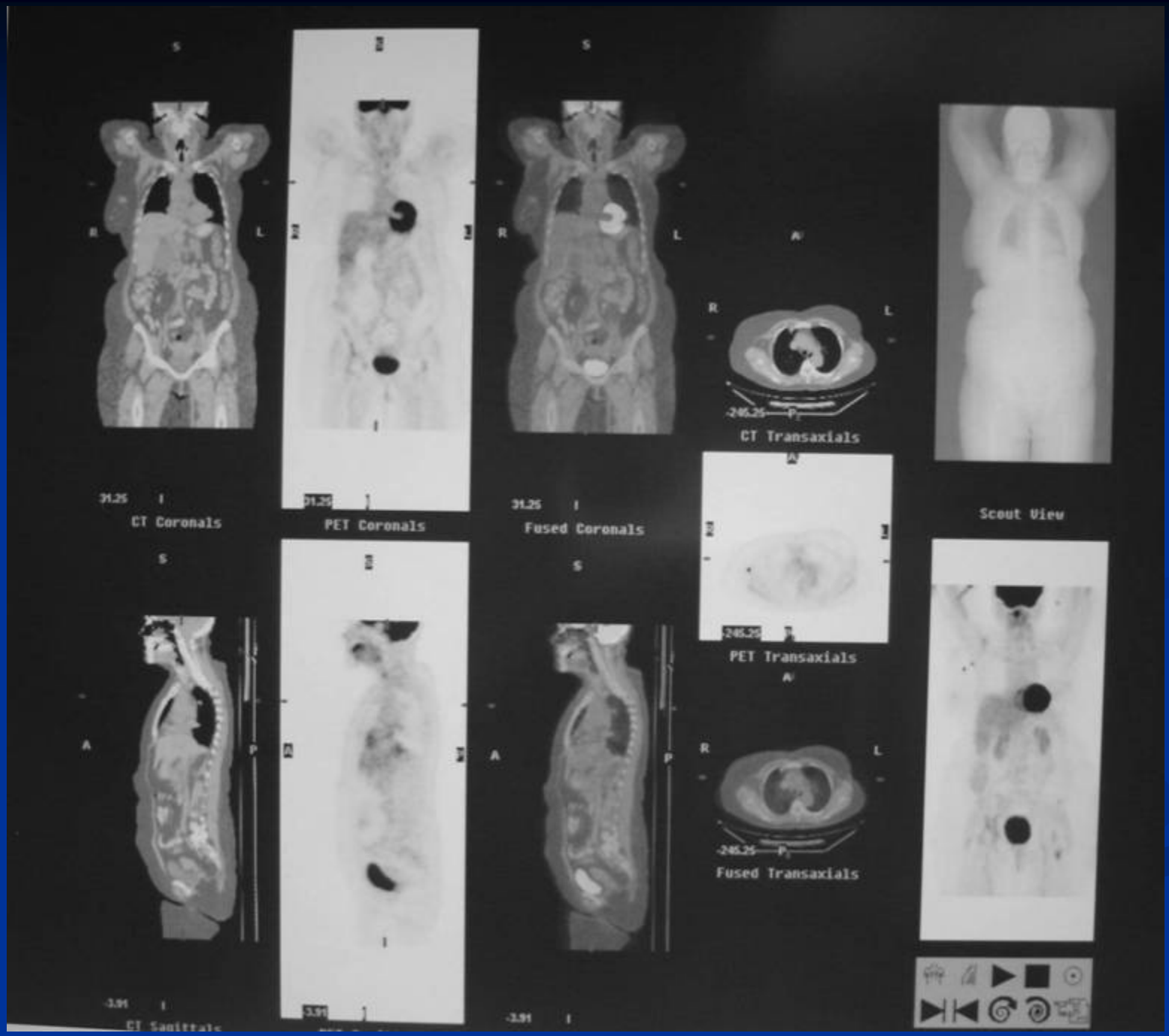
Nassau Radiological Group

PET Scan

- New Tool
- (18F)fluorodeoxyglucose---radiolabeled glucose
- Indentifies metabolically active areas
- Nonspecific
- Must correlate with other studies
- May be useful for monitoring response to treatment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PET Coronals
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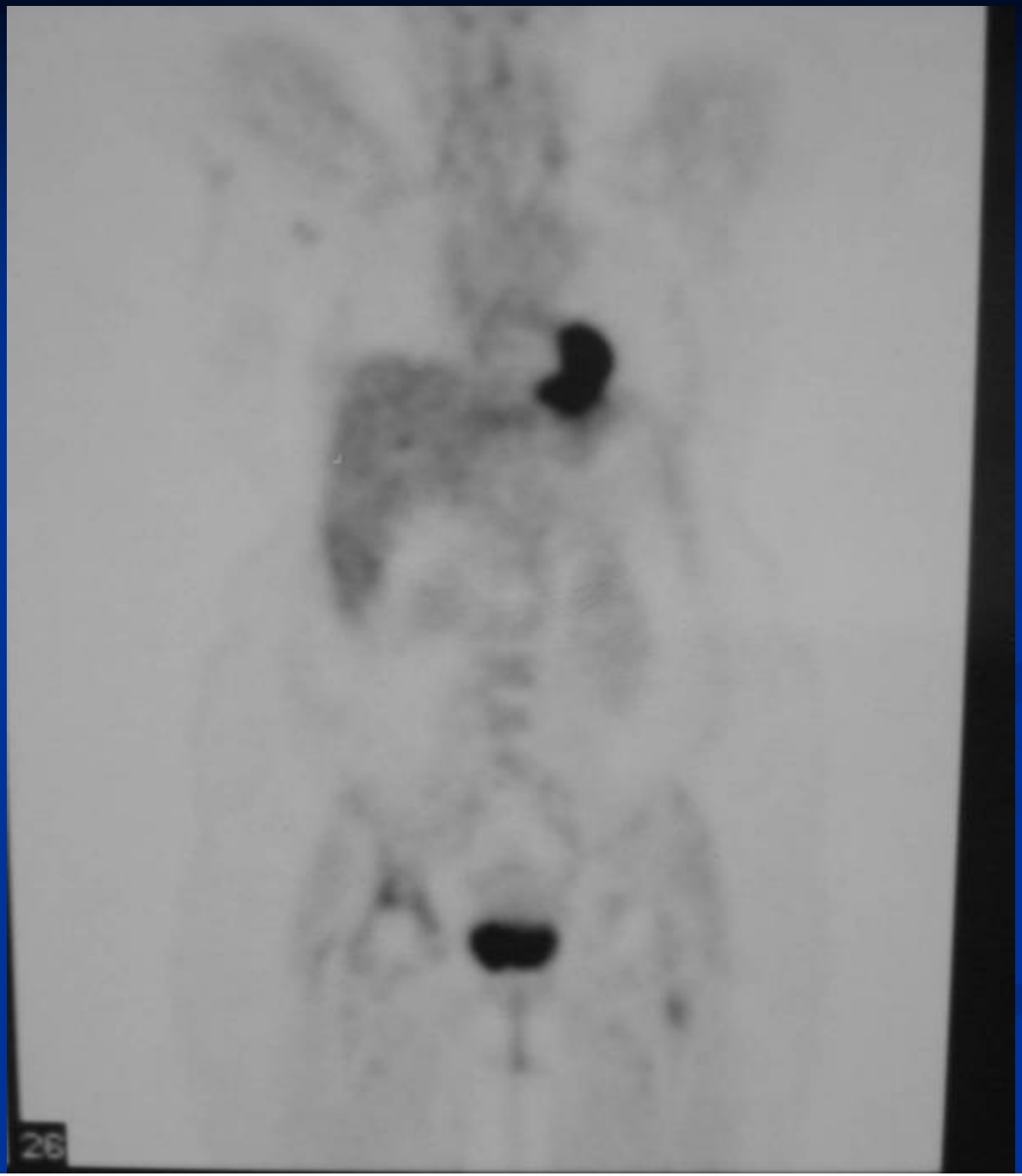
CT Transaxials
Scout View
PET Transaxials
Fused Transaxials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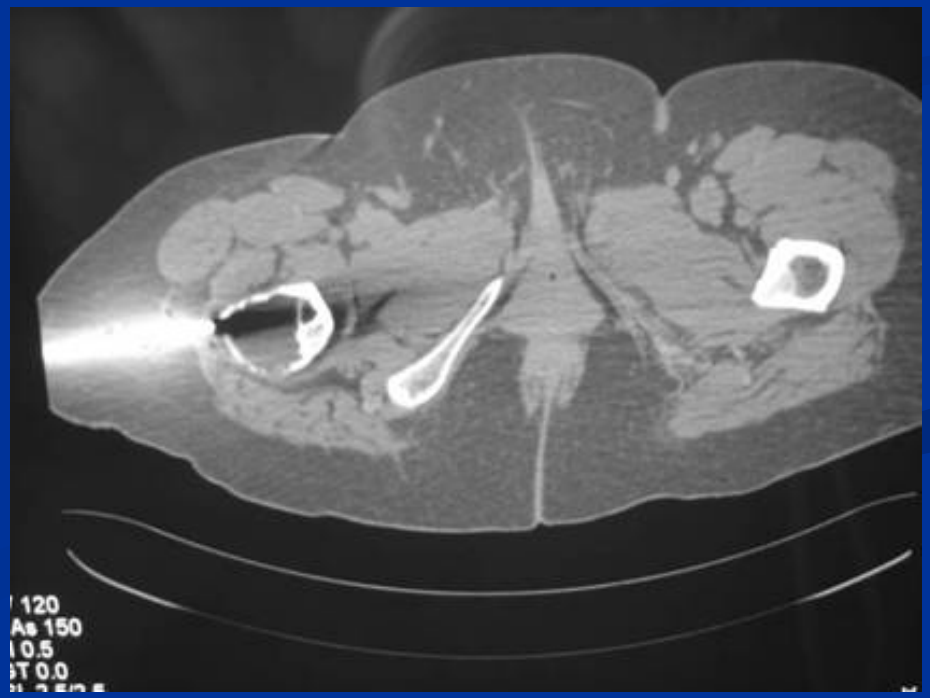
Biopsy Indications

- Confirm metastatic disease in a patient with a known primary
- Solitary or multiple bone lesions in a patient without a known primary tumor (rule out sarcoma, dedifferentiated chondrosarcoma, paget's disease, metabolic bone disease, brown tumor of hyperparathyroidism)
- Disease progression
- Hormonal/immunohistochemical studies

Types of Biopsies

- CT guided core needle biopsy
  - Preferred method; Minimally invasive; Less risk of infection and hematoma; Less soft tissue contamination
  - Diagnostic accuracy up to 90% (same as open biopsy when performed by experienced radiologist and pathologist)
  - Biopsy site in line with incision for definitive procedure
  - Needle directed to portion of lesion most likely to yield diagnostic tissue
  - Especially useful for pelvic and spine lesions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Types of Biopsies

- Fine needle aspiration (FNA)
  - Confirm presence of metastatic carcinoma in a patient with known metastatic disease (Not for solitary tumor)
- Open biopsy
  - At time of surgery, confirm metastatic carcinoma in pt with known mets
  - Failed CT guided biopsies

Nonsurgical Management

- Hormonal Therapy—Prostate and Breast Cancer
- Chemotherapy/Immunotherapy
- Bisphosphonates--pamidronate
- Radiation
- Radiopharmaceuticals (Strontium 89, Iodine 131)---end stage diffuse painful bone mets

Surgery

- Surgical intervention must be undertaken with the intention of avoiding future surgery and complications (poor medical condition and limited life expectancy of patients)

- Most patients without a fracture do not require surgery however fractures are best treated by operative internal fixation

Goals of Surgery

- Pain relief
- Preservation and maintenance of function
- Facilitation of nursing and custodial care
- Local tumor control
- Skeletal stabilization
  - Immediate weight bearing and return to activity
  - Do not rely on fracture healing
  - Presence of tumor negatively affects the ability of a fracture to heal

Principles of Surgical Management

- Preoperative embolization of suspected vascular lesions
- Administration of perioperative antibiotics
- Correction of hypercalcemia
- Transfusion to correct preexisting anemia, thrombocytopenia and coagulopathy
- Modify surgical approach to avoid previously irradiated fields and ensure adequate soft tissue coverage
- Curettage to remove all gross tumor

Principles of Surgical Management

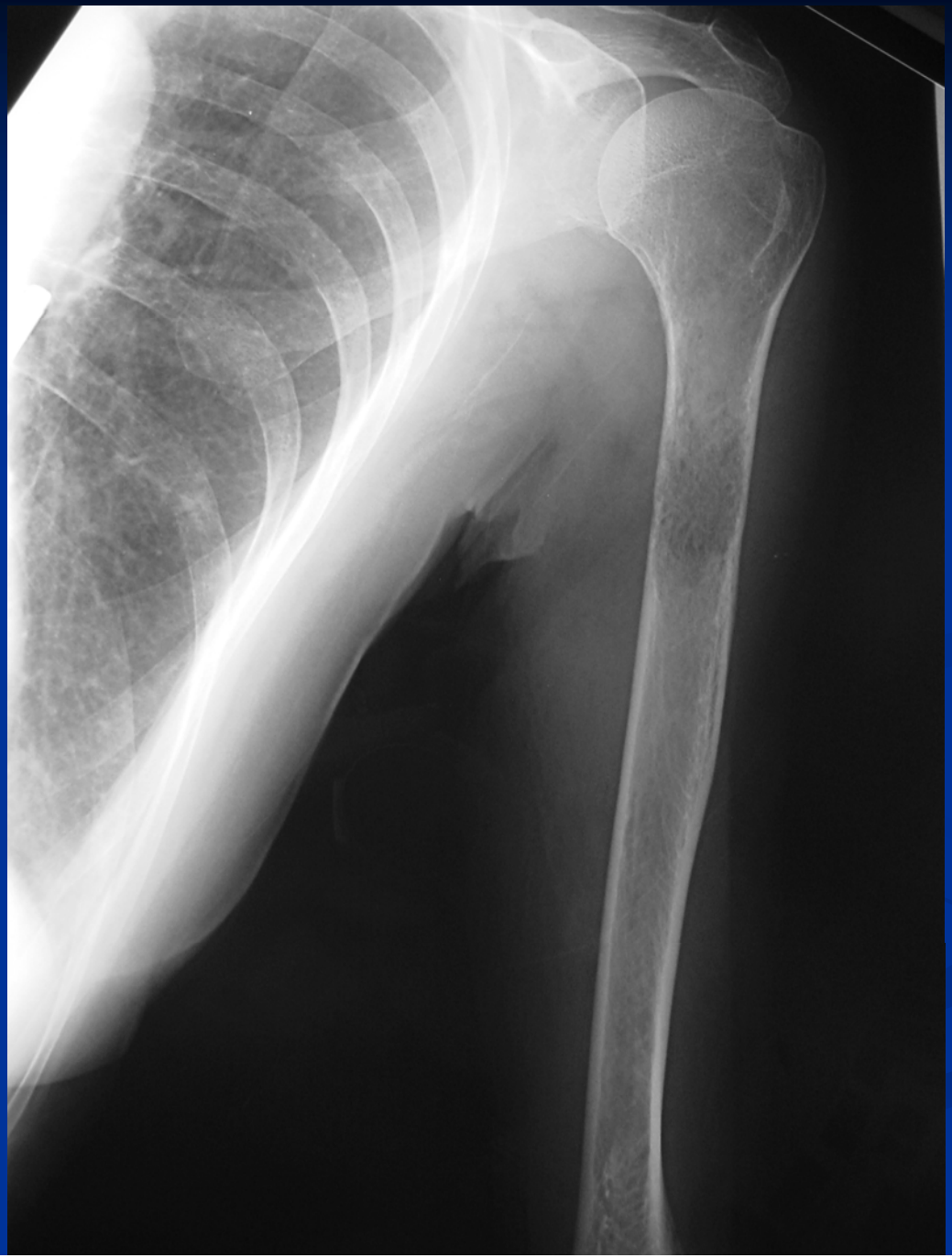
- Immediate rigid internal fixation supplemented with PMMA or cemented prosthetic replacement
- Filling defects with PMMA
- Postoperative nutritional supplementation to promote wound healing
- Adjuvant radiotherapy and/or chemotherapy

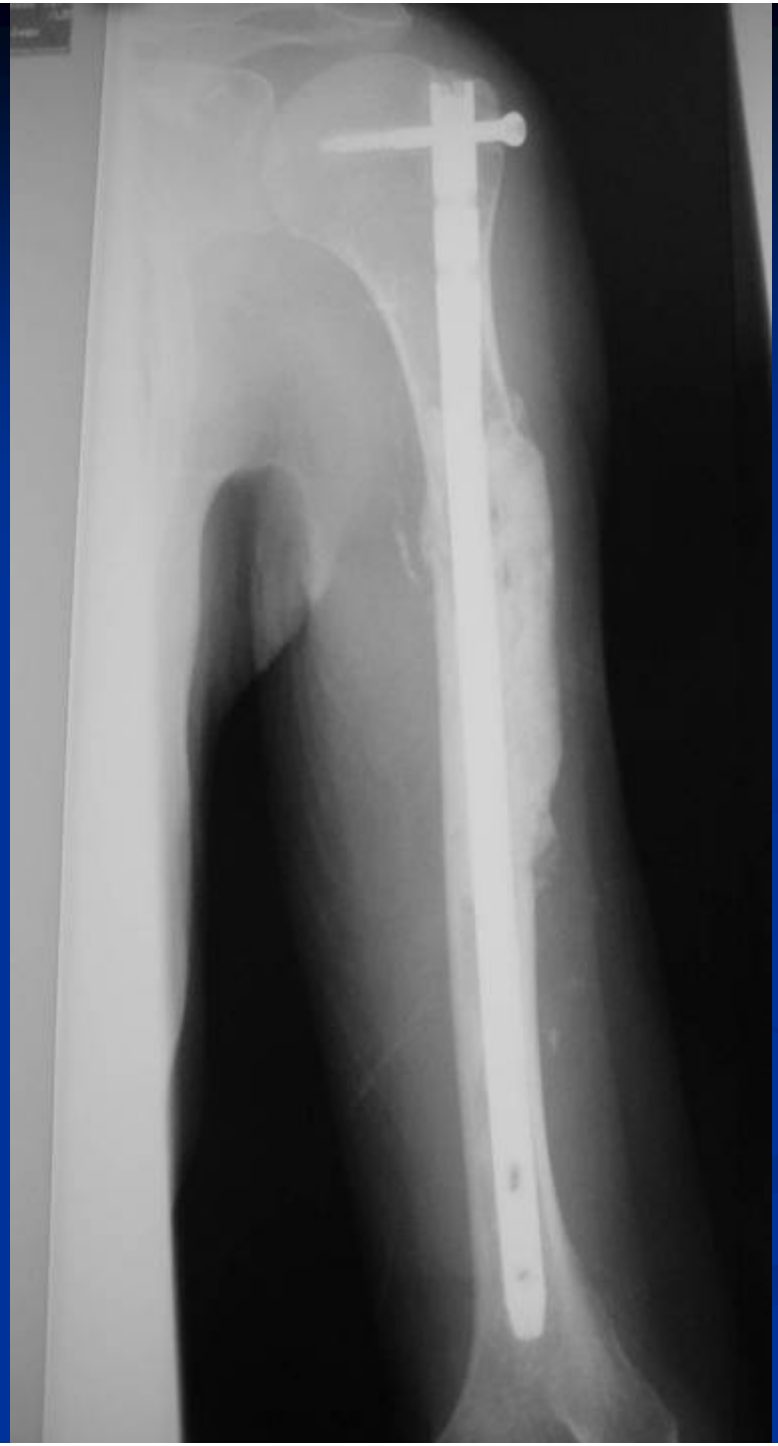
Tumor Excision

- Biological Control
- Curettage if sufficient bone remaining for reconstruction with PMMA
- Resection for total bone loss or if single isolated metastasis
- Patients with an isolated bone met may be rarely cured or rendered with prolonged disease free survival following resection

Composite Osteosynthesis

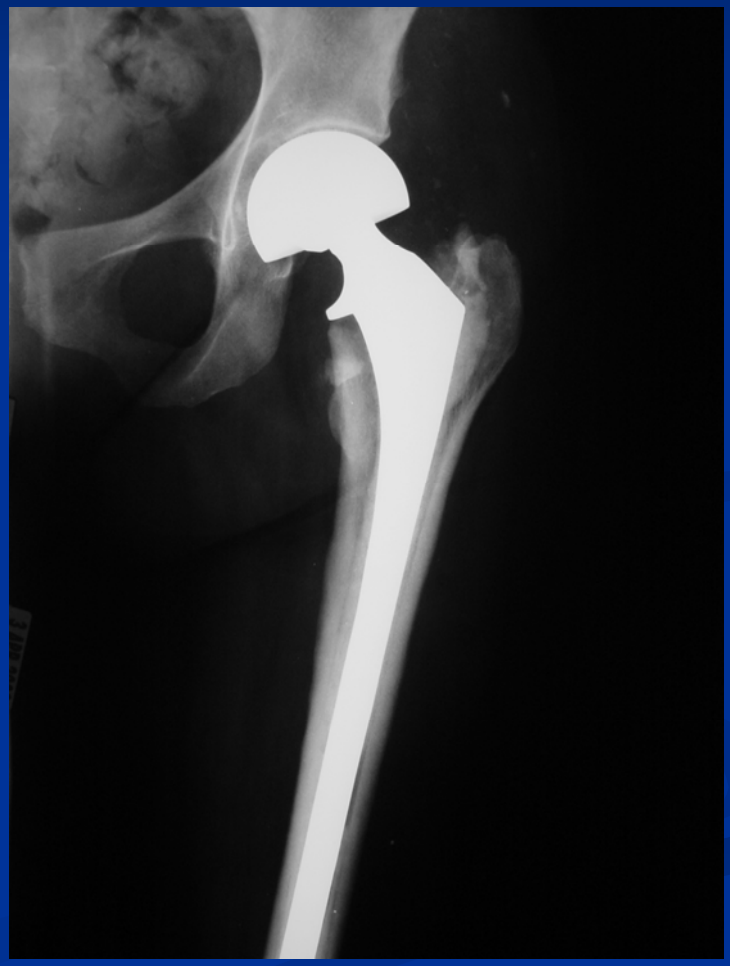
- Internal fixation devices usually combined with PMMA
- Use of PMMA to fill the defect reduces risk of fixation failure
- Fixation of impending and pathological fractures of the shaft of long bones (humerus and femur)
- Fix and protect entire bone when feasible
- Intramedullary rods have lower rates of failure than plates
- Intramedullary rods may be impossible with extensively sclerotic lesions—like drilling cement



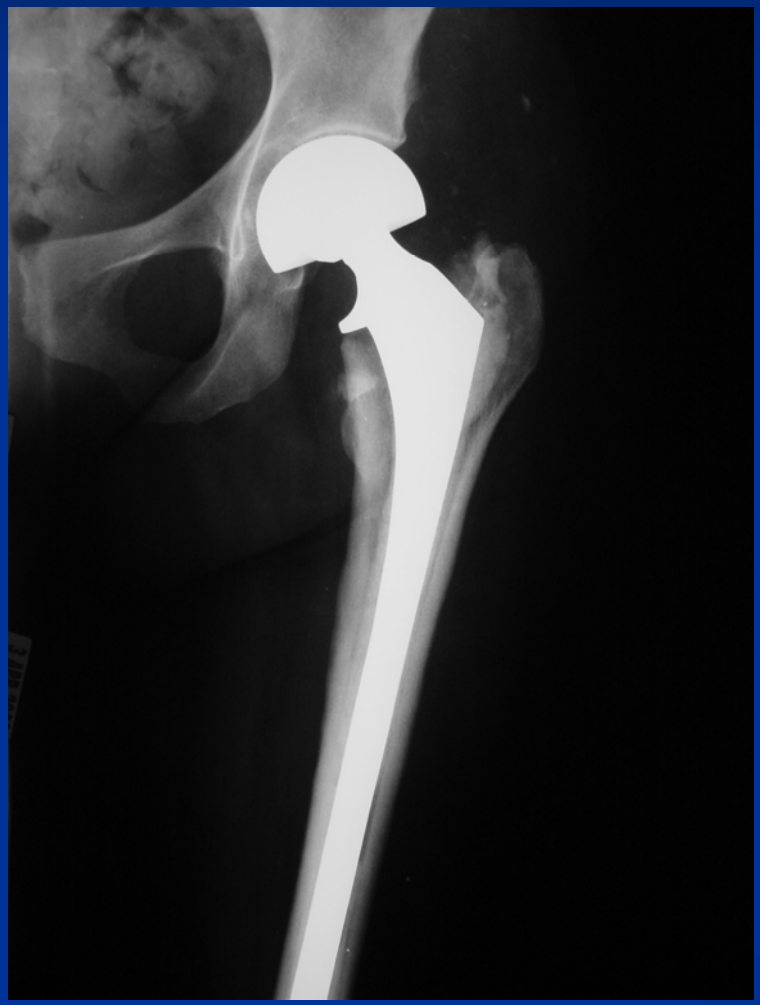


Joint Replacement

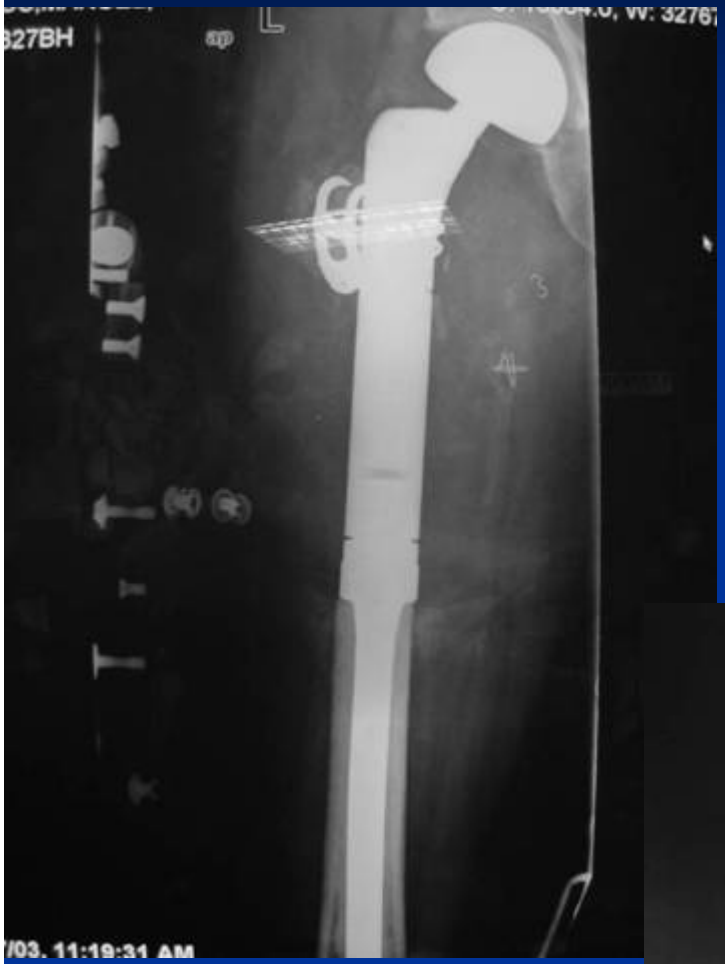
- Resection and reconstruction of a joint using a prosthesis combined with cement
- Most commonly used around the hip and shoulder
- Long stem prosthesis often utilized
- Tumor prostheses for extensively destructive lesions or for a single bone metastasis



Long Stem Cemented Hemiarthroplasty



Segmental Prosthetic Replacements



Cryosurgery

- Use of liquid nitrogen as an adjunct to surgical curettage to freeze and destroy any residual microscopic cells
- Indications
  - Failed radiation treatment
  - Hypernephromas, Metastatic Thyroid
  - Tumors in difficult anatomic locations or where XRT may cause problems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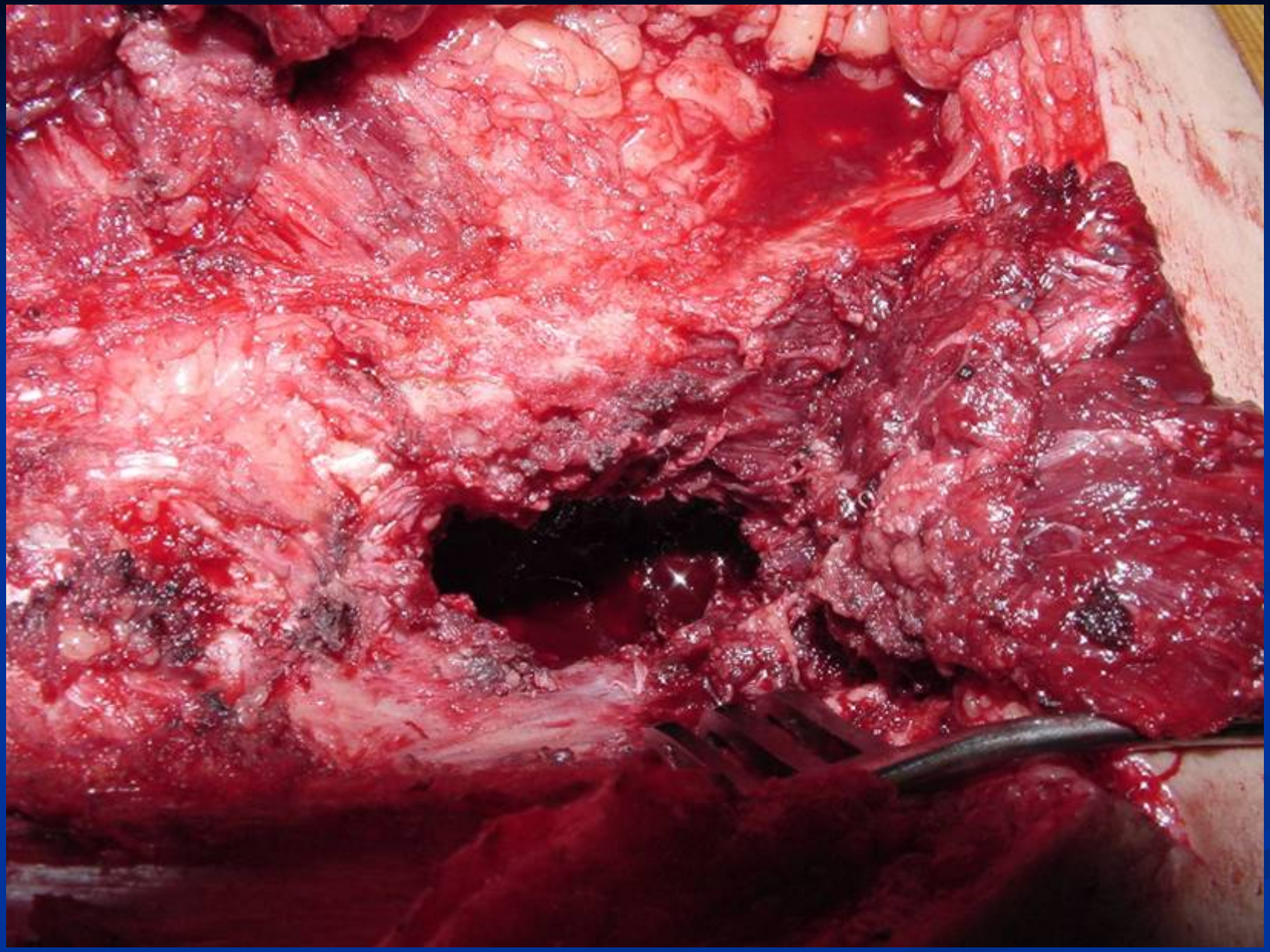
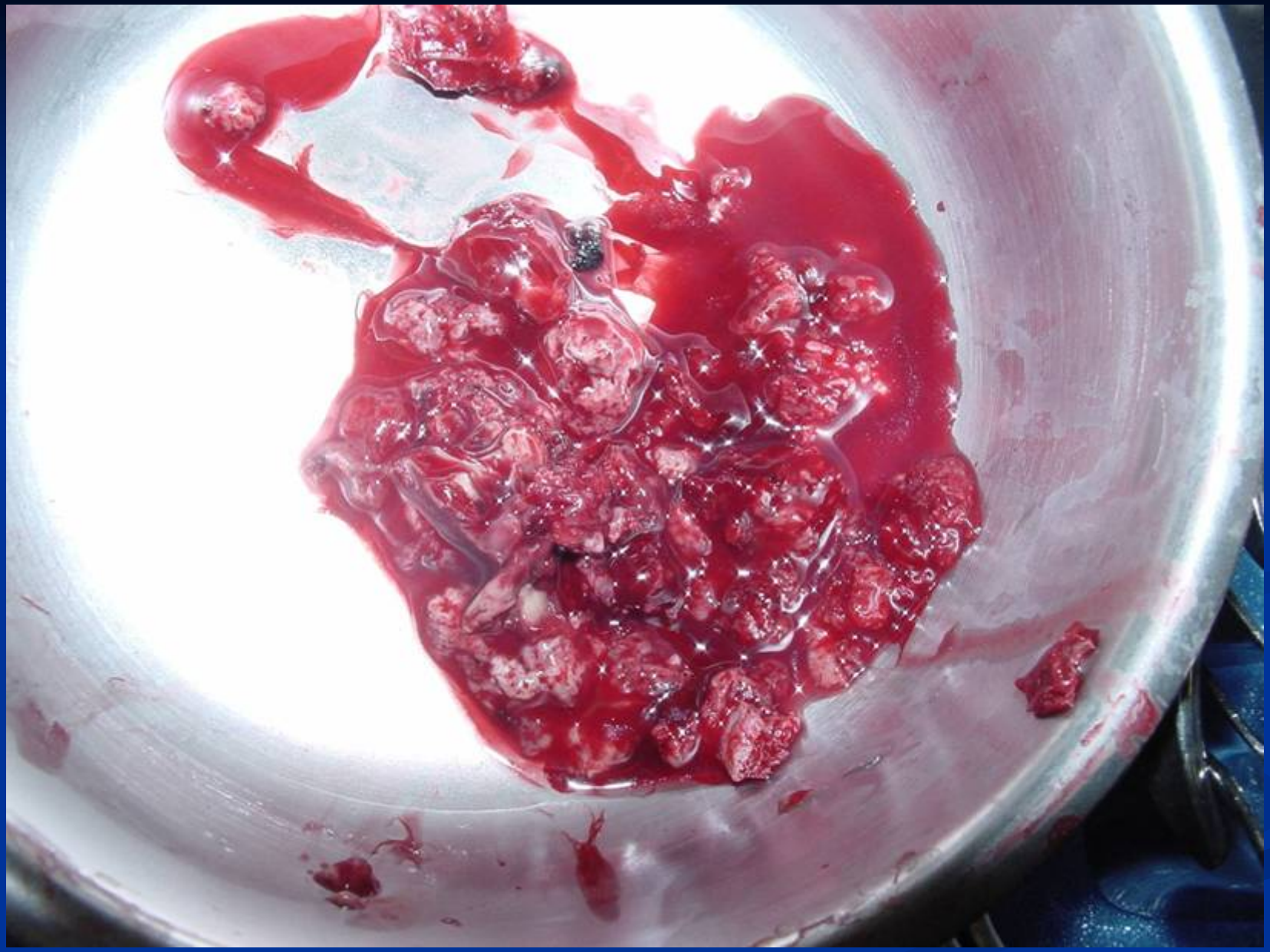
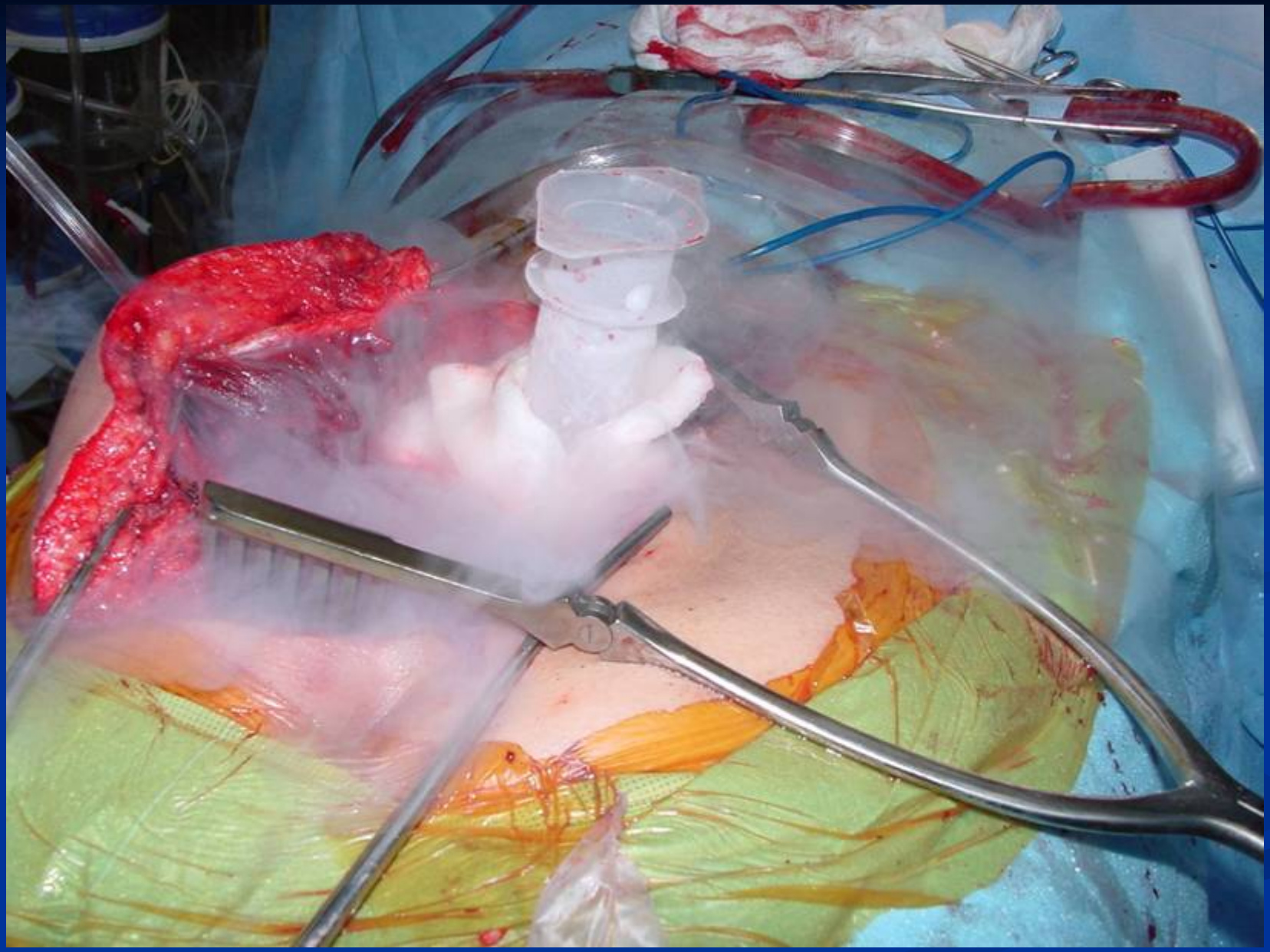






Amputation

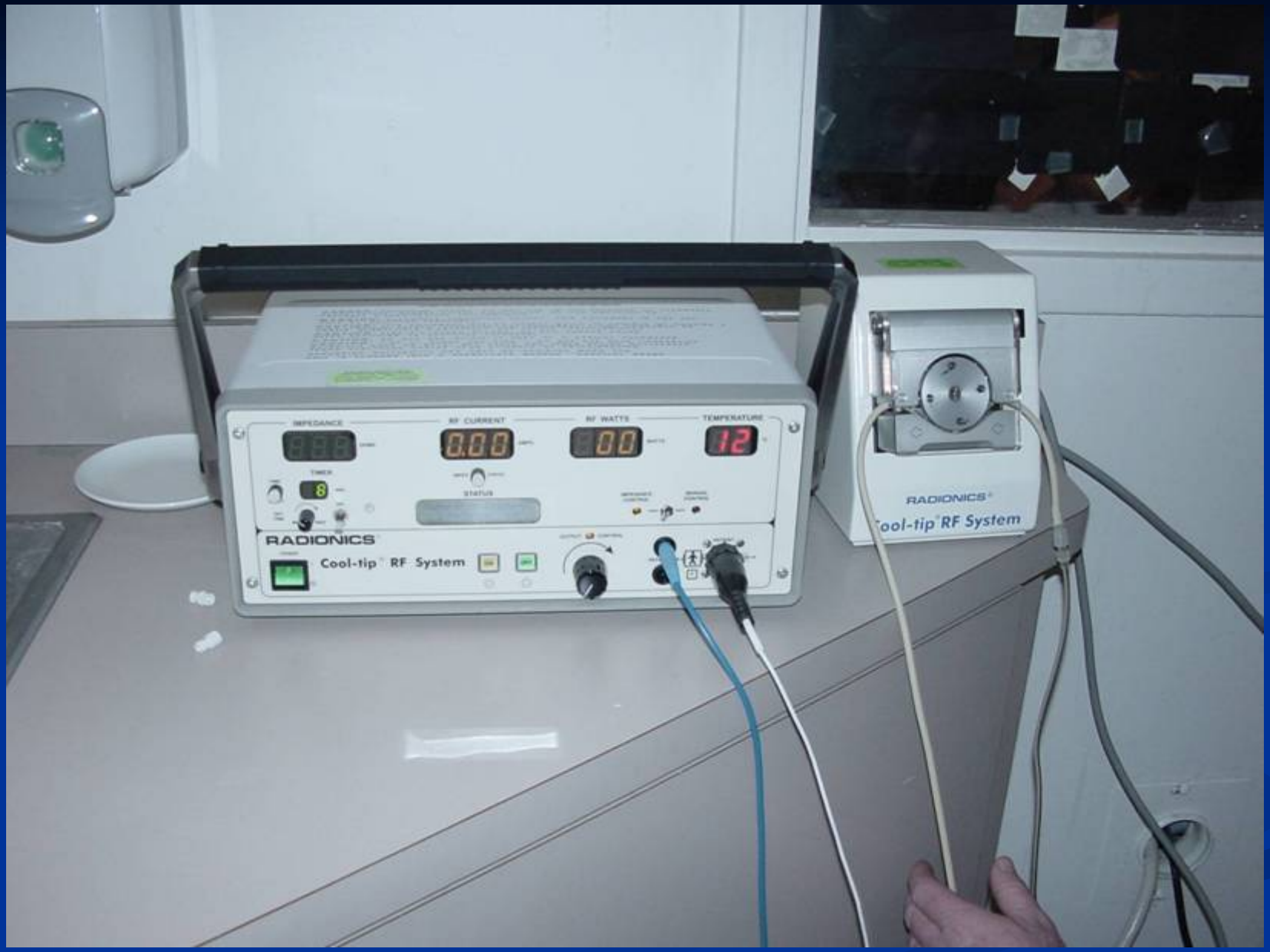
- Limited role in treatment of metastatic carcinoma
- Advanced cancer results in uncontrollable, intractable pain, a functionless extremity, tumor fungation, venous gangrene, sepsis or uncontrollable hemorrhage
- Can improve a patient's quality of life and provide palliation

Radiofrequency Ablation (RFA)

- Minimally invasive procedure
- CAT Scan guidance by a musculoskeletal radiologist.
- Needle or probe into lesion and destroying it with the use of heat.
- Outpatient procedure with the patient returning home the same day.

Radiofrequency Ablation (RFA)

- Indications (not well defined)
  - Small painful lesion with low risk of pathological fracture
  - At risk lesion; small lesion if progresses will place patient at risk of a pathological fracture
  - Failed radiation treatment
  - Tumor in area where it may be preferrable to avoid XRT (ie pelvis because of bone marrow suppression and need to get chemotherapy)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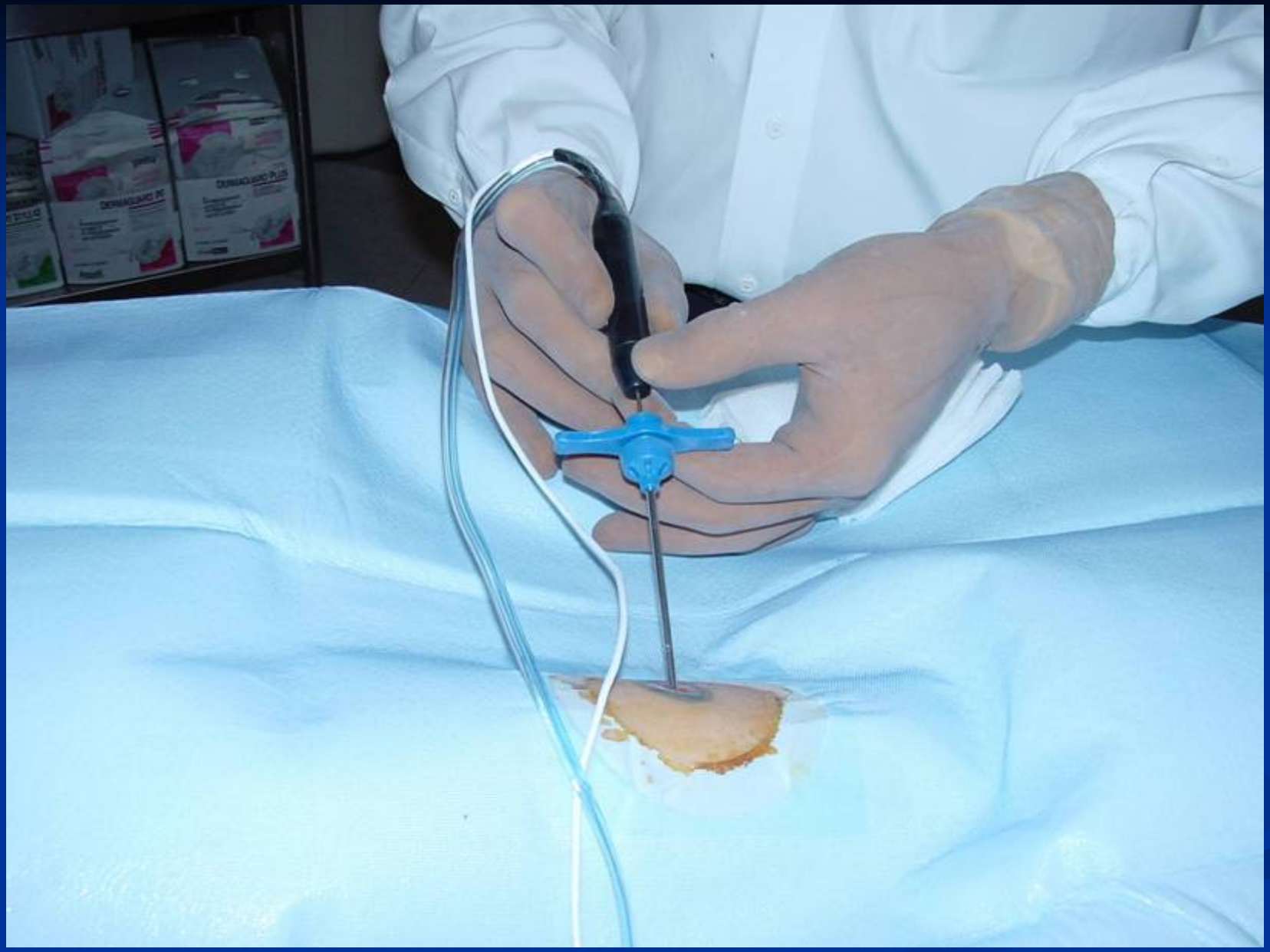

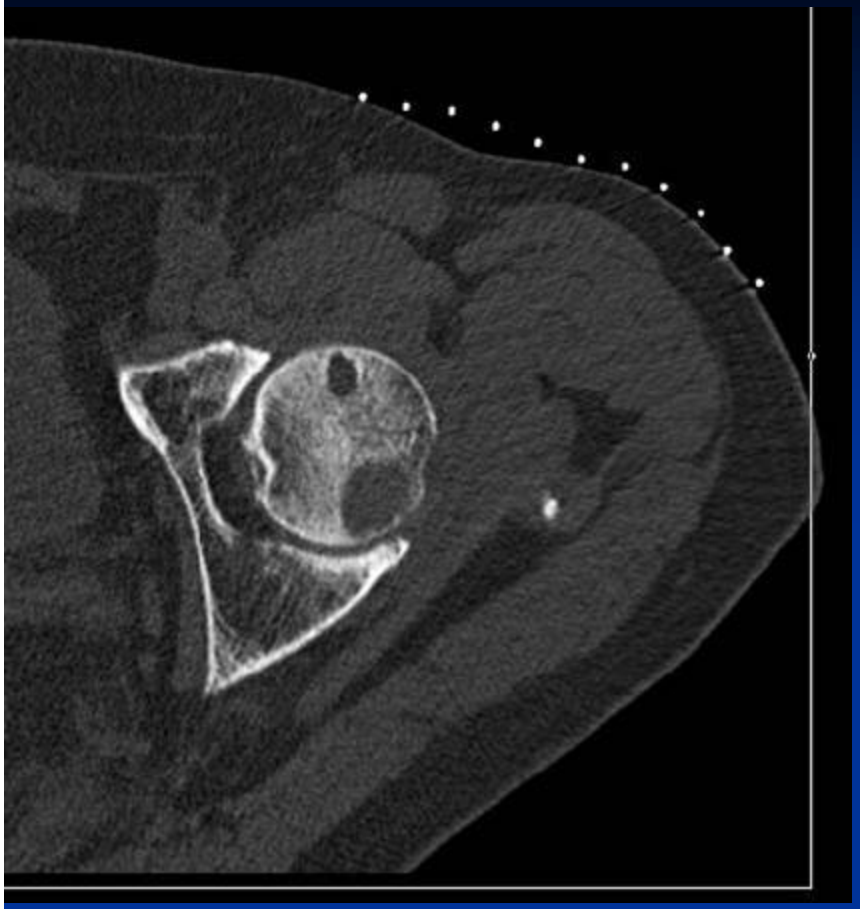

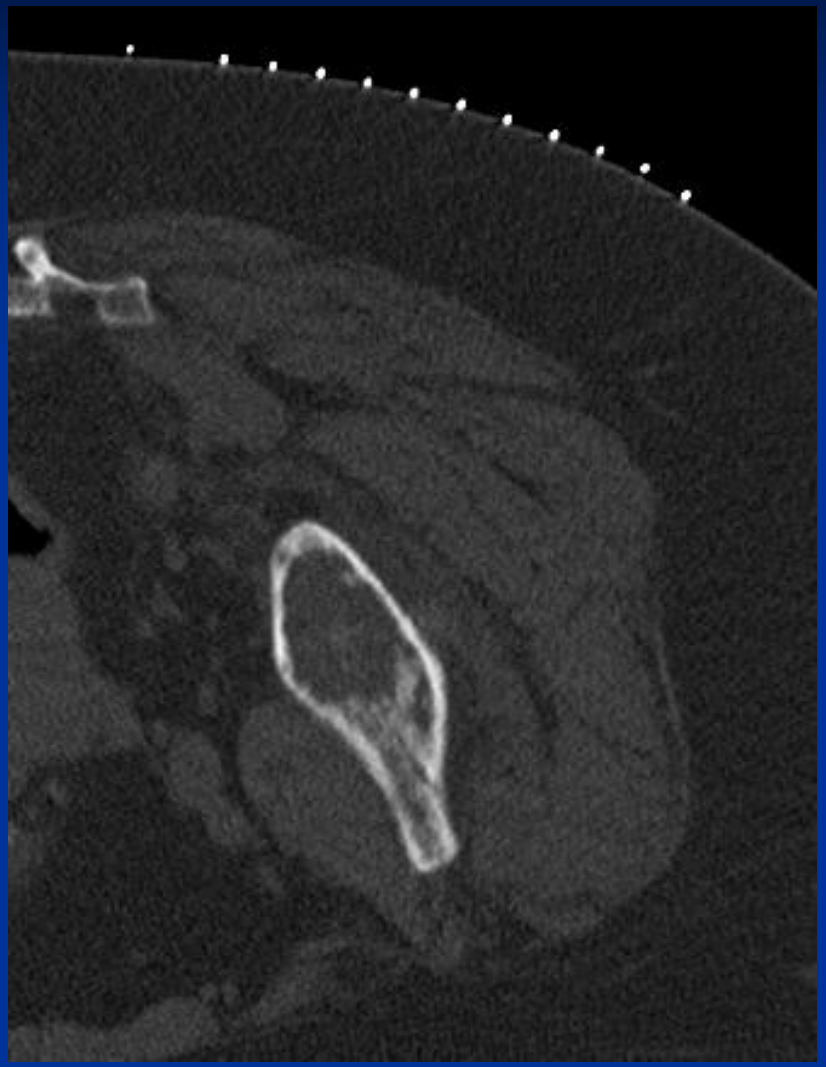

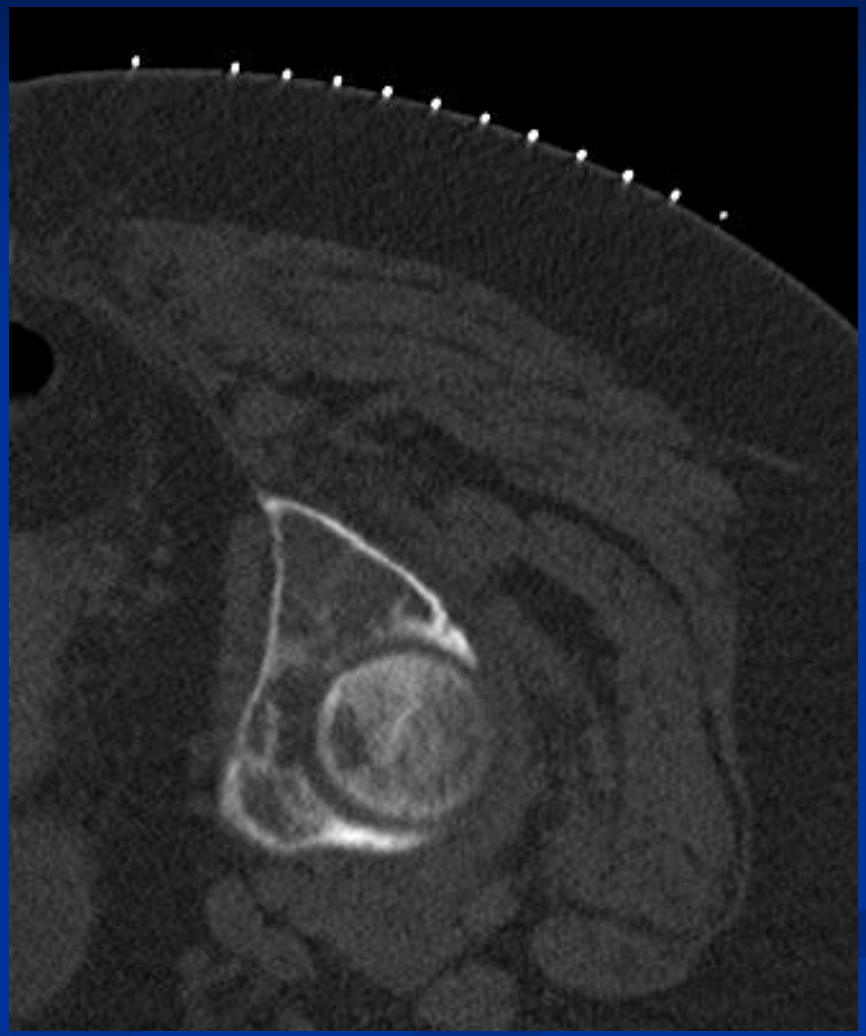

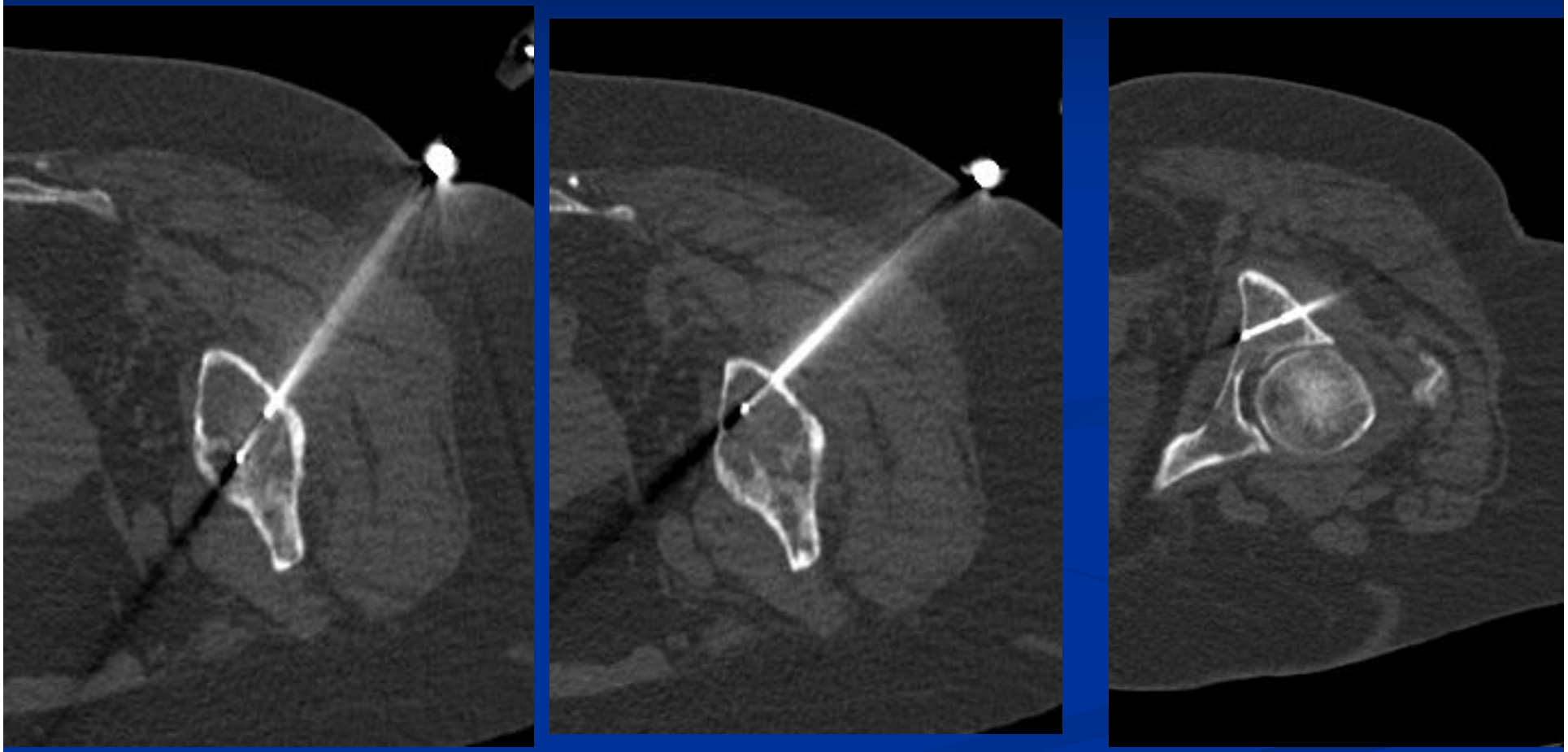


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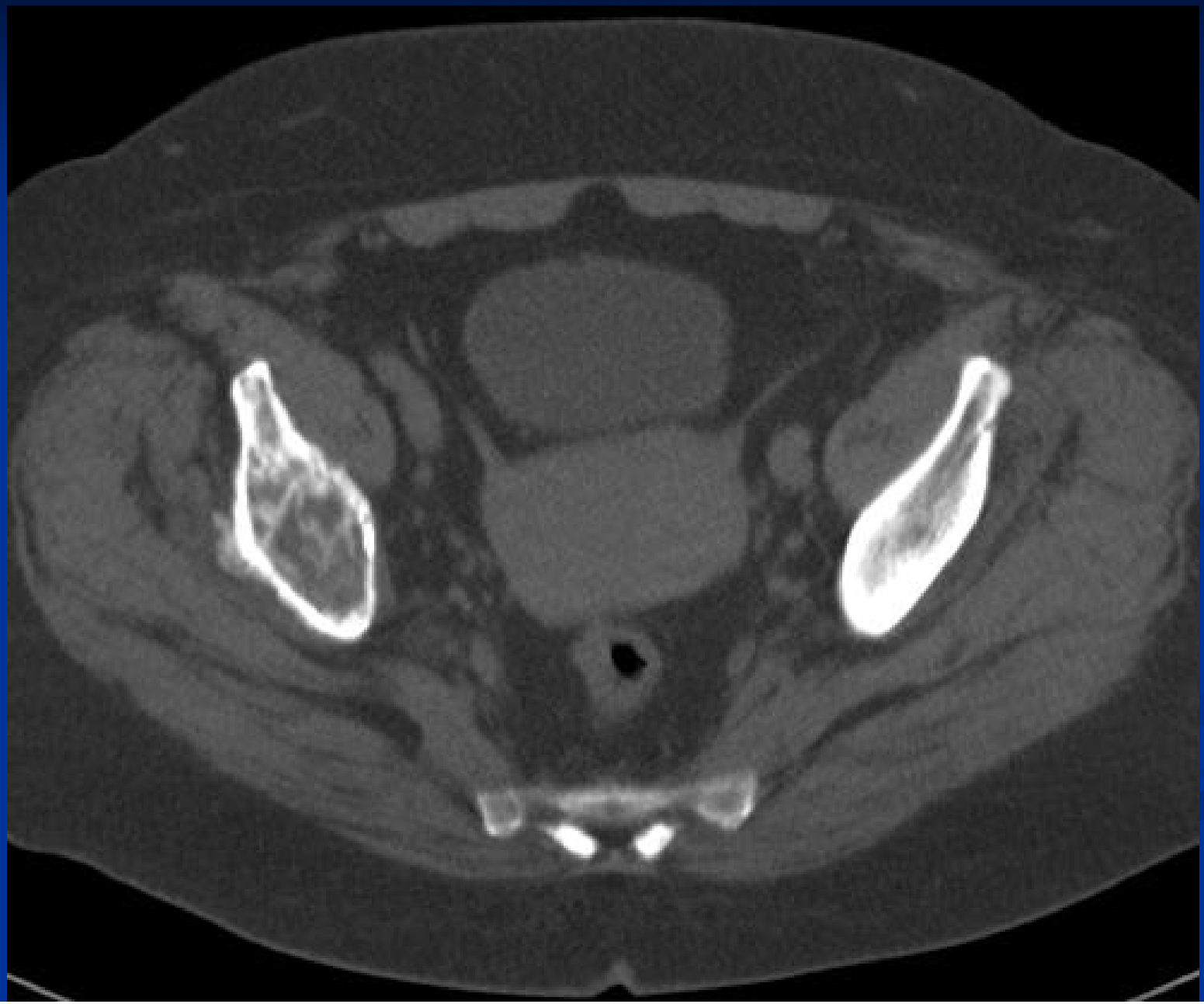
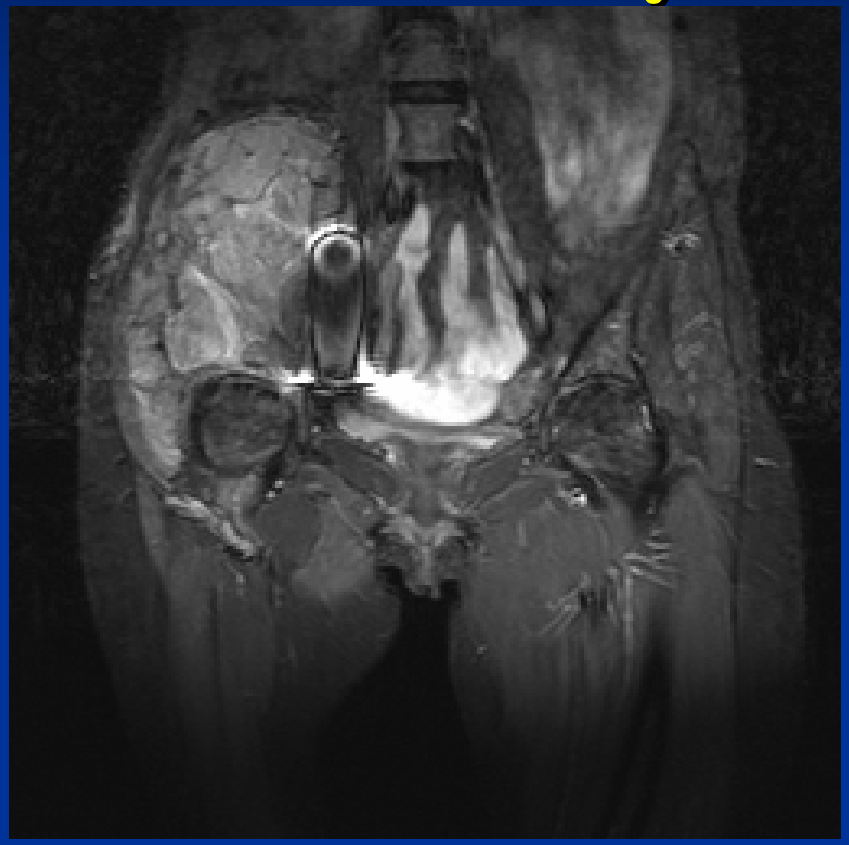
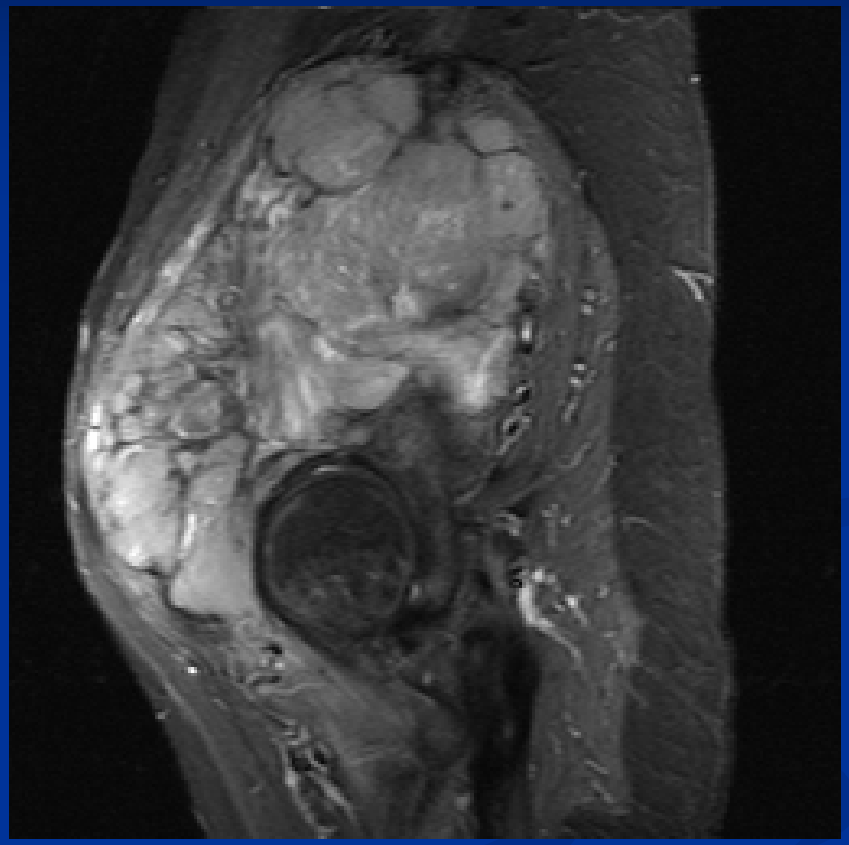


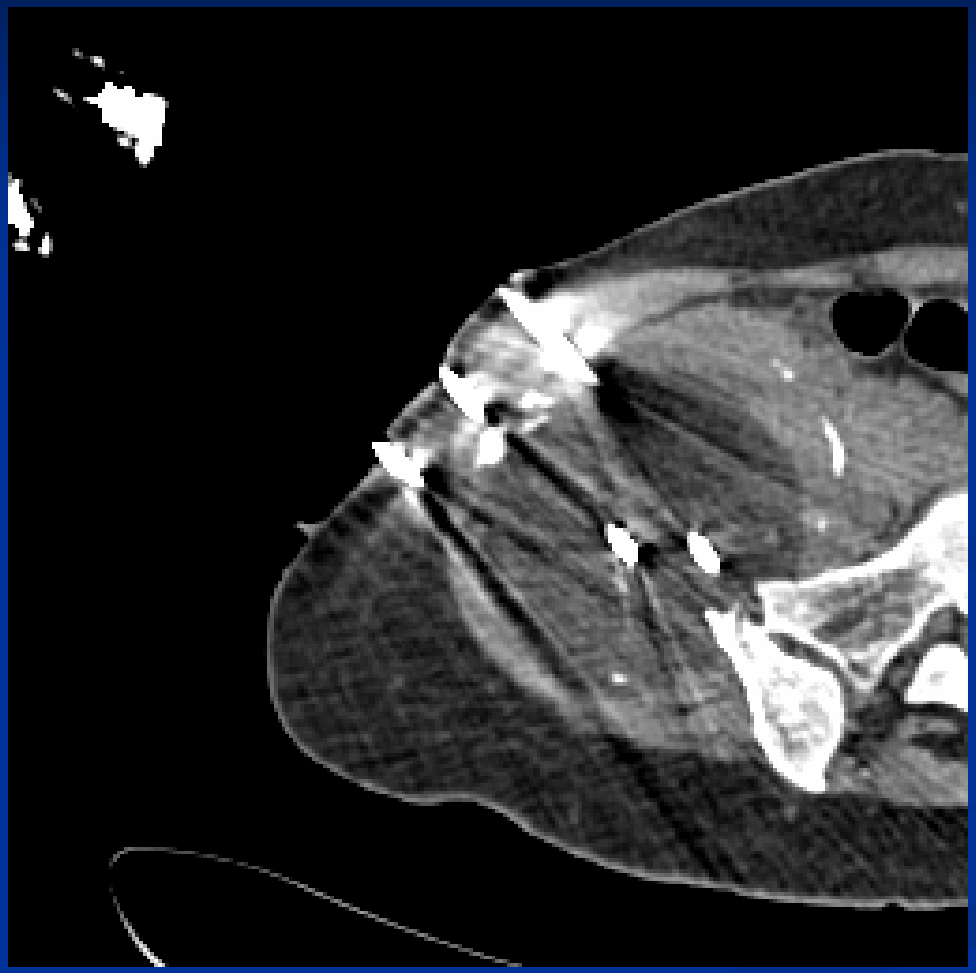
Percutaneous CT guided Cryoablation

- Minimally invasive treatment of a lesion with use of argon probes that directly freeze the lesion to subzero temperatures
- Preoperative planning for probe placement
- Ice ball is observed under CT
- Indications are poorly defined

Percutaneous CT Guided Cryoablation

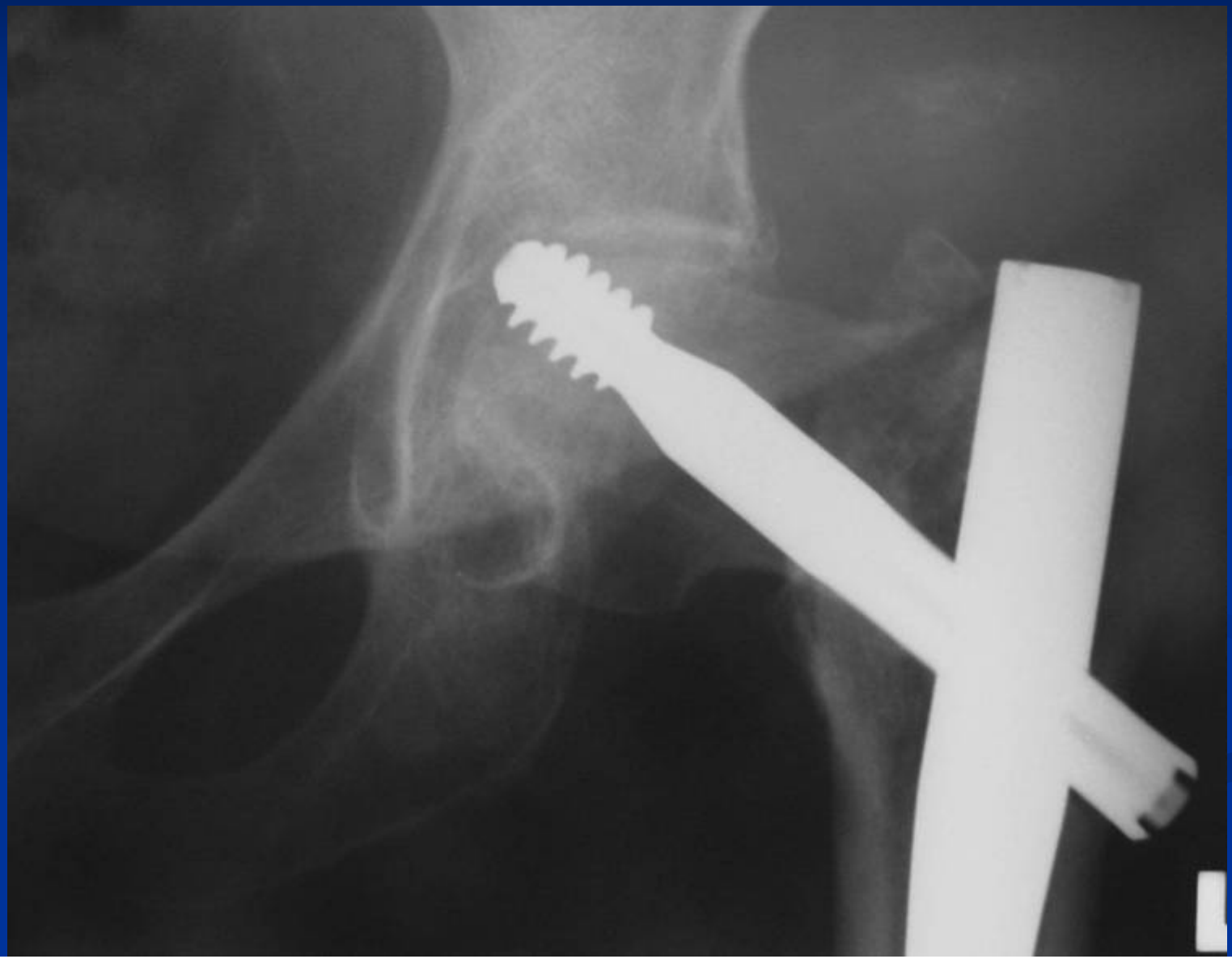






Pitfalls

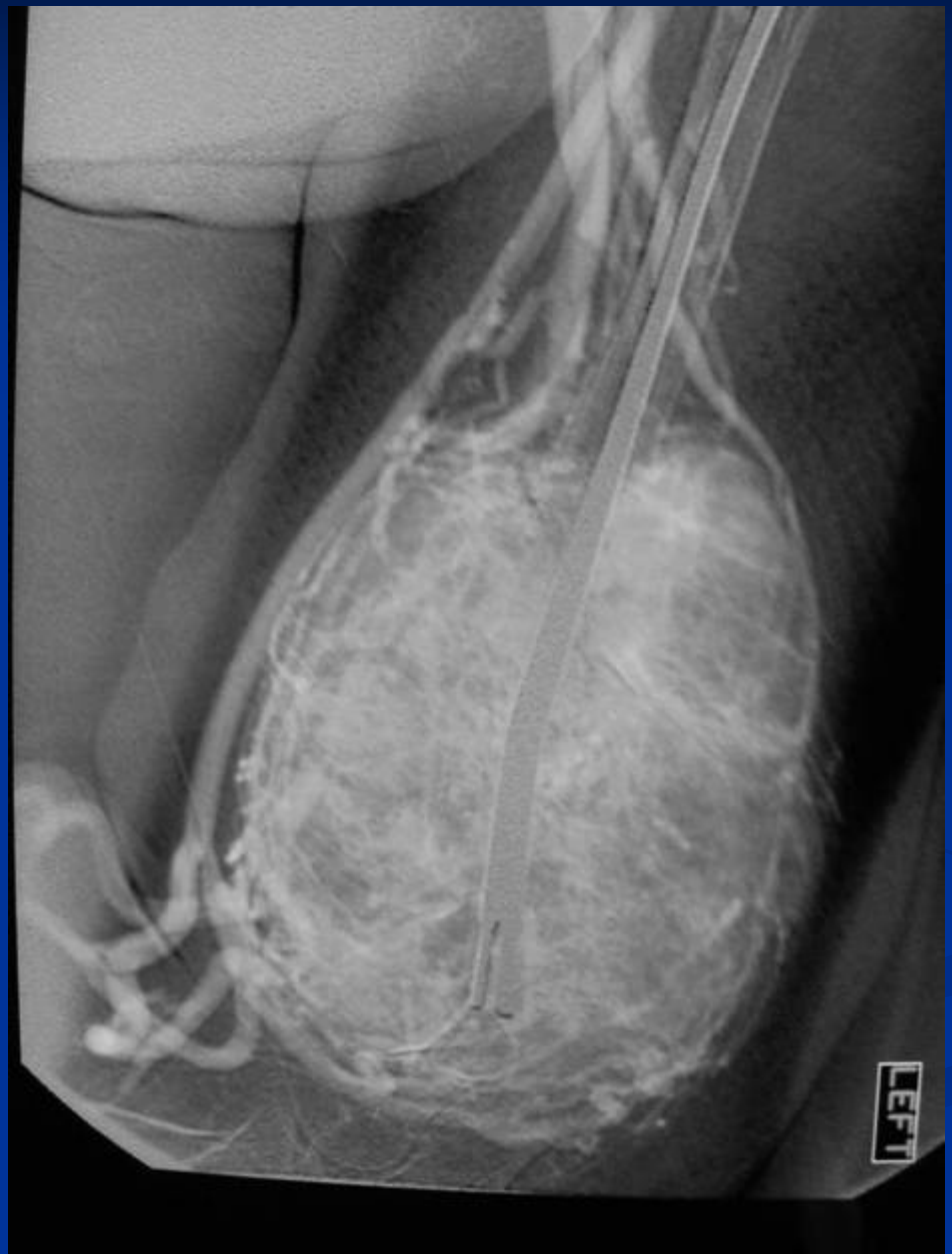
Path Fx of Femoral Neck
Breast Cancer



Metastatic Renal Cell Carcinoma of Pelvis


R 116

Metastatic Renal Cell


LEFT

Surgical Indications

- Pathological Fracture
- Impending Pathological Fracture
  - Pain
  - Location of lesion (weight bearing, pelvis/spine); Number of Lesions
  - Size of lesion
  - Medullary and/or cortical involvement
  - Primary tumor type and resposivenes to radiation
  - Undergoing chemotherapy?? Will systemic treatment be interrupted
  - Age
  - Health Status
  - Activity level; Weight of patient
  - Prognosis
  - Patient's acceptance of risking a pathological fracture with nonoperative treatment

Prophylactic Fixation

- Many studies designed to assess risk of actually fracturing
- Can not accurately assess the risk of fracturing because of many confounding variables
- Endosteal resorption of ½ cortical thickness reduces bone strength by 70%

Prophylactic Fixation

- Pain
- Site of lesion
- Blastic or lytic
- Size
- Medullary and /or cortical

Prophylactic Fixation

- Painful medullary lytic lesion resulting in 50% endosteal resorption of cortex
- Painful lytic lesion involving cortex that is more than 2.5 cm long or larger than the cross sectional diameter of the bone
- Lesion producing functional pain after radiation therapy
- Using these criteria, during surgical exploration the bone is found to be practically fractured


ap
R

Conservative Management

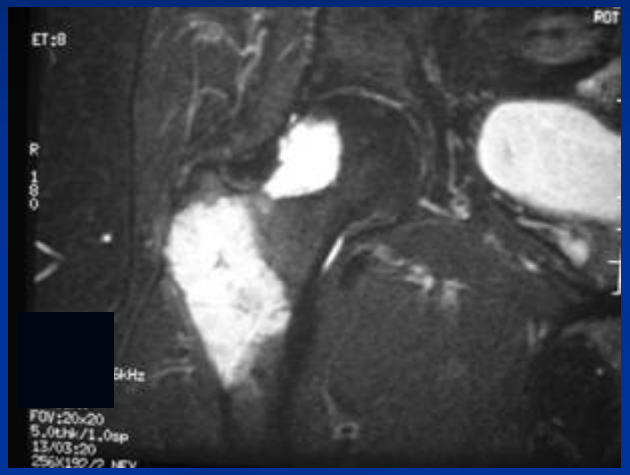
- Braces
- Wheel chair
- Radiation
- RF Ablation
- Cryoablation

Type of Surgery/Fixation Method

- Depends on Site and Extent of Disease
  - Epiphyseal
  - Metaphyseal
  - Diaphyseal

Epiphyseal Fractures

- Arthroplasty-cemented
- Stem length chosen to treat existing or potential lesions in the same bone
- Usually Long Stem



Metaphyseal Fractures

- Prosthetic replacement
  - Can be difficult if bone is actually fractured and there is extensive bony destruction
  - Much easier for impending fractures
- Intramedullary rods
  - May not adequately control the proximal fragment
  - At risk for failure if tumor progresses proximally or does not respond to radiation
  - At risk for failure if fracture does not heal—augment with PMMA
- Plate and screw combinations
  - Does not fix entire bone
  - More prone to failure than intramedullary rods
  - Mostly for metaphyseal fractures with densely sclerotic bone

Diaphyseal Fractures

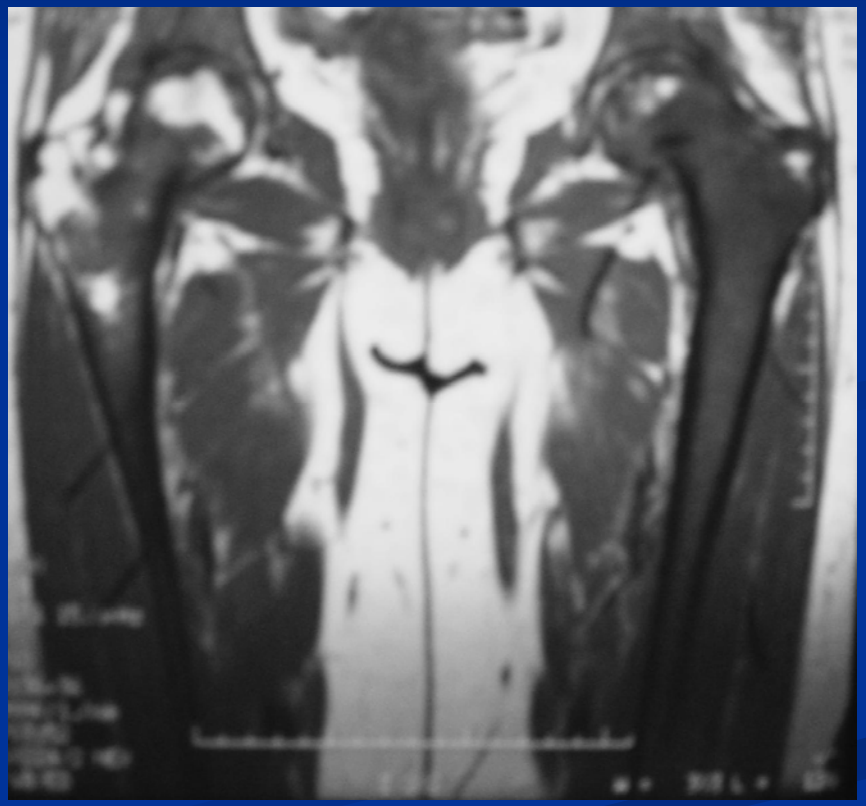
- Cephalomedullary intramedullary rods
  - Fixes entire bone
- Rush rods with cement
  - May be good for humerus if want to avoid shoulder pain/rotator cuff
- Flexible nails

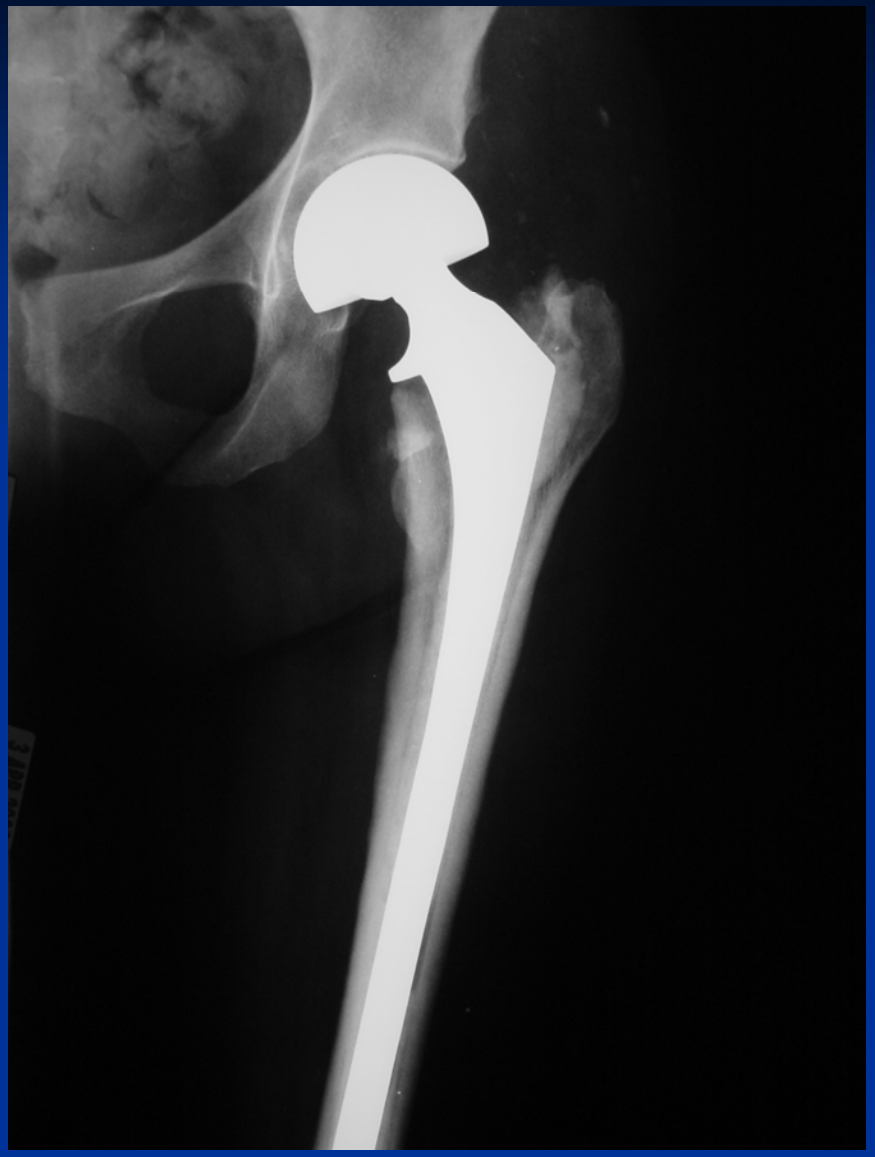
Specific Anatomic Sites

Proximal Femur

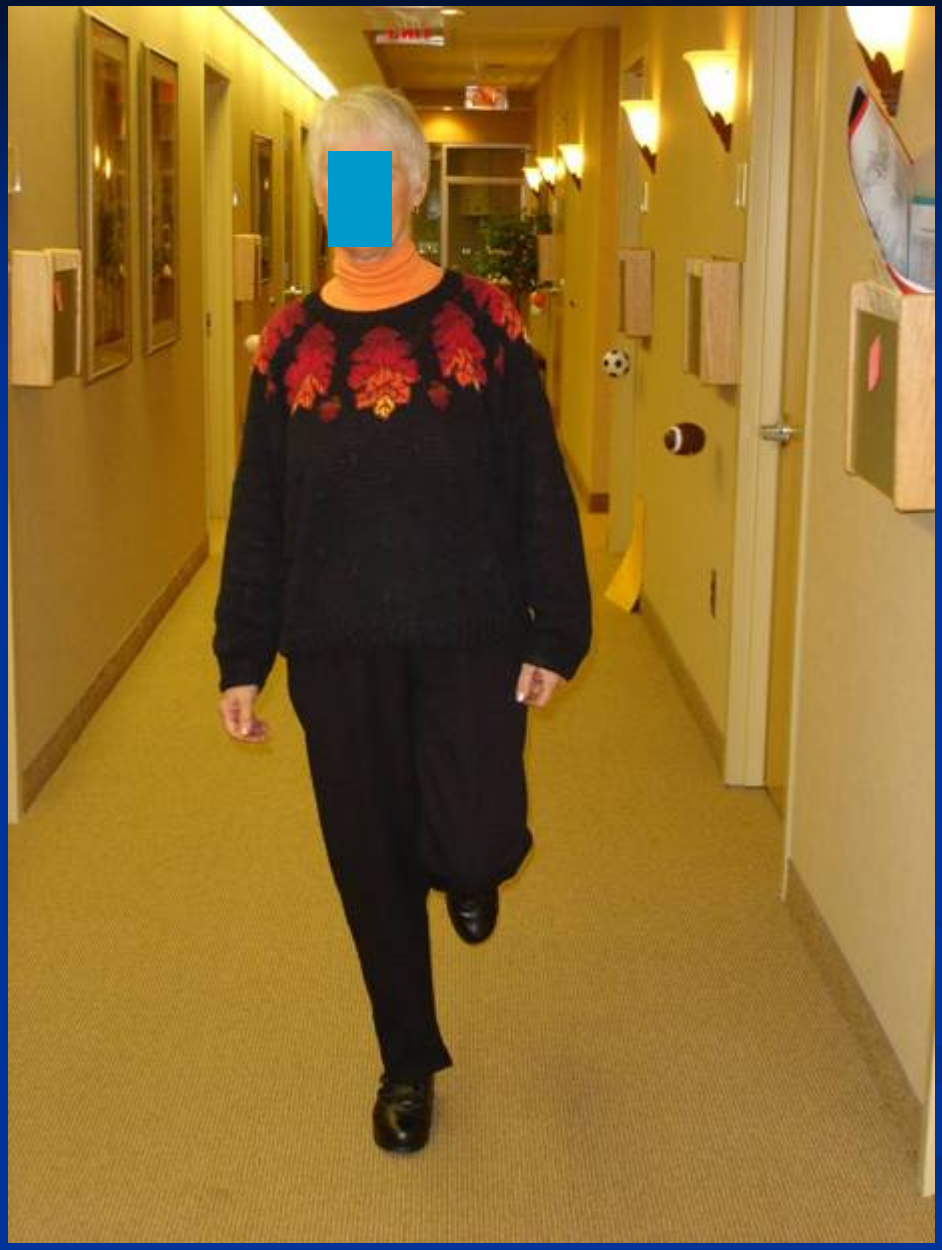
- Long stem cemented hemiarthroplasty
  - Femoral Neck, Intertrochanteric, Subtrochanteric
- Cephalomedullary nail
- Compression screw and side plate
- Cannulated screws

Proximal Femur

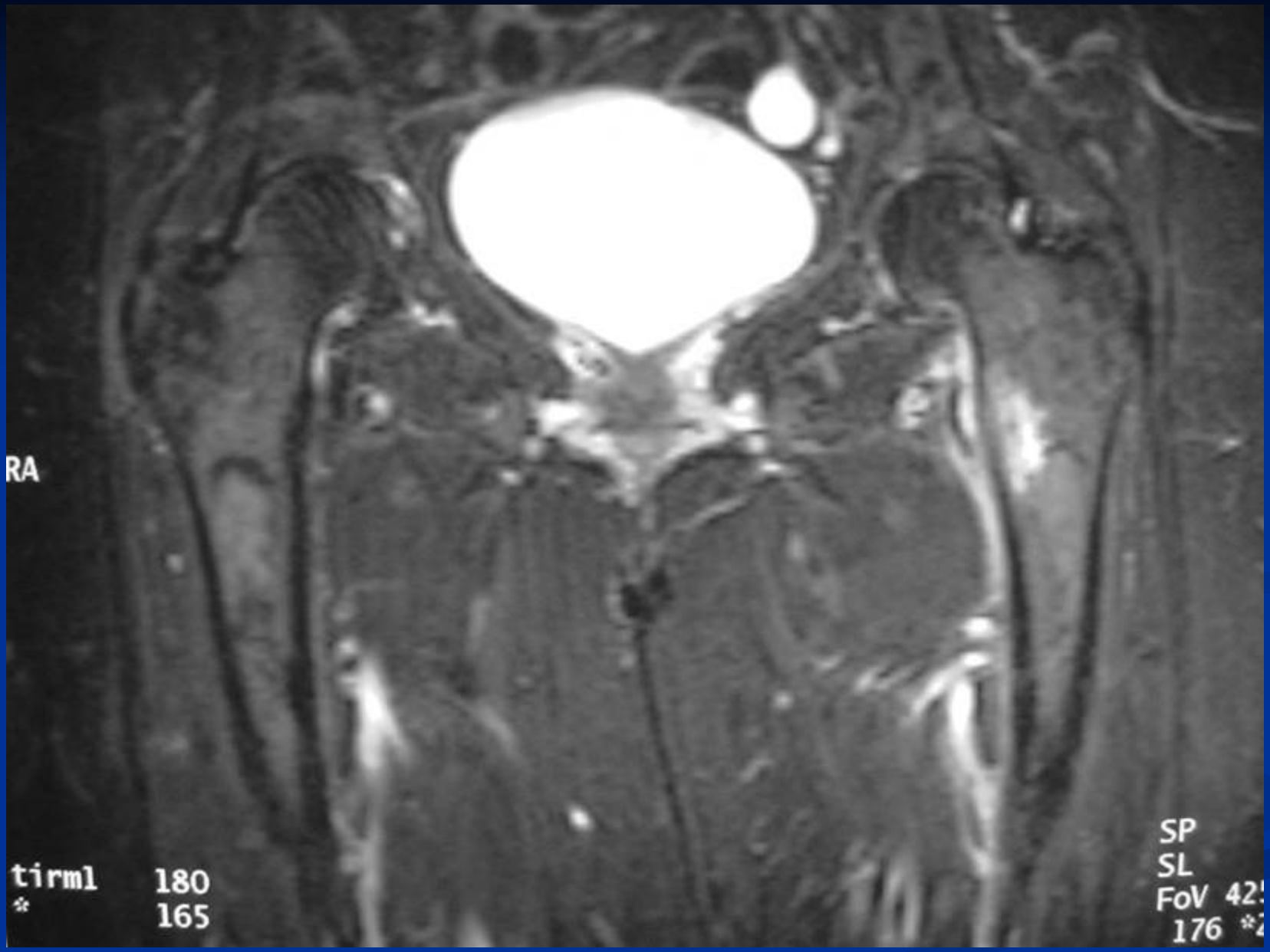





EXIT



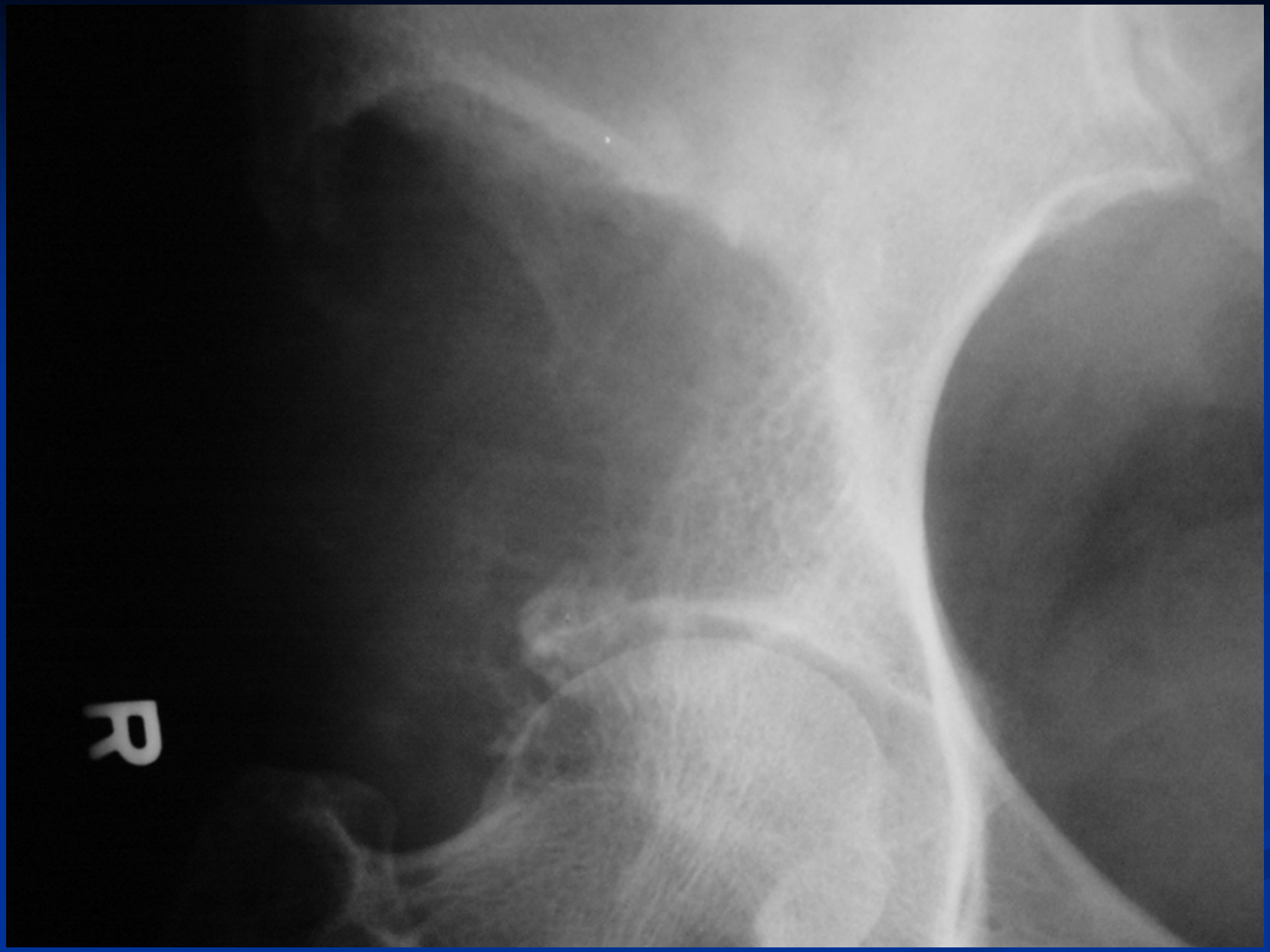

90
SP
SL
FoV
256


RA
tirm1
*
180
165
SP
SL
FoV 42
176

Acetabulum

- Polyethylene Spacer, cement, threaded steinman pins
- Acetabular cage, total hip replacement, cement, steinman pins
- Saddle prosthesis

Acetabulum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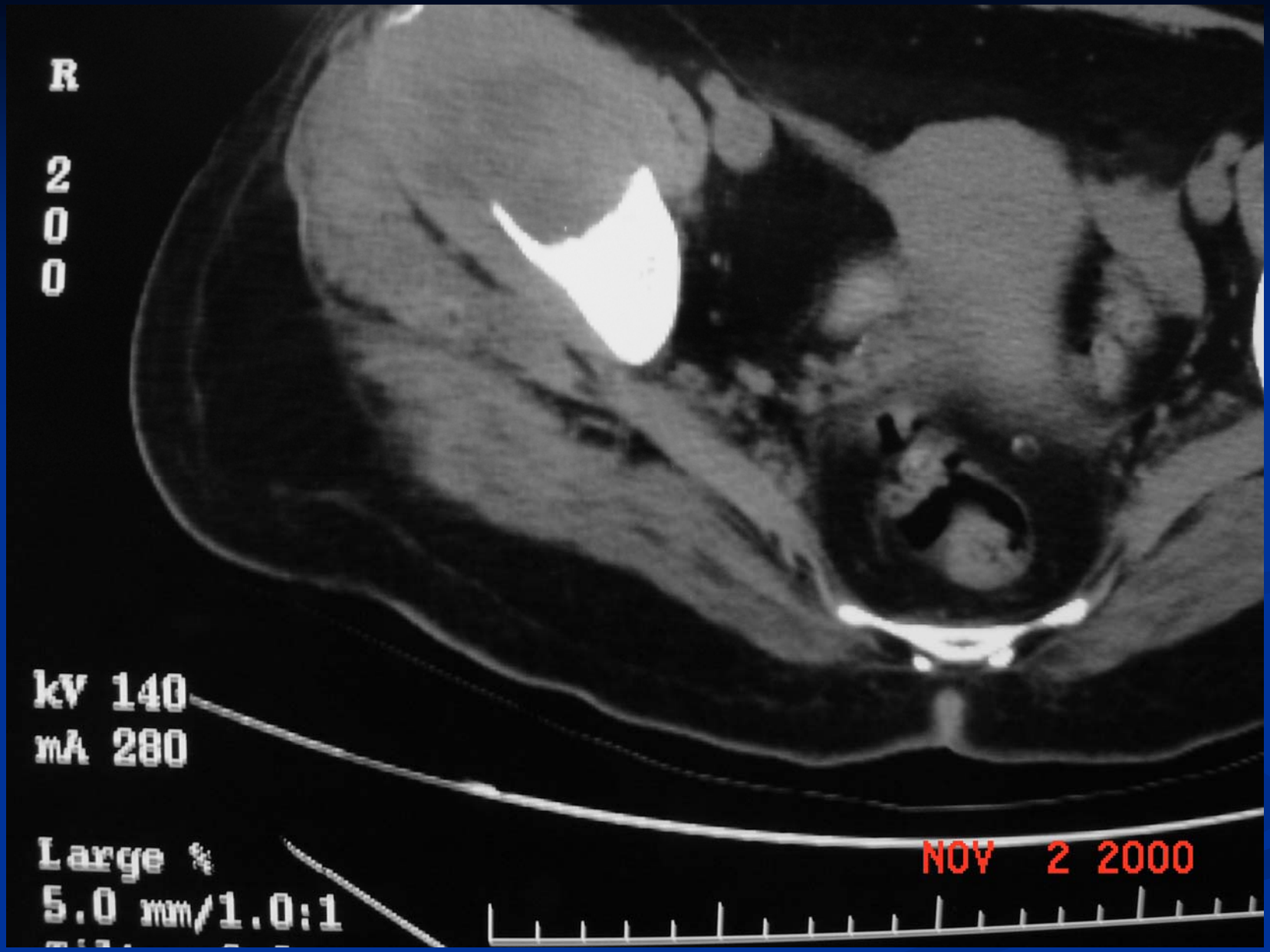
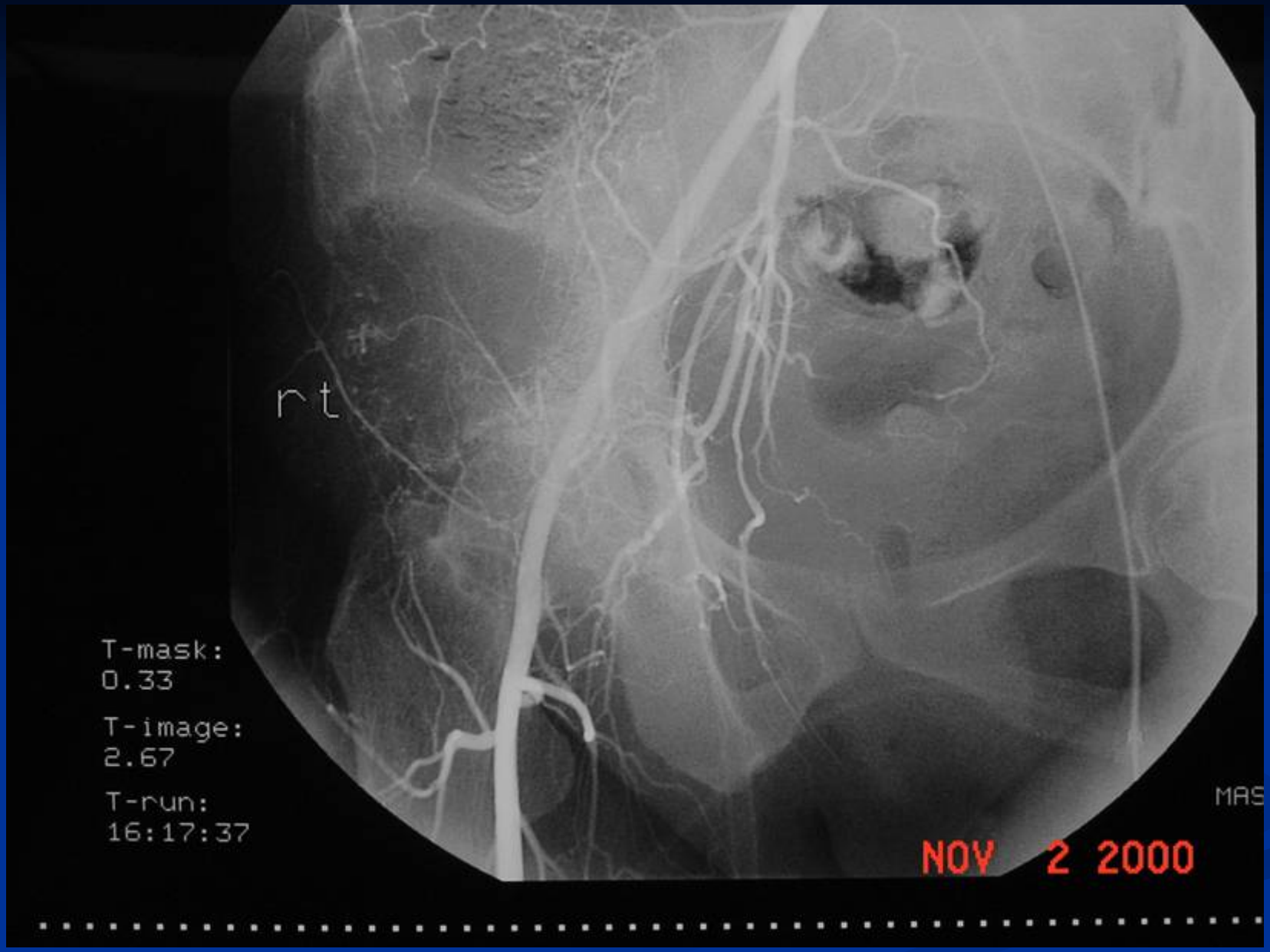
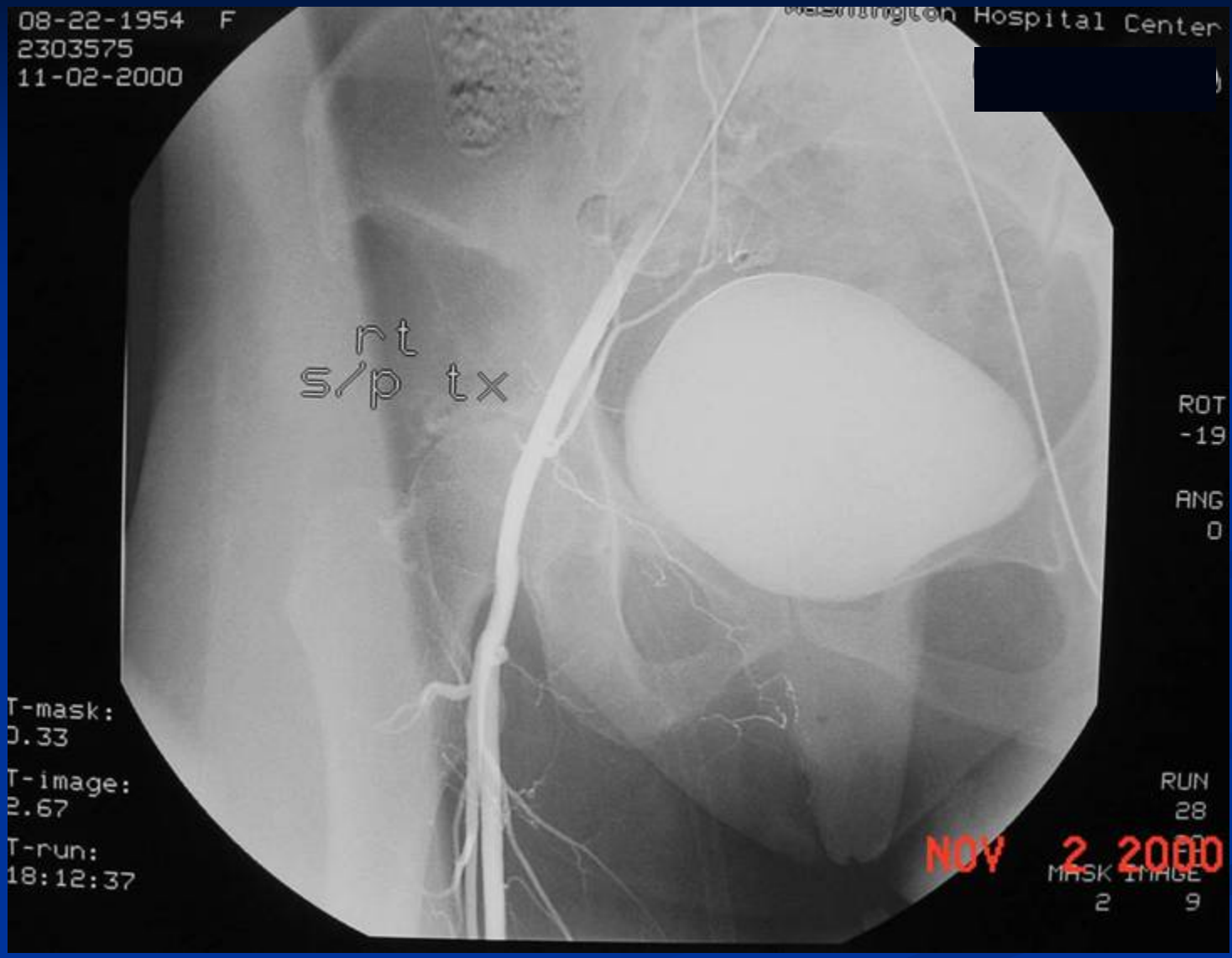
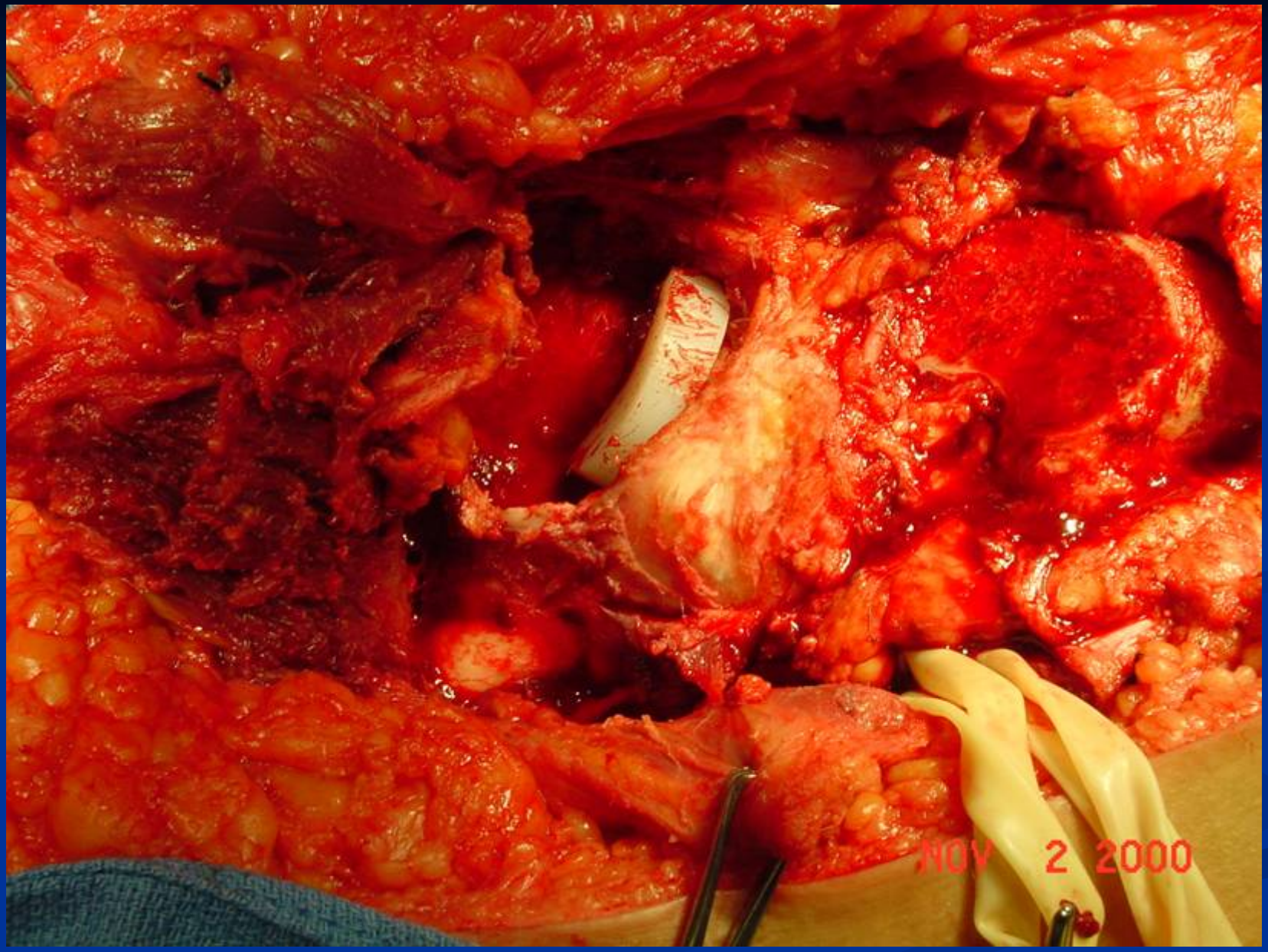

R
2
0
0
kV 140
mA 280
Large %
5.0 mm/1.0:1
NOV 2 2000


rt
T-mask:
0.33
T-image:
2.67
T-run:
16:17:37
NOV 2 2000


08-22-1954 F
2303575
11-02-2000
Hospital Center
rt
s/p tx
ROT
-19
ANG
0
T-mask:
0.33
T-image:
2.67
T-run:
18:12:37
RUN
28
NOV 2 2000
MASK IMAGE
2 9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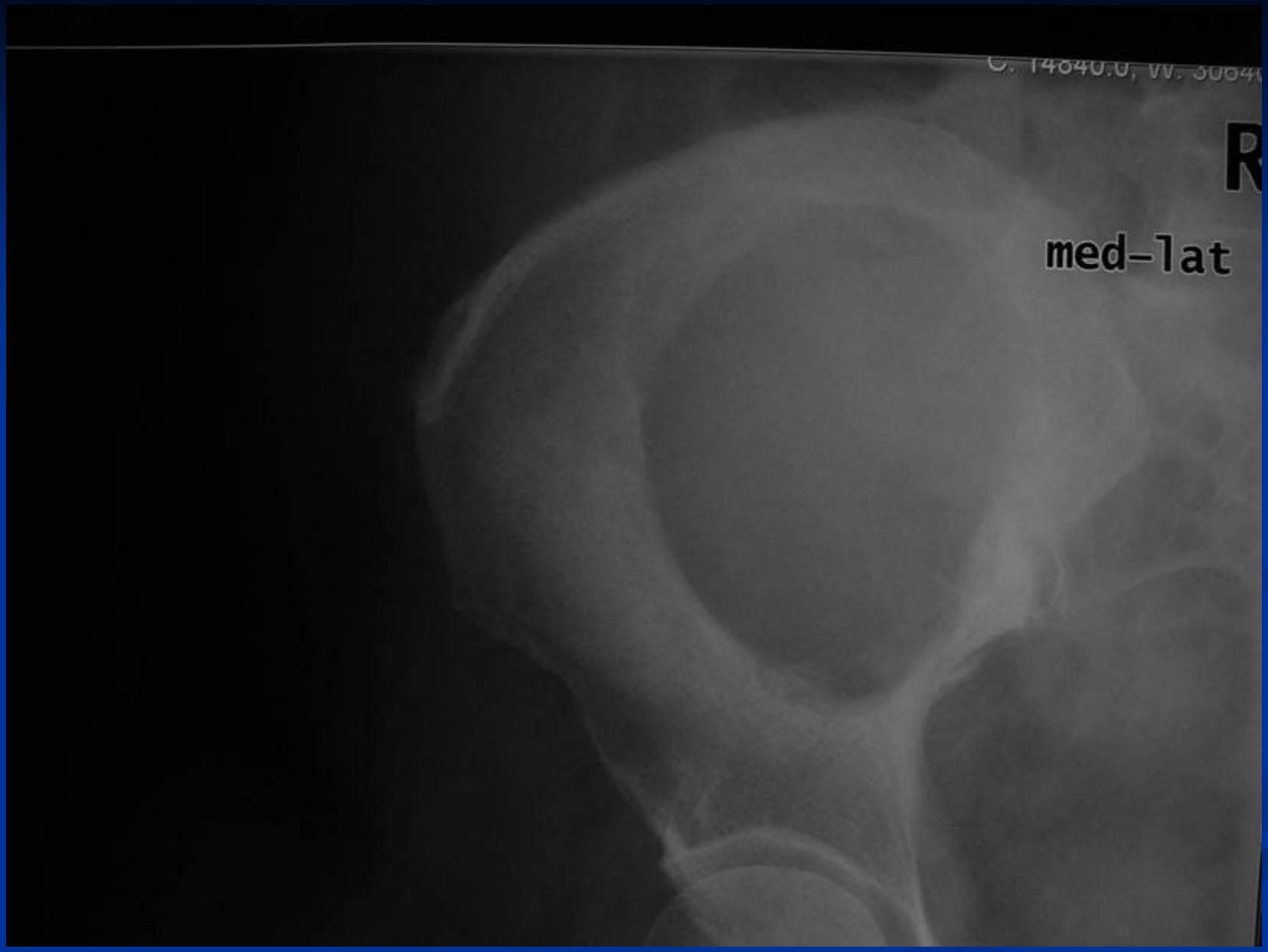
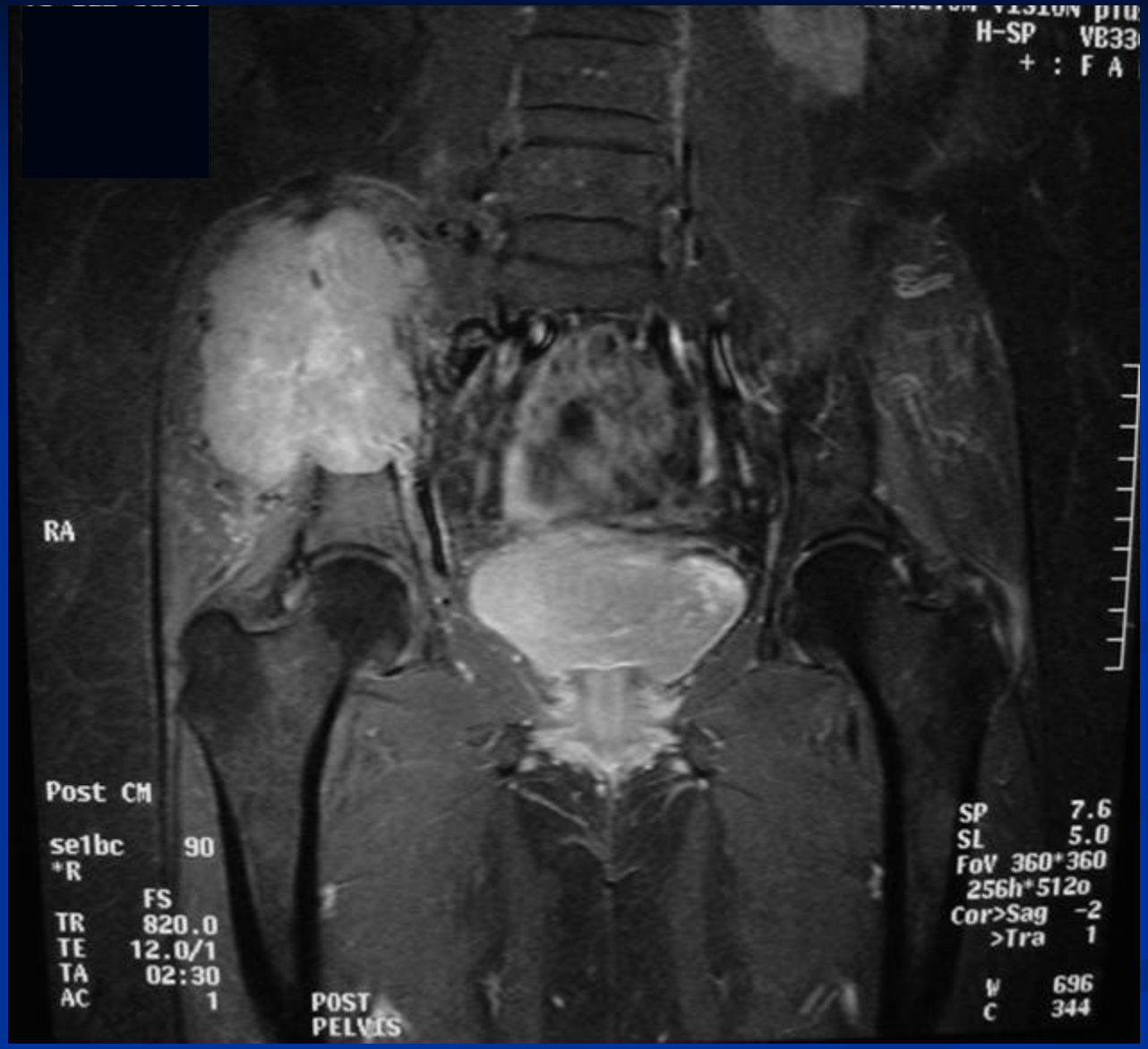

R
med-lat


H-SP
RA
Post CM
se1bc 90
*R
FS
TR 820.0
TE 12.0/1
TA 02:30
AC 1
POST
PELVIS
SP 7.6
SL 5.0
FoV 360*360
256h*512o
Cor>Sag -2
>Tra 1
W 696
C 344

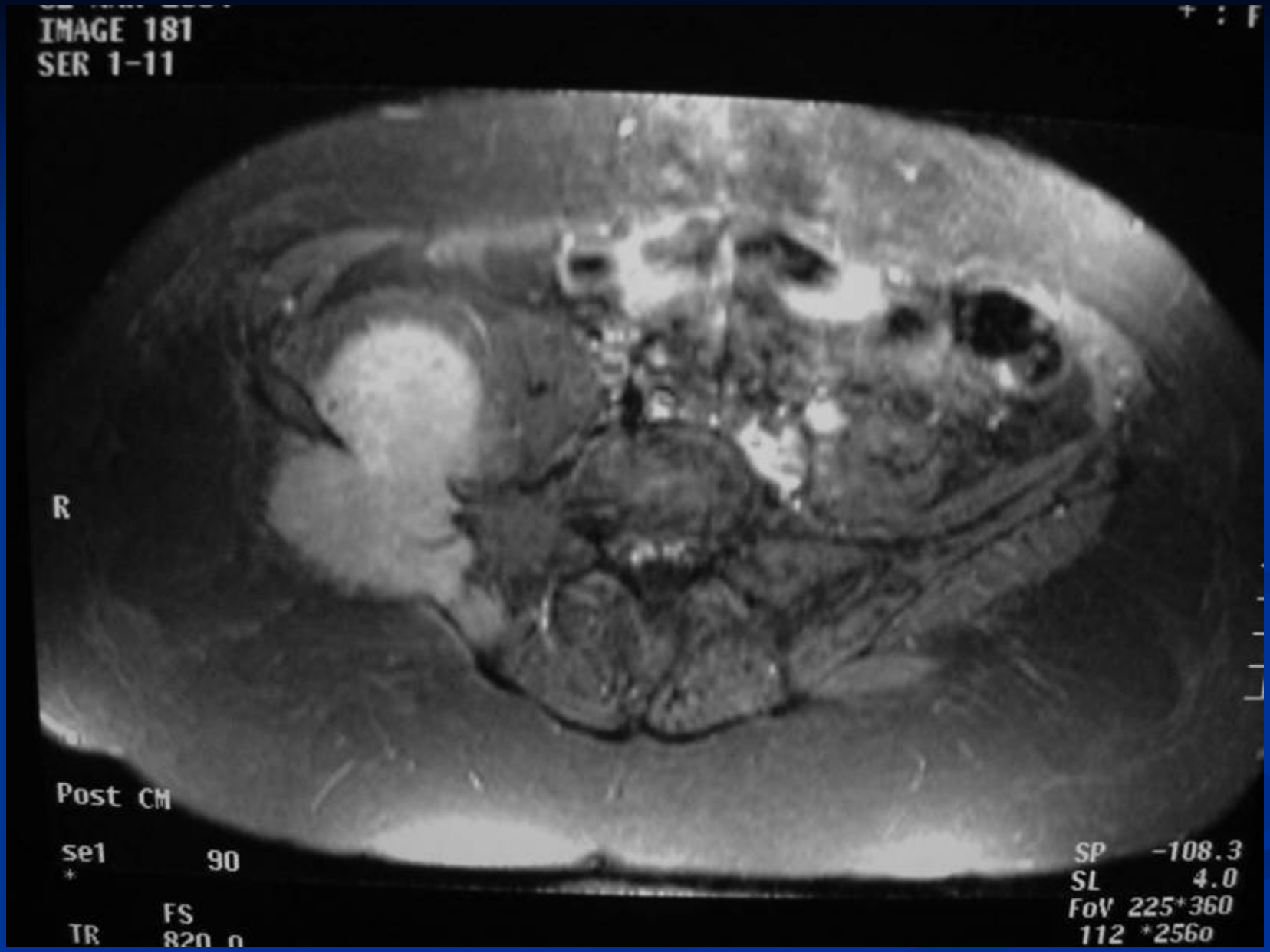
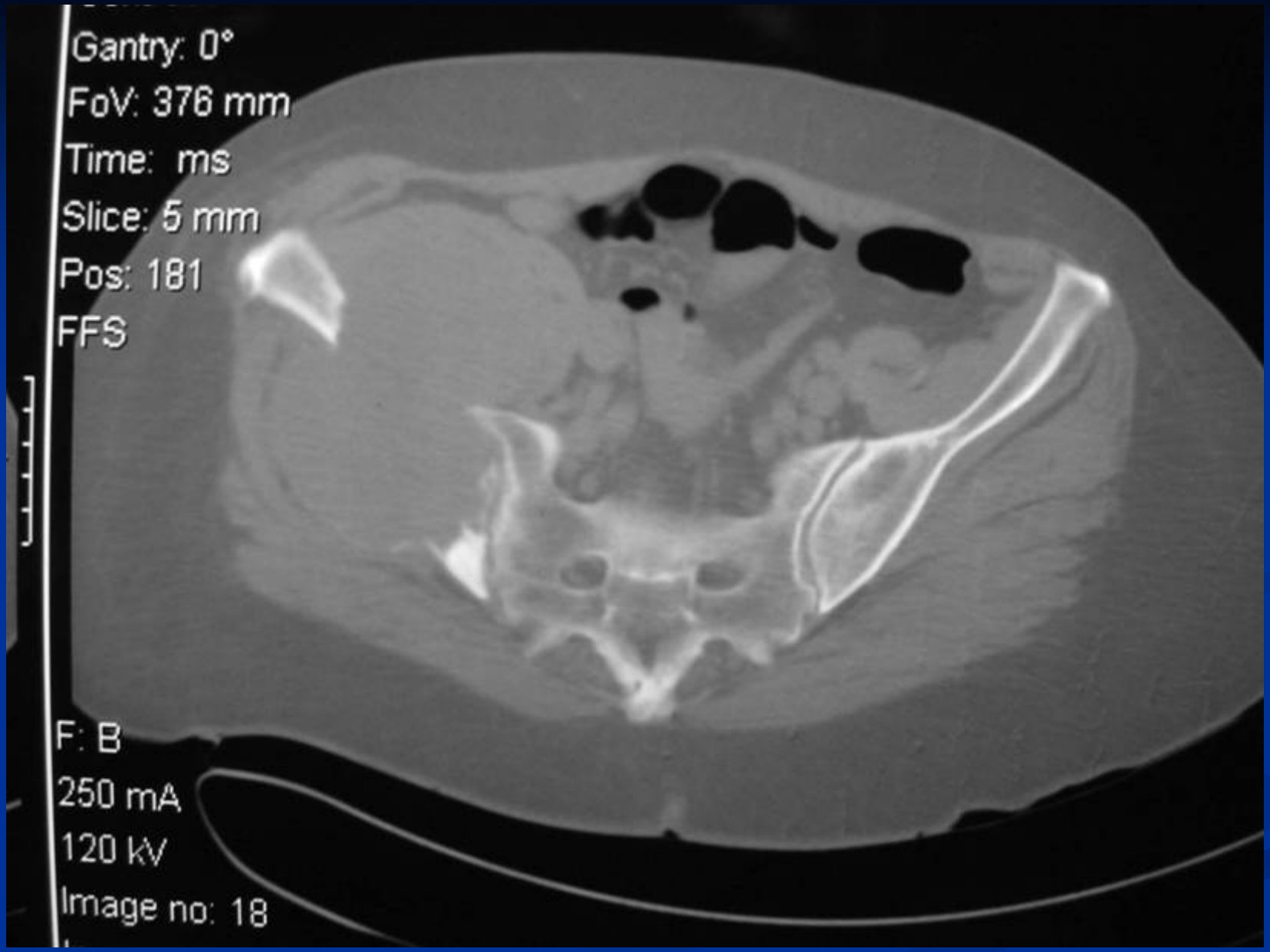
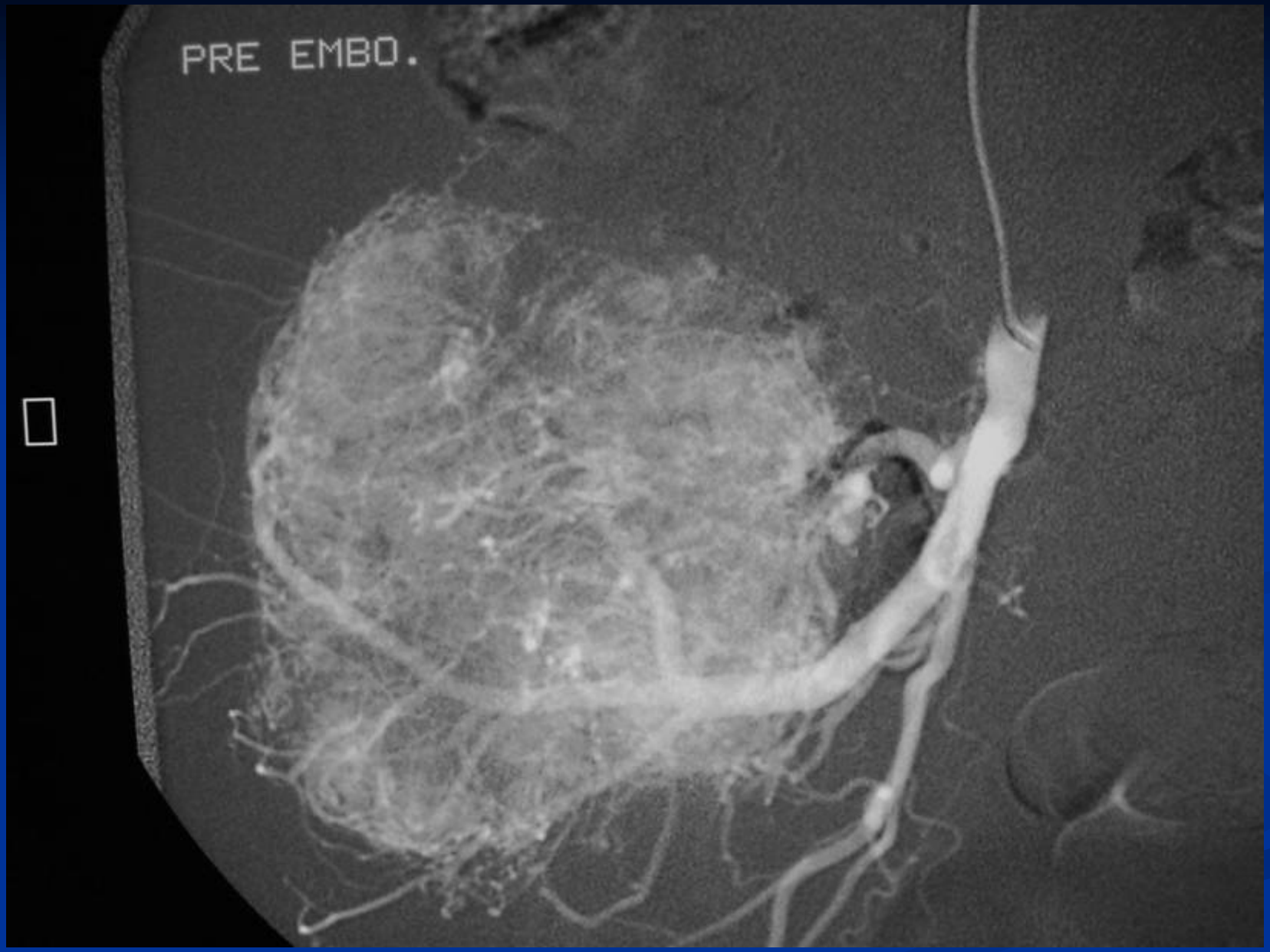
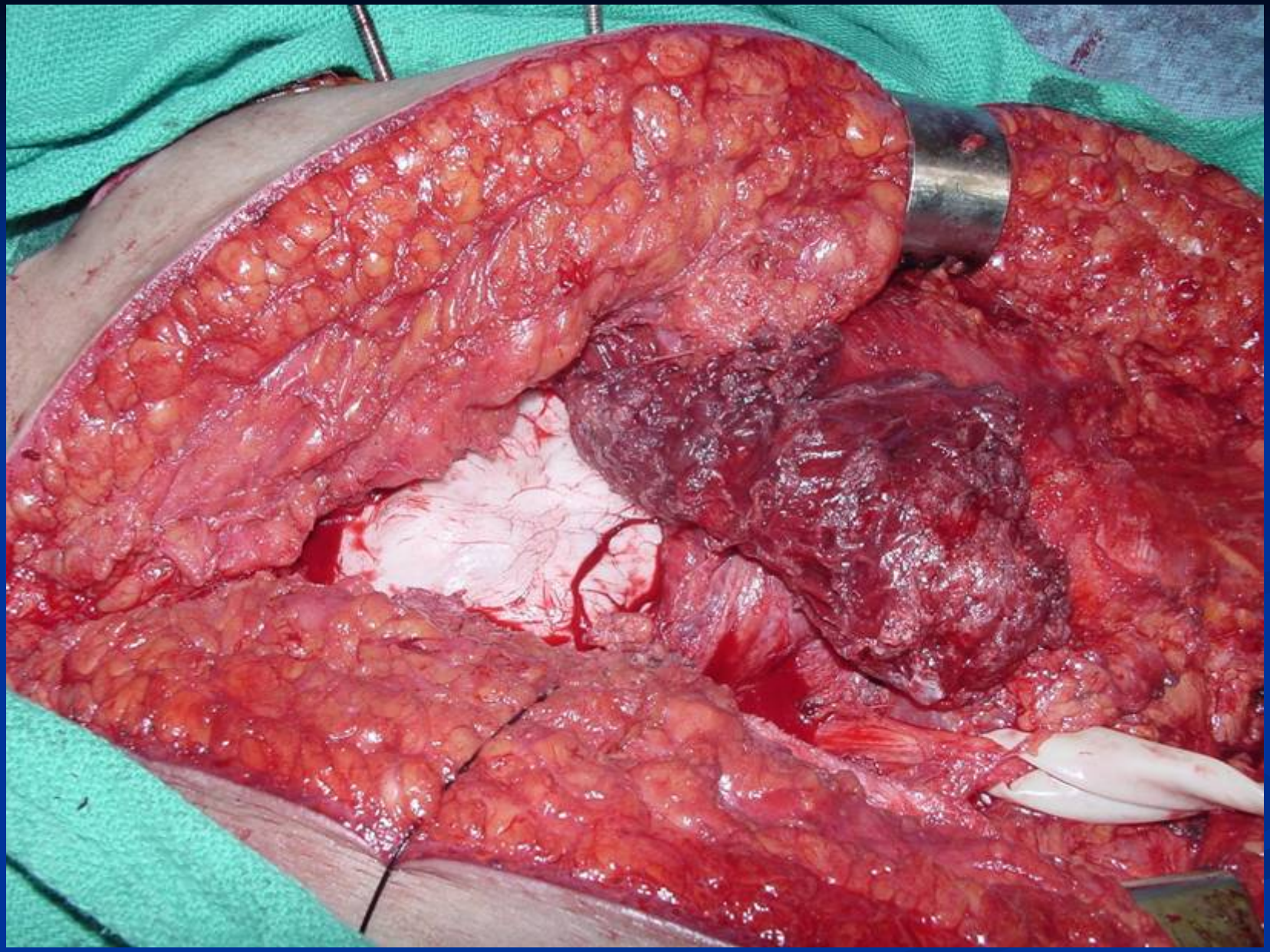


IMAGE 181
SER 1-11
R
Post CM
se1
90
FS
SP -108.3
SL 4.0
FoV 225*360
112 *256o


Gantry: 0°
FoV: 376 mm
Time: ms
Slice: 5 mm
Pos: 181
FFS
F: B
250 mA
120 kV
Image no: 18


PRE EMBO.

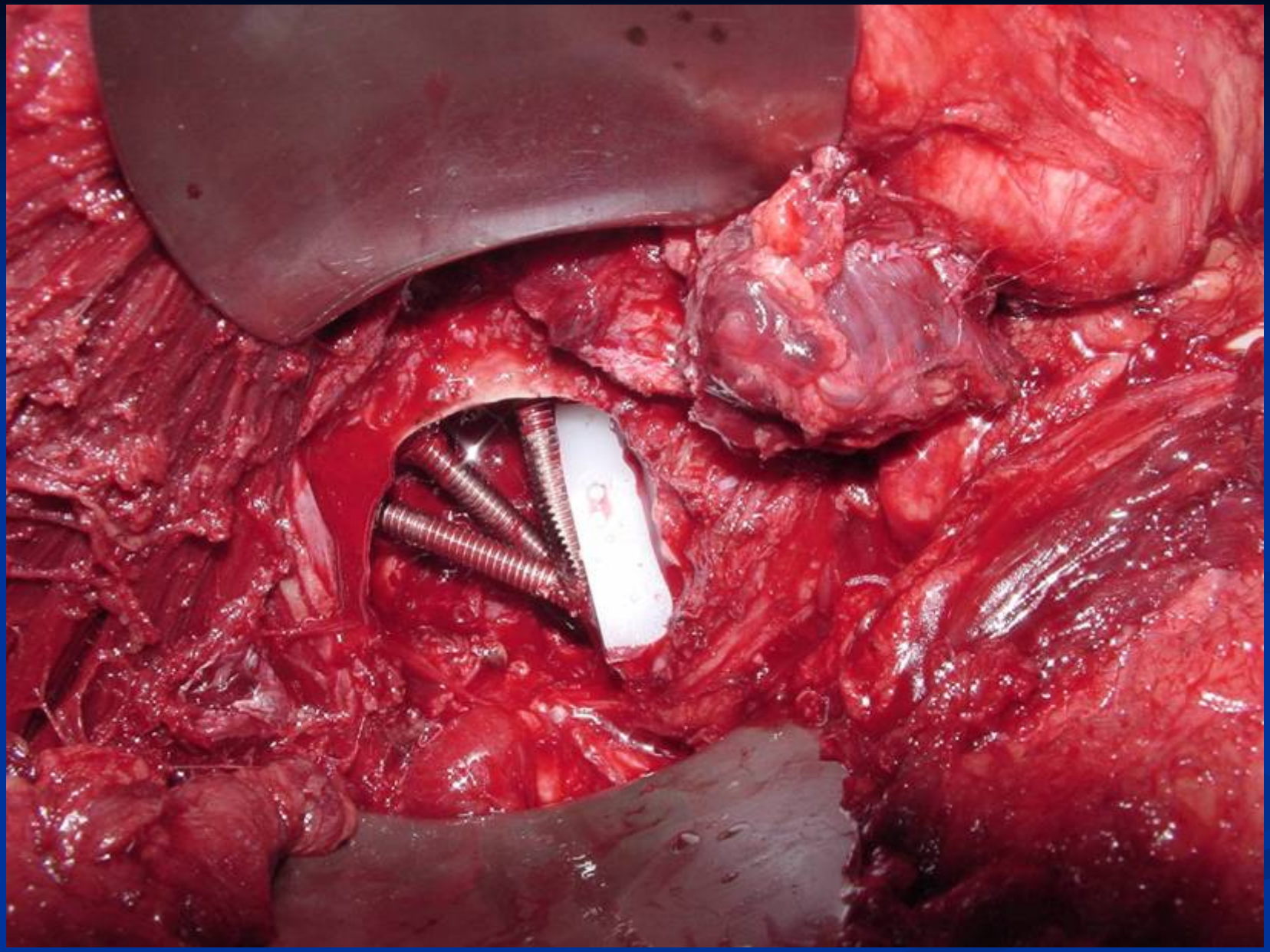

POST EMBO.
10:38:20
0.50
2.50
MASK
2

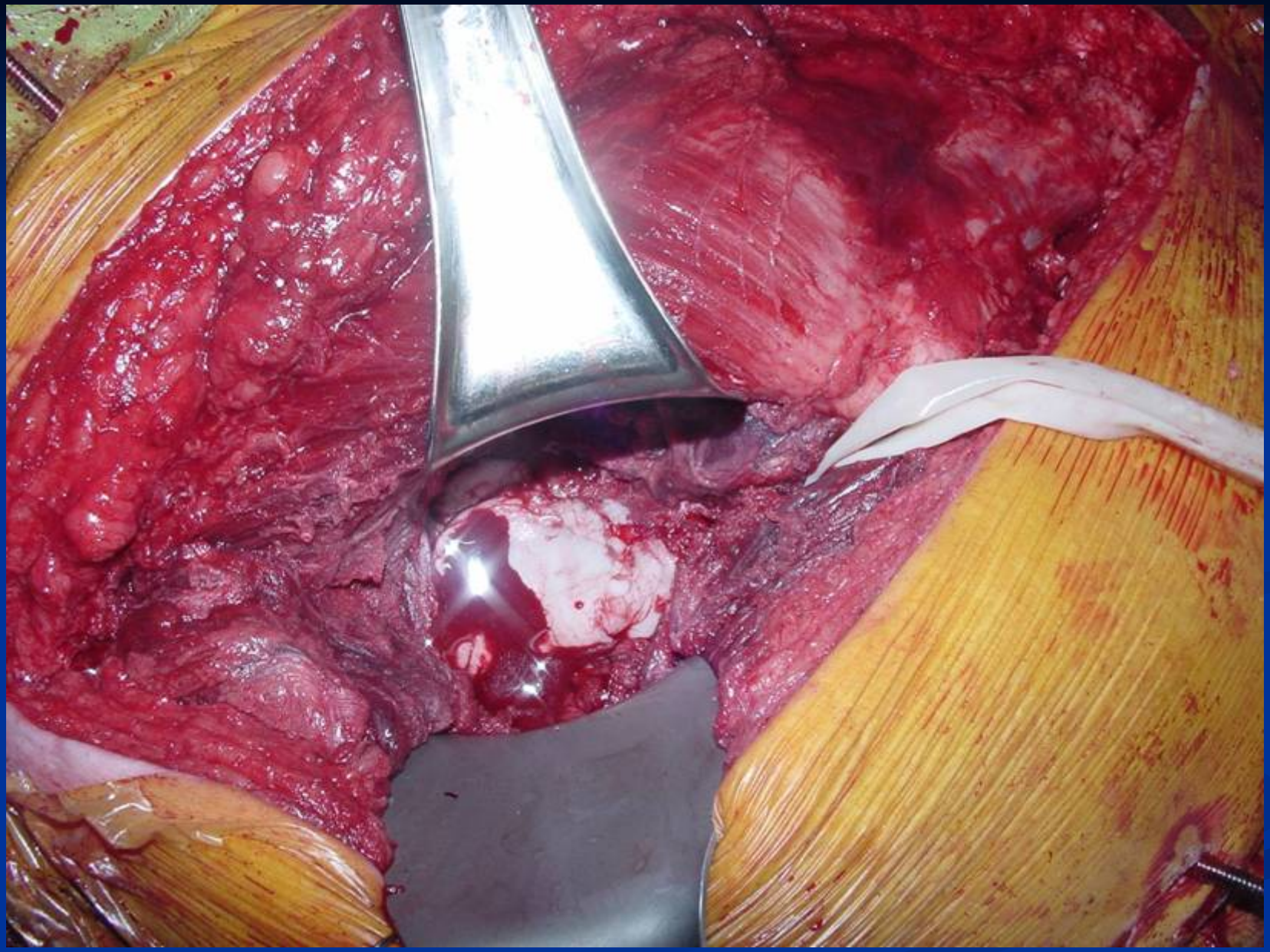


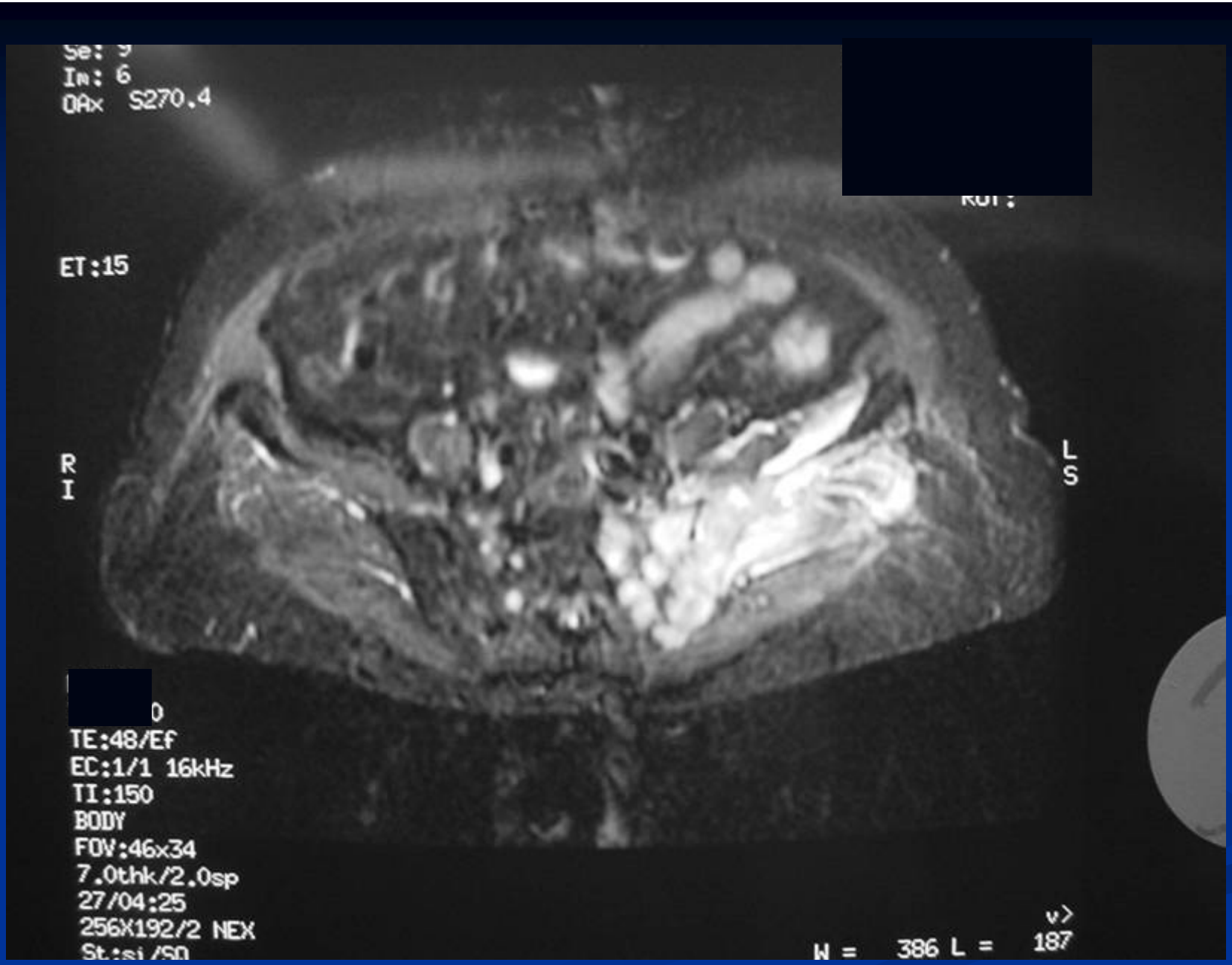

872966BH
15
5/12/2004, 1:55:26 PM

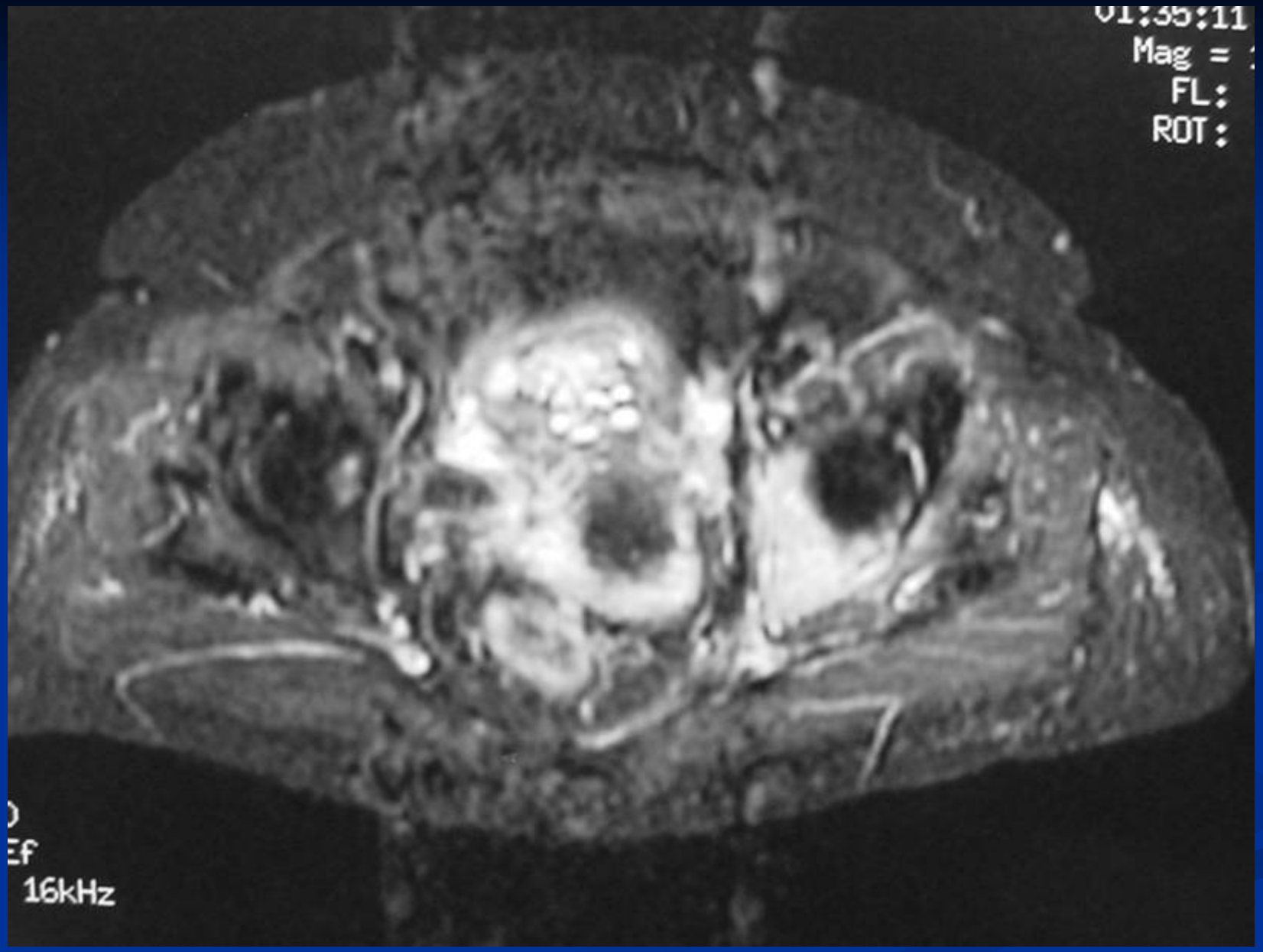

DFOV 36.0cm
BONE
Aug 19 2003
512
MF:1.1
FLT:e3
R
164
L
164
kV 120
mA 320
Large
5.000mm/7.50 0.75:1
Tilt: 0.0
0.8s

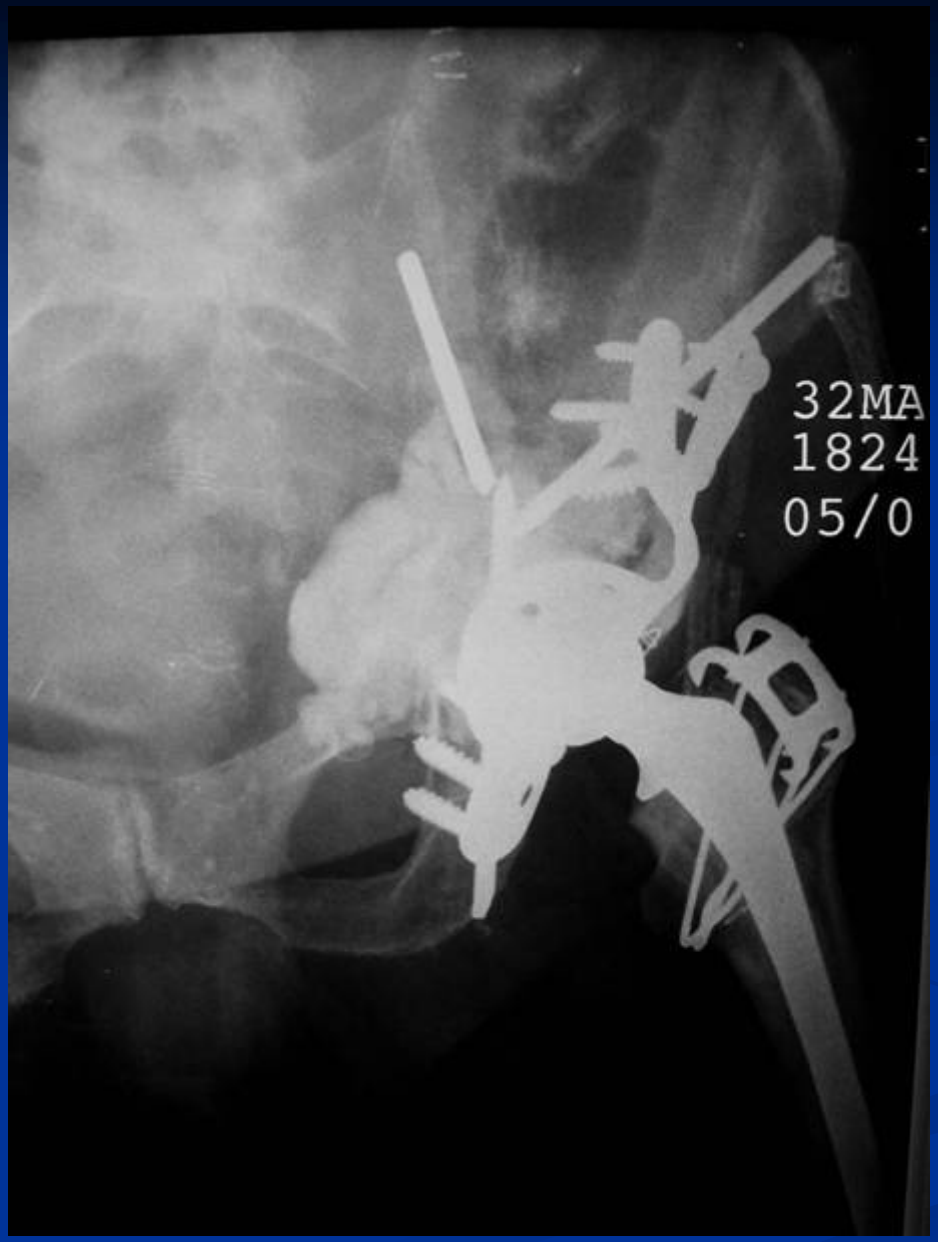

BONE
512
MF:1.1
FLT:e3
R
164
L
164
kV 120
mA 320
Large
5.000mm/7.50 0.75:1
Tilt: 0.0
0.8s /HE 09:11:01 AM/14.93

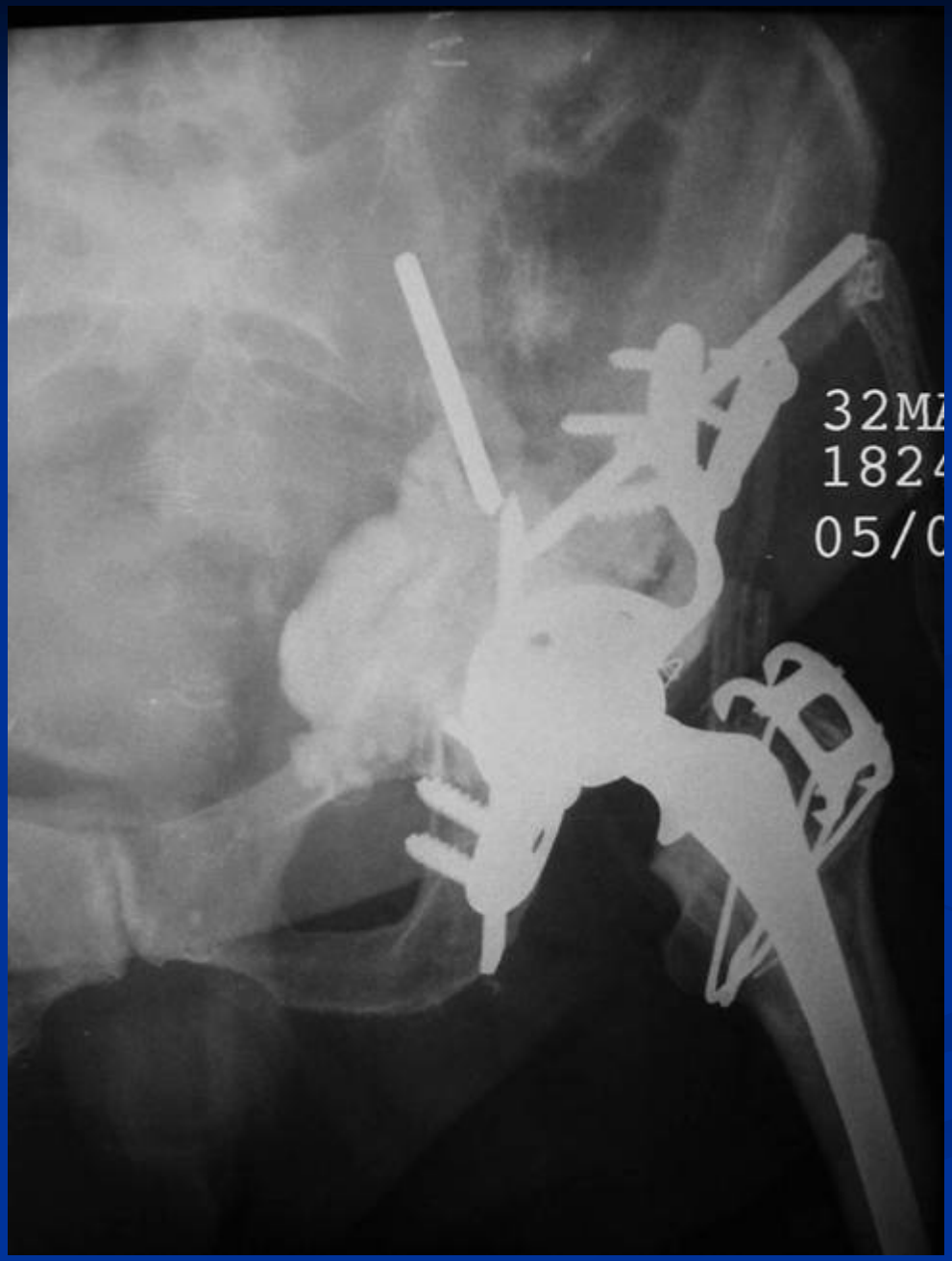


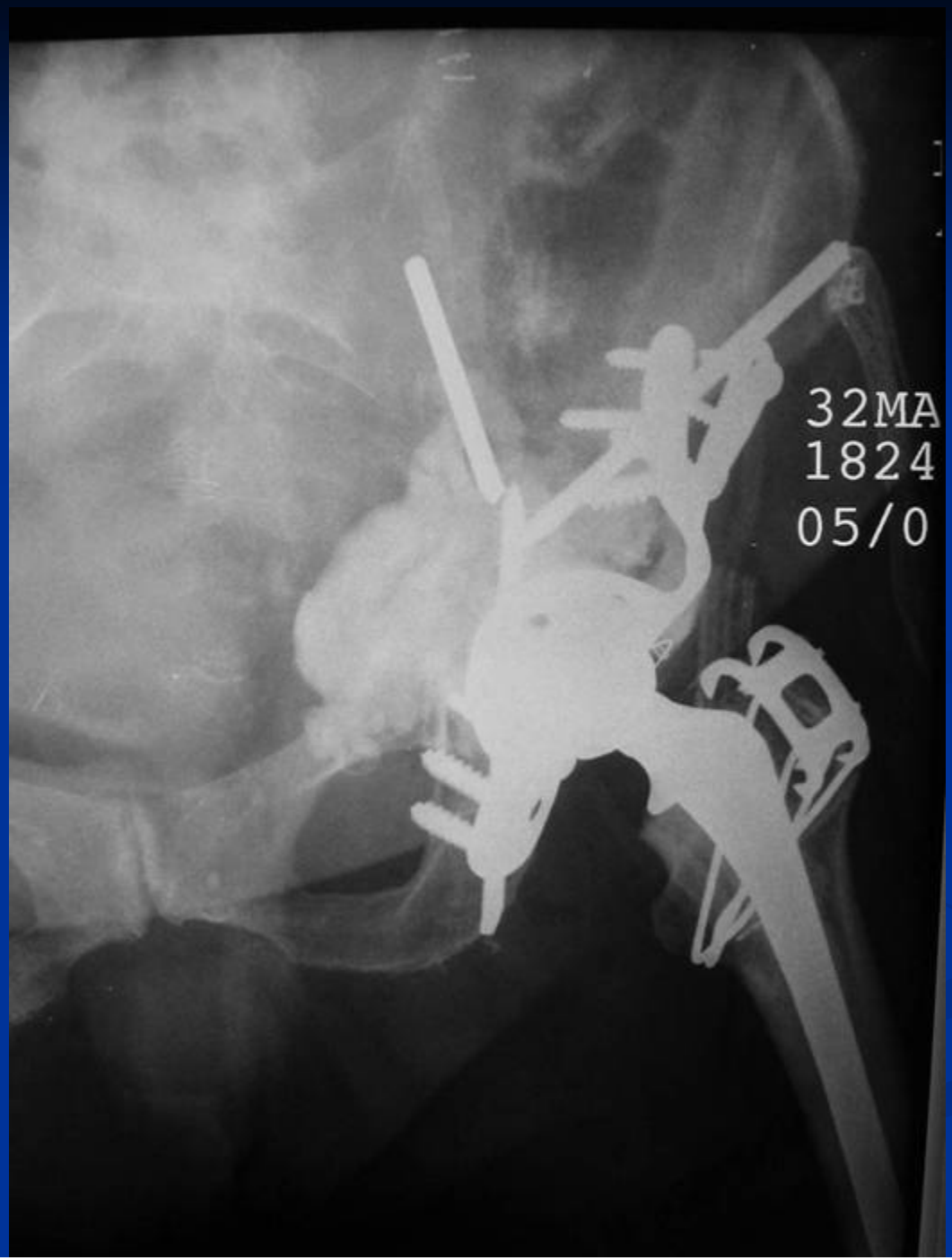



Se: 9
In: 6
OAx S270.4
ET:15
R
I
L
S
TE:48/Ef
EC:1/1 16kHz
TI:150
BODY
FOV:46x34
7.0thk/2.0sp
27/04:25
256X192/2 NEX
W = 386 L = 187


01:35:11
Mag =
FL:
ROT:
16kHz


32MA
1824
05/0


32M
1824
05/0


32MA
1824
05/0


R
116


DFOV 36.0cm
BONE/+
512
120
180~
mart mA 154
arge %
.0 mm/1.5:1
ilt : 0.0


DFOV 36.0cm
BONE/+
Dec 31 01
512
R
I
1
8
7
kV 120
mA 180~
Smart mA 154
Large %
5.0 mm/1.5:1
Tilt : 0.0
0.8 s/HE+ 12:08:55 PM/17.92
W:2500 L:150
P 180

3 Months After Saddle Prosthesis


SHARP

9 Months Postop

Femoral Shaft

- Cephalomedullary nail (gamma nail)
- Fleible nails and cement


L


Spin: -0
Tilt: 0
10cm
A
W 1500
C 450


L

Distal Femur

- Cephalomedullary nails
- Retrograde femoral nail
- Flexible nails, Rush rods

Proximal Humerus

- Long stem hemiarthroplasty
- Cephalomedullary nail
  - No Distal Interlocking Screw
- Rush rods


L


DFOV 37.8cm
STND/+
NOV 10 2003
512
kV 120
mA 280
Large
5.000mm/13.50 1.35:1


, 73Y
821
L
AT:
W HUMERUS AP
G +2.00

Humeral Shaft

- Intramedullary (cephalomedullary) nail
  - Cemented
  - No distal interlocking screw
- Rush rods


L


9 OCT 2000

Elbow/Distal Humerus

- IM Nail
- Rush Rods/Flexible Nails

Tibia

- Intramedullary rods
- Rush rods

Segmental Prostheses

Hip/Proximal Femur

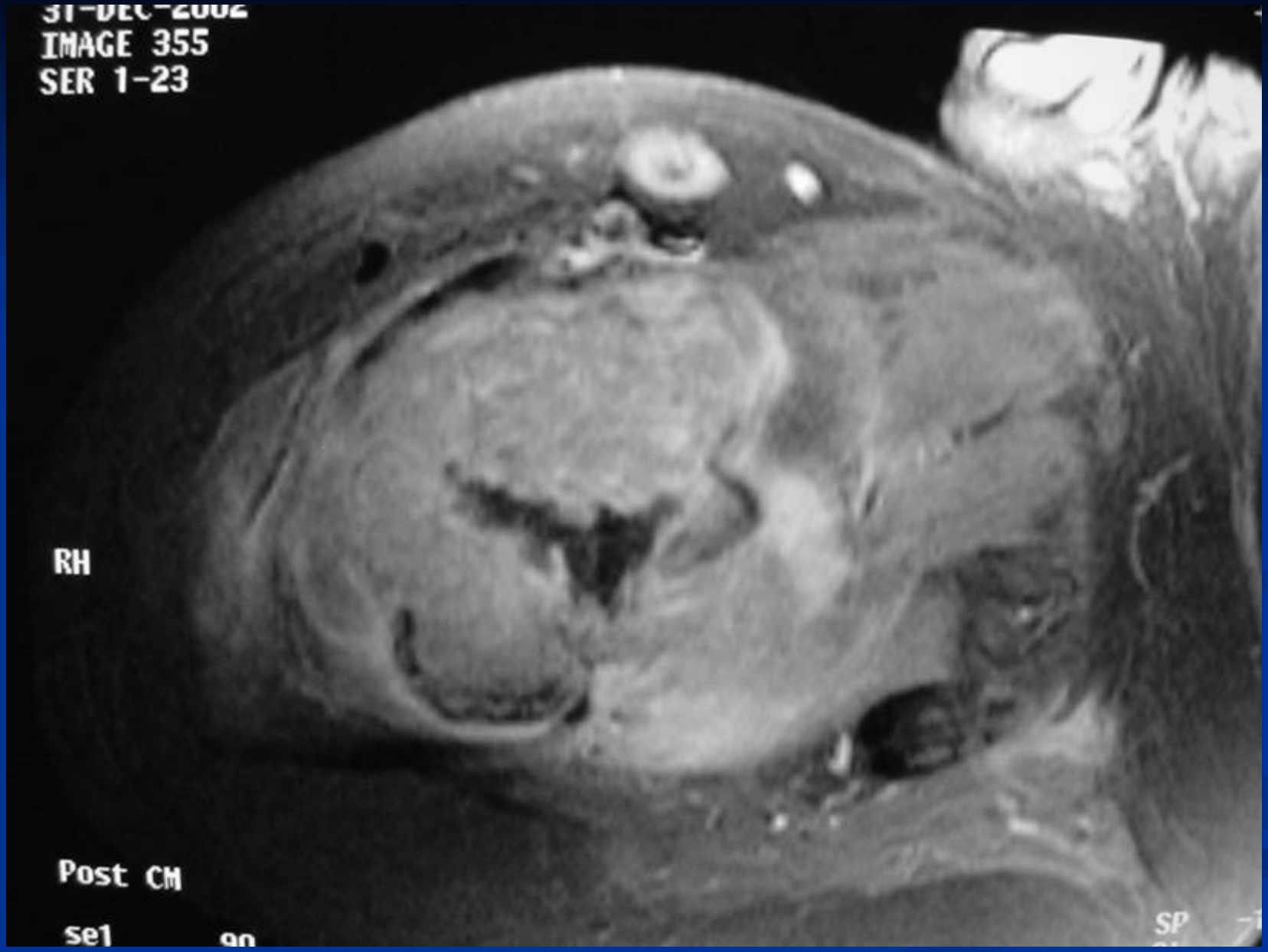
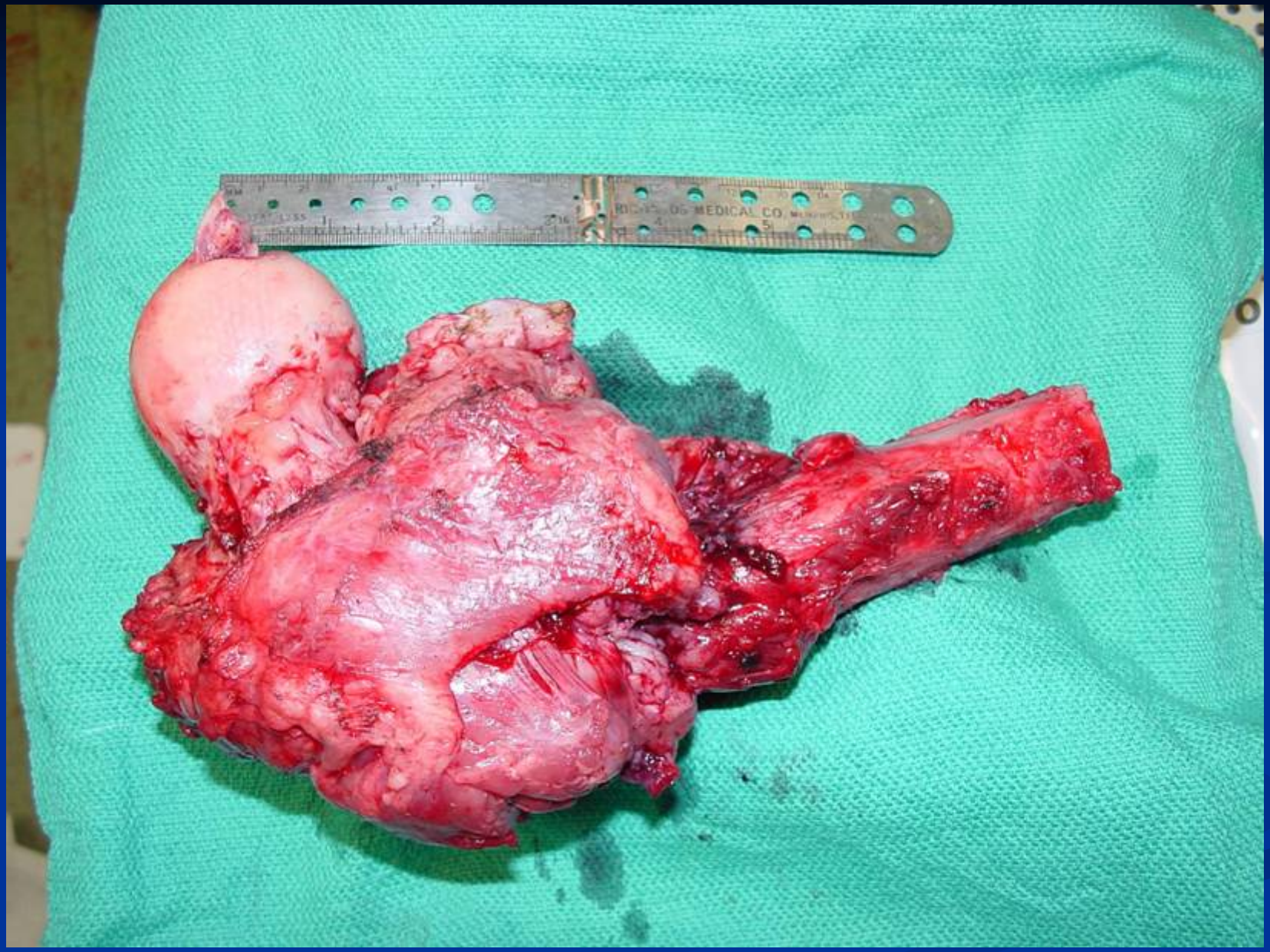
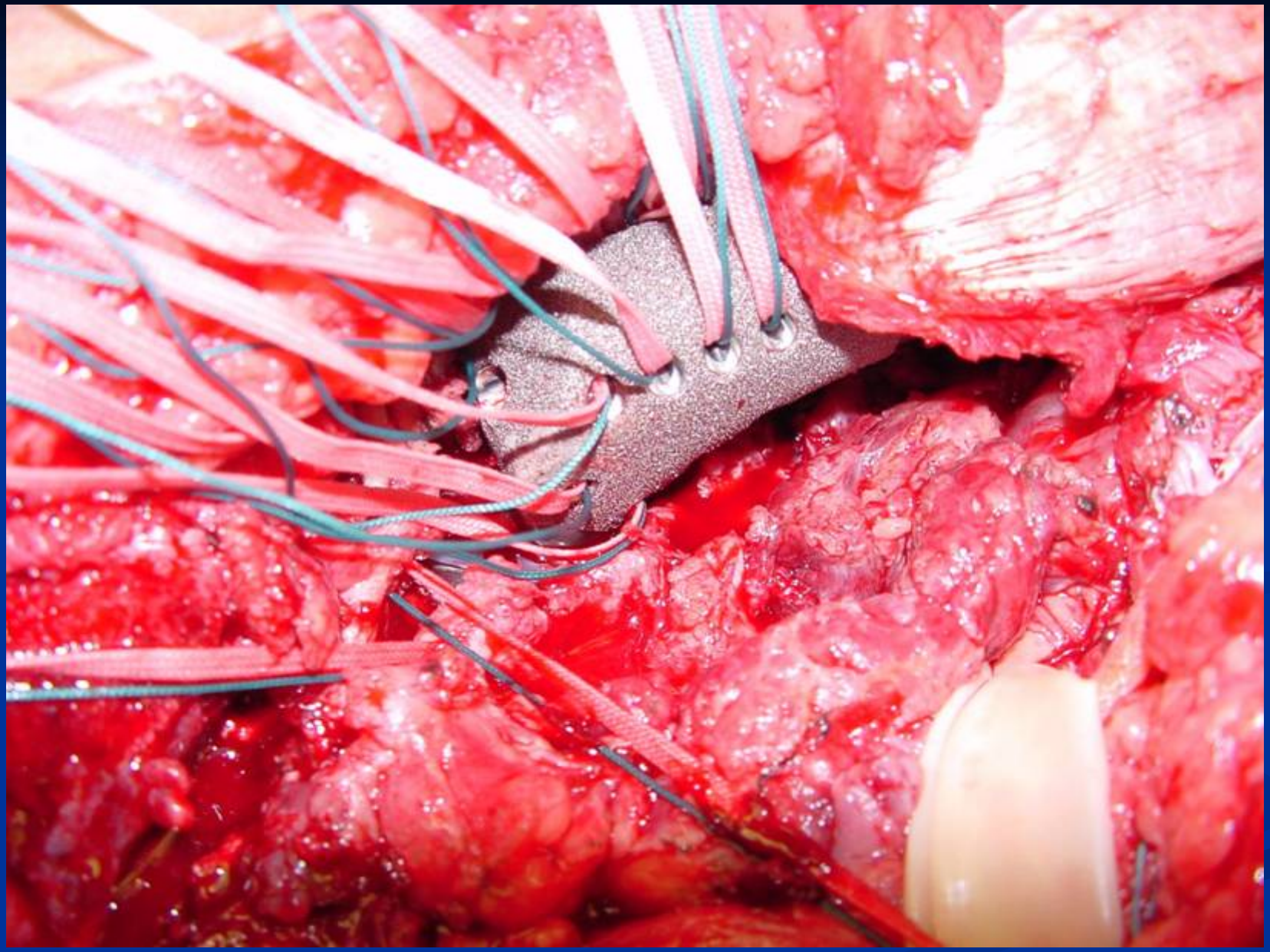
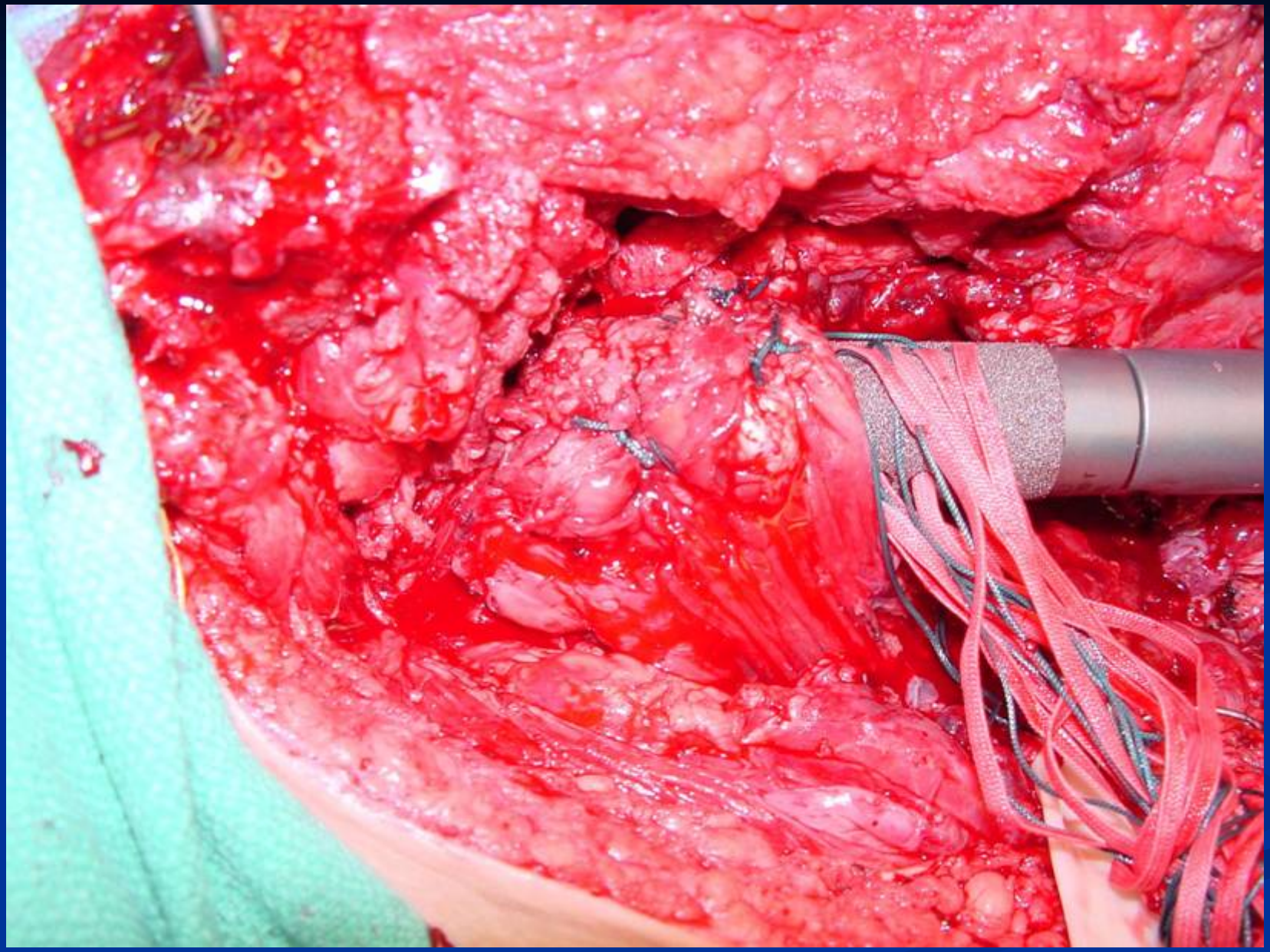


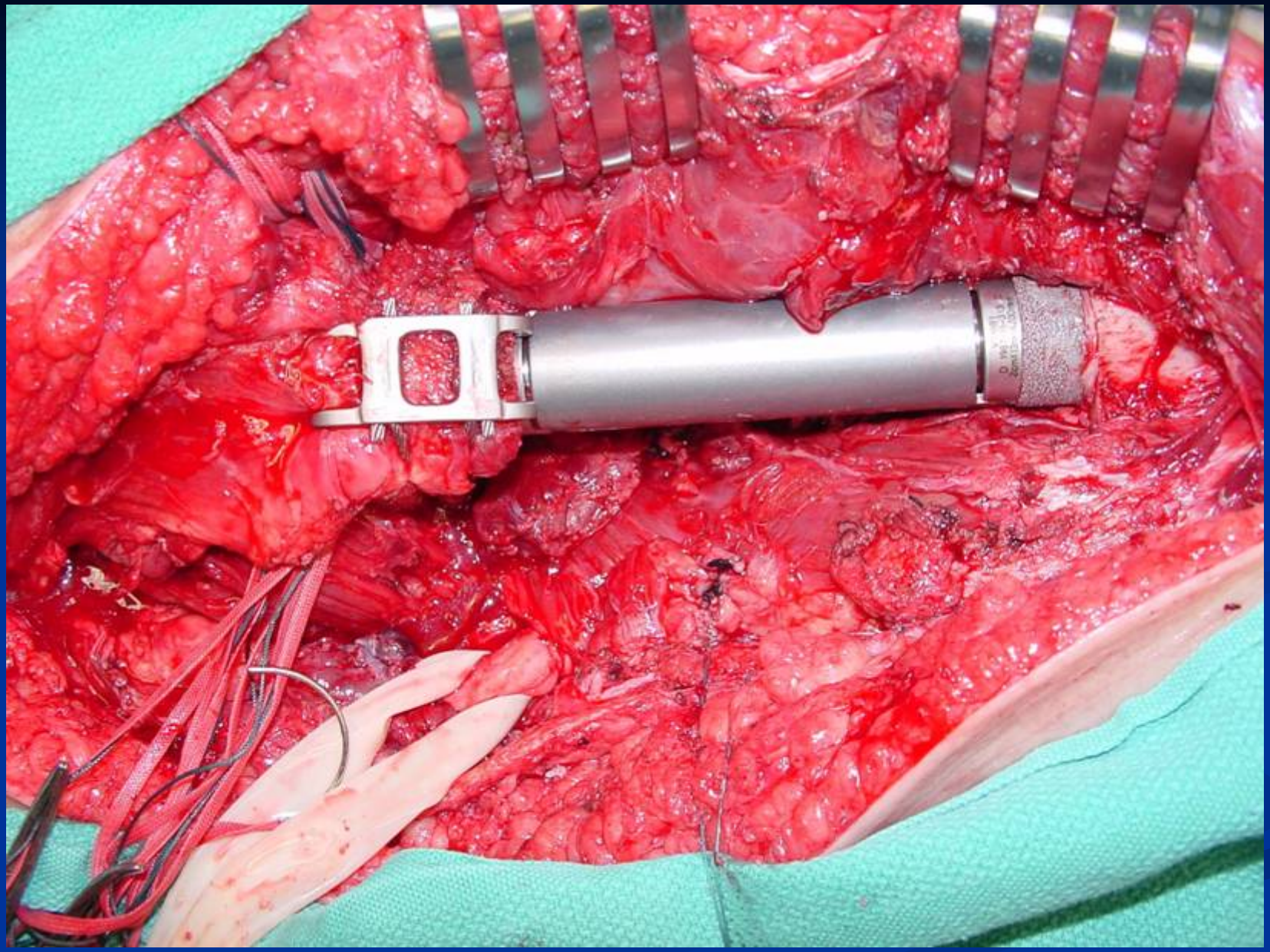
IMAGE 355
SER 1-23
RH
Post CM

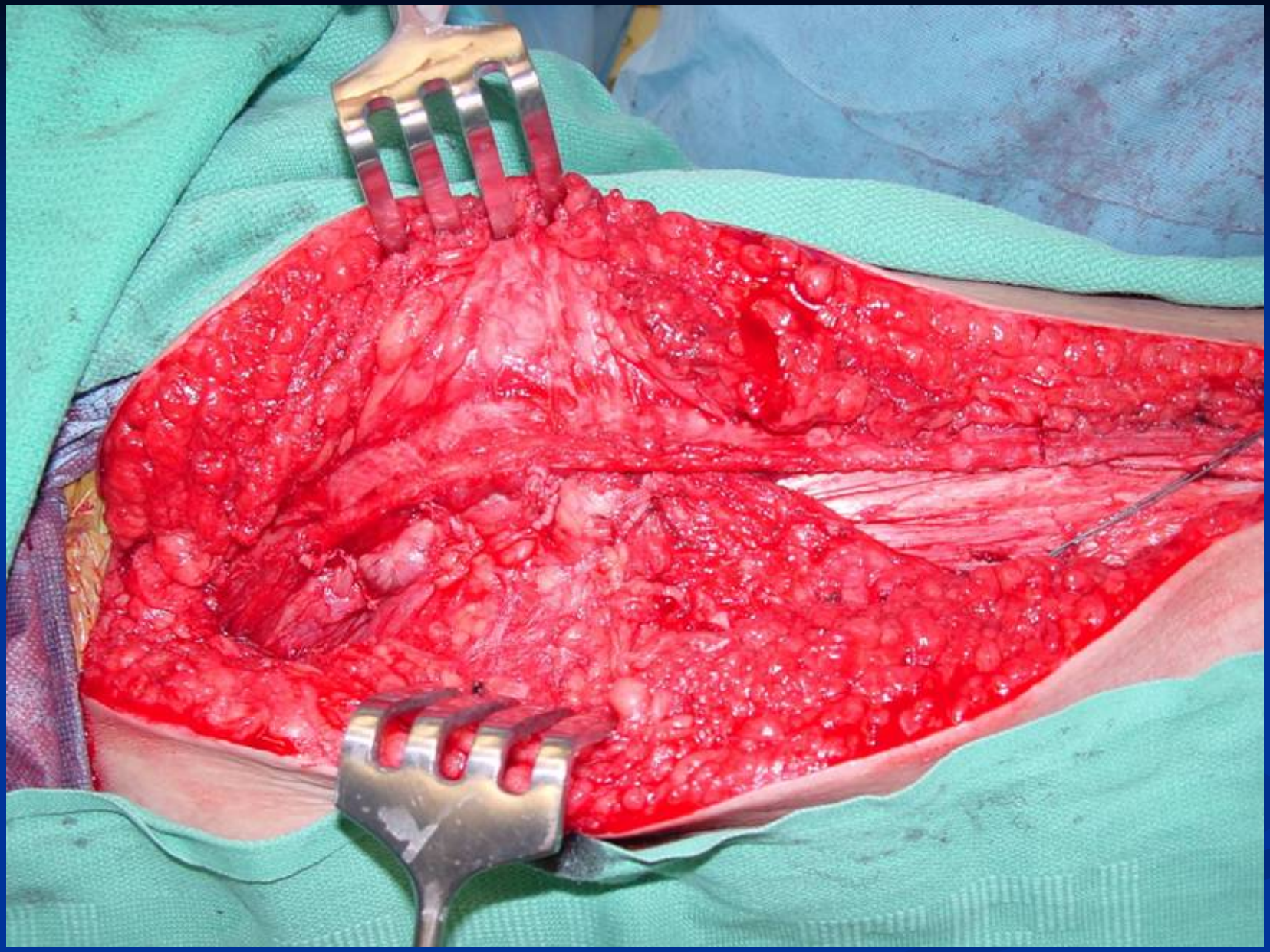

FoV: 360 mm
Tid: 1782 ms
Snitt: 2 mm
Pos:
F: BONE
320 mA
120 kV
mage 64 of 106











3 Months Postop

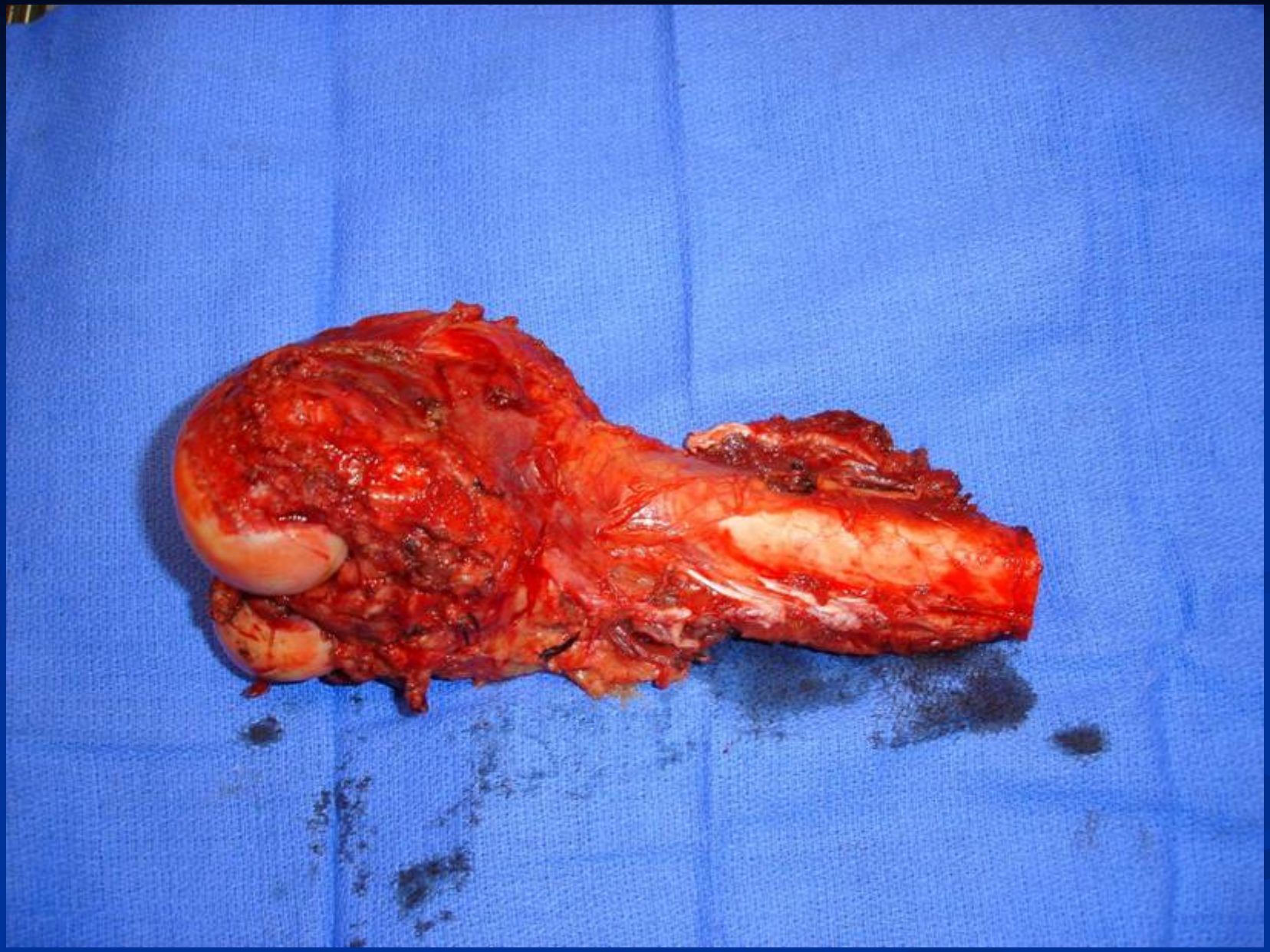

EPH
R
FEMUR WITH HIP AP

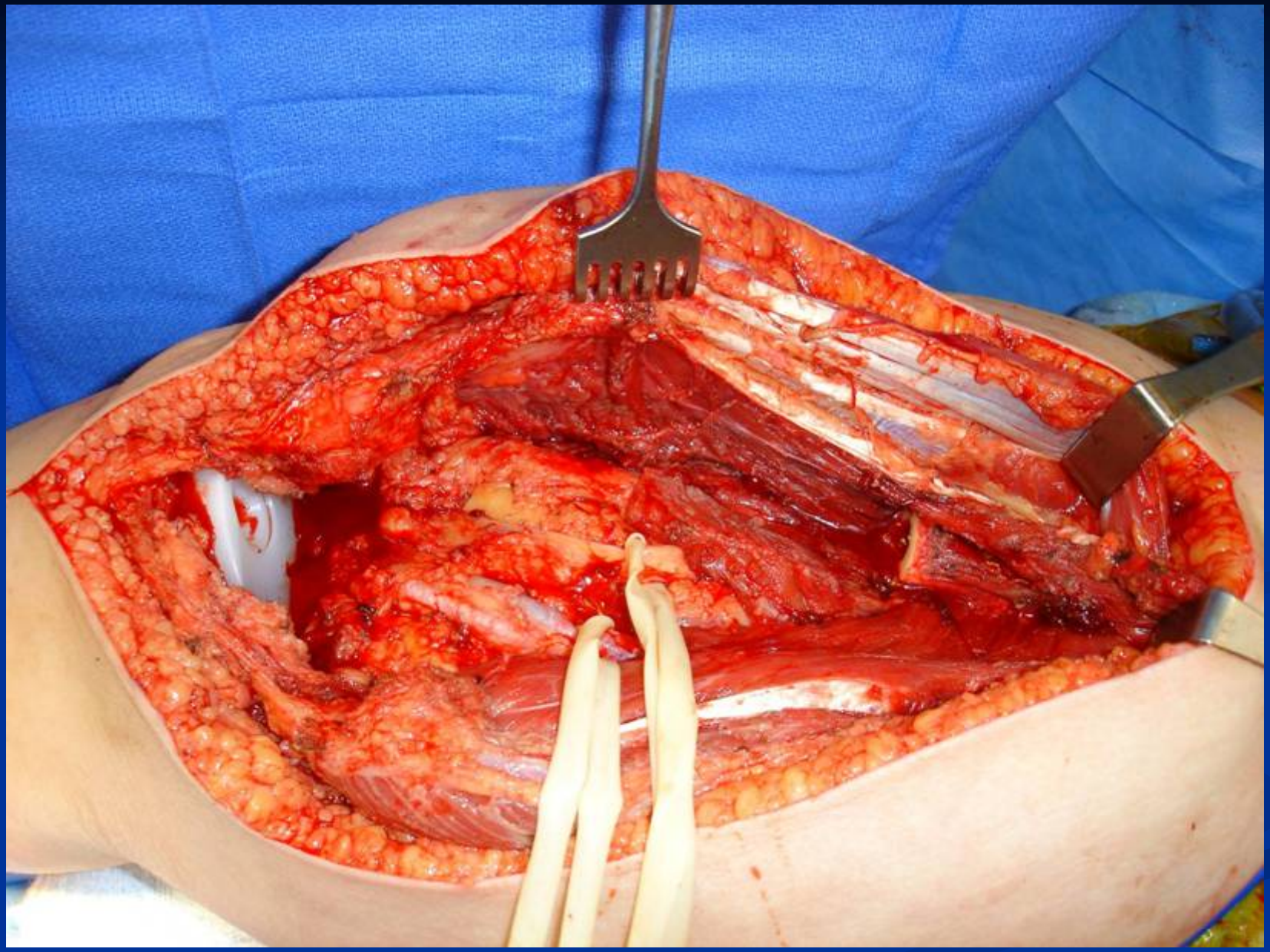

R

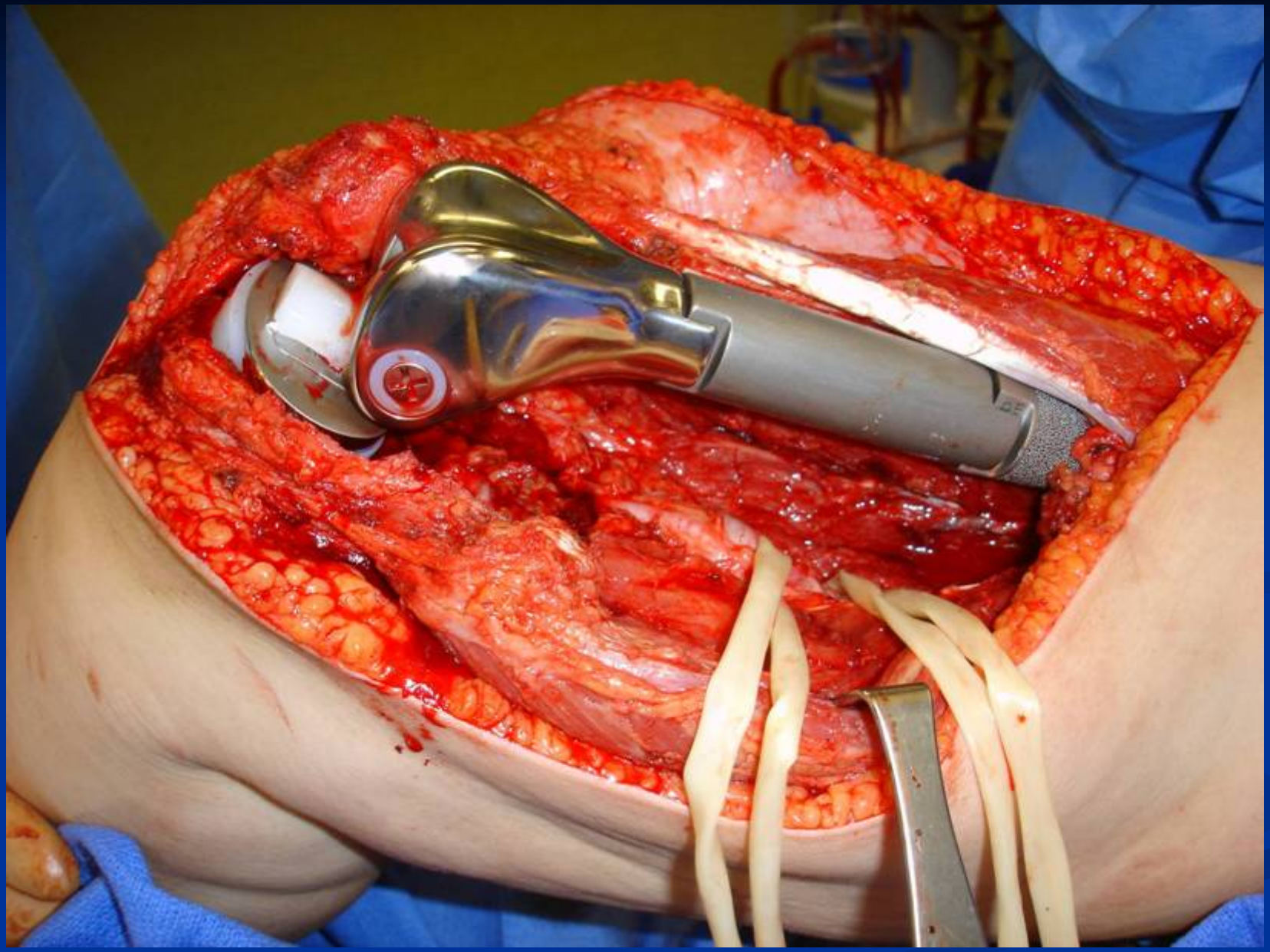
1 Year Postop

Distal Femur


23:20 PM

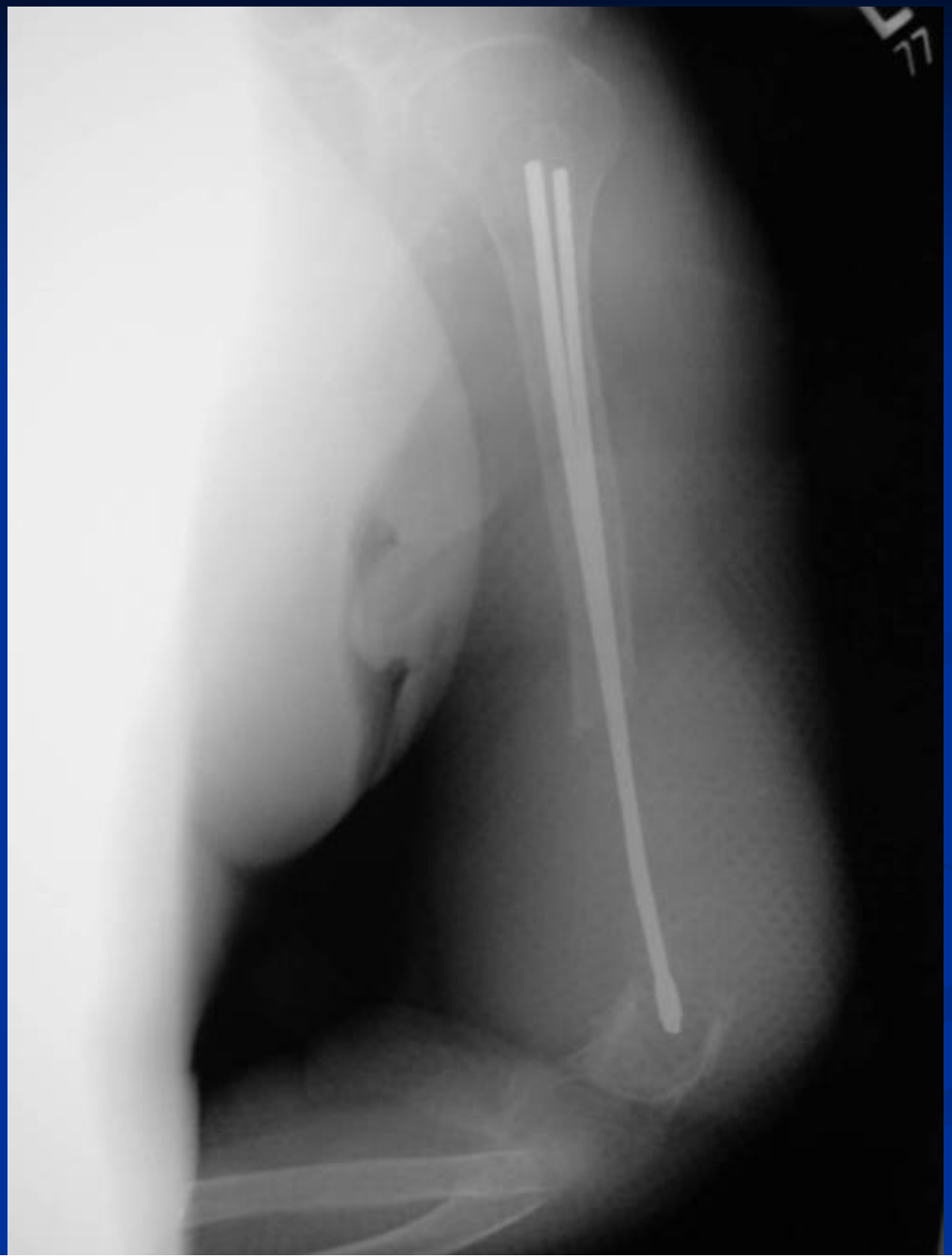




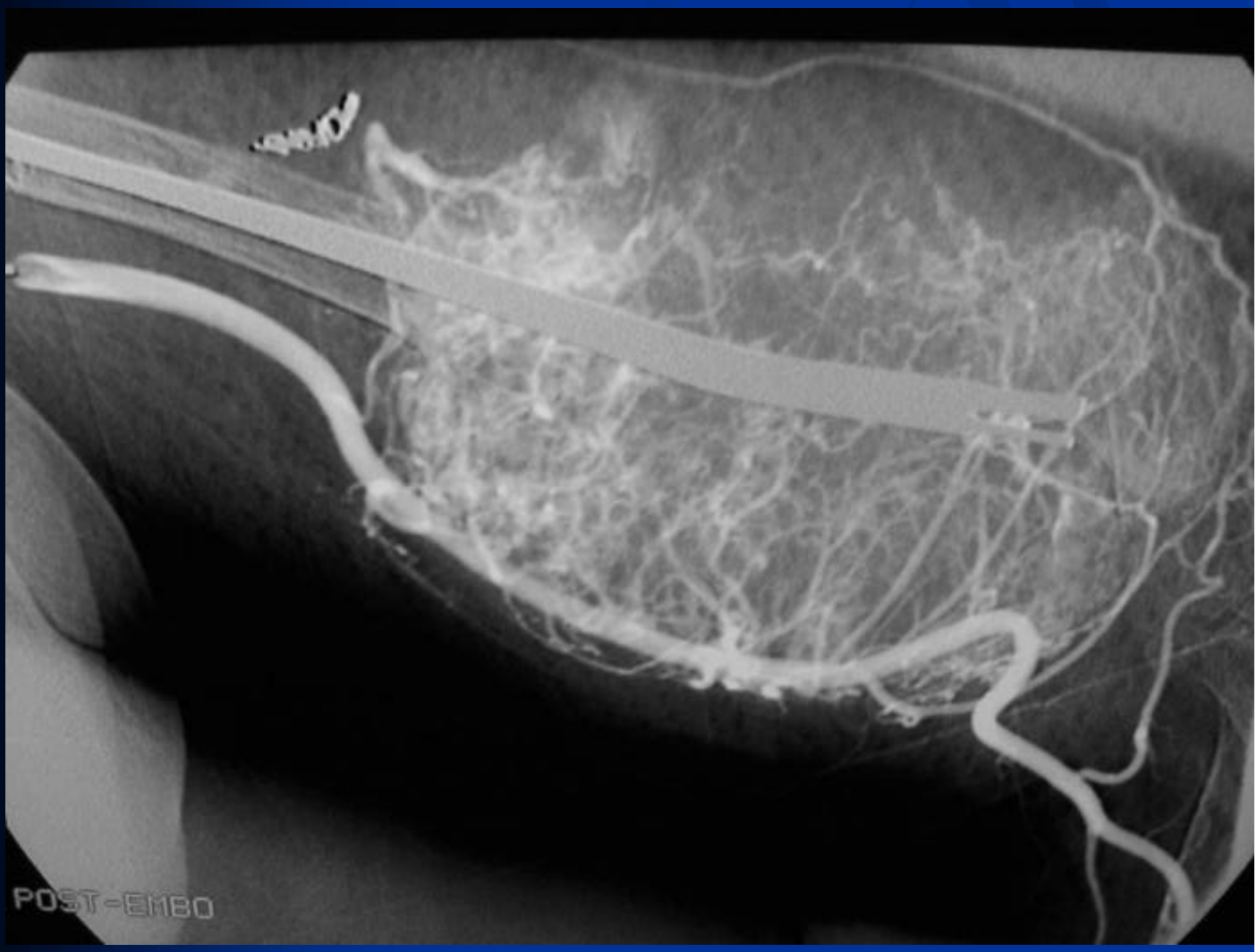


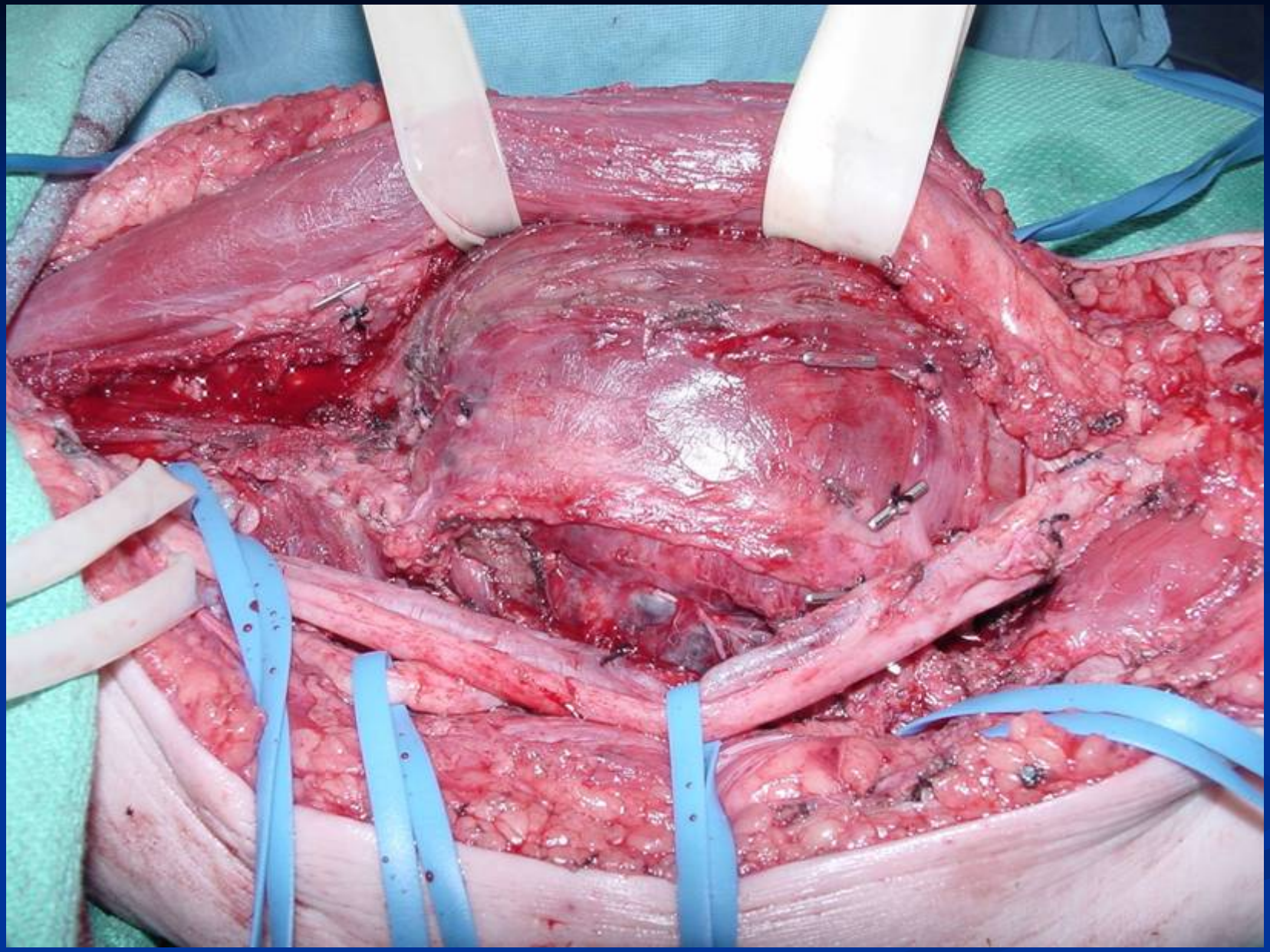

12
R

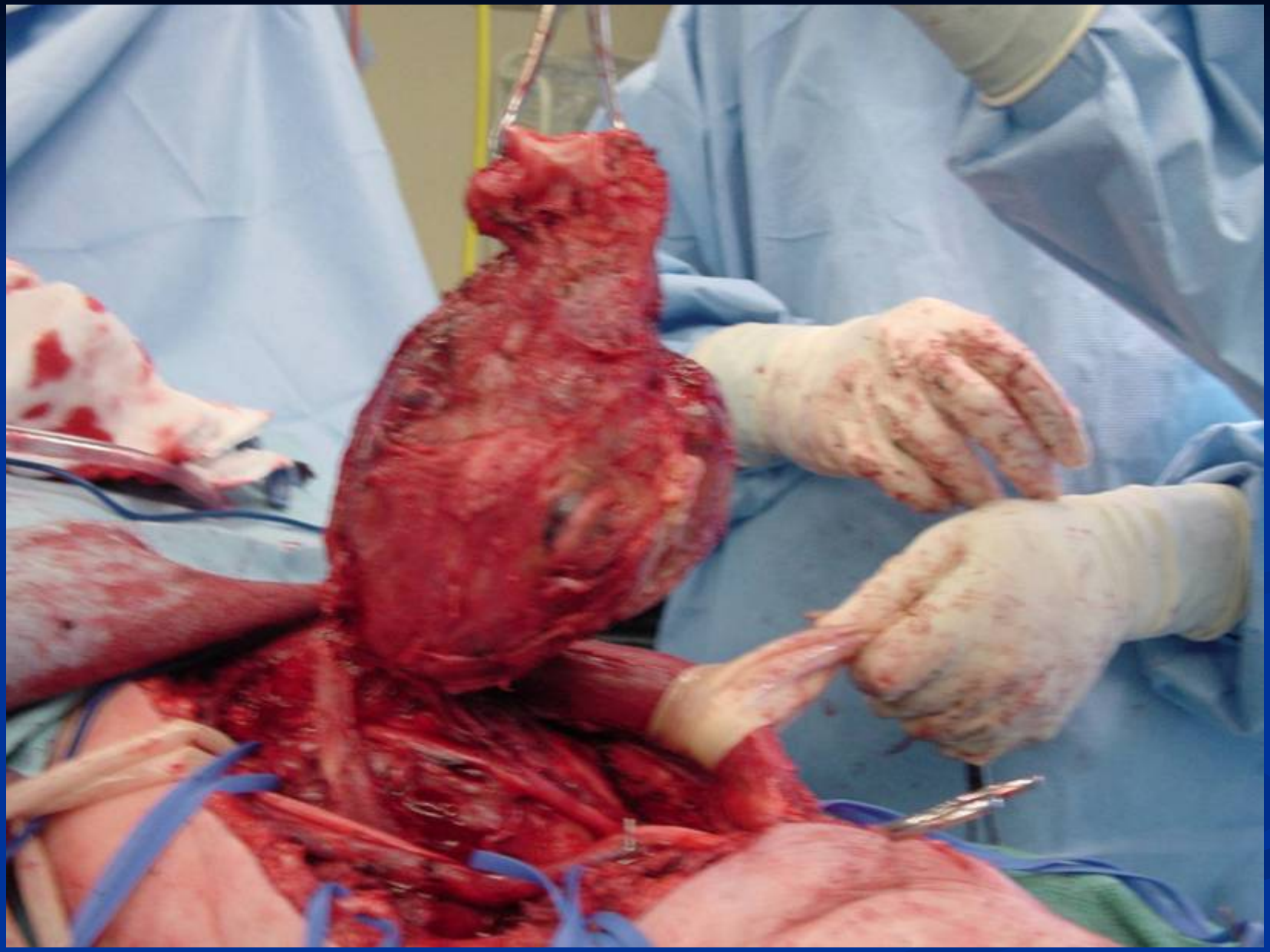
Elbow

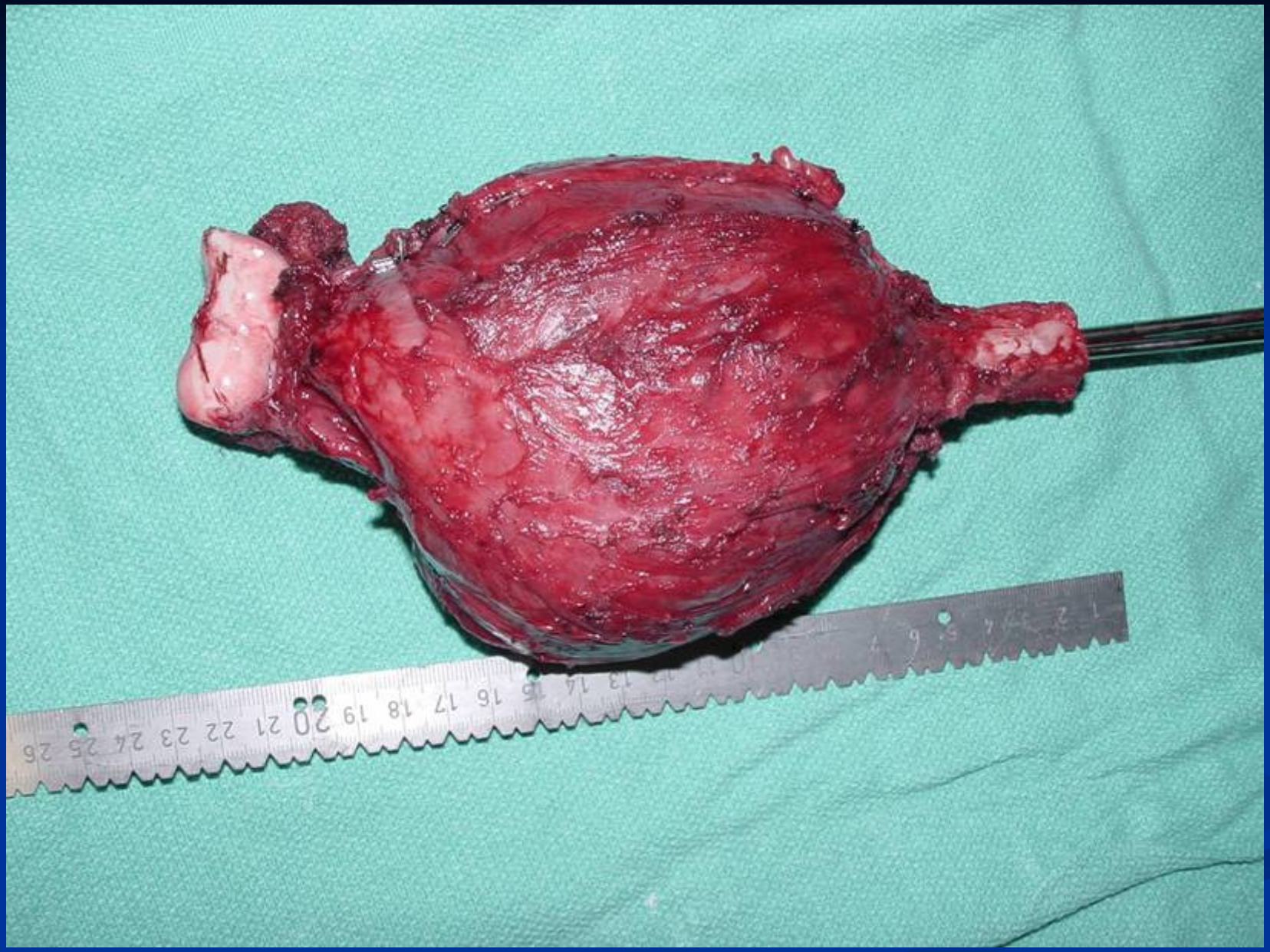


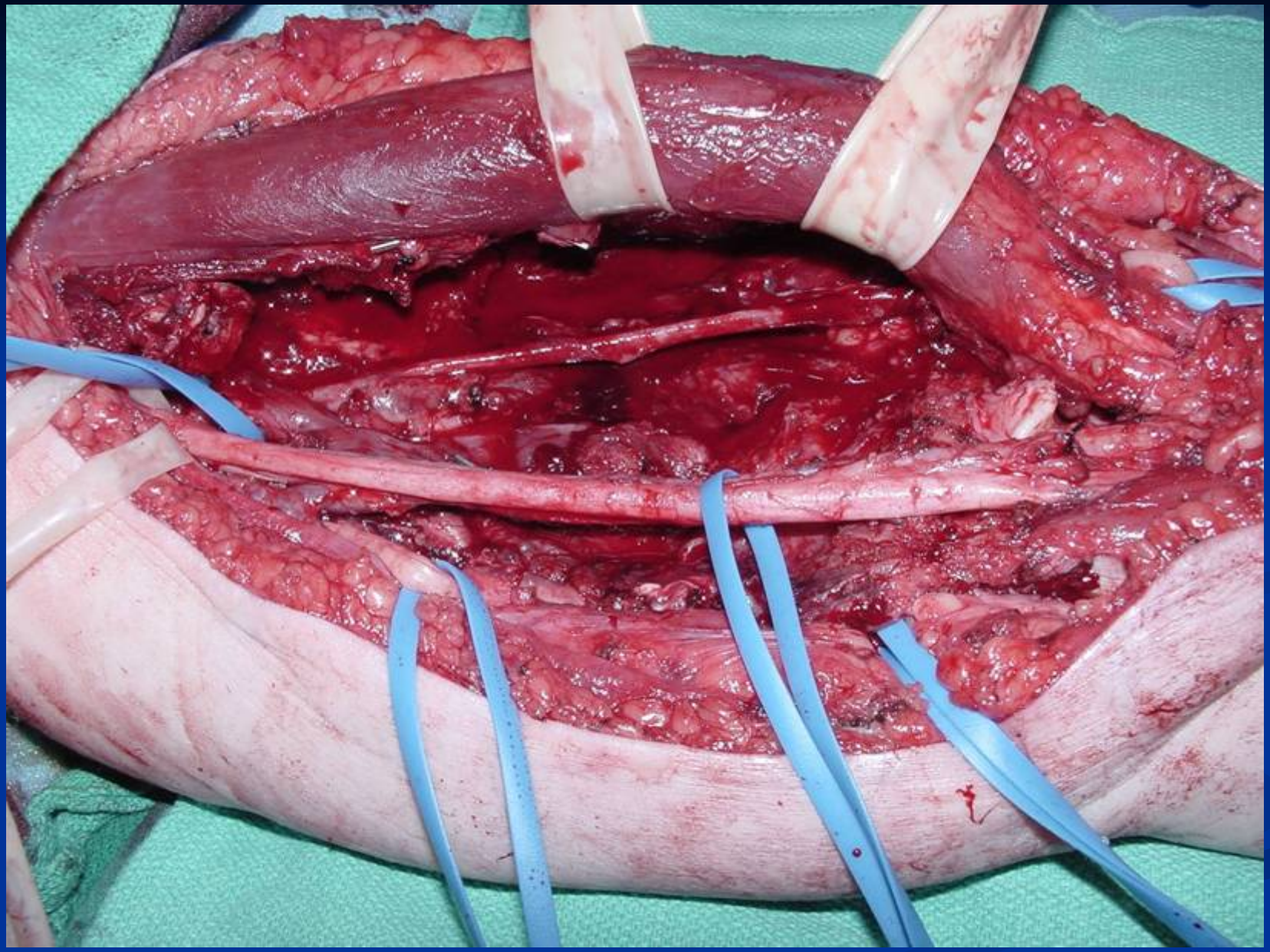

LEFT

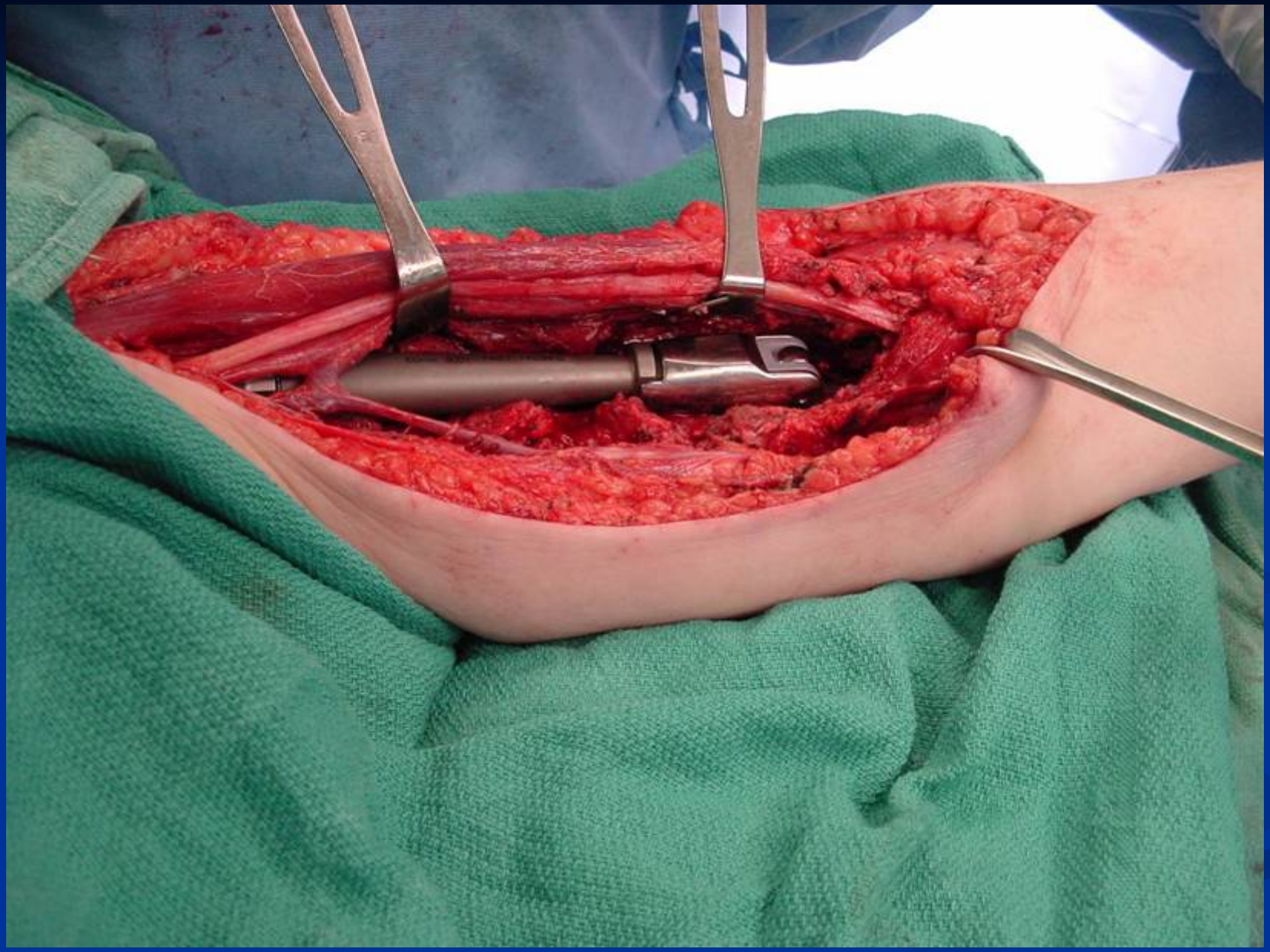

POST-EMBO

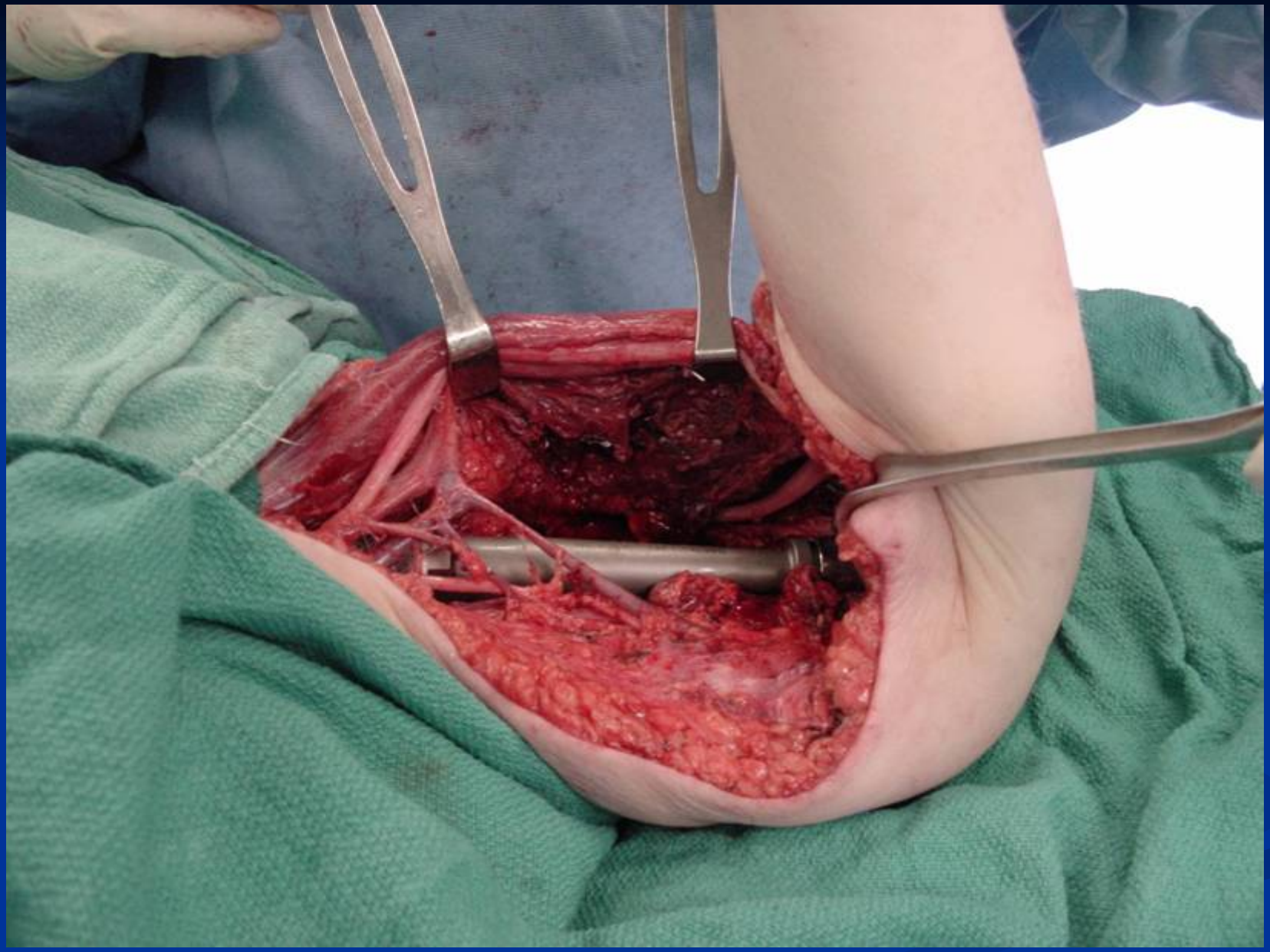




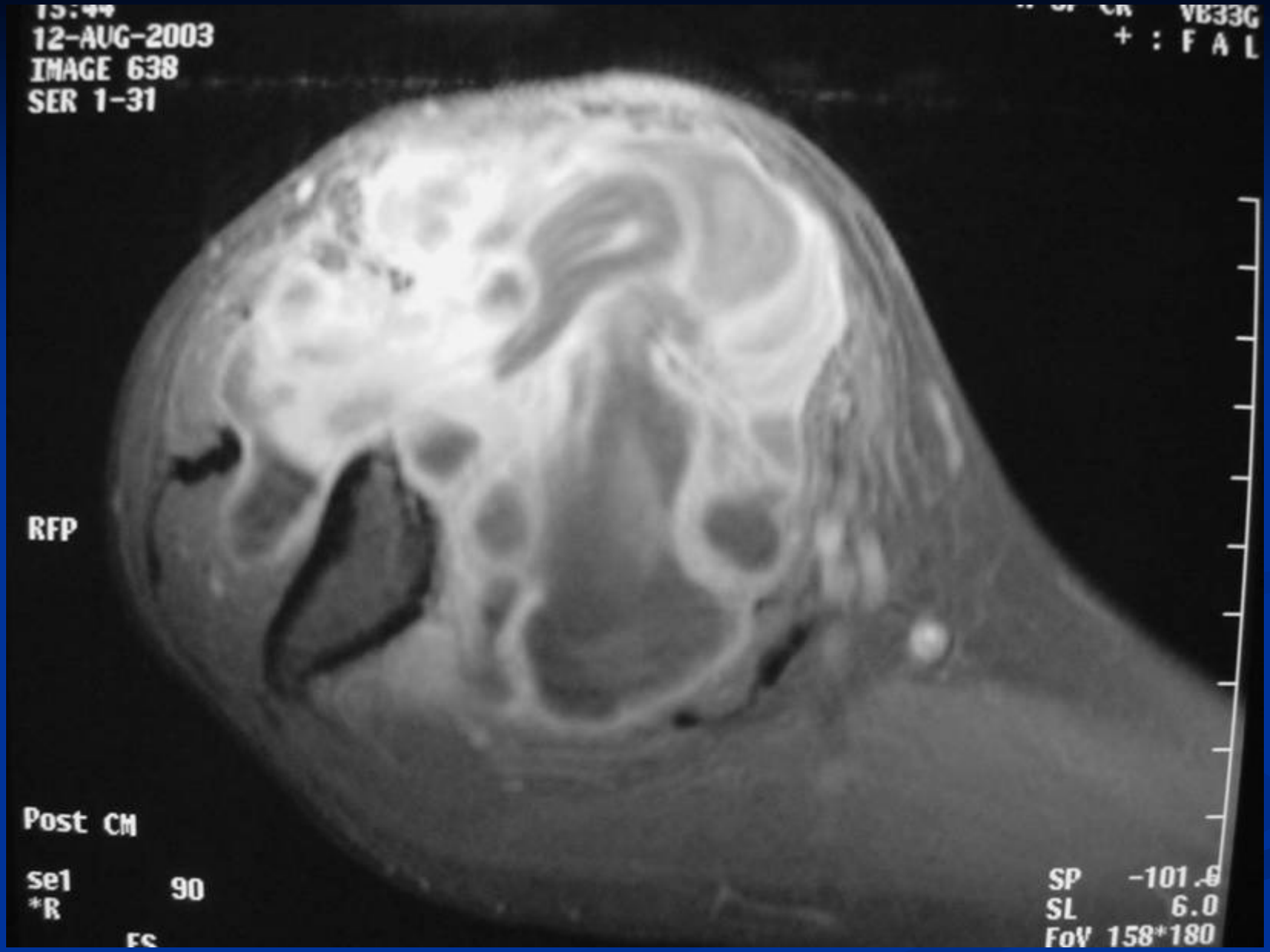








12 Weeks Postop


12-AUG-2003
IMAGE 638
SER 1-31
RFP
Post CM
se1
*R
90
SP
SL
6.0
FoV 158*180

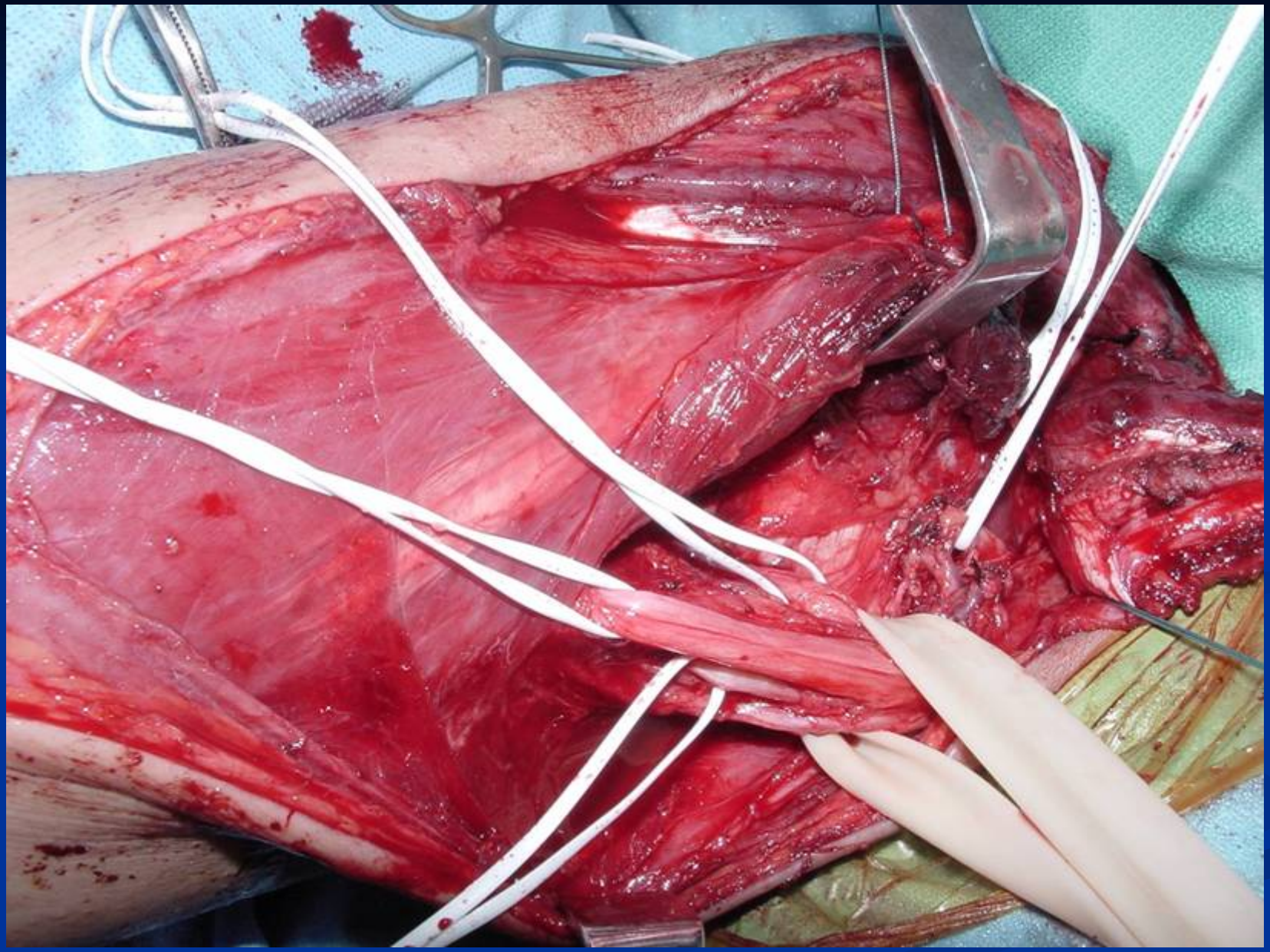

24 FEB 2004

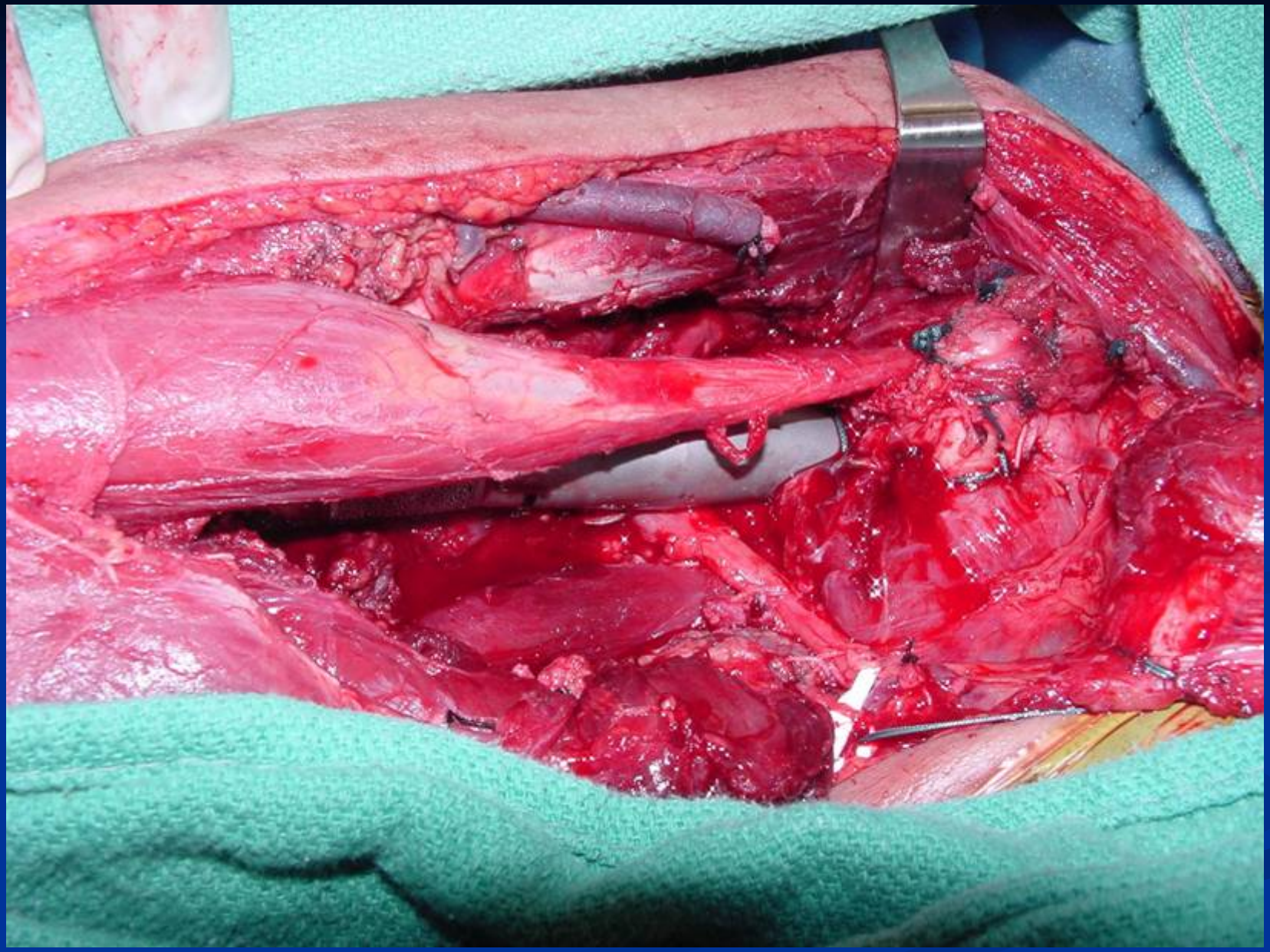
12 Weeks Postop

Proximal Humerus


R
81


RIGHT
14:05:39
0.33
2.33





3 Weeks Postop

Rehabilitation

- Important to restore function and improve mobility as soon as possible
- Important for patient to gain independence

Thank You!!