In the name of God

Cementoplasty in Bone Pain

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Kind of Cementoplasty

- Vertebroplasty - AT
- Pediculoplasty
- Sacroplasty
- Long bone cementoplasty
- Wide bone cementoplasty

Protic

Turmatic

Canceric (primary – secondary)

Aneurismal Bone Cyst

Painful hemagiom

- Fibrous dysplasia cyst
- Treatment induced complications

History

- VP was first performed in 1984 by Galimbert and Dera
- who found that the “internal casting” provided by polymethyl methacrylate (PMMA) injected into a symptomatic vertebral hemangioma provided substantial pain relief.
- The first AT was balloon kyphoplasty, introduced in California, in 1998
- AT devices have been developed, and at moment, up to 21 systems are available worldwide in which vertebral height restoration is obtained through mechanical processes; only after the deployment of those systems, PMMA is injected through the cannula.

Epidemiology

- Approximately 1- to 1.5 million VCFs occur annually in the United States (US) alone.
- Based on the age- and sex-adjusted incidence, it is estimated that 25% of women 50 years of age and older have at least one VCF Moreover, it is estimated that 40% to 50% of patients over age 80 years have sustained a VCF either acutely or recognized incidentally during clinical workup for a separate condition.
- Recent reports cite the thoracolumbar junction (i.e., the segment from T12 to L2) as the location afflicted with 60% to 75% of VCFs, and another 30% occur at the L2 to L5 region.
- In younger patients, about 50% of spine fractures are due to motor vehicle collisions with another 25% being due to falls.
- This is in stark contrast to the elderly mechanism of injury at presentation. Studies have reported an estimate of 30% of VCFs occurring while the patient is in bed. As the population continues to age, the population at risk of sustaining low energy fragility fractures will continue to increase as well.
- Currently, 10 million Americans are already diagnosed with osteoporosis, and another 34 million have osteopenia.
- The annual incidence of VCFs is 10.7 per 1000 women and 5.7 per 1000 men.
- In the United States, the incidence of compression fractures is more than 500,000 patients per year with a 16% lifetime risk in women and 5% lifetime risk in men.

Multicenter prospective study

- In a multicenter prospective study, vertebroplasty performed for metastatic compression fractures in 4,547 patients (13,437 vertebral levels) provided significant pain relief with average pain score decrease from 8.3 to 1.7.
- A meta-analysis that reviewed the clinical outcomes from 2000 to 2014 (111 studies with 4,235 patients) of both vertebroplasty and kyphoplasty for pathologic compression fractures showed a significant pain reduction, reduction of analgesic use, and improvement in disability scores

Pain for osseous metastases

- Pain attributable directly to the cancer:
- Tumor growth that results in periosteal tumor-associated inflammation,
- Tumor mass effect on adjacent soft tissues,
- Cortical bone destruction that causes structural instability or fracture, or erosion of tendon attachments.
- Indirectly due to cancer-related osteoporosis :
- immobility or from cancer-associated pain
- altered bone metabolism related to chemotherapy, hormone therapy, steroid therapy, and radiotherapy.

Several effective interventional oncology treatment options are available including:

- embolization,
- ablation,
- vertebral augmentation,
- cementoplasty,
- and percutaneous screw fixation.
- Treatments are often individualized for pain palliation, local tumor control, prevention of future skeletal-related events, or a combination of the preceding.
- The approach is tailored to overcome the unique treatment challenges of the metastasis to provide cure or remission when possible and improve the patient's quality of life and mobility, decreased opioid dependence, and lower overall healthcare costs

Unilateral versus bilateral percutaneous vertebroplasty for osteoporotic vertebral compression fractures in elderly patients A meta-analysis

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- Ying-Chun Chen, MM,* Lin Zhang, MB, Er-Nan Li, MD, Li-Xiang Ding, MD, Gen-Ai Zhang, MD, Yu Hou, MD, and Wei Yuan, MD

Vertebral osteoporotic fractures

- Osteoporosis is also called “the silent epidemy”, considering the increasing number of patients affected by this disease; a systemic medical approach is mandatory to reduce the effects of porotic VCF, such as respiratory and gastrointestinal dysfunctions.
- The main indication for vertebral cementoplasty is porotic VCF with spinal pain refractory to medical/physical treatment and orthesis devices.
- In a patient affected by a vertebral fracture, the risk to develop a new fracture in another metamer is 20% per year higher than in a patient without vertebral fractures; two-third of patients affected by porotic VCF will recover within 6–8 weeks, since the beginning of the clinical onset.

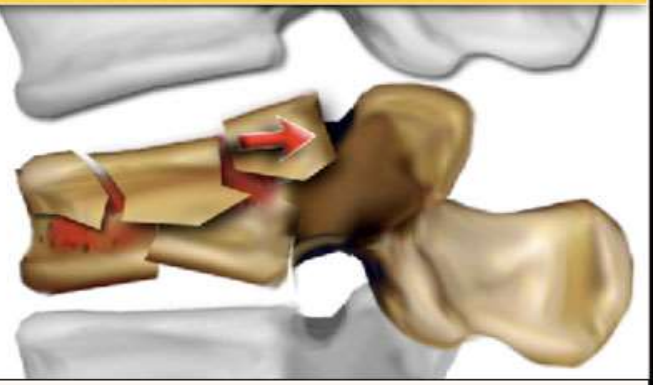
Pain associated with Compression vertebral fractures

- Primary osteoporosis
- steroid-induced osteoporosis
- Neoplastic-induced fracture
- Sub-acute traumatic collapse
- Vertebral angiomas
- Symptomatic micro fracture [MRI]
- Lytic lesion [CT] without loss of vertebral height

Compression 1 pnt

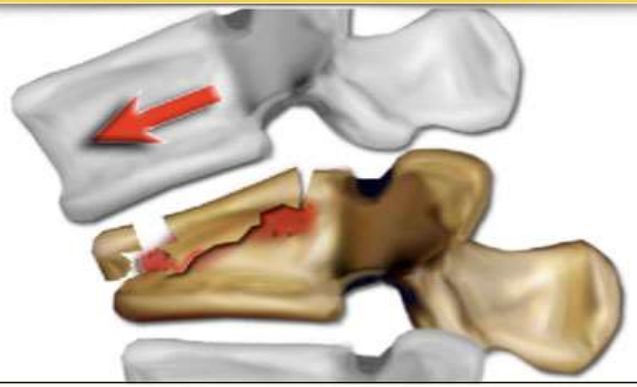
- Simple compression
- Wedge deformity

Burst 2 pnts



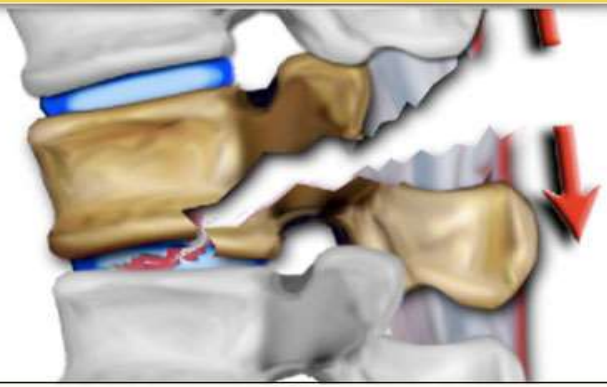
- Compression with retro-pulsion of superoposterior body fragment

Translation/rotation 3 pnts



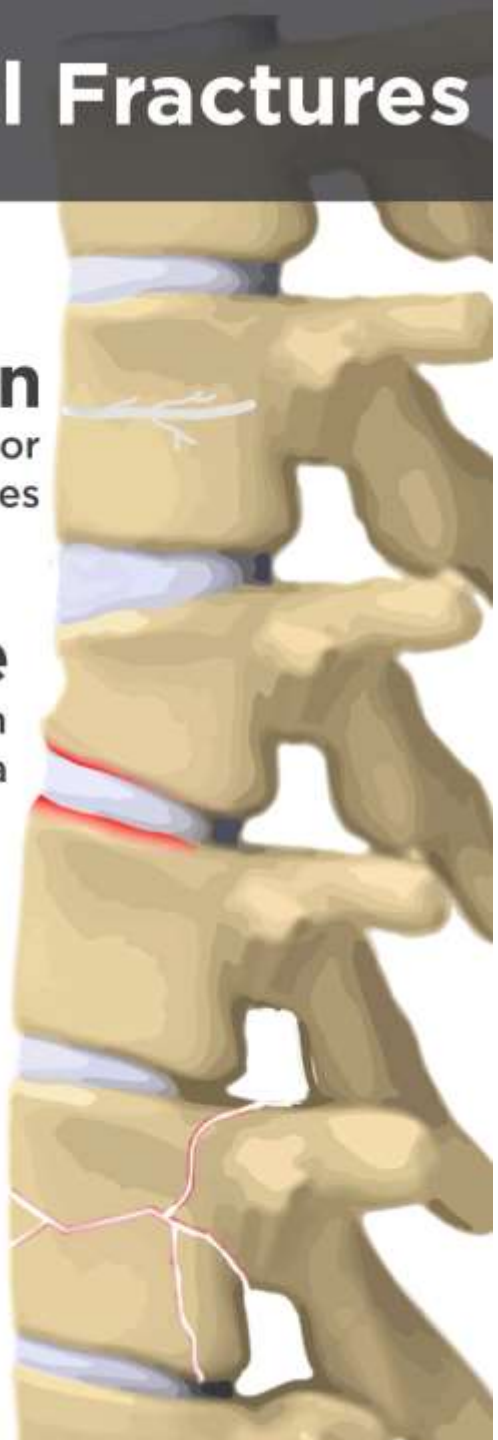
- Rotatory / shearing
- Anterior or lat displacement
- Facet joint displacement

Distraction 4 pnts



- Horizontal fracture of posterior elements
- Separation of posterior elements

Types of Spinal Fractures



Compression

collapsing as a result of pressure or degeneration of the spinal bones

Wedge

result from degeneration of the spine or trauma

Burst

when a disc/bone in your spine is extremely compressed, becoming crushed, spreading fragments throughout your spine

The Thoracolumbar Injury Classification and Severity (TLICS) Score

Injury Category	Point Value
Injury morphology	
Compression	1
Burst	2
Translation or rotation	3
Distraction	4
PLC status	
Intact	0
Injury suspected or indeterminate	2
Injured	3
Neurologic status	
Intact	0
Nerve root involvement	2
Spinal cord or conus medullaris injury	
Incomplete	3
Complete	2
Cauda equina syndrome	3

Scores: <4 non operative, 4 non operative or operative, >4 operative; PLC- posterior ligamentous complex

Imaging

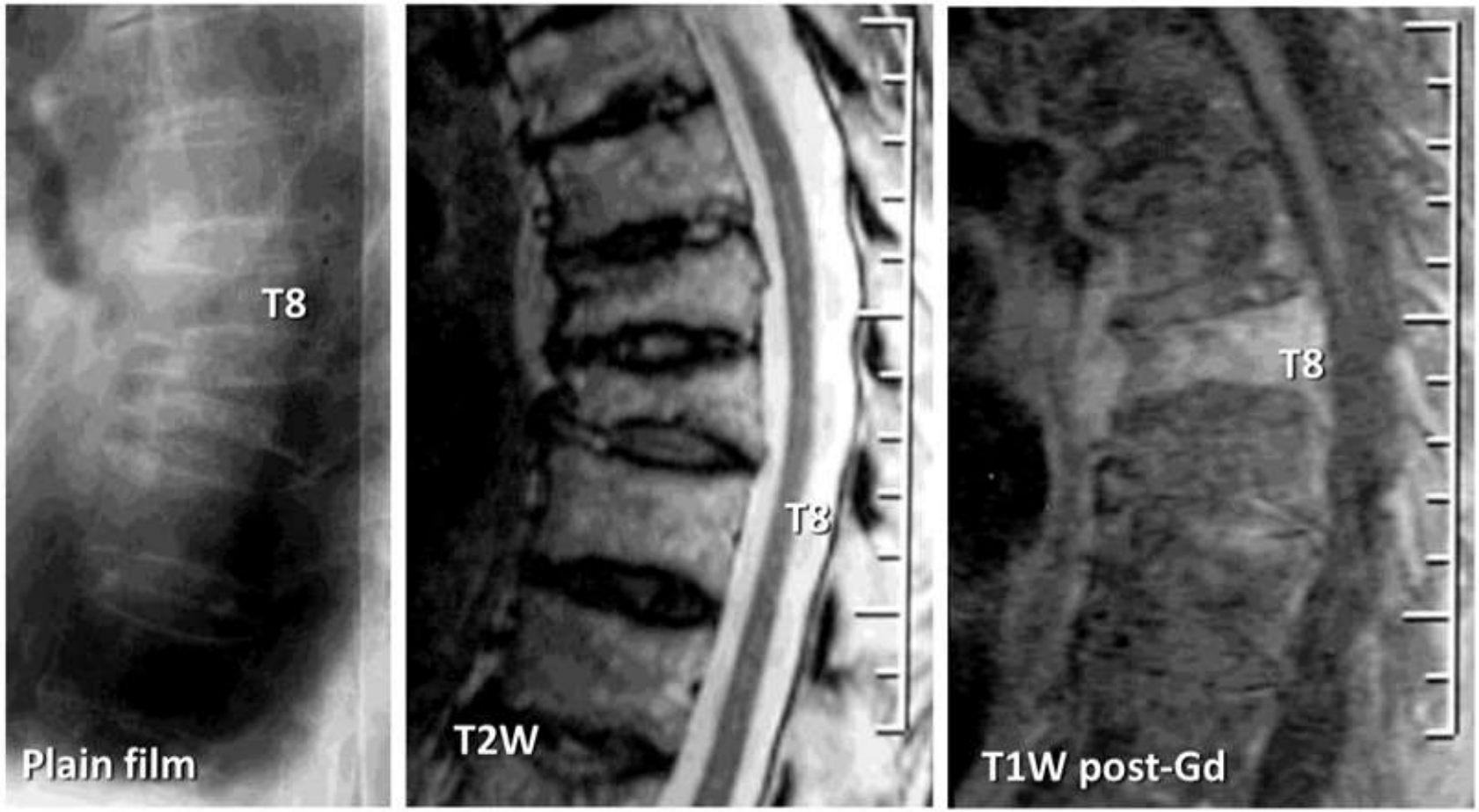
- Studies to consider in the evaluation of patients for vertebroplasty include plain film X-ray, CT scan, and MRI of the spine. These three modalities will help determine which vertebra is to be injected.
- MRI will allow for evaluation of canal narrowing or osteomyelitis. CT will allow for evaluation of lytic or blastic bone lesion and plain films can be useful for procedural planning.
- Obtaining informed consent and a thorough discussion of the risks, benefits, and alternatives is an important aspect of any procedure.

Principal indication to both VP or AT

- Presence of a painful porotic VCF associated with an MR examination detecting hypointensity in T_1 weighted sequences and hyperintensity in T_2 short tau inversion recovery sequences corresponding to the suspicious level.
- This imaging-based approach is mandatory to plan the procedure and the number of vertebral bodies to treat; indeed, T_2 weighted hyperintensity due to bone marrow oedema is a sign of not healed fracture.
- Reduction of the kyphotic deformity is the major target of AT.
- AT should be recommended in case of loss of the vertebral height of at least 30–40% or more of the normal anatomical morphology.
- Recently, a cadaveric study demonstrated that sagittal height restoration was significantly better when using SpineJack® system (Vexim®, France) than balloon kyphoplasty
- using the SpineJack device, the force needed to reduce the fracture can be directed in the craniocaudal direction, while in balloon kyphoplasty, individual anatomy and the balloon itself orientate the force direction.

Vertebroplasty – how to do it

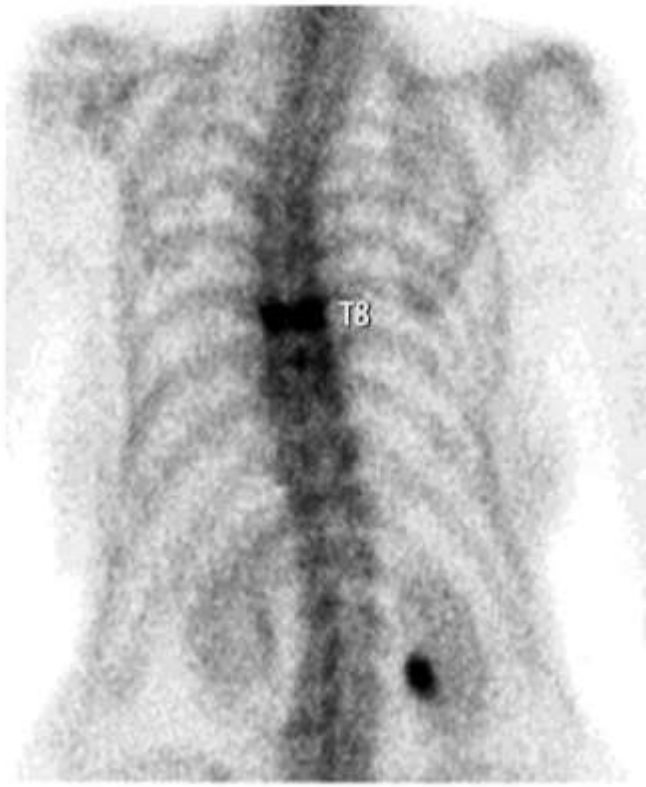
MRI of Acute Compression Fracture



showing a significantly enhanced T8 indicating a recent fracture.
T9 is a chronic fracture and does not need vertebroplasty.

Pre-Operative Bone Scan

- In patients who cannot have an MRI
- In identifying which fractures are more acute in nature and most likely to contribute to the patient's symptoms.



We use MRI for

Preoperative evaluation of vertebroplasty

in all patients unless contraindicated

Precontrast sagittal T1,

fat suppressed T2-weighted and

postcontrast sagittal fat suppressed T1-weighted images

- In clinical practice, vertebral cementoplasty has major indications in selected patients affected by porotic VCF, trauma and primary and secondary spine tumours.
- In patients with porotic VCF suffering from insufficiency fractures located in the sacrum, upper thoracic and cervical levels, VP still remains the only treatment indication.
- AT is indicated in case of porotic or metastatic fractures at thoracolumbar levels with vertebral height reduction of at least 30–40%; the goal of this approach is the restoration of the vertebral height and the reduction of the kyphotic deformity.

indications

- Indications for percutaneous vertebroplasty include painful, non-healing osteoporotic or neoplastic vertebral compression fractures refractory to medical therapy. When these conditions result in loss of normal vertebral body height, balloon kyphoplasty or vertebral augmentation with implants such as Stryker's SpineJack system can be utilized in order restore normal vertebral alignment while also treating pain.
- For patients that may not be candidates for vertebroplasty (see Contraindications) or choose to not pursue invasive treatment, medical management options are available.
- Medical treatment of compression fractures consists of bed rest, pain control with non-steroidal anti-inflammatory medications, calcitonin, narcotics, and external bracing.
- Patients whose compression fractures fail to heal after completion of the aforementioned conservative regimen over a course of 3–6 weeks should be considered for vertebroplasty.
- Patients without fractures but pain resulting from lytic metastatic neoplasm or rare symptomatic hemangioma are also candidates for vertebroplasty.
- Vertebroplasty can also be performed prophylactically to stabilize a weakened vertebra before a planned surgery.

Contraindications

- Absolute contraindications:
- Fractures that are asymptomatic
- Active osteomyelitis of the target vertebra
- Coagulopathy that is not amenable to correction
- Allergy to cement or opacifying agent used in procedure
- Fractures that cause compromise of the spinal canal and subsequent myelopathy or radiculopathy
- Relative contraindications: [15]
- Significant central canal narrowing from retropulsion of bony fragment or epidural tumor
- Ongoing systemic infection
- Disruption of the posterior cortex of the vertebral body

The most frequent **adverse reactions** reported with acrylic bone cements are:

- Transitory fall in blood pressure.
- Elevated serum gamma-glutamyl-transpeptidase (GGTP) upto 10 days post-operation.
- Thrombophlebitis.
- Loosening or displacement of the prosthesis.
- Superficial or deep wound infection.
- Trochanteric bursitis.
- Short-term cardiac conduction irregularities.
- Heterotopic new bone formation.
- Trochanteric separation.

BCIS (Bone cement implantation syndrome)

• is characterized by a number of clinical features that may include hypoxia, hypotension, cardiac arrhythmias, increased pulmonary vascular resistance (PVR) and cardiac arrest. It is most commonly associated with, but is not restricted to, hip arthroplasty. It usually occurs at one of the five stages in the surgical procedure; femoral reaming, acetabular or femoral cement implantation, insertion of the prosthesis or joint reduction. It is an important cause of intraoperative mortality and morbidity in patients undergoing cemented hip arthroplasty and may also be seen in the postoperative period in a milder form causing hypoxia and confusion.

• Hypoxaemia.

• Cardiac arrhythmia.

• Bronchospasm.

• Adverse tissue reaction.

• Haematuria.

• Dysuria.

• Bladder fistula.

• Local neuropathy.

• Local vascular erosion and occlusion.

• Transitory worsening of pain due to heat released during polymerization.

• Delayed sciatic nerve entrapment due to extrusion of the bone cement beyond the region of its intended application.

• Intestinal obstruction because of adhesions and stricture of the ileum due to the heat released during cement polymerization.

- VP has been used for osteoporotic or malignant fractures. The procedure was first described by Galibert et al
- Vertebroplasty can increase patient mobility, decrease narcotic needs, prevent further vertebral collapse resulting in altered forces on intervertebral discs, and avoid the complications associated with prolonged immobility.
- Percutaneous vertebroplasty (PVP) usually involves percutaneous injection of PMMA into the vertebral bodies. Occasionally, PMMA has also been placed manually into vertebral lesions during open surgical operations.
- Kyphoplasty is often mentioned alongside vertebroplasty. Kyphoplasty differs from vertebroplasty by adding an important additional step: insertion and inflation of a balloon before cement delivery, which also serves to restore vertebral body height and spine alignment. [2] Kyphoplasty is often used interchangeably with vertebroplasty and is considered a subset of vertebroplasty.
- Spine jack is a new system that corrects vertebral height, reduces the incidence of endplate damage by inserting an implant that mechanically augments the height of the vertebral body to better restore alignment followed by injection of cement.

Osteoporotic vertebral fracture management study

- An important consideration in the discussion of vertebroplasty is the VERTOS study, which directly compared vertebroplasty to medical management. The VERTOS study prospectively compared osteoporotic compression fracture treatment of 18 patients with vertebroplasty to 16 patients with optimal medical management and found improvement in pain relief for the vertebroplasty group. [7]
- These results were confirmed with the VERTOS II study, a larger prospective randomized trial consisting of 101 patients treated with vertebroplasty and 101 treated with conservative management).
- Two important studies to consider are those by Buchbinder et al. and Kallmes et al., each of which compared vertebroplasty to sham procedures and importantly demonstrated no significant improvement with vertebroplasty. [10, 11] This mixed evidence has sparked considerable debate as to the appropriate role of this procedure.

Titanium-implantable vertebral augmentation devices versus vertebroplasty or kyphoplasty

- Even after balloon kyphoplasty, osteoporotic compression fractures have a high rate of continued collapse with subsequent loss of height and the development of angulation and deformity. This appears to increase the risk for adjacent level fractures.
- The SpineJack system (Stryker Corp, Kalamazoo, MI) consists of bilateral expandable titanium implants supplemented with bone cement. This system provides more symmetric and balanced lateral and anterior support, and requires lower volumes of bone cement compared to balloon kyphoplasty.
- Using this system, clinicians can now achieve better pain control, restore vertebral body height, restore spinal alignment, and reduce the risk of adjacent level fractures.
- One important advantage of SpineJack kyphoplasty over standard balloon kyphoplasty or vertebroplasty is the ability to perform kyphoplasty safely in patients with mild–moderate retropulsion of the posterior endplate without neurological compromise. In certain situations, the SpineJack device has been used to elevate the fractured endplates serving to reduce the retropulsed bone fragment. In circumstances where patients have a retropulsed bone fragment, SpineJack is superior for the aforementioned reason. Retropulsed bone fragments are a relative contraindication to balloon kyphoplasty.
- This finding was noted in the SAKOS study, which directly compared SpineJack kyphoplasty versus balloon kyphoplasty and showed that SpineJack patients had better pain reduction at 1 month and 6 months post treatment. The SAKOS study also showed that SpineJack is associated with a reduced incidence of adjacent level fractures.

Spinal tumors & Vertebral hemangioma

- The role of vertebroplasty in spinal tumors is palliative. Generally, in previously untreated painful vertebral metastasis, radiotherapy is used in 70% of cases to alleviate spinal pain. However, this effect is delayed and often can take up to 2–6 weeks to provide relief. Vertebroplasty can achieve the same goal of pain relief with an almost immediate analgesic effect. [14]
- Vertebroplasty has successfully treated severe focal spinal pain with radiologically unaggressive vertebral (body) hemangioma as originally described by Galibert in 1984.

Patient selection
The key to success of vertebroplasty

- Pain should be
  - focal,
  - intense,
  - deep,
  - local tenderness
  - corresponding with imaging findings,
  - No radiation to the legs.

Medicolegal

- The procedure is discussed
  – with the patient and/or family,
  – benefits, risks, and possible complications are explained.
- Obtain informed consent.

Before discussing the technique.. Possible complications..?

- Bleeding
- Infection
- Fracture of the pedicle
- Damage to the nerve roots or spinal cord
- Worsening of symptoms
- Spinal cord or nerve root compression (radiculopathy) from cement leakage
- Pulmonary embolism

Complications - < 10%

- Neuralgia
- Infection
- Cord compression
- Pulmonary Embolism
- Vascular injury- hematoma
- Rib fractures
- CSF leakage
- Hypotension
- Increased pain

Technique

- Equipment
- Multiple vertebroplasty kits are available. Each manufacturer has their own specific subsets with unique names for the devices, but the basic components are the same: access needle, syringe, cement, and cement mixing apparatus. See individual manufacturers' guidelines for further information on individual kits.
- Preprocedure
- patient evaluation

1. history and physical exam.
2. localized tenderness
3. deep pain with sudden onset
4. midline location
5. exacerbation by motion and standing

Setup and positioning

- Procedure time can vary but ultimately lasts anywhere from 40 to 120 minutes.
- Conscious sedation and local anesthesia are used in the majority of cases.
- Use of MAC anesthesia has also been described.
- Prophylactic antibiotics such as cefazolin should be considered.
- Place the patient in the prone position.
- Align posterior ribs to obtain a good lateral view.
- On the anteroposterior (AP) view, find the obliquity that projects the pedicle over the upper outer third of the vertebral body.
- Mark this point.

- Trans pedicular approaches:
- For a Unipedicular approach, advance needle into the anterior third of the central vertebral body.
- For a bi pedicular approach, advance needles into the mid portion of the hemi vertebrae.
- A Para pedicular approach may be considered as well.

Polymethylmethacrylate mixing and injection procedure

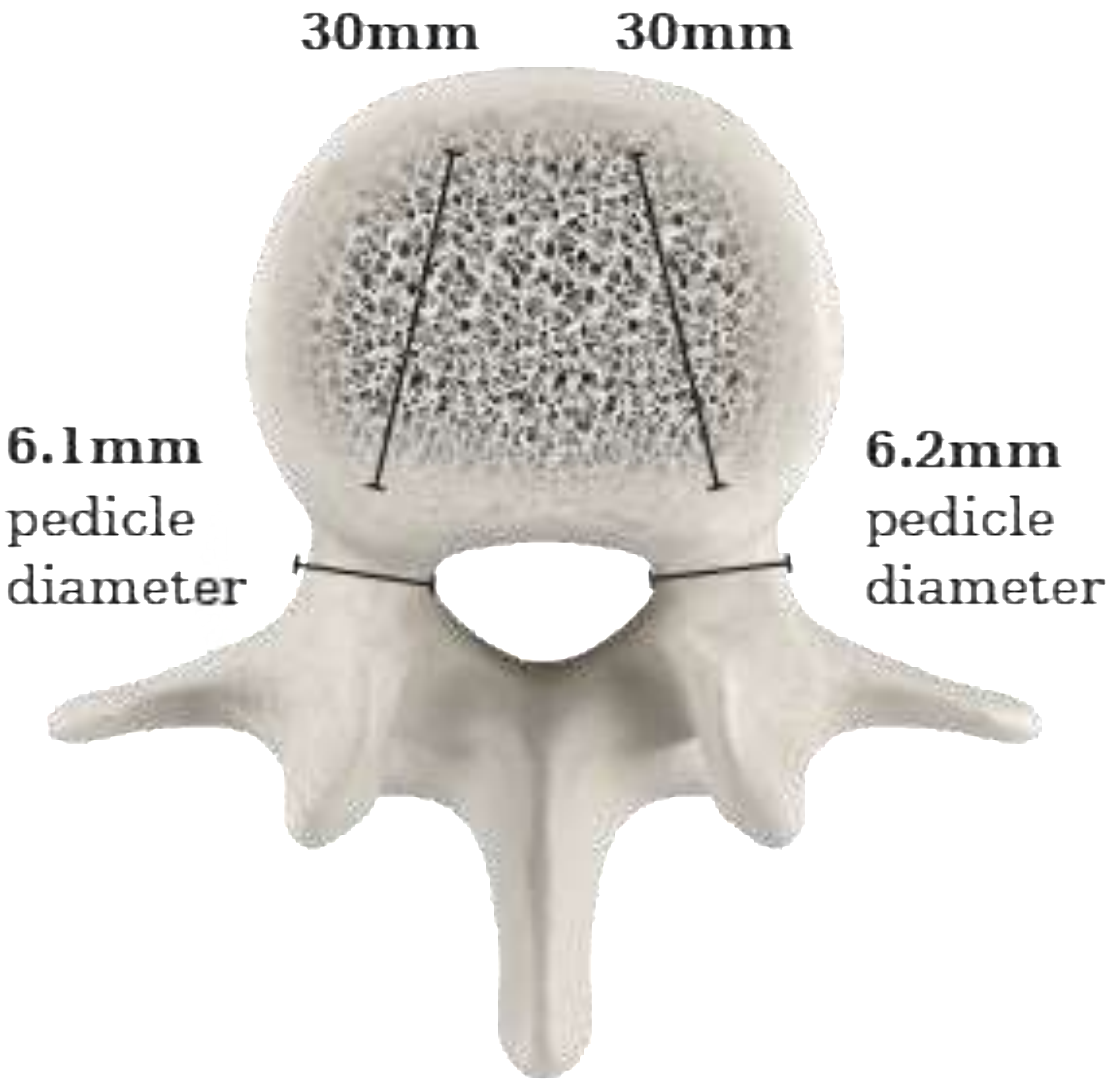
- Depending on the manufacturer, there can be different methods to make the cement.
- Depending on the agent of choice, both polymethylmethacrylate (PMMA) and barium sulfate (opacifying agent) should be made as per the manufacturer's instructions.
- Slowly inject this mixture until the vertebral body is well filled, making certain to stop before PMMA leaks posteriorly into the epidural area or significantly fills a vein.
- An important consideration is the volume of cement used to fill the vertebral body. Pain relief is not associated with cement volume, thus attempting to fill the vertebral body as completely as possible is not necessary. [19

Postprocedural care

- Generally, patients are kept on bed rest for 1–2 hours and given analgesics for postoperative pain with muscle relaxants for spasm.
- Patients with osteoporosis should be managed medically and closely followed after the procedure. Without systemic osteoporosis therapy, 20% of patients with a fracture develop a second fracture.
- Treatment for osteoporosis includes DEXA scans, lifestyle modifications (smoking cessation, alcohol moderation, exercise), dietary supplementation (calcium, vitamin D), and medical management (antiresorptive)

Needle placement

- Lidocaine with epinephrine is commonly used for local anesthetic and a spinal needle to anesthetize the periosteum. Proper trajectory may be confirmed with AP and lateral fluoroscopic views.
- Depending on the size of the pedicle, different gauge needles can be used. 11-gauge is recommended for lumbar and lower thoracic pedicles; but a 13-gauge will suffice midthoracic pedicles.
- A large clamp will allow for maintenance of tension along the back to allow for easier placement of the needle. A sterile hammer can be used to gently tap the needle. Direct the needle into the vertebral body, using AP and lateral views for verification.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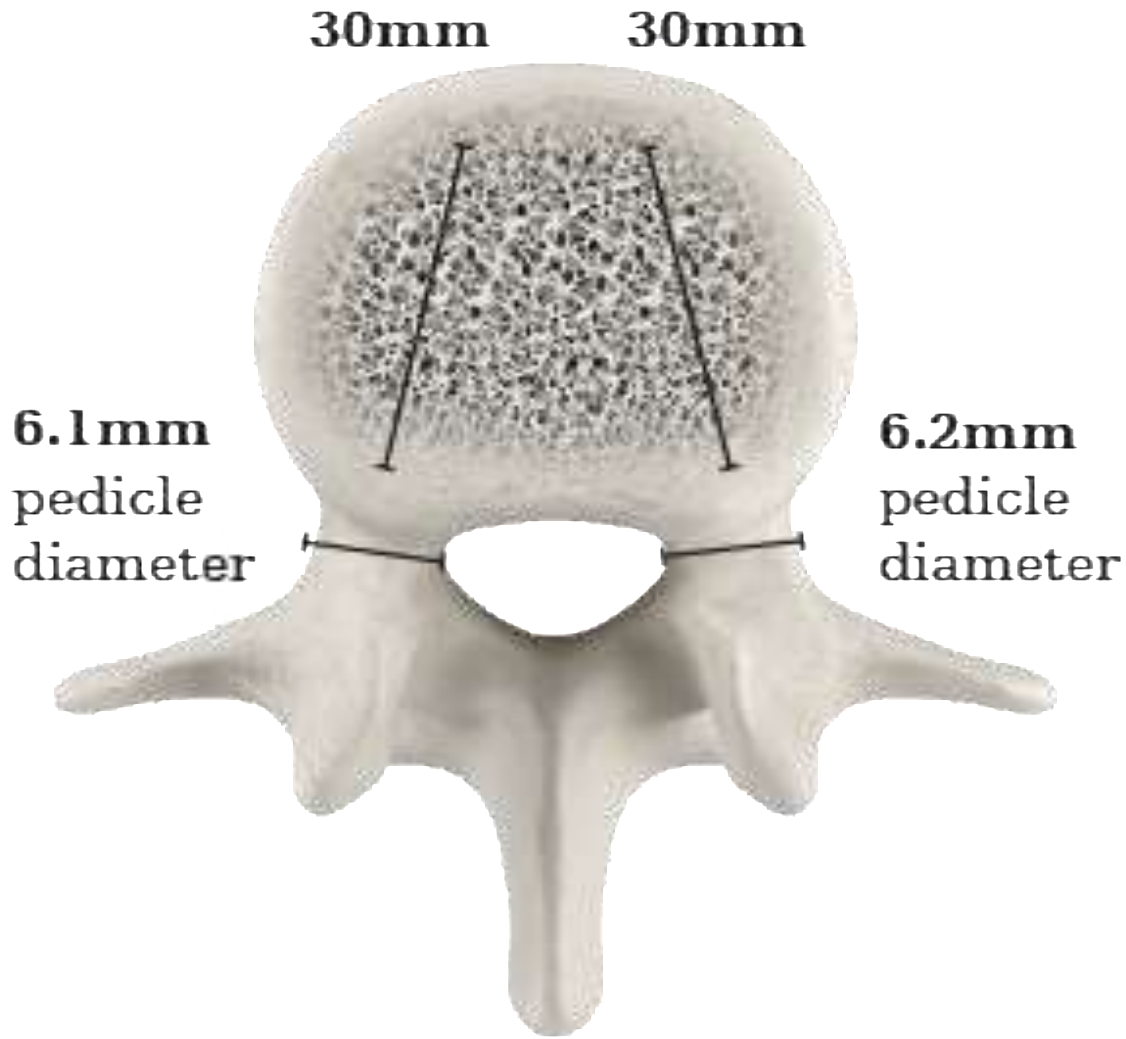
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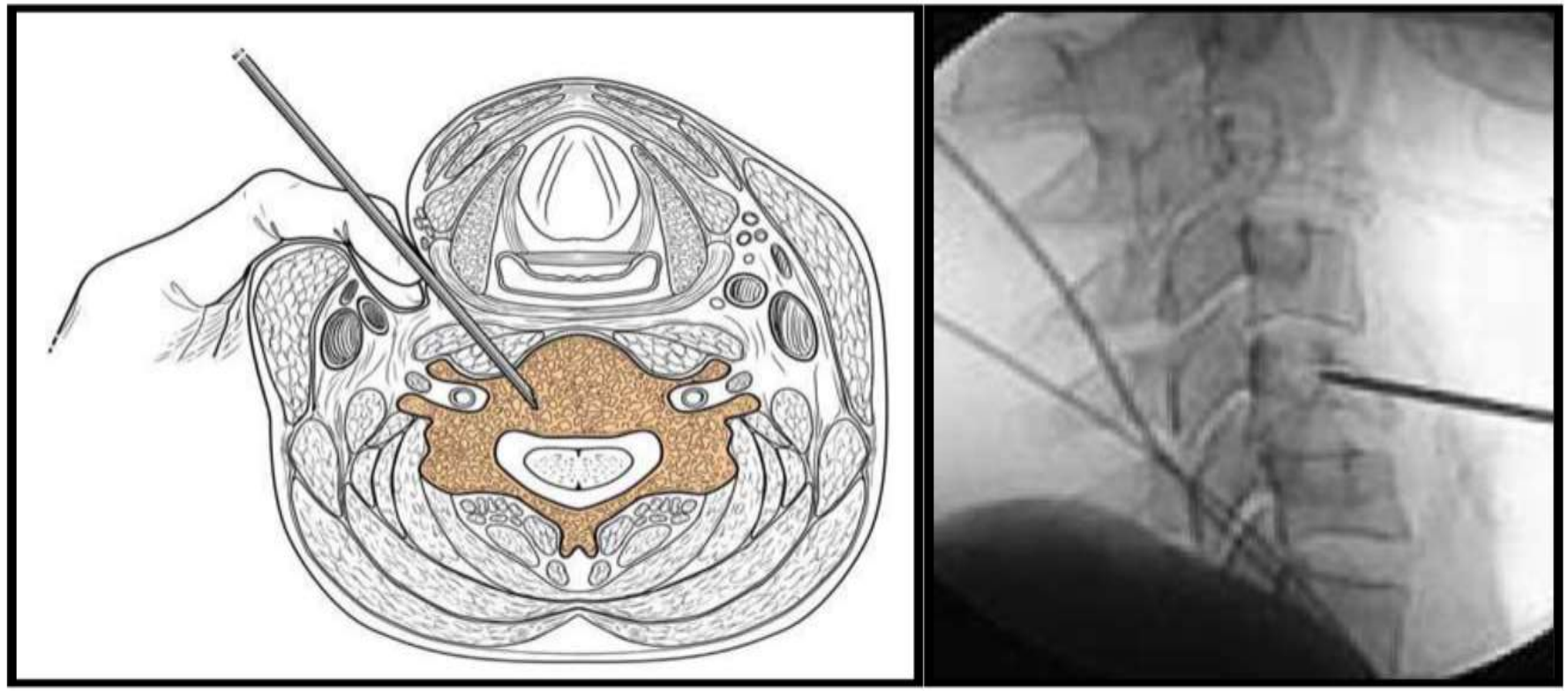
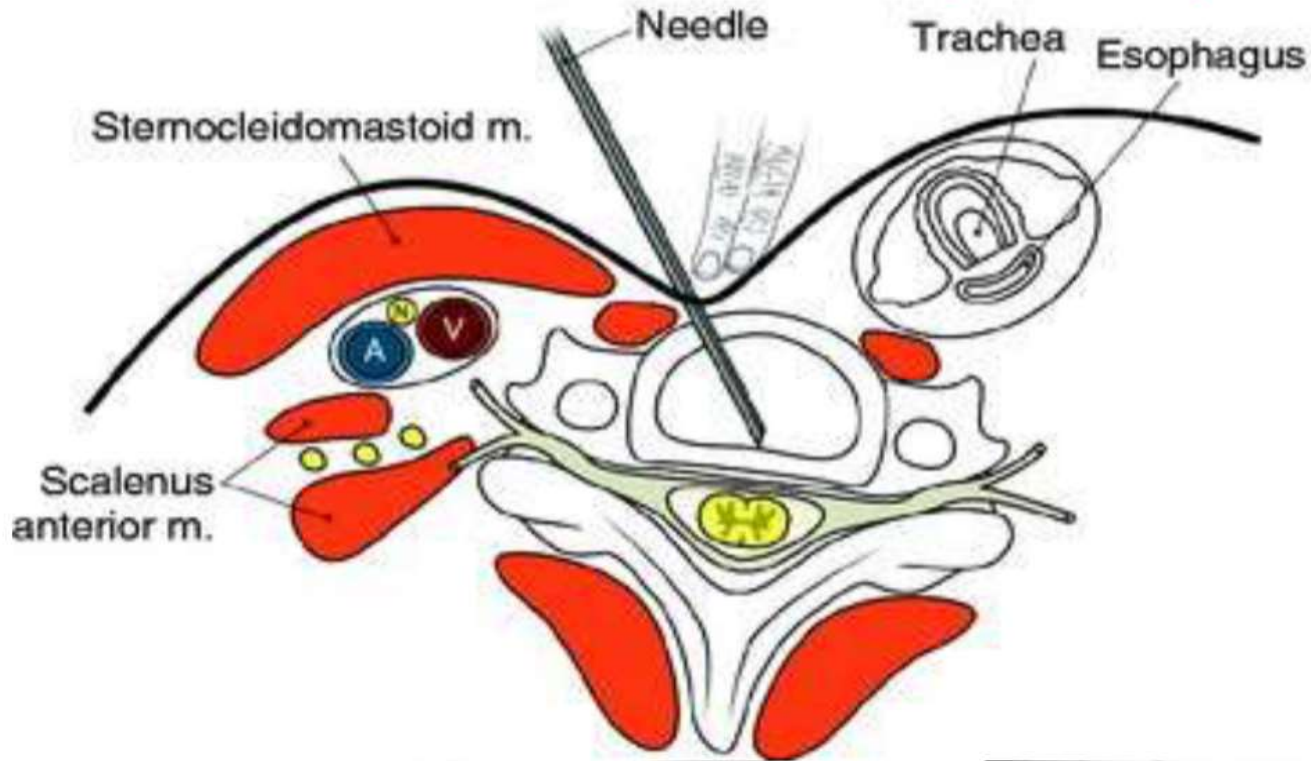
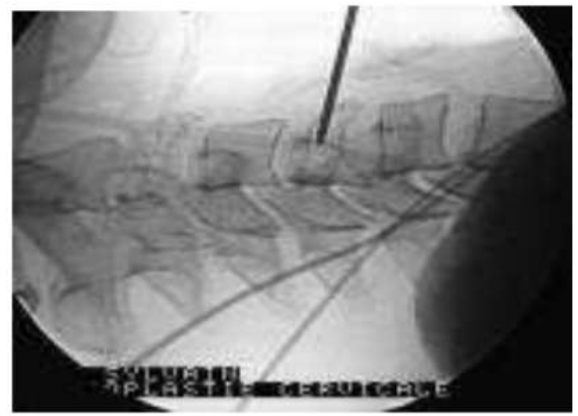
Anterior Cervical Approach



Manual displacement of the carotid–jugular complex
Guide needle insertion
Needle position can be confirmed with CT.

Cervical Vetebroplasty





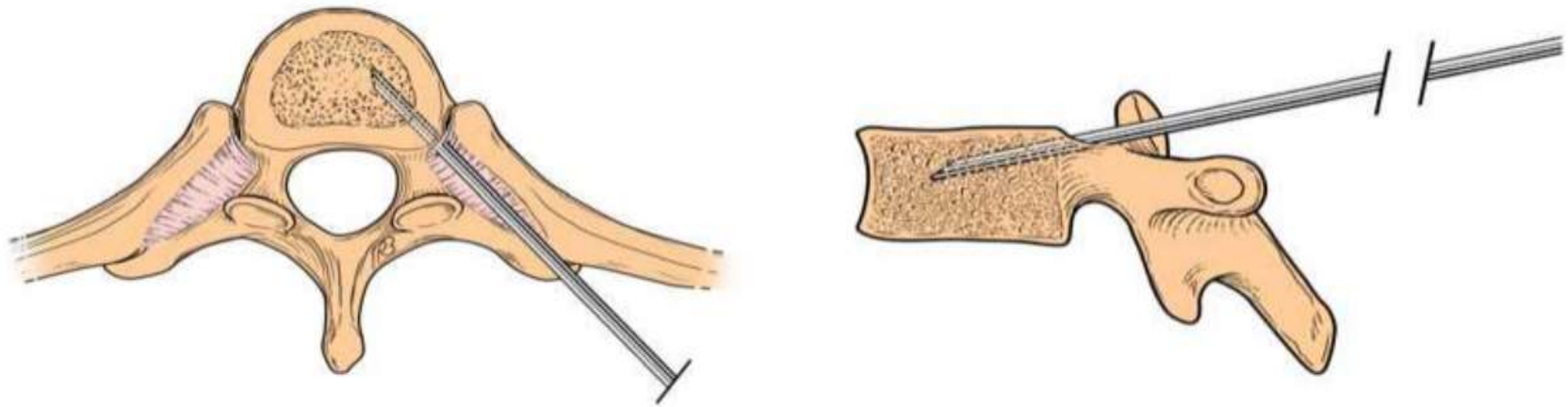
C3 VP for metastasis

The needle was inserted with finger compression of the visceral tissue (left). Bone cement was injected into the C3 vertebral body, and simultaneously an esophagogram was performed to check the esophageal injury (middle). Postoperative lateral view (right).

Thoraco-lumbar Vetebroplasty

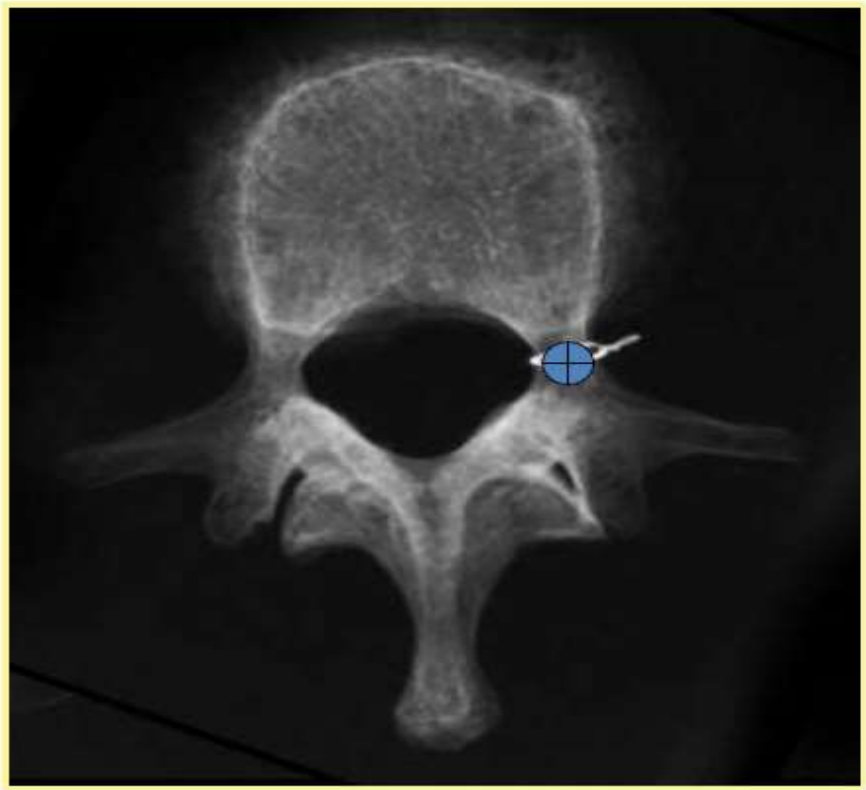
- Choose approach
  - Transpedicular
  - Parapedicular
  - Lateral-transpedicular
  - Lateral-antepedicular
- Needle insertion:
  - unilateral or
  - bilateral

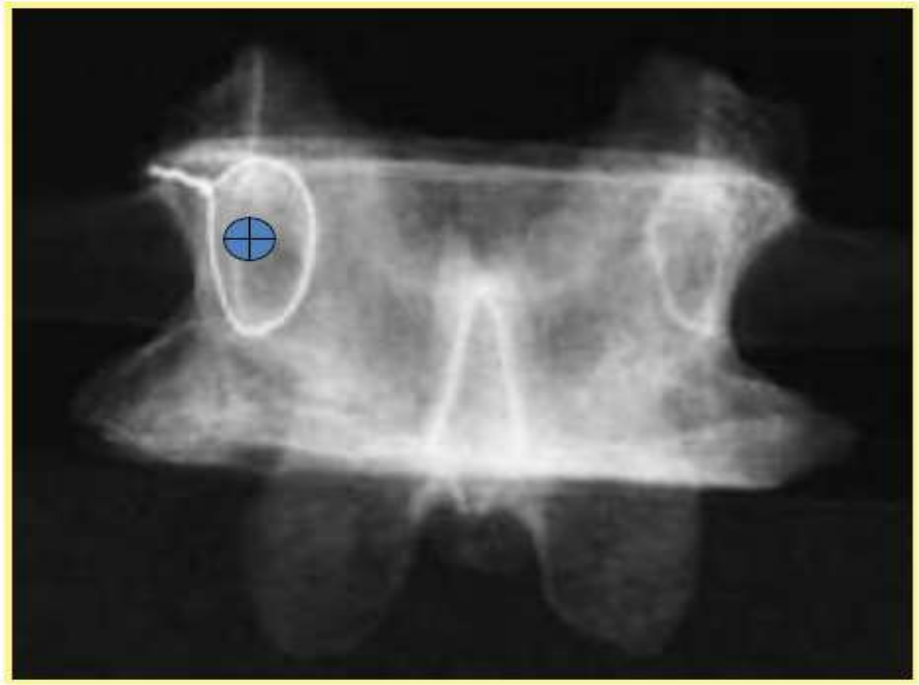
Parapedicular Approach (lateral to pedicle and above the transverse process)



This avoids the exiting nerve root (courses under the pedicle)
The needle entry site along the lateral aspect of the vertebra
Does not allow local pressure after needle removal,
the chance for bleeding higher than with the transpedicular approach

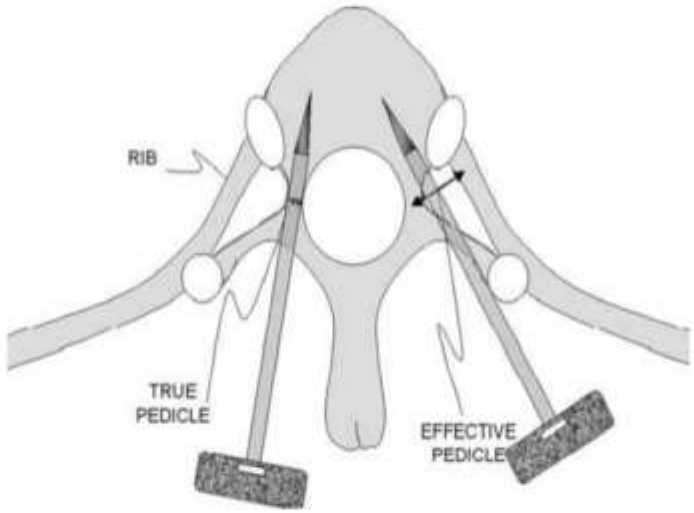
PEDICLE DEFINITION, L1 VERTEBRA



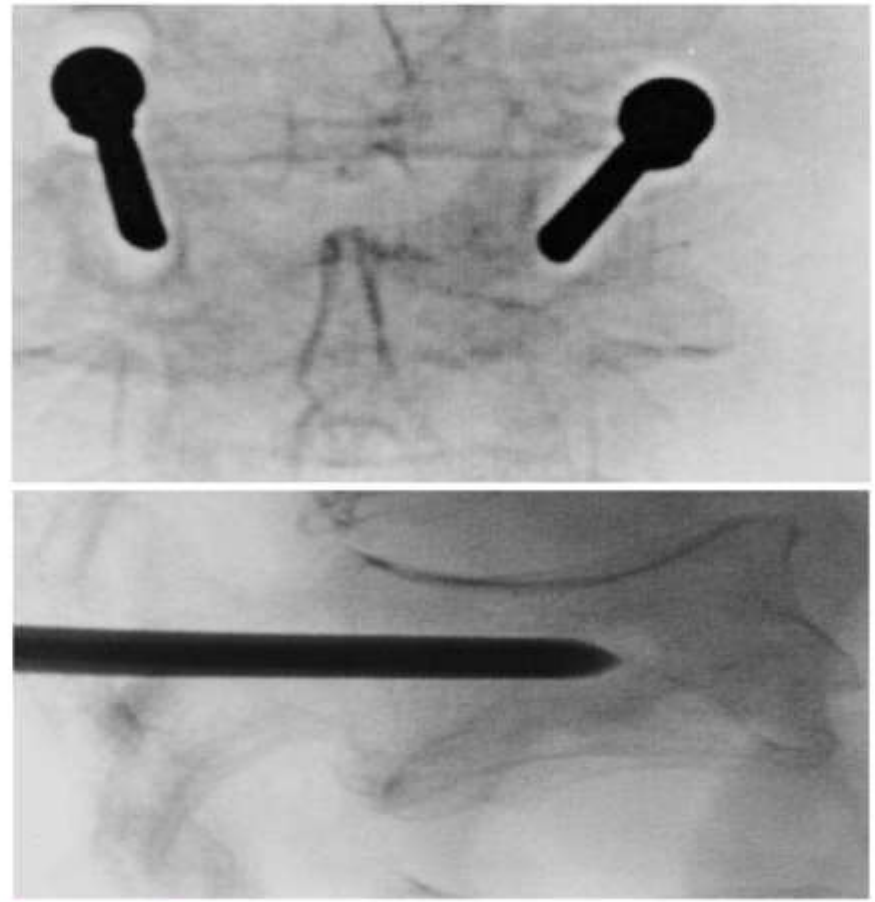


The A-P image of the pedicle corresponds to the waist of the pedicle, not the base

Lateral Extrapedicular Approach utilizes Effective Pedicle (the rib-pedicle complex)



The instrument must also be angulated more toward the midline to avoid lateral penetration of the vertebral body



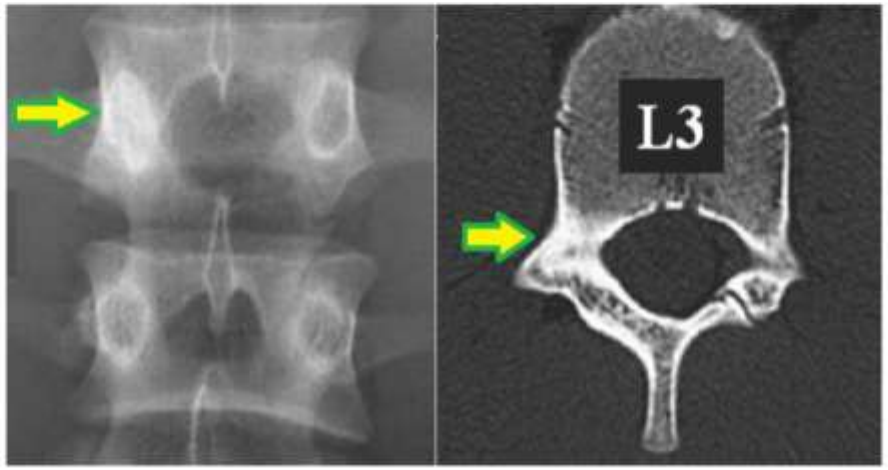
Bilateral Transpedicular Approach

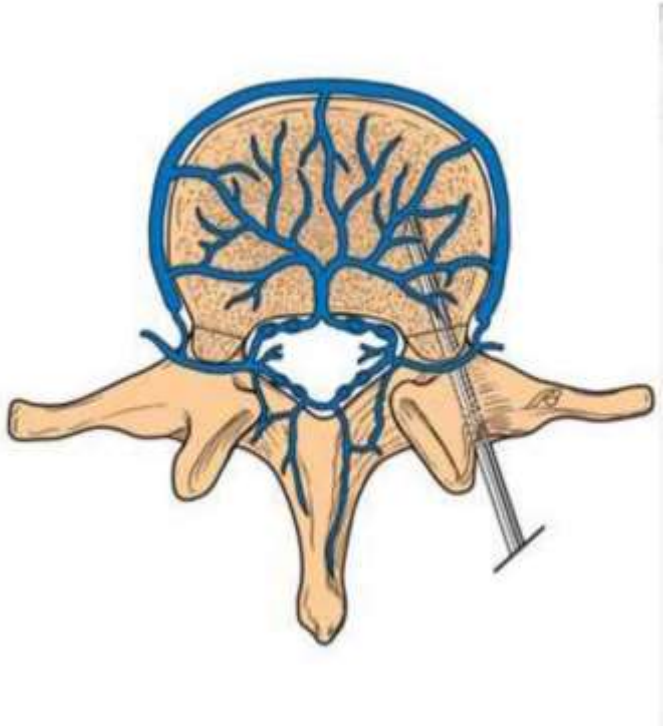
Transpedicular Approach

Sclerotic hard pedicles
difficult Jamshidi placement

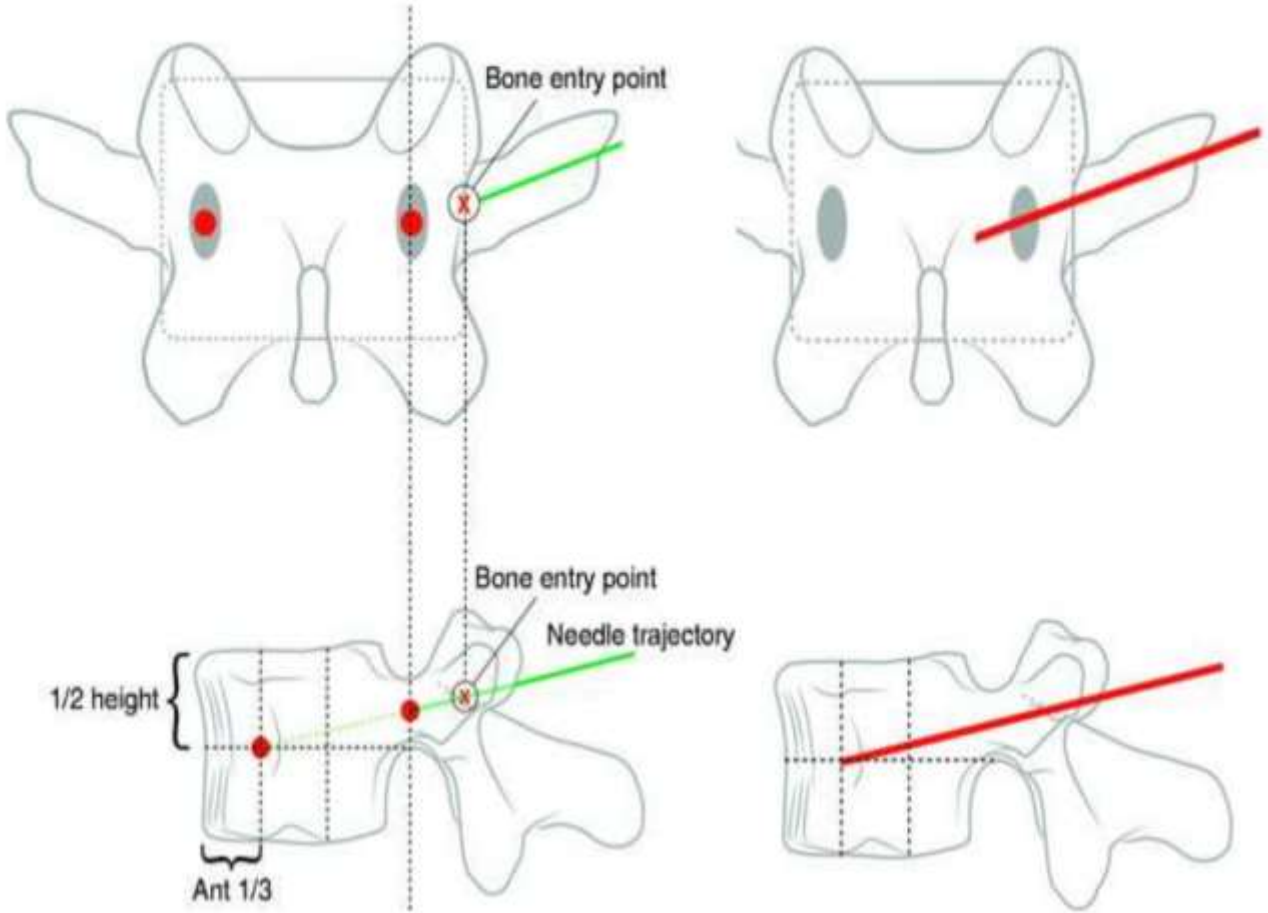
Can be frustrating

Rarely the technique needs to be abandoned and an open direct cannulation of the pedicle with a high-speed drill is required





Entry point & trajectory of needle insertion in transpedicular approach



Cannulation of small pedicles

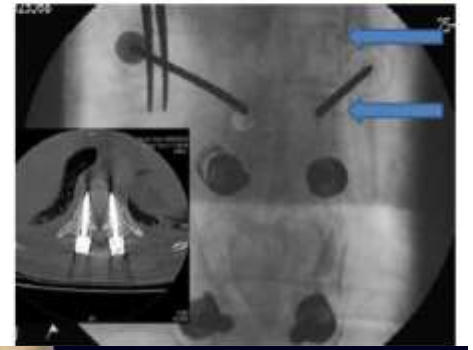
technically difficult

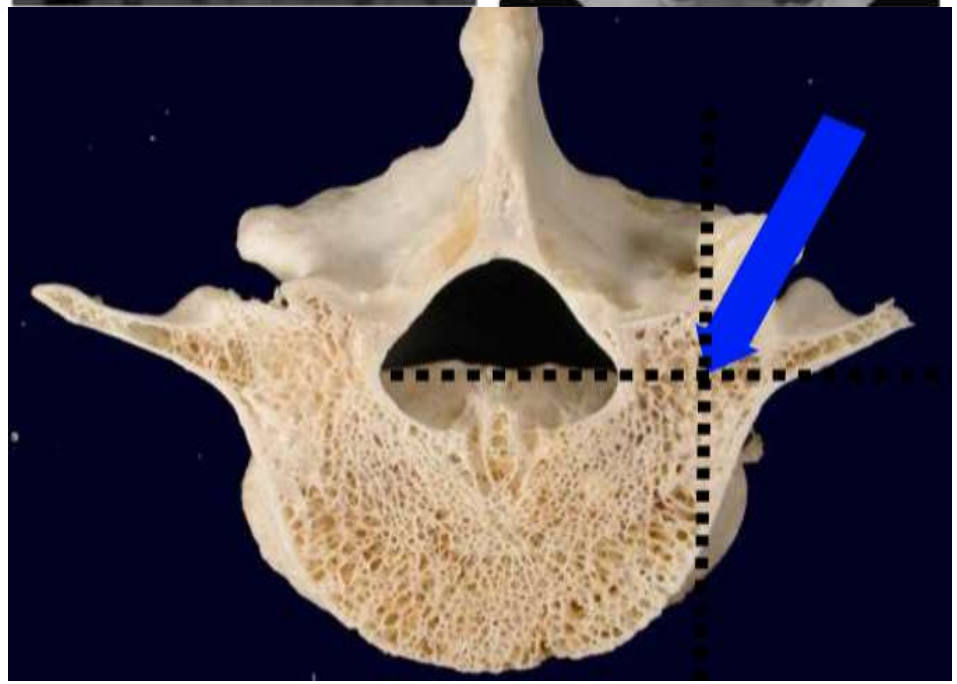
In the mid-upper thoracic spine

The change in pedicle angulations at the T1 to T4 levels.

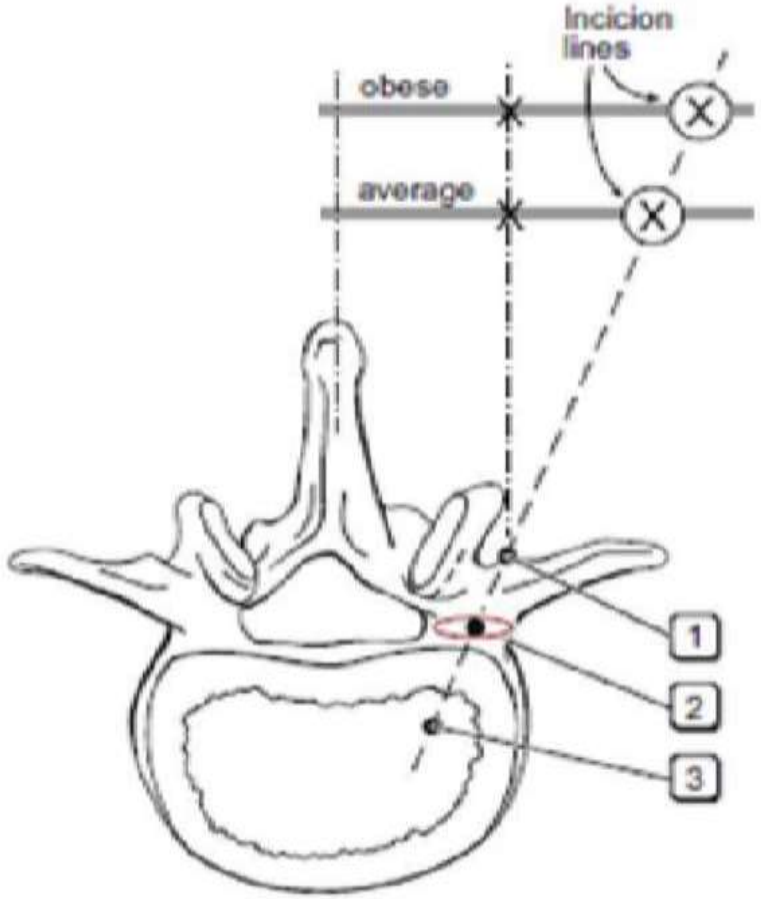
Pre-operative

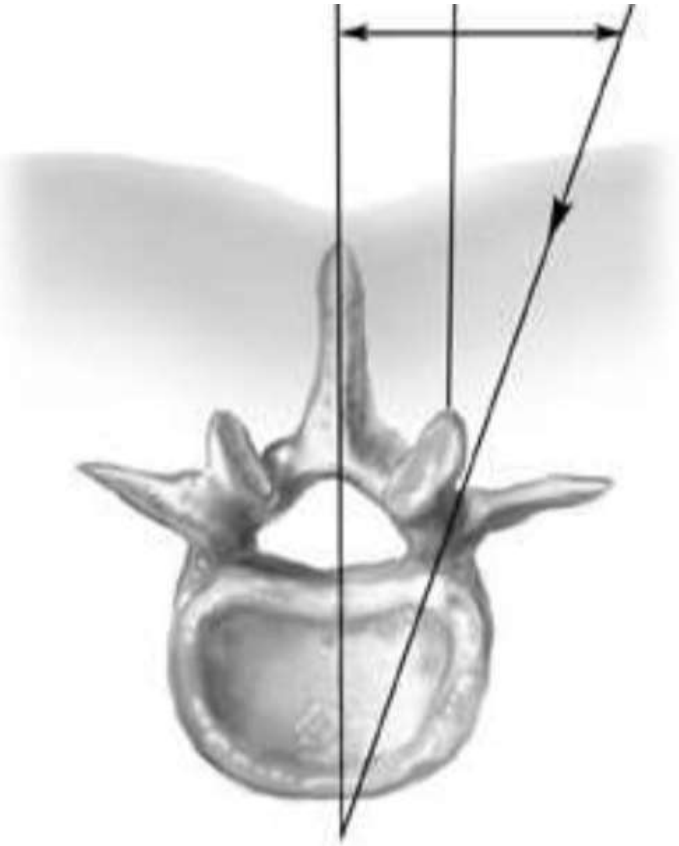
The pedicle must have a width of at least 3 to 4 mm.





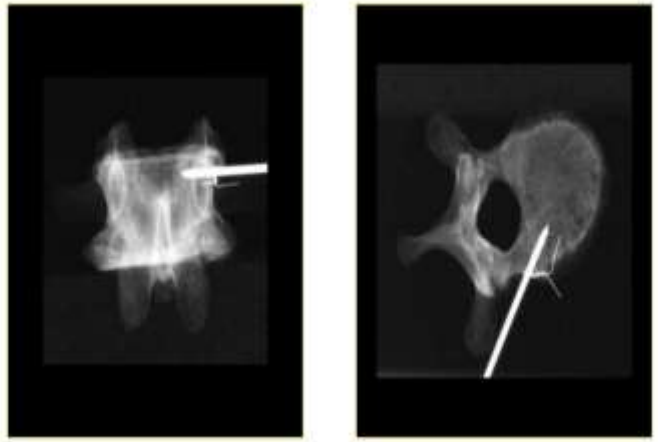
Paramidline incision overlying transverse process-facet junction

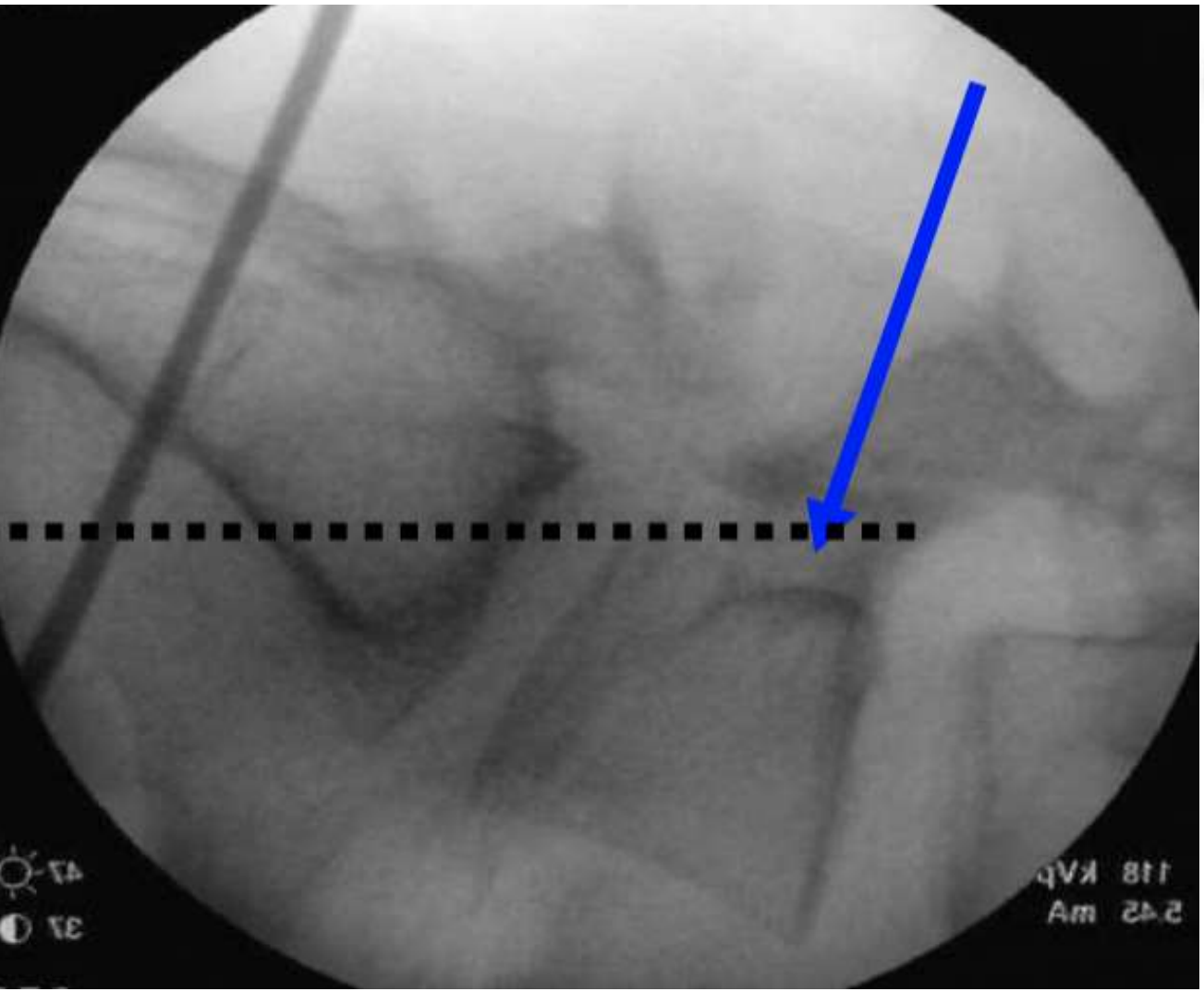




Entry Point

- **Transpedicular**: at 10 & 2 o'clock at the pedicular rim
- **Extrapedicular**: at 9 & 3 o'clock, 2 mm lateral to the pedicular ring





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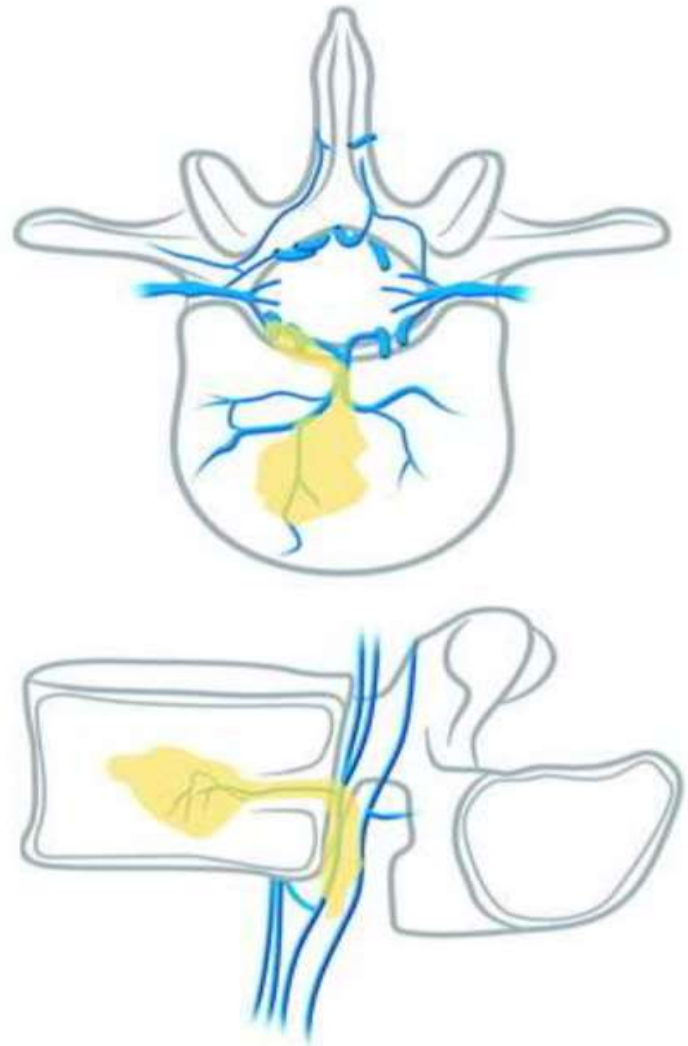
Compare the 2 views

Epidural leakage

- High, up to 50–70% in osteolytic metastasis or myeloma
- Mostly asymptomatic; however, few patients may undergo surgery because of radiculopathy.
- can occur through
  - fracture line,
  - cortical destruction,
  - needle track, or
  - epidural and paravertebral venous plexus



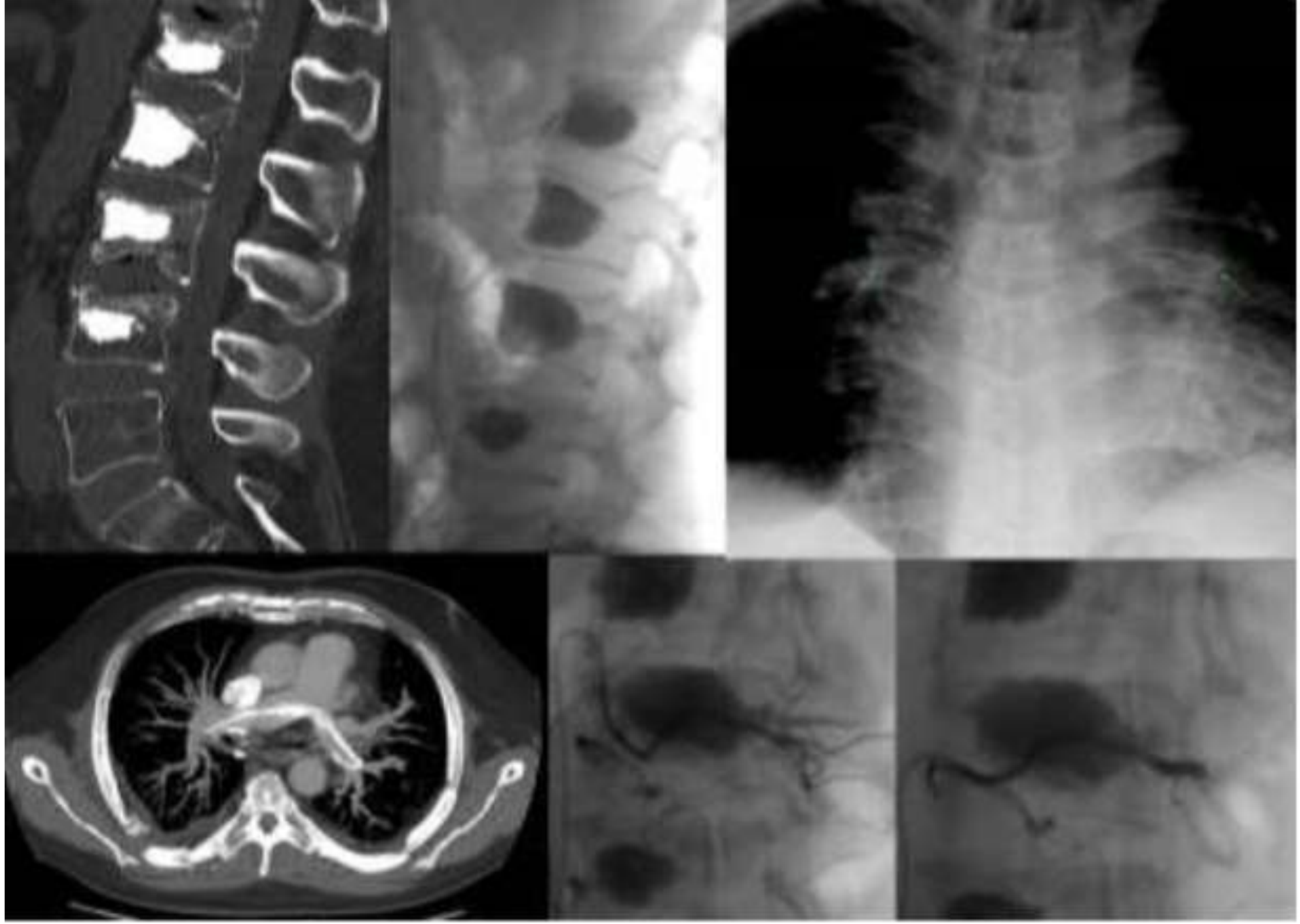
Pulmonary embolism

- Bone cement via the venous channel can enter the systemic circulation.
- Filtered in the pulmonary circulation system (3–4%)
- Most patients may be asymptomatic.
- If symptomatic, patients complain of – Tachypnea
- – Respiratory difficulty.
- So, tachycardia is monitored.
- Most patients can be treated with anticoagulant therapy and respond favorably.

Termination of injection ??

- Cement in posterior 1/4 of vertebral body on lateral projection

- Cement extending outside vertebra

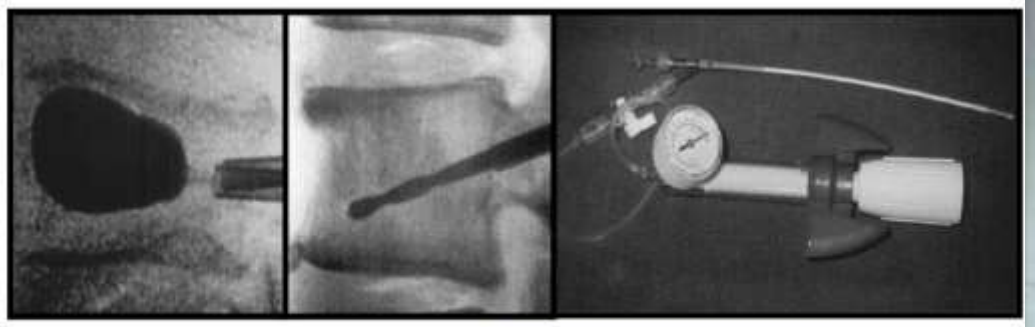


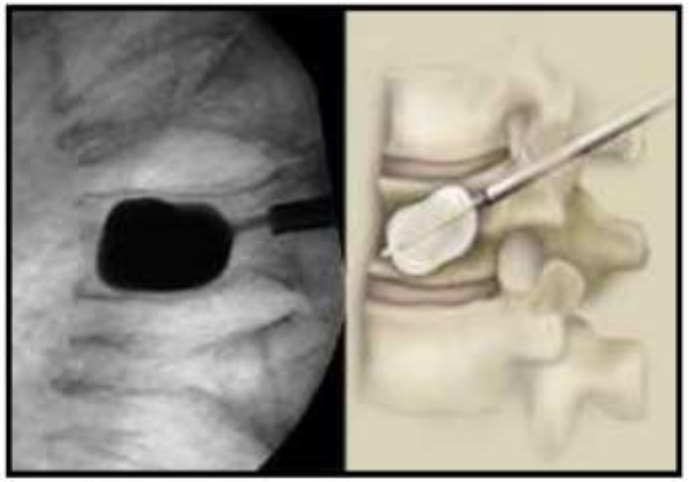
KYPHOPLASTY

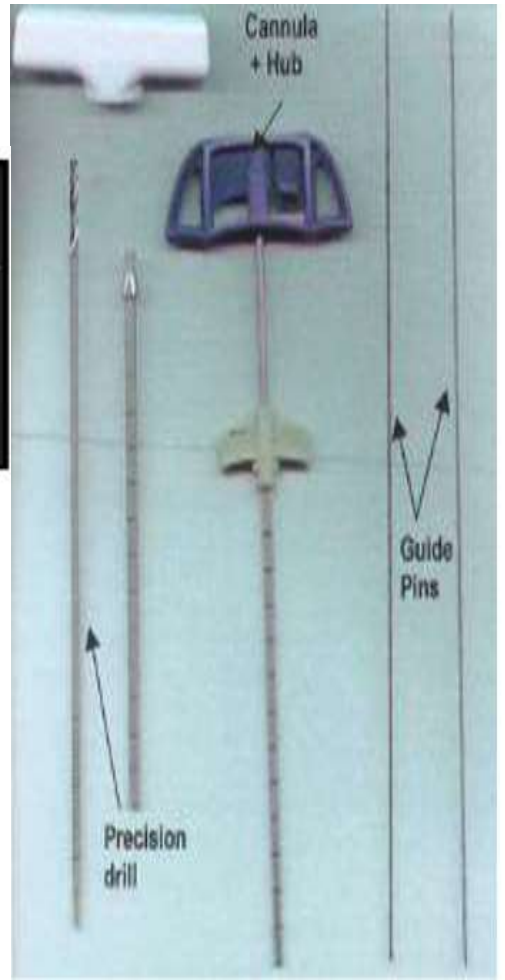
- Percutaneous introduction of balloon into the vertebral body through a cannula

– Cannula
– bipedicular approach

– Balloon inflation
– reduce Fx
– balloon deflation
– PMMA







Difficult Reductions:

Balloon does not inflate adequately

Using the Bone Curette

- in older fractures
- a specially designed curette retracted and advanced to score the bone in the region.
- The curette is removed, and balloon inflation is again attempted.

	Advantages	Disadvantages
Vertebroplasty	Lower cost Shorter procedure Decreases pain Increases VB strength Increases VB stability Infrequent clinical sequelae due to cement extravasation May be done through unipedicular approach Often done under local anesthesia	Increased risk of cement extravasation Cannot correct lost VB height Cannot correct sagittal imbalance
Kyphoplasty	Lower extravasation rate than vertebroplasty Lower complication rate than vertebroplasty? Equivalent pain relief Can restore lost vertebral body height Can correct sagittal imbalance Can use more viscous cement Increases vertebral body strength Increases vertebral body stability	Increased cost Increased procedural time Requires general anesthesia Usually requires overnight hospital stay Larger device Requires bipedicular approach

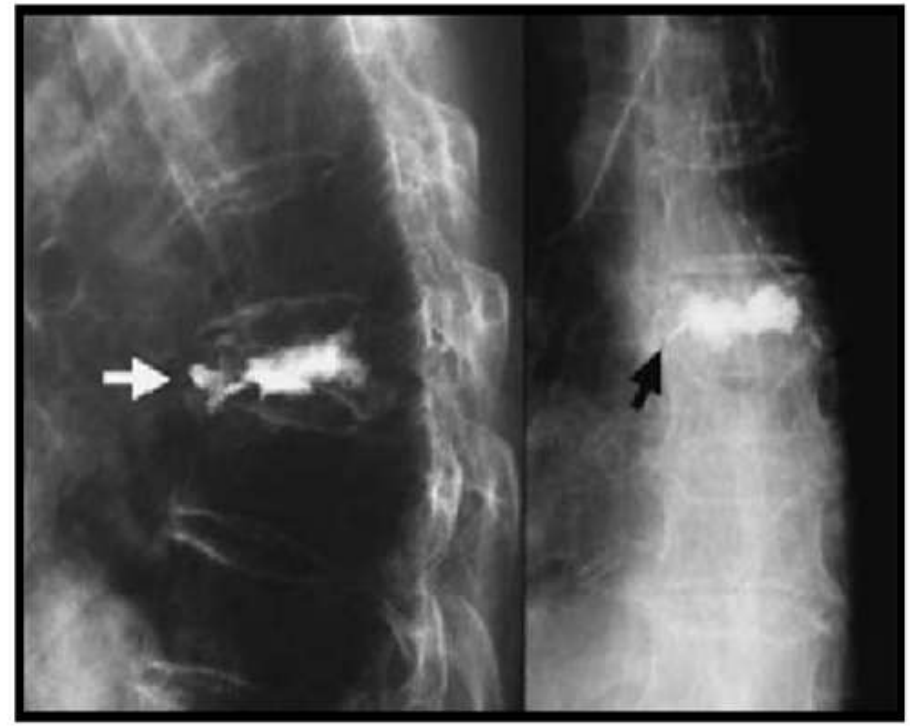
Kyphoplasty – "The Good"

- A modification of the vertebroplasty procedure to:
  - restore vertebral body height
  - Low risk of clinically evident cement extravasation.

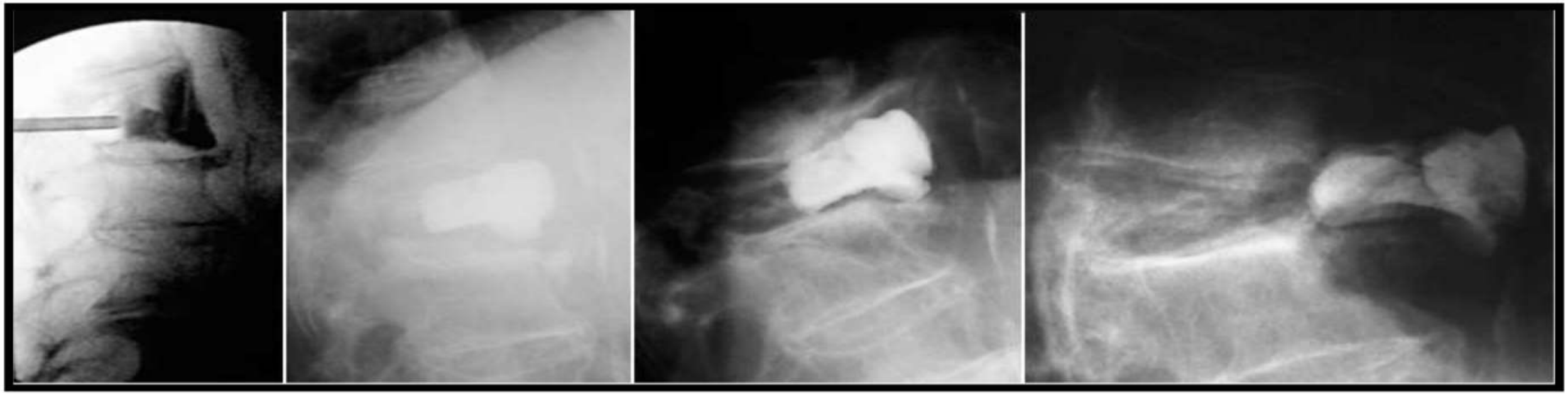
Kyphoplasty – "The Bad"

There is still a risk of extravasation

Close analysis of literature indicates height restorations as an insignificant result.!!!

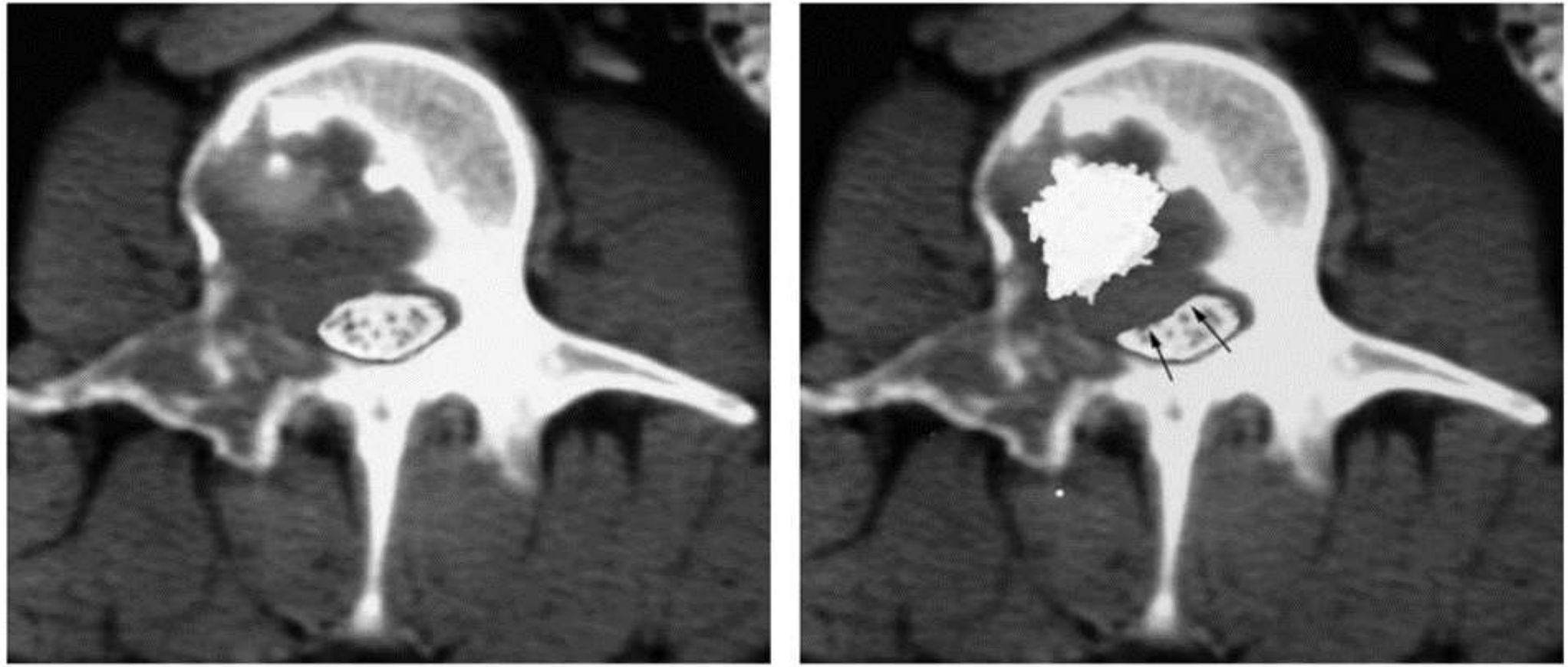


Dislocation of the cement

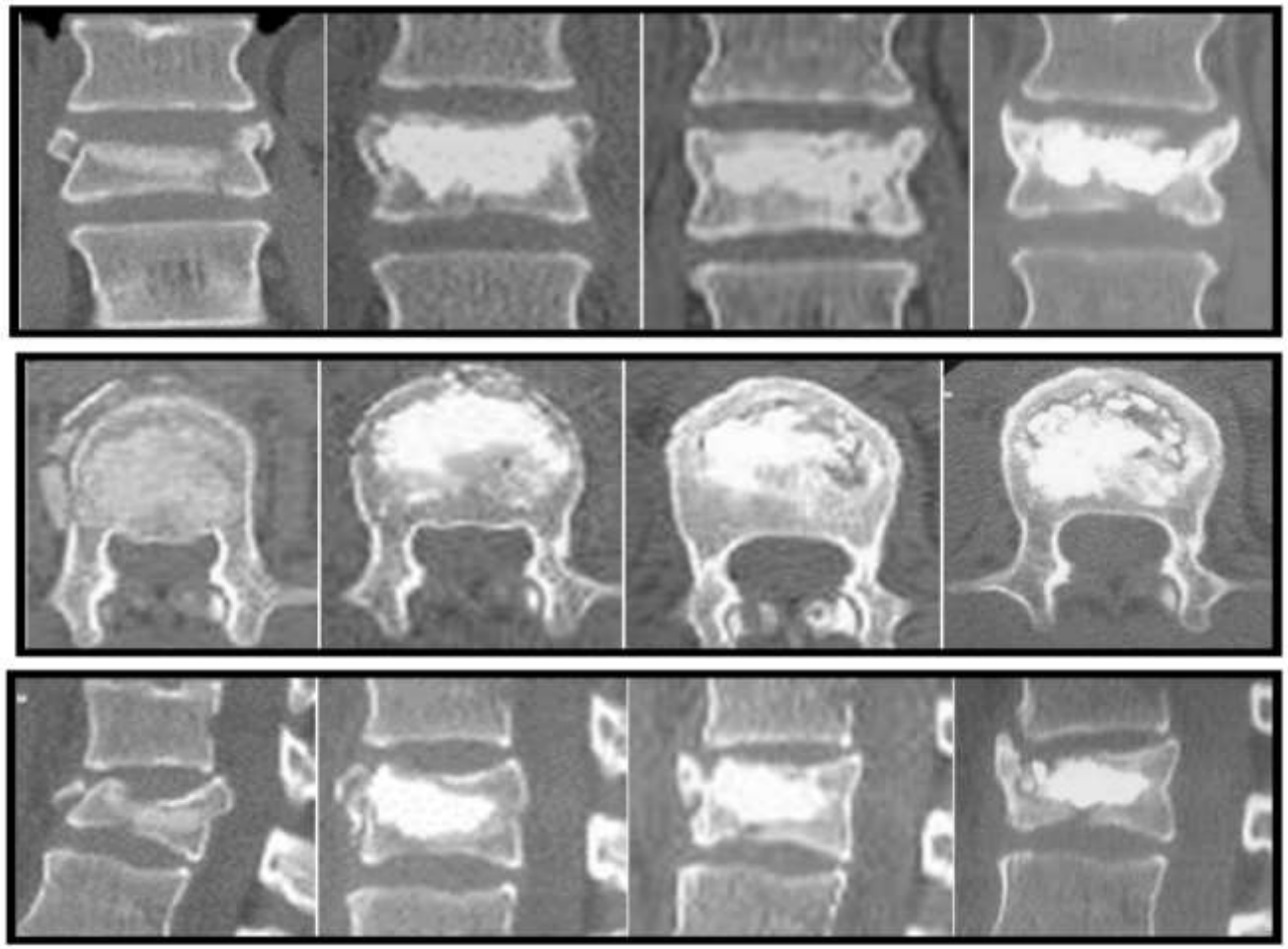


Intraop. 3 weeks 9 months 2 years

Vertebroplasty of T12 with osteolysis and unknown primary tumor with ventral dislocation of the cement beginning after 3 weeks



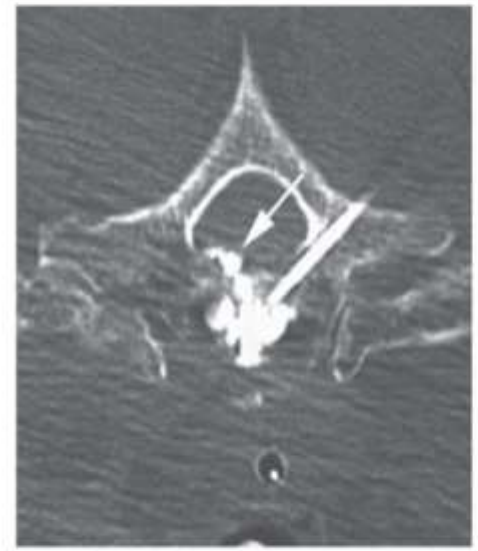
Tumour migration with cement injection



Pre Post 1y 3y

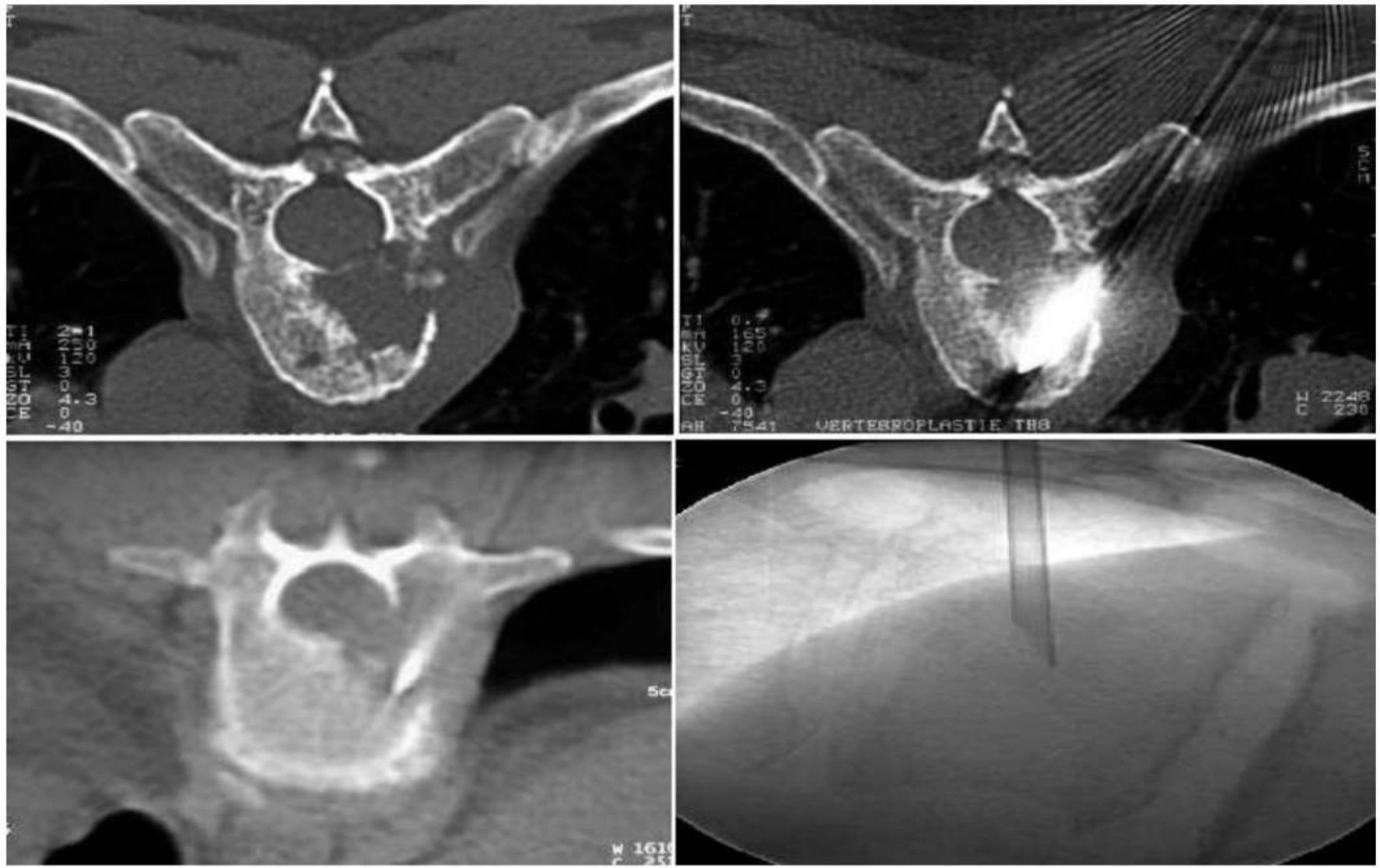
C7 & T1 Visualization

fluoroscopically impossible shoulders



very small epidural leak of cement (CT guided PV)

PEDICULOPLASTY



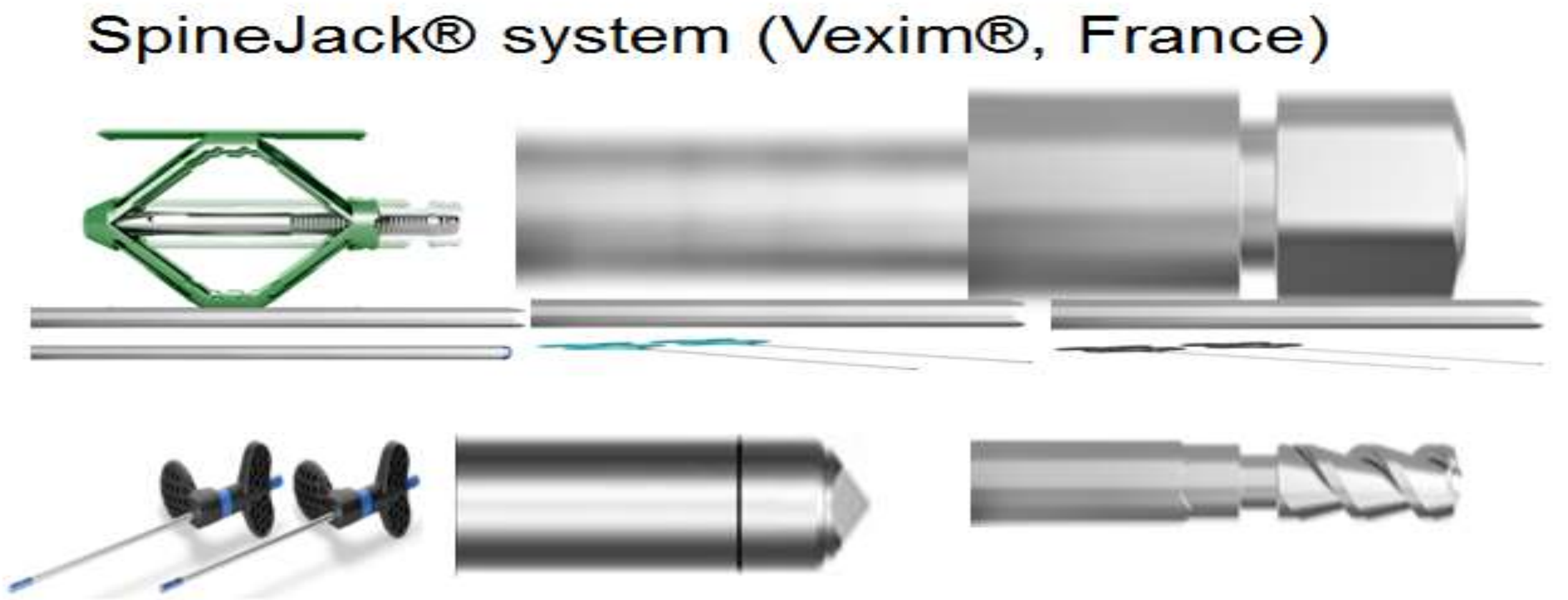
Two major categories of treatment are included under the voice “vertebral cementoplasty”:

- (1) simple VP: cement injection is performed through
- a needle positioned within the vertebral body
  (2) ATs VT: a device of different sizes and shapes is first inserted into the metamer in order to restore the vertebral height, reach a better cement distribution and reduce the kyphotic deformity of the spine, and then, cement is injected.

Stryker SpineJack System

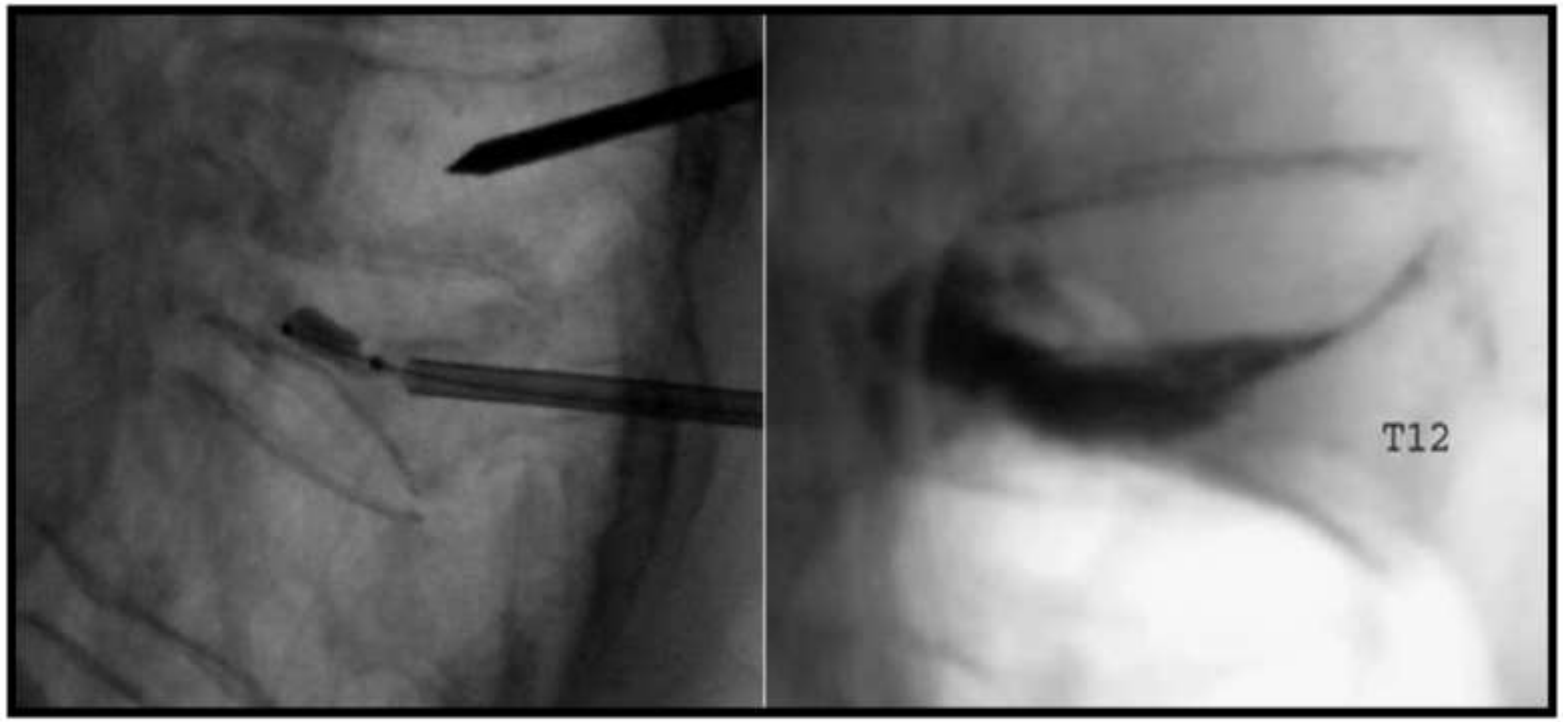
- Osteoporotic compression fractures have a high rate of continued collapse with subsequent loss of height and the development of angulation and deformity after these procedures, which increases the risk for adjacent level fractures.
- The SpineJack system (Stryker Corp, Kalamazoo, MI) consists of bilateral expandable titanium implants supplemented with bone cement. This system provides more symmetric and balanced lateral and anterior support, and requires lower volumes of bone cement compared to balloon kyphoplasty. Using this system, clinicians can now achieve better pain control, restore vertebral body height, restore spinal alignment, and reduce the risk of adjacent level fractures. [20]
- The SpineJack system offers three implant kit sizes: 4.2 mm, 5.0 mm, and 5.8 mm. Each kit contains the appropriate instrumentation for the procedure, first for preparation, then for expansion and fracture reduction. The range of sizes accommodates various anatomies and fracture types. The implant expands in a craniocaudal direction and combat compression forces up to 1000N of expansion force.
- A pedicle width of 0.8 mm larger than the desired implant size is recommended for safe placement. (e.g. 4.2 mm implant +0.8mm = 5mm minimum pedicle width).

Like a vertebroplasty, the Stryker SpineJack system utilizes a bipedicular approach to advance the access cannula to the posterior one third of the vertebral body. Then a guidewire is advanced to the midpoint of the vertebral body, then removal of the access cannula. Then following the path of the guidewire, the reamer is advanced until it is entirely within the vertebral body. Then the template is inserted to clean the implant site and verify the length of the implant. Then the spine jacks are expanded to reduce the fracture and restore anatomy. Then PMMA is advanced and good closure is obtained with adequate hemostasis



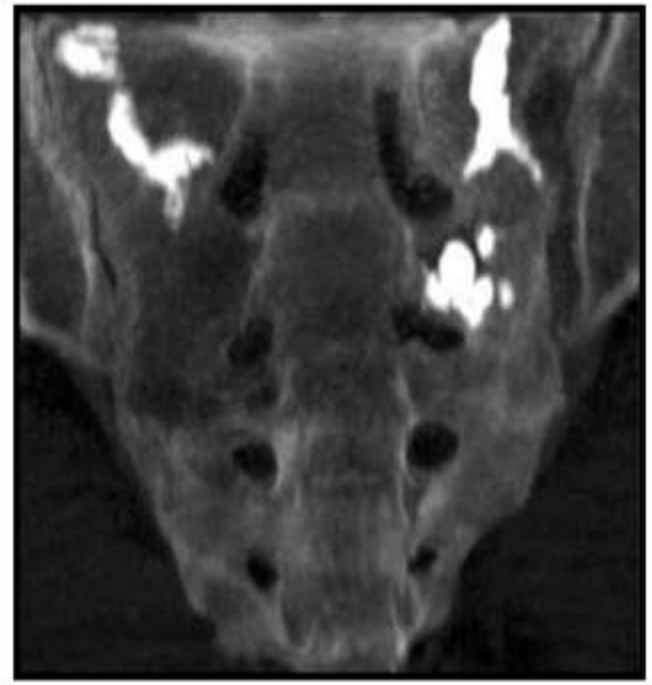
Advantages

- The advantages of the AT are increased vertebral height capacity compared with VP, a low-pressure cement injection, use of high-density cement and low rate of vascular and disc leakage.
- Disadvantages of the AT *vs* VP are related to higher invasivity, higher costs and need for general anaesthesia in several cases;
- moreover, this procedure cannot be performed or at least there are no clear indications, in certain anatomical regions such as the sacrum, cervical–upper thoracic levels and in case of multilevel spine treatments. In these patients, no significant differences between VP and AT in terms of pain relief have been reported.



The amount of cement into an extremely collapsed vertebra much smaller than is usually used for less collapsed vertebrae

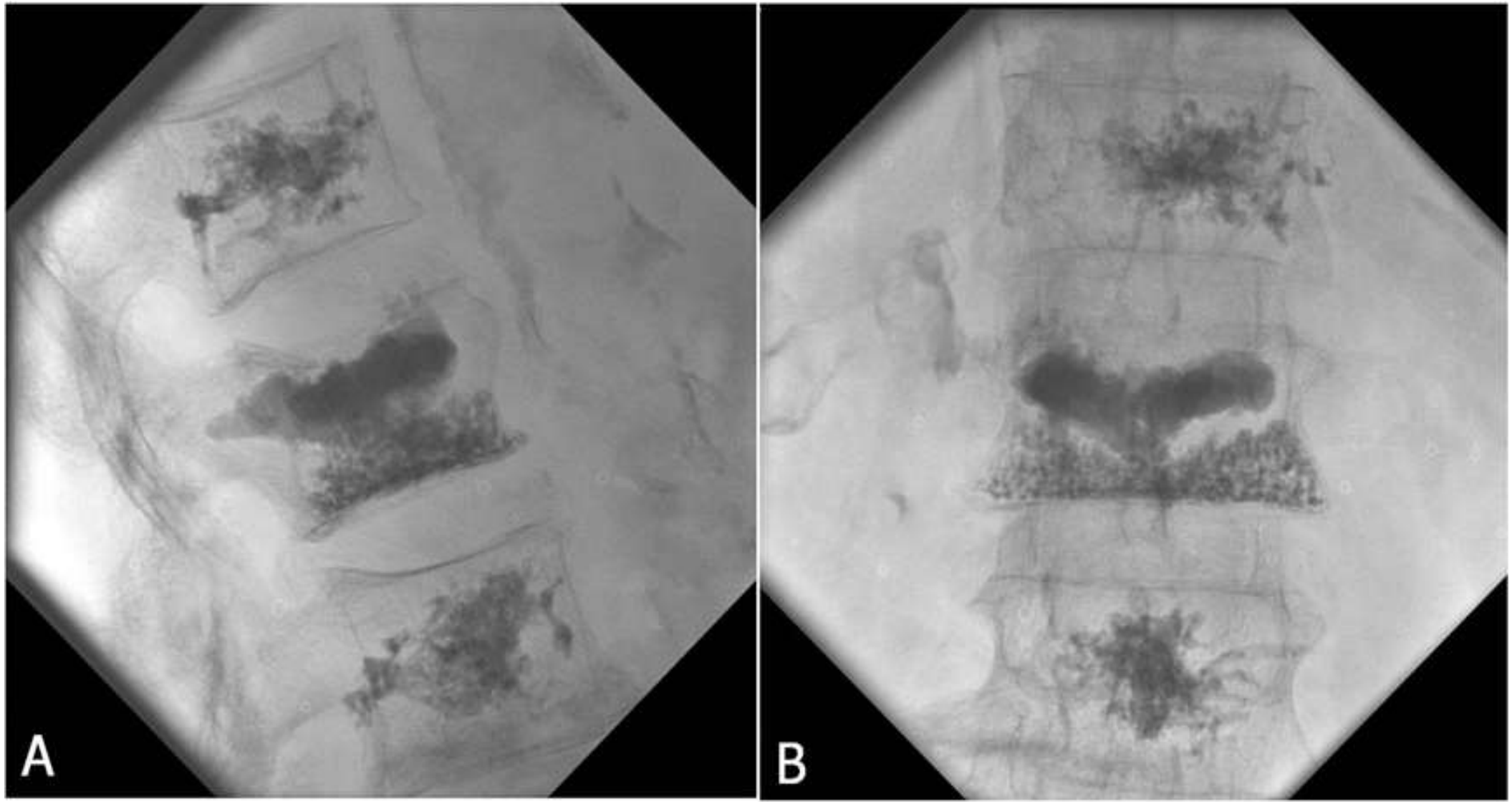
Sacroplasty



Sacral insufficiency fractures
Best performed under CT guidance.

approximately 20% and 24% of patients undergoing VP after 1 year will present a new VCF

- This complication often occurs on the adjacent vertebra in approximately half of the cases, especially in the inferior endplate immediately superior to the treated level or the superior endplate of the vertebrae immediately inferior to the treated vertebra.
- For this reason, some authors proposed prophylactic VP by injecting bone cement into the adjacent part of the adjacent vertebral bodies, including the caudal part of the superior adjacent vertebral body and the cephalic part of the inferior adjacent vertebral body; this procedure should prevent the propagation of vertebral fractures by significantly lowering the incidence of adjacent fractures and reducing the necessity of multiple repeated VP procedures (Figure 1).[22]


A
B

Spine malignancies

- Prolongation of life expectancy in patients with oncological disease has led to an increase in vertebral metastasis detection, especially in case of
- breast, lung,
- renal,
- Prostate
- and hematopoietic cancers;
- approximately 70% of patients with secondary lesions have at least one vertebral metastasis.[26]
- At least 20% of patients affected by neoplastic disease present spinal metastasis symptoms as initial presentation.

Management of spinal tumours

- Includes different therapy options such as medical therapy (corticosteroids and chemotherapy), radiotherapy, surgical treatment, VP and radiofrequency (RF) ablation;
- depends on histology, tumor size, location, age of patient, and clinical data.
- Surgery is recommended in case of spinal cord compression (laminectomy, corpectomy and *en bloc* resection), spinal instability and severe pain.
- Despite chemotherapy and/or radiotherapy present a good outcome in terms of mass reduction/resolution with pain relief effect up to 71% of patients, their action requires long time while the immediate risk of vertebral fracture remains.'

Management of spinal tumors

- condition consists of: loss of spinal integrity associated with pain related to movement, symptomatic deformity and progressive neurological deficit under physiological load.
- The risk of sudden collapse of a vertebra depends on the level involved:
- in the thoracic district, it is elevated if the tumor involves 60% of the vertebral body or in case of 30% body destruction associated with costovertebral joint involvement;
- in the lumbar district, it is elevated if the lesion involves 35–40% of the vertebral body or in case there is only 20–25% of body destruction but associated with posterior arch and/or pedicle involvement.

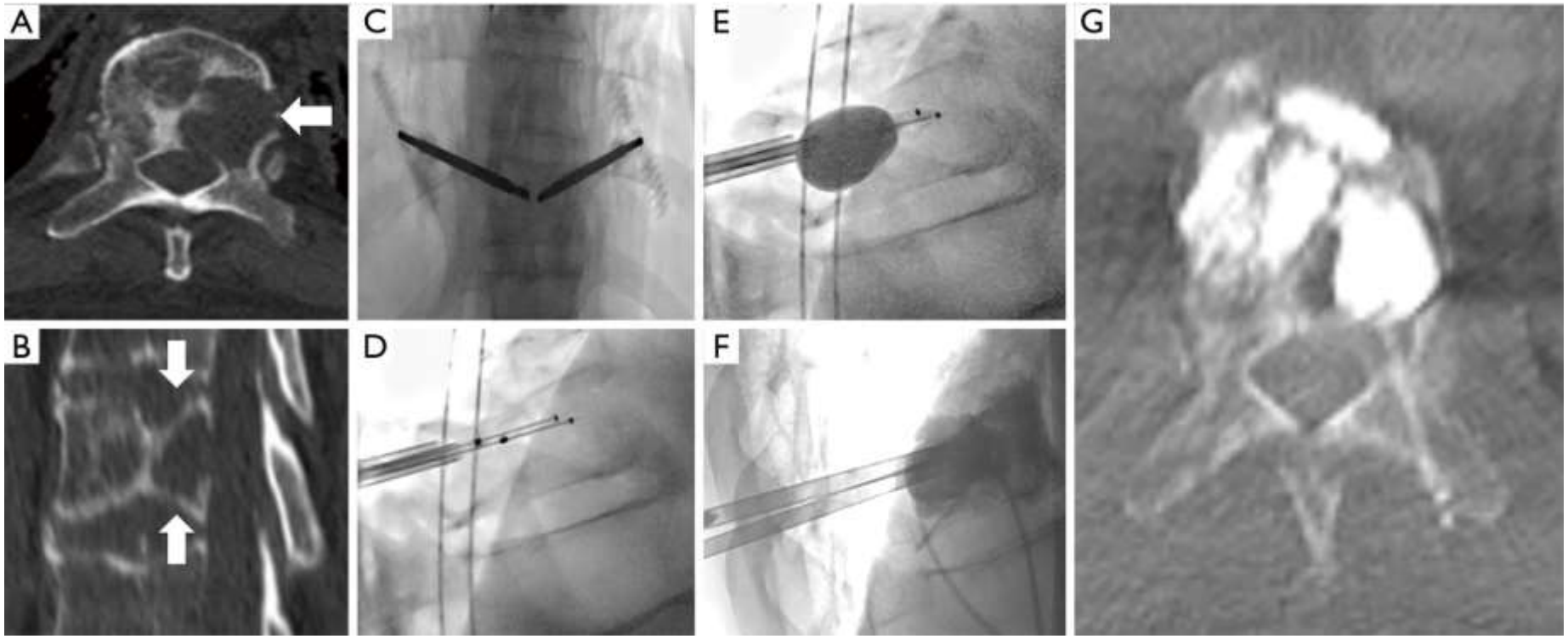
Management of spinal tumors

- VP has been validated as an excellent procedure in the stable and possible unstable groups,[33] producing a rapid pain relief effect in 84–92% of patients and asymptomatic paravertebral cement leakage accounting for only 4–9.2% of patients.

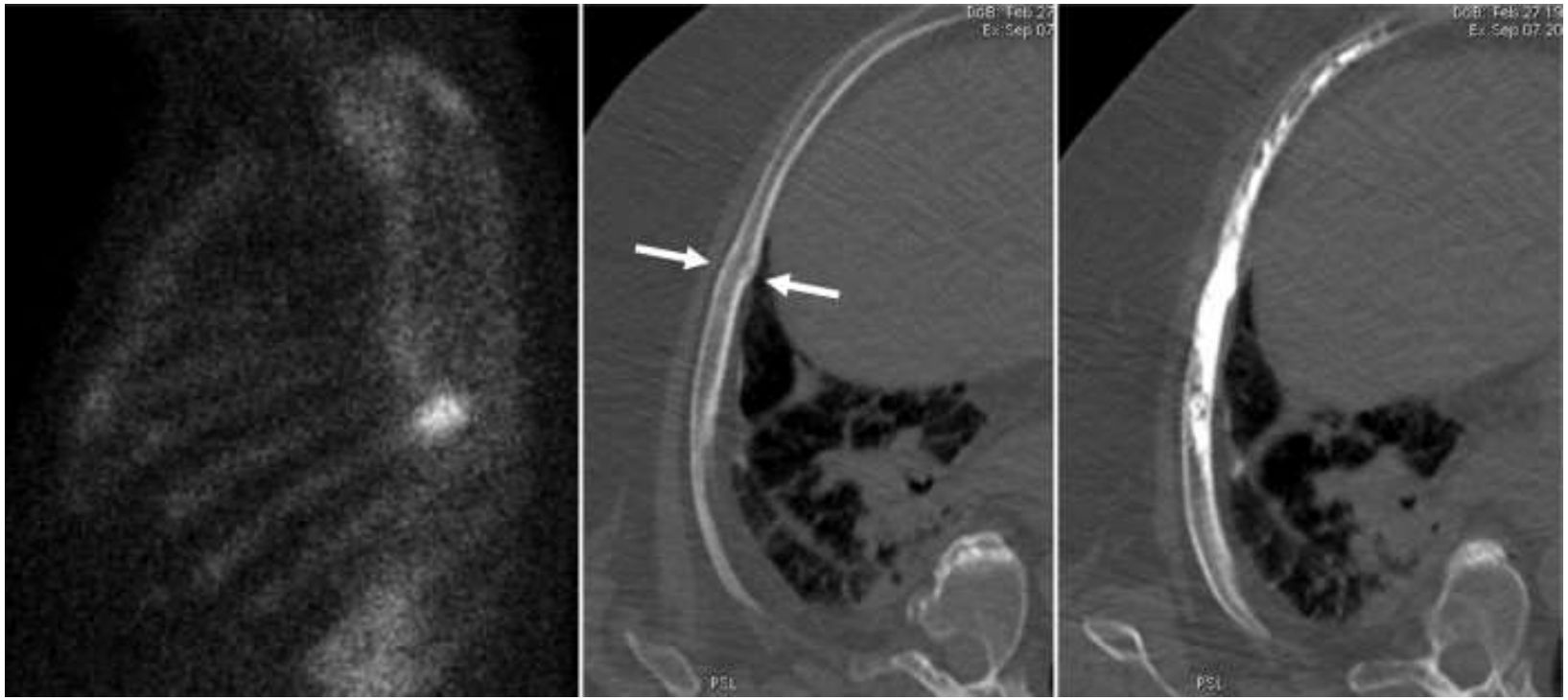
In this context, VP has two aims:

- (a) mechanical stabilization of the vertebra, in order to prevent deformation of the vertebral body and complications related to neural compression;
- (b) pain resolution related to the disease (Figure 2).

A 57-year-old woman with metastatic melanoma to the T10 vertebral body resulting in pathologic fracture (arrows; A,B) with significant positional and weight-bearing pain that limited mobility and activities of daily living. Given the pain presentation and the location of the lytic lesions along the posterior aspect of the vertebral body, the treatment access to the vertebral body was bipedicular (C), with radiofrequency ablation for pain palliation and local tumor control (D), and balloon kyphoplasty [(E) demonstrates balloon & (F) demonstrates injection of PMMA cement]. Post-procedure CT demonstrates PMMA (polymethyl methacrylate) throughout the vertebral body (G) without clinically significant leakage.



Analgesic cementoplasty of a costal metastasis of a prostatic adenocarcinoma in flat bone.



Management of spinal tumours

- Neoplastic vertebral erosion, epidural and/or posterior wall involvement are not contraindications to VP anymore.
- Performing VP using high-viscosity and dense cement, with long working time and slow injection rate under continuous fluoroscopy control leads to a severe reduction of venous or spinal canal leakages
- Another recent VP indication is the possibility to perform VP in case of vertebral lesions associated with extra vertebral soft-tissue mass.
- Previous literature considered extra vertebral tumor mass as a contraindication, especially in case of severe epidural extension.
- Today, severe compressive myelopathy remains an indication for conventional open surgery for spinal cord decompression, but VP can be performed even in case of epidural involvement with palliative target.

Management of spinal tumors

- High- viscosity cement with low risk of emboligenous dissemination.
- if the pedicle/posterior arch is involved by the tumor, 25% body erosion is enough to cause vertebral instability.
- To prevent fractures and to stabilize the spinal segment, a double-fluoro-CT-guided VP can be performed using small-gauge needles (13–15 G) and multiple PMMA mini-injections in order to restore every part of the posterior arch, sparing the spinal canal.

Neoplastic involvement of the sacrum

- Apart from the traditional transpedicular approach, new access routes to reach the vertebral body have been adopted by several authors, like the parapedicular or transdiscal access;
- the main advantage of performing procedures guided by both fluoroscopy and CT is the possibility to choose the best route to reach the target, as no skeletal markers (*i.e.* pedicles) are needed.
- curved steerable needles are applied also to target cement injections into regions technically challenging to access with straight needles, like sacrum and extra vertebral locations as posterior acetabulum.

Neoplastic involvement of the sacrum

- can be part of secondary diseases, being responsible for severe local pain, preventing the patient to sit or stand-up position.
- Metastases are frequently observed in the sacrum because of the improved survival rate of many neoplasms characterized by lytic metastases;
- furthermore external radiation, oriented directly to the sacrum or scattered from pelvic radiations, and osteoporosis, paraneoplastic or related to chemotherapy, are responsible of sacral fractures.[51]
- sacroplasty using intra tumoral injection of cement revealed a powerful tool in pain relief, even in case of very small sacral lesions Figure 5.
- While cementoplasty can provide substantial palliative benefit, the procedure is less effective in locations subjected to torque stresses or when tumor invades a joint or tendon insertion

Cementoplasty

- Pelvic cementoplasty is used for pain management and bone reinforcement in certain cases of pelvic bone fractures and metastasis.
- A well-planned approach will be determinant for optimizing bone filling with acrylic surgical cement, while reducing the risk of extra osseous leakage.
- Treatment of extensive lesions may require the insertion of several needles to optimize bone filling.
- After needle positioning, a pasty cement is injected under real-time imaging control in order to stop the injection when a satisfactory filling is obtained or a leakage is detected.
- Extraosseous cement leakage in the vicinity of neural structures (typically, sacral canal and foramina, and posterior aspect of the acetabulum) and into the hip joint should be avoided.
- Neural pain due to cement leakage next to a nerve can be treated with cortisone infiltrations around the affected nerve.
- Symptomatic leakage to the hip joint may uncommonly require surgical removal of the cement.

The risk of performing Sacroplasty is related to Foraminal leakage especially injecting standard PMMA,

- all lesions should be evaluated carefully with MRI and CT before the procedure. During sacroplasty procedures, a combined fluoro- and CT-guidance associated with manual PMMA micro-injections with small syringes (*i.e.* 1.5–2 cm^3) are the best options to reduce the leakage risk;
- the best needle entry points and orientations can be easily chosen: according to the shape of the sacrum and the distribution of sacral osteolysis, the needle should be positioned in order to cover the whole extension of the sacral fracture
- usually, given their ease relative to long-axis approaches, multiple short-axis trajectories perpendicular to the sacral ala are preferred to maximize treatment volumes, at the expense of multiple needle placements.[51]

Aneurysmal bone cysts

- The aneurismal bone cyst (ABC) is a pseudotumoral hyperaemic/haemorrhagic, expansive osteolytic lesion with a thin wall, containing blood-filled cystic cavities.
- Although benign, the ABC can be locally aggressive and can cause extensive weakening of the bony structure and impingement on surrounding tissues; malignant transformation is extremely rare.
- It tends to affect patients younger than 20 years, with female preponderance.
- The true etiology is still unknown.
- About 14% of all ABCs are encountered in the spine, with those in the cervical spine being only 2%.
- Usually, it produces a pain syndrome, resistant to continuous medical medications

Aneurysmal bone cysts

- Treatment of spinal ABC is controversial.
- Surgery is still considered to be the treatment of choice including resection, curettage and spine fixation.
- These procedures entail the post-operative risks of spinal deformity and hemorrhage owing to their high vascularity.
- Percutaneous intralesional direct embolization with different agents (glue, Onyx, alcohol, Ethilbloc) represents a relatively new mininvasive therapeutic option for the treatment of ABCs, sometimes combined with surgery or endovascular treatments, especially for large and resistant lesions.
- In these lesions, VP aims to combine pain relief with spine stability, filling the lesion with cement.
- Until today, the bone cement most commonly used was the above-mentioned PMMA; the success of this material is based on immediate pain relief and mechanical stabilization improving physical functions, as well as low cost.

Aneurysmal bone cysts

- However, clinical trial results have highlighted potential weaknesses such as thermal injury to surrounding tissues with neurological damages, increasing fracture risk in adjacent levels owing to the high inherent stiffness and potential toxicity caused by the reactive elements.
- New injectable materials such as calcium phosphate, bioactive glass and calcium sulphate cement are being developed, and they seem suitable for vertebral stabilization and augmentation in young patients,
- However, some authors reported that these osteoconductive cements, even when presenting immediate and long-term effectiveness with long-lasting pain relief and improved quality of life, entail some disadvantages compared with standard PMMA cements: higher costs, higher rates of disc and venous leakages and new incidental adjacent fractures.

Vertebral haemangiomas

- Vertebral haemangiomas (VH) are benign tumours with a rich vasculature; they are relatively common, representing 2–3% of all spinal tumours.
- Usually, these are asymptomatic and are diagnosed as accessory findings during X-ray or MRI examinations performed for other purposes.
- If symptomatic, they can present from simple vertebral pain (54% of cases)—sometimes resistant to conservative medical treatment—to progressive neurological deficits.

Vertebral haemangiomas

- Symptomatic VH, with or without aggressive signs on MR (marked enhancement, epidural tissue,hypointensity on T_1 weighted with hyperintensity on T_2 weighted or short tau inversion recovery sequences and cortical erosions),
- is a strong indication to VP, with an antalgic effect ranging from 90% to 100% of cases. The basic principle of this approach is to overfill completely the vertebral lesion with cement (PMMA) in order to determine an irreversible deafferentation and sclerosis of the haemangiomatous venous pool;

Vertebral traumatic fractures

- Vertebral traumatic fractures can be stable or unstable, in relation to the three- or four-column theory (Denis and Calzolari). The most applied classification for surgical or non-surgical treatment in case of vertebral fracture is the Magerl classification that divides the trauma into compression, rotation and distraction, with multiple subtypes.
- Vertebral cementoplasty with VP or AT, depending on the degree of vertebral height loss, has a major indication in patients with Magerl A1-type fractures.[11] These subjects can also be treated with orthesis devices, bed rest and medical/physical therapy for at least for 3–6 months;
- however, these treatments cannot exclude the possibility of worsening with an increase of kyphotic deformity and consequent problems related to orthesis, such as cardiorespiratory impairment, sleep problems and gastrointestinal motility reduction.
- AT can restore vertebral height, obtaining better homogeneous distribution of the cement with better axial resistance to load

Vertebral traumatic fractures

- In selected cases, vertebral cementoplasty can be considered also in patients with Magerl A2 and A3 fractures, such as patients with polytrauma with comorbidities (patients with long bone fractures, abdominal trauma etc.), elderly patients in whom surgical indication is not suggested and patients in whom surgical and anaesthesiologist risk is too high. There are no absolute rules about the age threshold regarding AT, however, in young patients the treatment should be performed as soon as possible;
- it must be considered that the bone metabolism in a young patient is much faster than in an old one.

Cerament™; Bonesupport®, Sweden

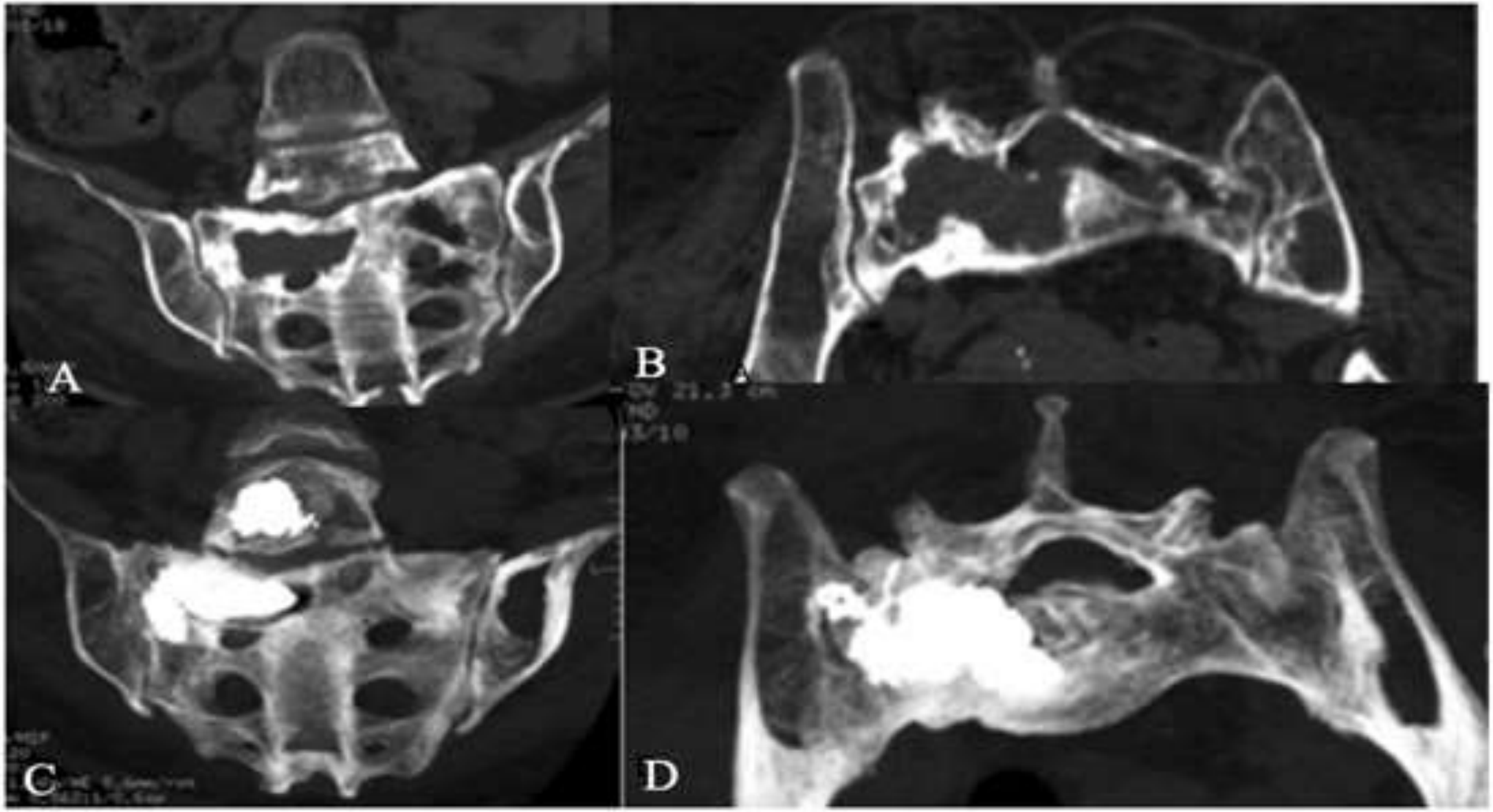
- To bypass these drawbacks, a new kind of bioactive osteoconductive material (Cerament™; Bonesupport®, Sweden) has been proposed in the attempt to obtain bone regrowth in the focal osteolytic area (Figure 6).
- It is composed of resorbable calcium sulfate and hydroxyapatite with osteoconductive properties; the hydroxyapatite acts as a slow or non-absorbable framework which slows down the absorption rate of calcium sulfate and, at the same time, acts as an osteoconductive template for new bone ingrowths
- this new generation of cement will be resorbed at a rate equal to new bone ingrowth, achieving complete bone remodeling and healing

Developments.....

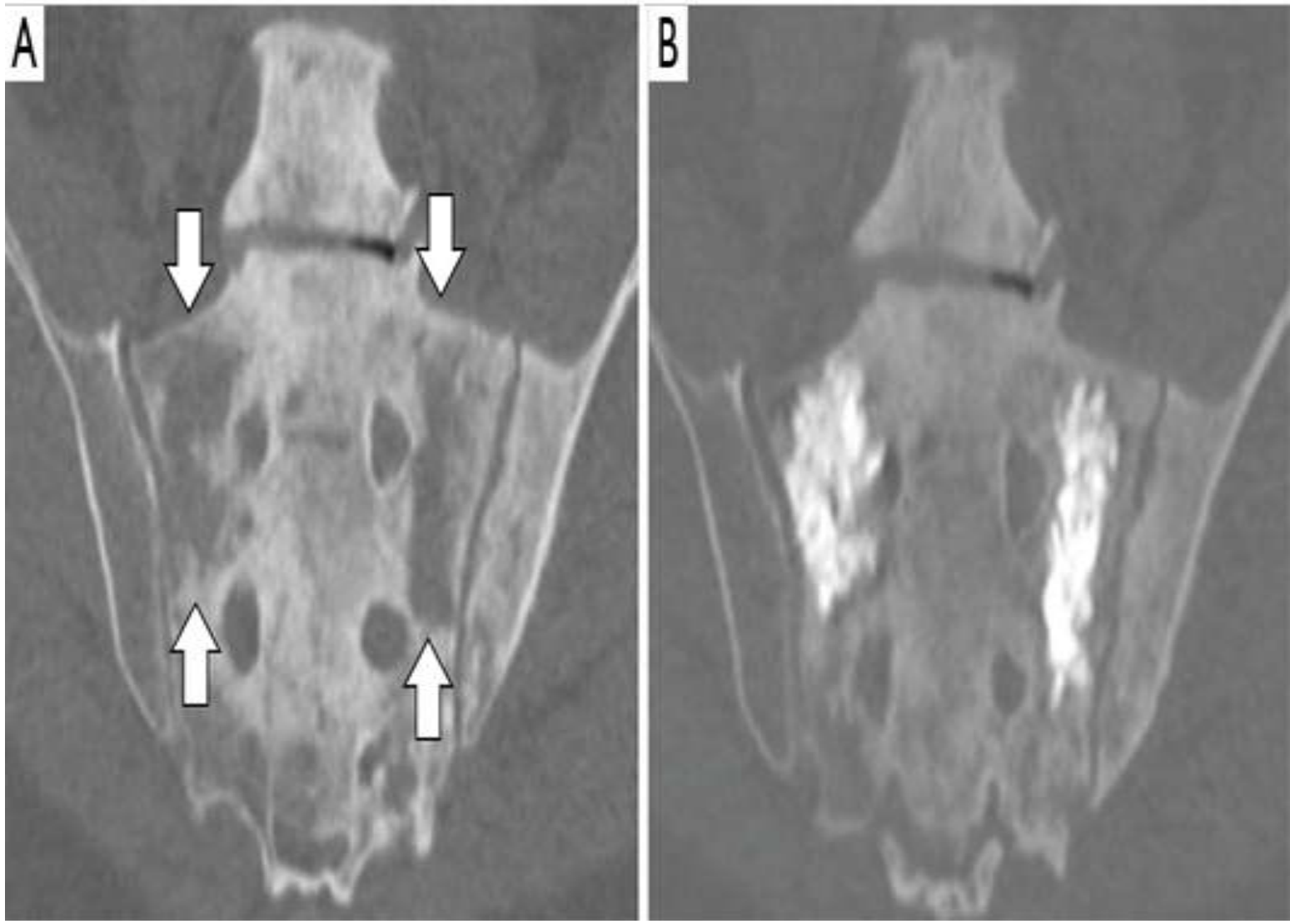
- Calcium phosphate in young patients with traumatic fractures
- Prophylaxis by adding chemotherapy agents or radioactive isotopes to the cement in tumour


A
B
B
C
D
D

A large non-Hodgkin lymphoma destroying the right hemivertebra of the L5 and right sacral wing (a–b).



A 70-year-old man with metastatic prostate cancer to the osseous structures, with a mixed lytic and sclerotic metastates in the sacrum. Lytic lesions (arrows; A) resulted in mechanical pain in the lower back with prolonged standing and transitions from a sitting to standing position. Percutaneous cementoplasty performed with injection of PMMA (polymethyl methacrylate) to the bilateral sacral lytic regions (B) resulted in relief of the mechanical pain.

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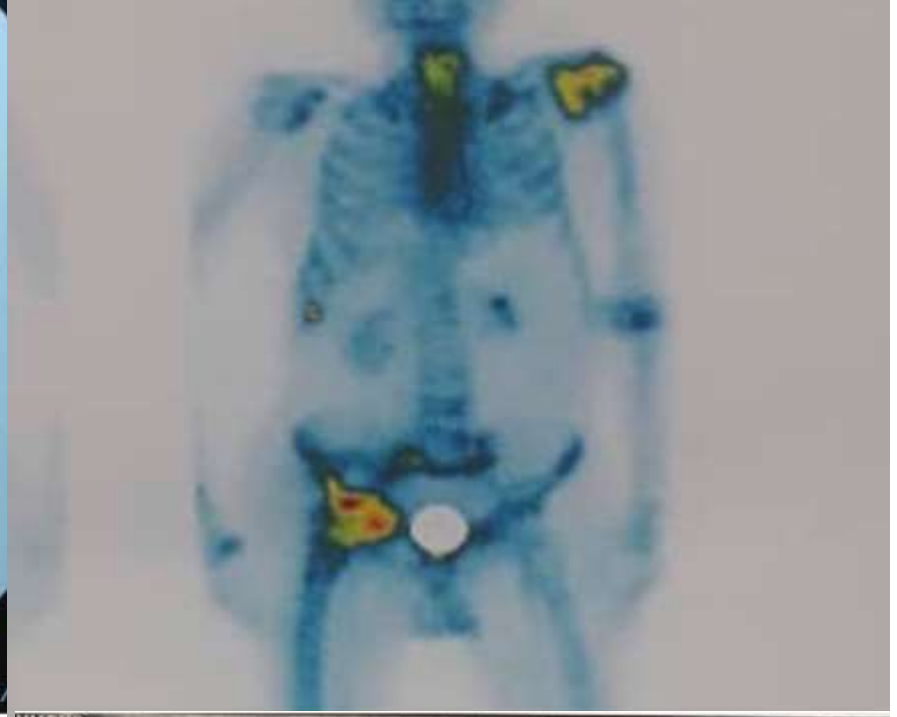


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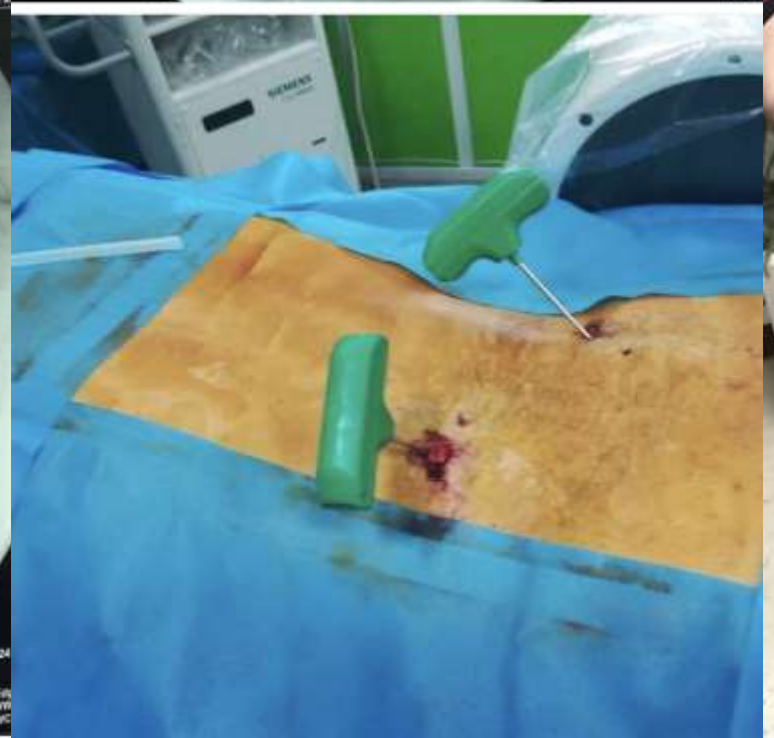
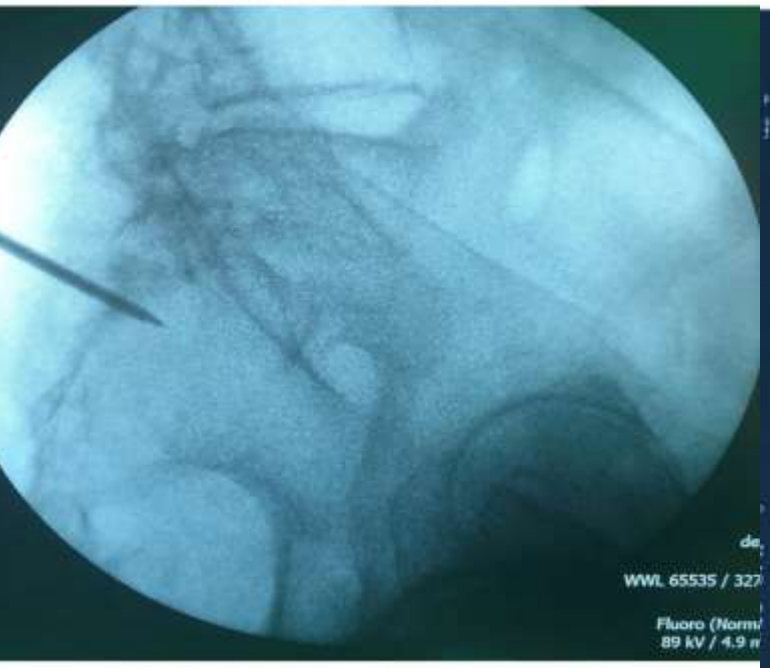
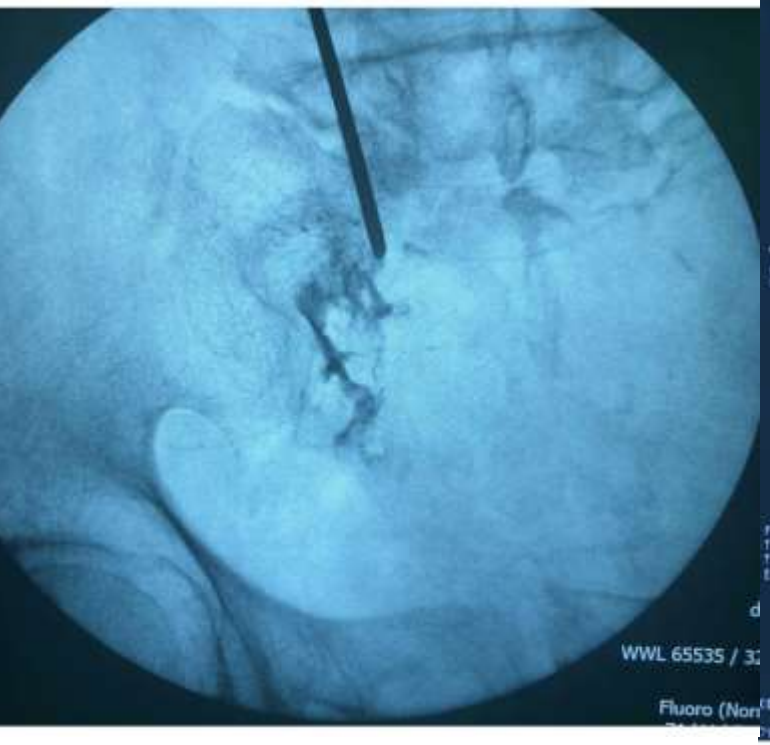
71 kV / 3.2 mA


1398-05-14 83Y
L

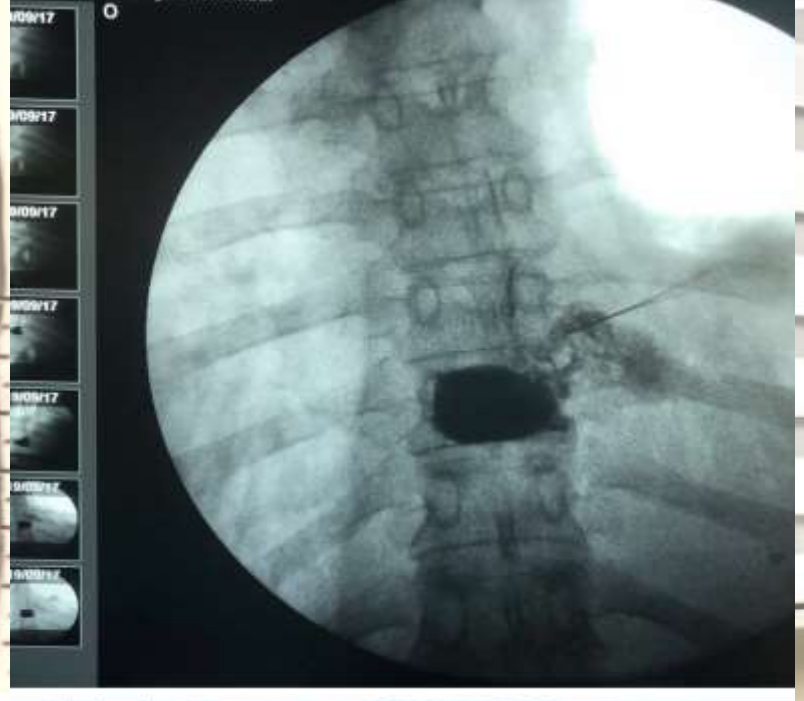



WWL 65535 / 327
Fluoro (Norm
89 kV / 4.9 m

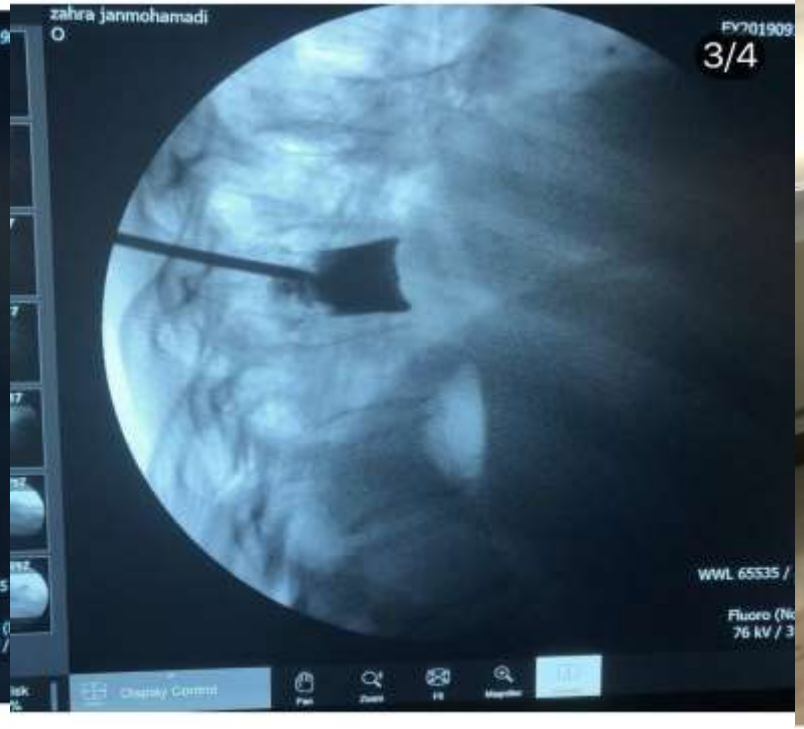

WWL 65535 / 3
Fluoro (Nor


1/6


1/4




zahra janmohamadi
WWL 65535


zahra janmohamadi
3/4
WWL 65535

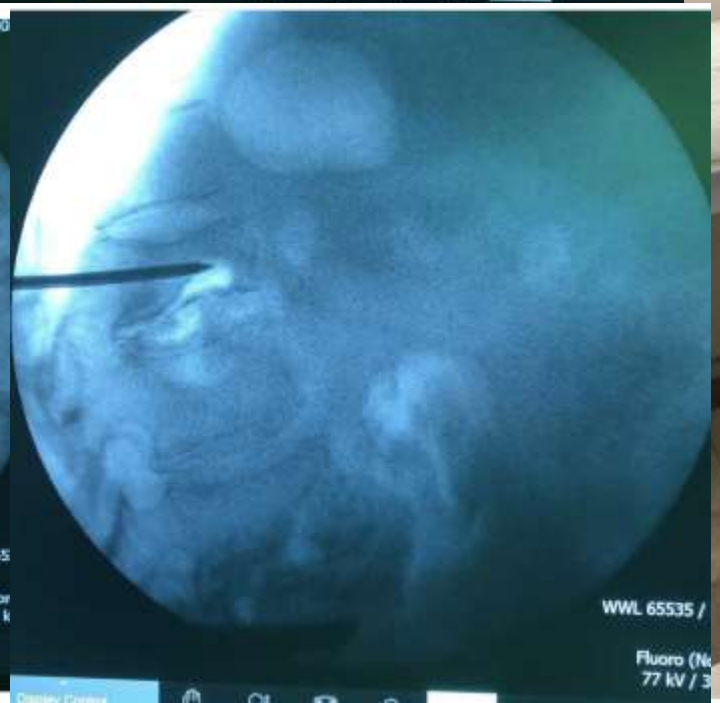

mahmoudbari4321
mahmoud bari
EX20200730215341
OP
RF
default
WWL 65535 / 32767
Fluoro (Normal)
55 kV / 1.8 mA


mahmoudbari4321
mahmoud bari
EX20200730215341
OP
RF
default
WWL 65535 / 32767
Fluoro (Normal)
55 kV / 1.8 mA

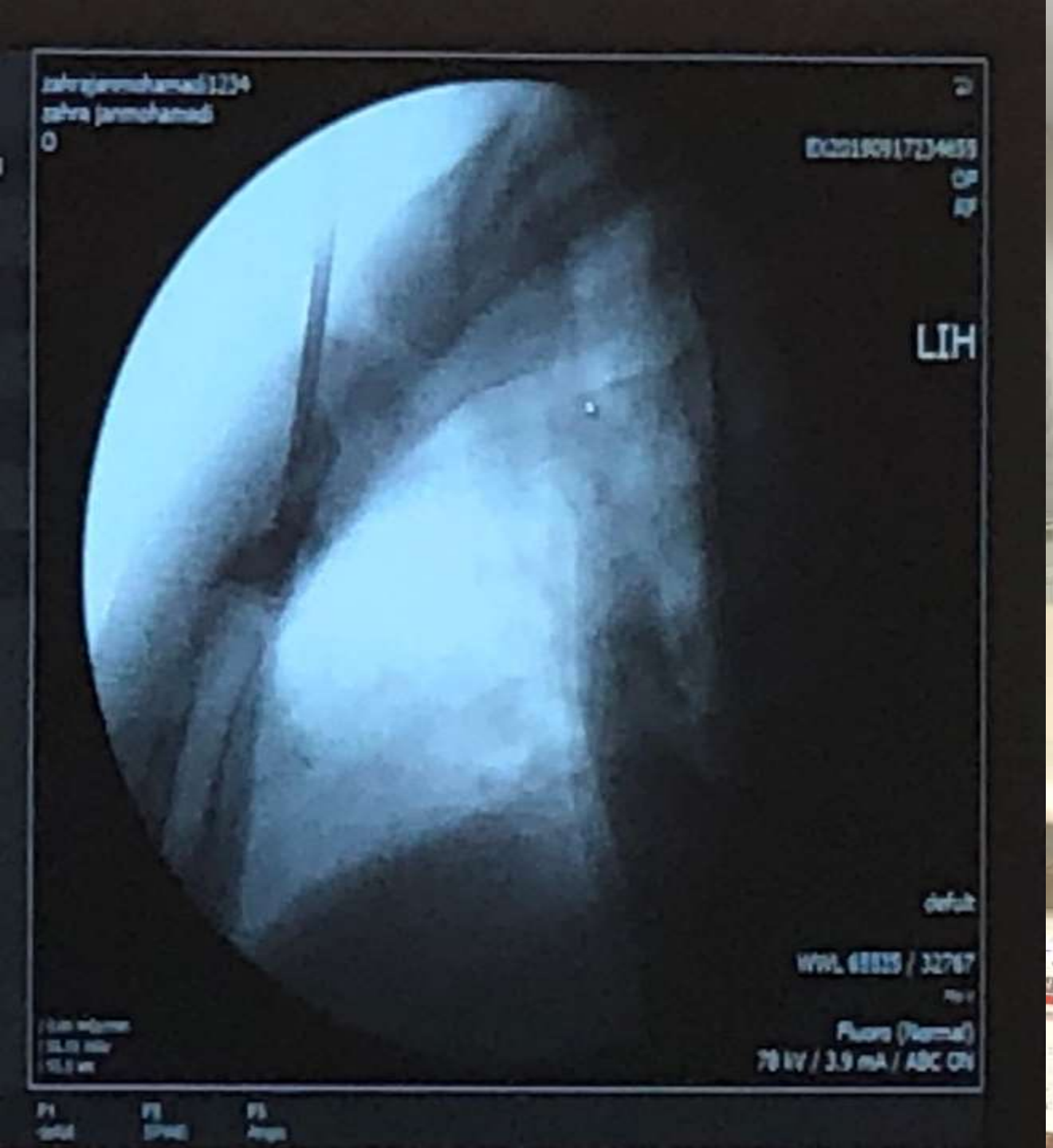

WWL 65535 / 32
Fluoro (Norm
76 kV / 3.7

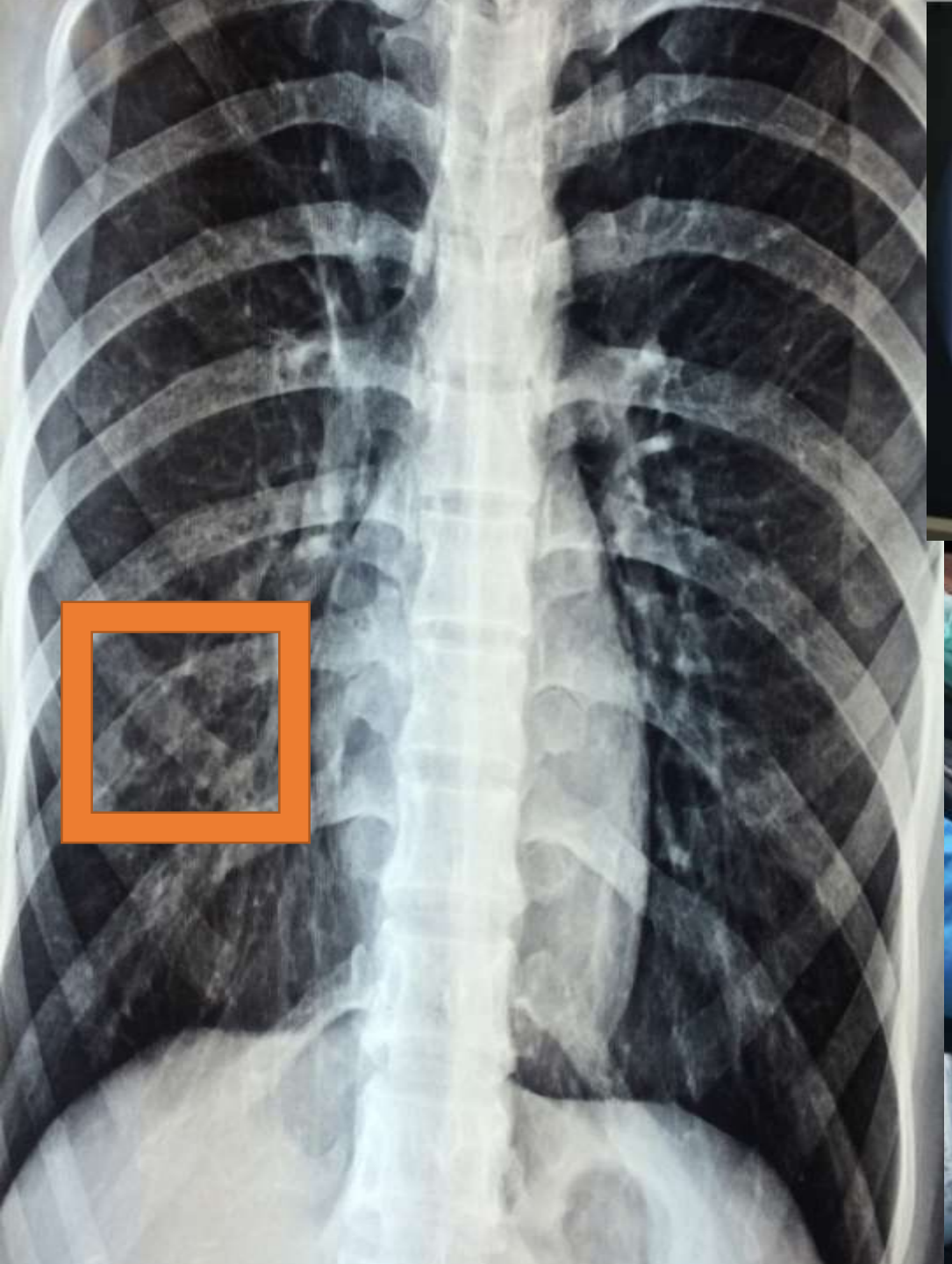

babali
0
WWL
Disk
7%
Display Control
Pan
Zoom
Fit
Magnifier


babali
0
WWL 655
Fluor
77 k
Disk
7%
Display Control
Pan
Zoom
Fit
Magnifier


WWL 65535 /
Fluoro (N
77 kV / 3

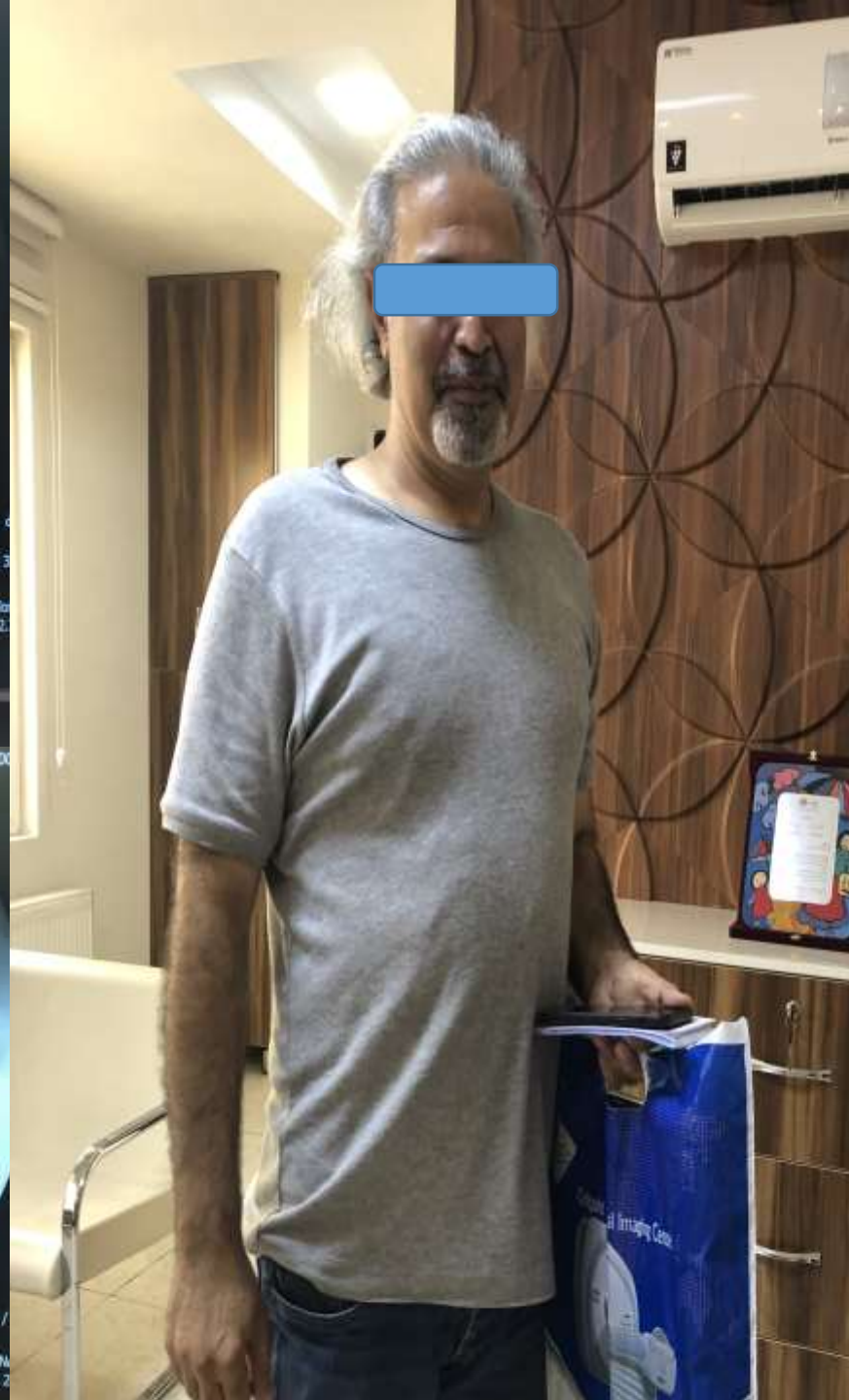

fatemedamanekhorshid...
fateme damane khorsh...
F
Large
4 E
2019/01/16
6 E
2019/01/16
8 E
2019/01/16
10 E
2019/01/16
12 E
2019/01/16
14 E
Disk
2%
Display Control
Pan
Zoom
Fit
Magnifier
Overlay
WWL 65535
Fluoro
83 kV

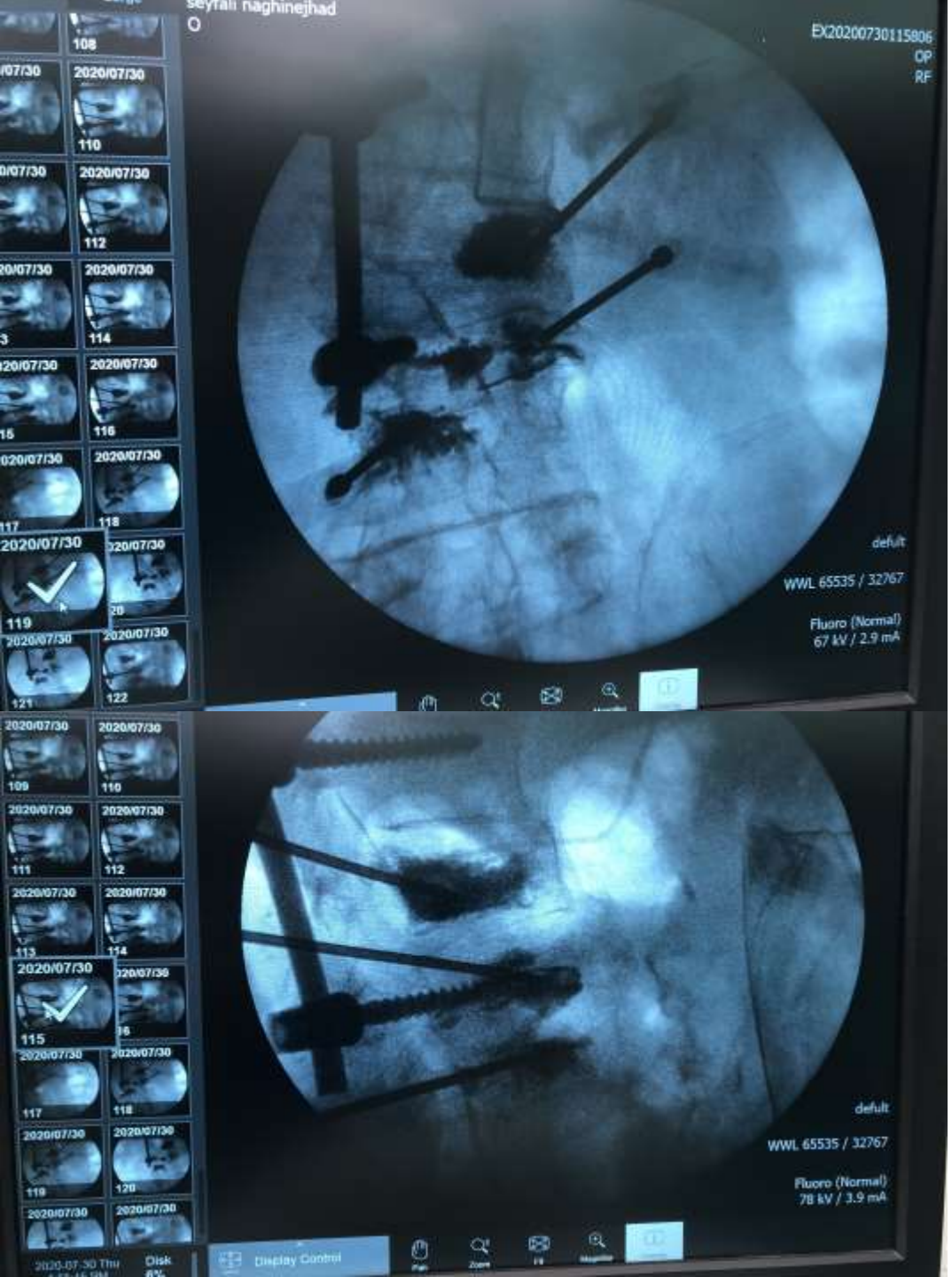

LIH
default
70 kV / 3.9 mA / ABC ON




fereydon esmaili
0
WWL 65535 / 3
Fluoro (Na
65 kV / 2.


fereydon esmaili
0
EX20200
2020/07/28
WWL 65535 /
Fluoro (N
65 kV / 2




EX20200730115806
OP
RF
default
WWL 65535 / 32767
Fluoro (Normal)
67 kV / 2.9 mA
default
WWL 65535 / 32767
Fluoro (Normal)
78 kV / 3.9 mA
Display Control

Thank you for attention

Any Questions?