Percutaneous biopsy and staging of musculoskeletal tumors

Learning objectives

1. To learn the compartmental anatomy for an adequate locorregional description of the tumor in the report.
2. To learn the anatomically based guidelines for percutaneous biopsy of musculoskeletal tumors and the different techniques.
3. To learn the bone and soft tissue malignant tumor staging system.

Background

Staging of musculoskeletal tumors is essential for their correct treatment, which nowadays tends to be a limb-sparing surgery. The musculoskeletal radiologist, as part of a multidisciplinary team, is now the leader figure in the staging process, that consists in the following three steps:

I Imaging differential diagnosis and MRI description of the local extent according to the compartmental anatomy.

II Percutaneous image-guided biopsy.

III Distant extent determination and tumor staging acording to major staging systems.

In this exhibit we will describe the staging systems, the imaging compartmental anatomy, and the percutaneous biopsy technique with drawings and representative examples.

Imaging findings OR Procedure details

I Compartmental anatomy

Imaging differential diagnosis of an osseous lesion is performed with conventional radiology (Rx). In our experience ultrasound (US) is an extraordinary tool for initial study of soft tissue tumors. Most of them are pseudotumors or benign tumors, and it is possible to characterize them correctly with this technique [Fig. 1 on page 9].

However, when a detailed analysis of local extent and anatomic relations is required by the nature of the lesion or the suspicion of malignancy, it is mandatory to perform an MRI study. One of the pillars of the staging system of the orthopaedic surgeon (Muskuloskeletal Tumor Society or MSTS) (see section III), is based on a compartmental anatomy model (1). The musculoskeletal radiologist's MRI report must be therefore based on the anatomic description of the tumor according to this model [Fig. 2 on page   ] (1,2).

These are anatomic spaces defined by tissues that act as a barrier to the local spread of pathologic processes, and therefore have a prognostic and therapeutic value. Natural barrier tissues are cartilage, periosteum and bone cortex, major fascial septae, synovium capsule and the tendinous insertions. [Fig. 3 on page 11], [Fig. 4 on page 12], [Fig. 5 on page 13], [Fig. 6 on page 13], [Fig. 7 on page 14], [Fig. 8 on page 15].

It is very important to include in the radiological report a detailed description of the size, shape and local extent of the lesion, specially the involvement of the superficialis fascia, extraosseous extent of a bone tumor [Fig. 9 on page 16], articular extent [Fig. 10 on page 17], as well as involvement or sparing of the neurovascular bundles of the different compartments of the limbs. It is beyond the scope of this article to discuss the sensitivity and specificity of MRI for the evaluation of these issues. We do remind that the MRI negative predictive value for the evaluation of these structures is very high. It is extremely helpful to correlate the images with the compartmental anatomy atlases based on MRI imaging, available on-line. We use e-anatomy (www.iamios.com) [Fig. 11 on page 18].

We must not forget that differential diagnosis is the other essential part of the radiological report. Concerning bone lesions, we can complement the classic semiology of conventional radiology (localization, margins, cortical involvement, matrix mineralization and periostic reaction), with MRI semiology: T1 and T2 signal [Fig. 12 on page 19], gadolinium enhancement in conventional and dynamic studies, and even diffusion weighted images. Concerning non-specific soft tissue lesions, it is helpful to make a

diagnostic approach considering localization and patient's age based on Kransdorf's articles (3).

II Percutaneous biopsy

Once we have performed all the imaging studies, and we have an optimal description of the local extent and a good differential diagnosis, in the first place we have to consider if biopsy is necessary. Avoid to biopsy "don´t touch lesions" as for example tendons avulsions or myositis ossificans [Fig. 13 on page 20].

The biopsy must be indicated within a multidisciplinary meeting (best in a referral Center), with the participation of at least the surgeon, the radiologist and the pathologist. With few exceptions, percutaneous biopsy is preferable to surgical biopsy. The first has the disadvantage of getting less amount of sample, but it is cheaper, less aggressive and above all it is cleaner surrounding healthy tissue. We must remember that the tissues affected during a surgical biopsy (hemorrhage, hematoma) should be resected in the final surgery. This contamination can be catastrophic in an excisional biopsy of a sarcoma [Fig. 14 on page 21].

On the other hand, knowledge of the technique and an adequate experience, the performance of different passes with thick needles (16-11 gauge), and the selection of areas with increased activity (gadolinium enhancement [Fig. 15 on page 22], with Doppler flow signal, uptake in bone scan and more recently in PET-CT [Fig. 16 on page 23]), minimizes the inconvenience of the small sample size, so that the effectiveness of percutaneous biopsy has been stated by different authors (4) and our own experience.

1. **Biopsy approach**

As a general rule we should select the most direct route without passing through another compartment, and without reaching neurovascular bundles, tendons or joints. The tract of a thick biopsy needle must also be excised, so it is a mandatory requirement for it to coincide with the final surgical approach. Otherwise it is possible to contaminate other compartments, or change the staging of the tumor, preventing the realization of a limb-sparing surgery, and changing the patient's prognosis significantly [Fig. 14 on page 21].

Although no universal guidelines can be given since every case is different, and should be studied individually (in multidisciplinary meeting), it is interesting to propose some general guidelines based on the anatomy and standard surgical incisions (2, 6) [Fig. 17 on page 24], [Fig. 18 on page 25], [Fig. 19 on page 25], [Fig. 20 on page 26],

As far as it is possible **avoid**:

- Middle or posterior thirds of the deltoid muscle, because this muscle is innervated from behind by the axillary nerve, so that the muscular portion anterior to the resection would be denervated and functionless.
- The gluteus muscles. Resection here is also associated with poor functional results. Perform approach through iliac crest or iliac spines (anterior superior, anterior inferior or posterior) [Fig. 16 on page 23].
- Rectus femoris and vastus intermedius because of poor functional outcome by the same reason.
- Sartorius muscle, and gracilis muscle to a lesser extent, because they may be necessary for tissue coverage or functional replacement.

The recommended scapula approach is through medial margin because that is the standard surgical approach for this bone.

1. **Technical aspects**

1. **Preliminary observations**

- The needles must be thick enough to ensure a sufficient amount of tissue for an accurate diagnosis (at least 13 G for bone biopsy and 16 G for soft tissue biopsy) [Fig. 25 on page 30].
- Informed consent.
- Recent coagulation study.
- Admission at the short term hospital.
- Sedation or anxiolytic. Usually analgesia is enough. But prior administration of a rapid onset of action anxiolytic (alprazolam) is advisable and decreases the risk of vasovagal reaction. Deeper sedation (under control by anesthesiologist) is recommended in cases of long bones biopsy with preserved bone cortex, especially in our experience in the humerus, because is more painful.

2. **Procedure for soft tissue tumor or bone tumor with soft tissue component**

- US-guided [Fig. 26 on page 31], [Fig. 27 on page 32], [Fig. 28 on page 33].

1. Location of an entrance point on the skin that allows real-time visualization of the needle track to the tumor. The track will be less vertical than CT-guided biopsy, because the needle has to be parallel to the ultrasound beam plane.

2. Asepsis of the field and analgesia: local anesthetic infiltration of the skin, the tract and around the lesion (specially periosteum and supicium of nerve sheath tumor). Skin incision.
3. Introduction of an automatic tru-cut needle (14-16 G) under real-time visualization (3 -5 passes).
4. Sending of the sample, fresh and in formalin. It might be interesting to obtain a cytology sample too, when a faster preliminary evaluation is needed, while the histological study is performed.

- CT-guided (deep location) [Fig. 29 on page 33]:

1. Location of the entrance point on the skin with metallic markings.
2. Asepsis of the field and analgesia: we use 19-22 G Chiba needle 16-20 cm long under CT control to infiltrate the anesthetic agent deeply and to mark the track.
3. Introduction of a 13G and 10 cm long needle coaxially to the beheaded Chiba needle.
4. Withdrawal of the Chiba needle and coaxial introduction of an automatic 16G needle sampling by 3-5 passes with slight angulations of the 13 G needle).

3**. Procedure for bone tumor with intact bone cortex (CT-guided)**

• Technique A:

1. 1-2 steps are the same as above.
2. Coaxial introduction of a bone biopsy 13-11 G needle and penetration into the bone by screwing (clockwise) or using a hammer. If the biopsy tract is quite difficult, it may help us to introduce previously a bevelled 13 G vertebroplasty needle [Fig. 30 on page 34].
3. Obtaining the sample of intramedullary aspirate and of bone cylinder.

• Technique B (hard or thick bone cortex) [Fig. 31 on page 35]:

1. 1-2 steps are the same as technique A, but the bone biopsy needle goes now until cortical surface.
2. Coaxial introduction of 15-16G Kirschner needle which is connected to a drill to pierce the cortex.
3. Withdrawal of the Kirschner and introduction the bone biopsy needle.

• Technique C (hard or thick bone cortex) [Fig. 32 on page 36]:

Special biopsy system Kit. It has very high penetration power without drilling, but it is more expensive.

4. Vertebra

Depending on the situation we can perform different biopsy approaches and techniques:

1. Paravertebral, costovertebral and transpedicular approaches [Fig. 33 on page 37].
2. Procedure 2 CT-guided [Fig. 34 on page 38].
3. Procedure 3 technique A. It is very interesting the possibility to lead the direction of the needle with a bevelled vertebroplasty needle [Fig. 35 on page 39].
4. **Transoral approach:** Lesions involving C2 are challenging to approach. This approach has been used by interventional radiologists for vertebroplasty as it is safer than other approaches for this vertebra, where nerve roots and vertebral arteries may prevent the more used posterolateral approach. This approach for image-guided biopsy is scarcely described in the literature, and most of them being under fluoroscopic guidance. Other authors (7) have recently reported transoral approach biopsy under CT guidance as a direct, safe and precise technique. They used general anesthesia and their biopsy yield was 50 %. In our series we performed two cases of transoral approach CT guided biopsy just with sedation of the patient, and both of them were positive: one ostemyelitis in a patient with clinical history of cavum carcinoma treated with radiotherapy [Fig. 36 on page 40], and the other one was a unique metastasis [Fig. 37 on page 41]. We used thinner needles (17-18 G) and we had no complications.

5. Final recommendations

- Local cold: 20 minutes - 2 hours.
- Analgesia if needed, avoiding aspirin.

Concerning histological concordance percutaneous biopsy-surgery, it was important in our series:

- The selection of the cases. Percutaneous biopsy was less accurate for:

- Lesions composed mainly of blood , such as aneurysmal bone cyst (primary or secondary), or soft tissue spontaneous hematoma (two cases)
- Low aggressiveness chondral lesions (low grade chondrosarcoma vs enchondroma) (one case)
- Some benign tumors such as hemangioma or schwannoma, or one case of intermediate aggressiveness (one angiomatoid fibrous histiocitoma).

- The selection of the area of the lesion. It must be the most active or representative in the different imaging techniques.

- Very difficult approach or without adequate analgesia or sedation:

- Humerus (sometimes more painful, two cases)
- Spine (sometimes difficult approach, two cases)

There were no noteworthy complications in our series.

III Staging

Bone tumor

1. The staging system of **benign bone tumors** according to the Enneking system is based on radiological criteria of aggressiveness and on the clinical behaviour: a latent lesion with well-defined transition zone (stage 1), active and moderately defined lesion (stage 2), and aggressive lesion, ill-defined or with cortex penetration (stage 3).
2. The staging system of **malignant bone tumors** according to Enneking system [Figure 38 on page 42] is the one adopted by the Musculoskeletal Tumor Society (MSTS). The American Joint Committee on Cancer (AJCC) has established other staging systems based on the previous one. The 2002 AJCC system [Figure 39 on page 43] may have better prognostic value, but it's verification with appropriate multicenter studies is still pending (8).

Soft tissue sarcoma

There are different staging systems for this extremely heterogeneous group of tumors, in an attempt to obtain an optimal prognostic and therapeutic predictive value. Some authors (9) have compared the more relevant local staging systems and have concluded that there are two that seem to have more prognostic-therapeutic interest: the MSK (Memorial Sloan-Kettering Cancer Center) based on certain adverse factors, and the AJCC 5th edition [Figure 40 on page 44].

The study of distant tumor spread is based on chest CT (lung metastases) and bone scan (bone metastases). PET-CT is being used recently, and has proved valuable in prognosis and adjuvant treatment monitoring of osteosarcoma and Ewing sarcoma.
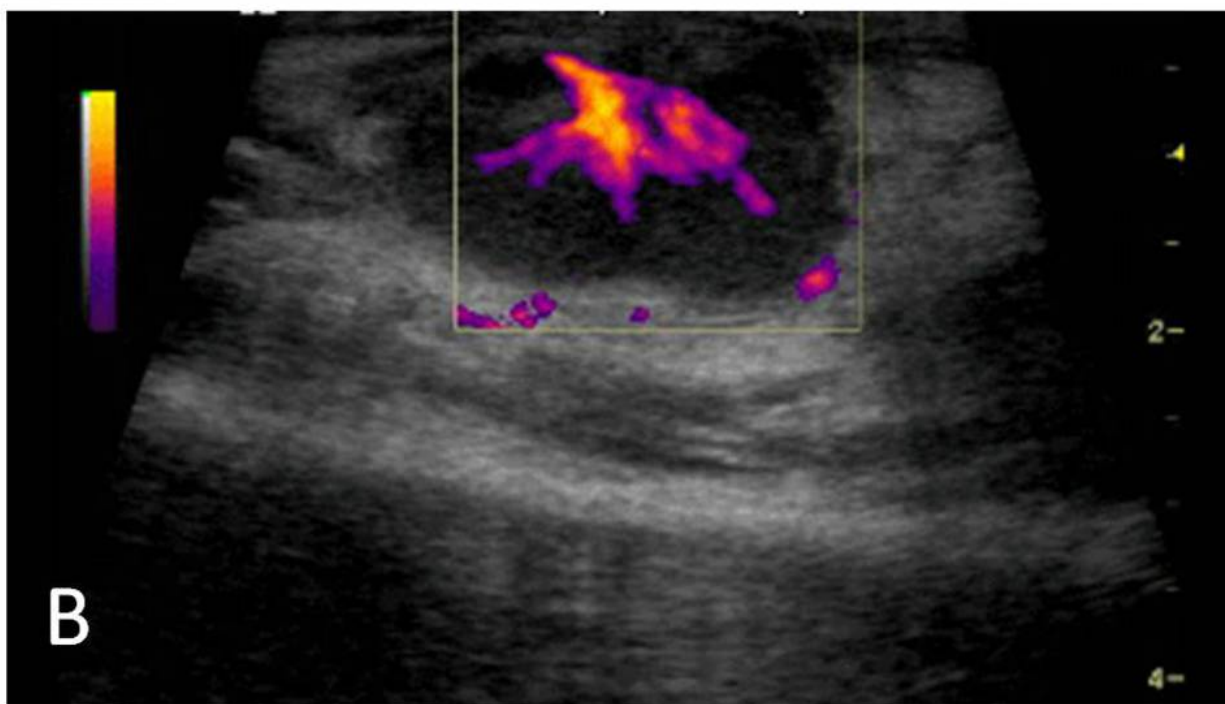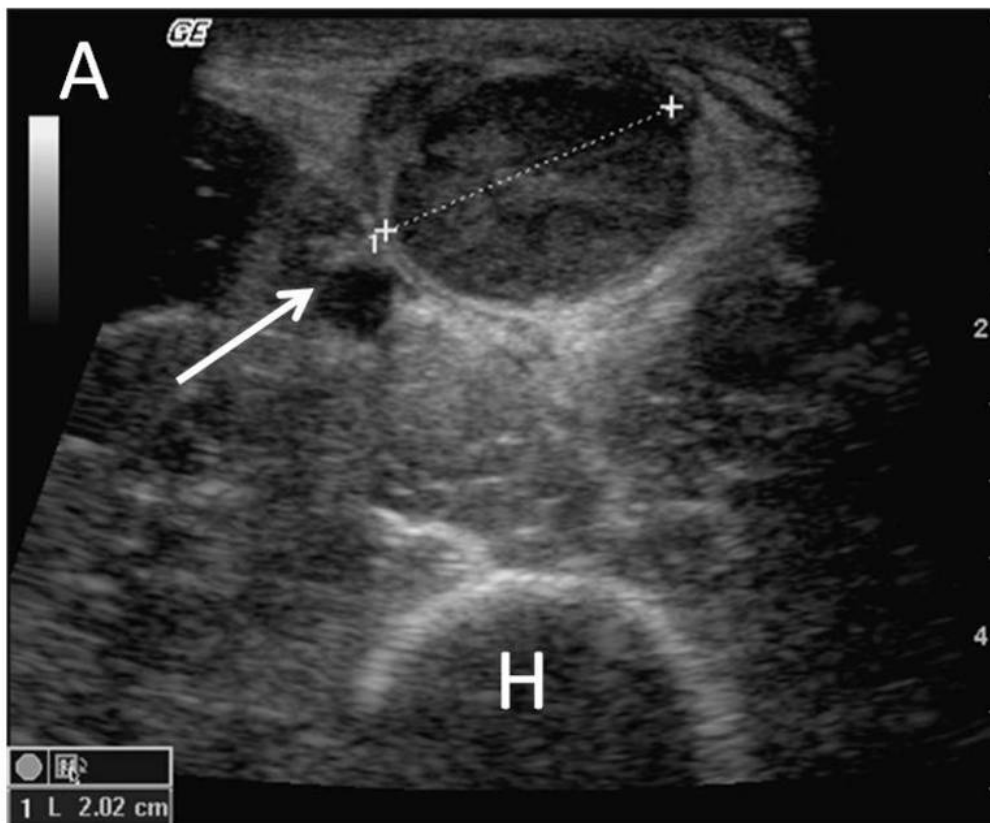
Images for this section:

Fig. 1: A Transverse US image. B longitudinal power-Doppler image.This patient came with a lump in the anterior aspect of his arm, at distal humeral shaft level (H), next to the elbow. The transverse US image showed a well-defined solid lesion located at the brachial bundle (arrow). The US-structure and the hilia vascular Doppler were in relation

to an inflammatory lymph node. The diagnostic was cat scratch disease after clinical history and laboratory tests (bartonella henselae).

Table I. Anatomic compartments

Extracompartimental Spaces		General	Upper Extremity	Lower Extemity	Pelvis

Head, neck
Axilla
Wrist
Groin
Ankle
Paraspinal tissue
	Periclavicular tissue
	Antecubital fossa
	Dorsum hand
	Popliteal fossa
	Dorsum foot
		Skin & subcutaneous fat
		Bone
		Paraosseous space
		Joint
			Periscapular tissue
			Arm:
			  anterior
			  posterior
			Forearm:
			  dorsal
			  volar
			Palmar hand
				Thigh:
				  anterior
				  posterior
				  medial
				Leg:
				  anterior
				  posterior
				  deep posterior
				  lateral
				Plantar foot:
				  medial
				  central
				  lateral
					Individual bone or muscle

Fig. 2
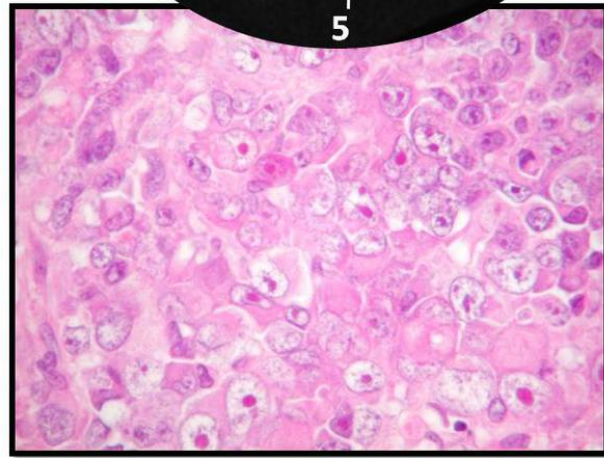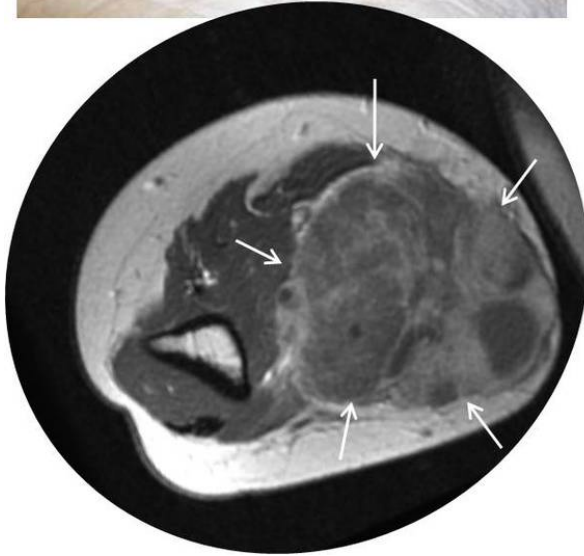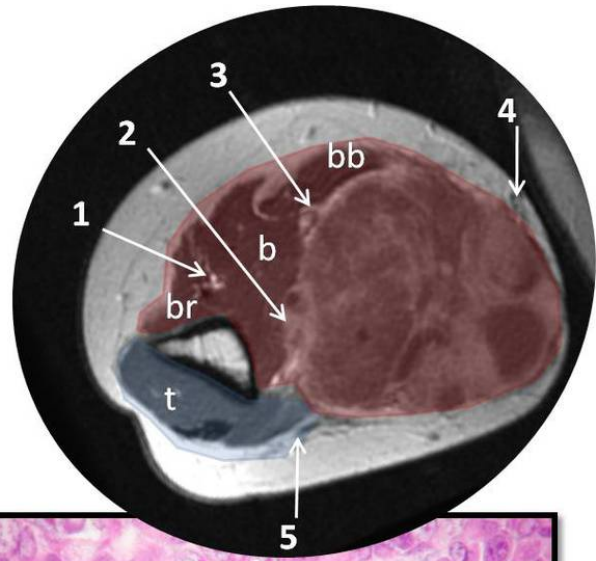
Fig. 3: Synovial sarcoma. Axial enhanced T1 MR image. Note the two anatomic compartments of the arm: Posterior (blue) and anterior (red) compartments. This tumor is located in the anterior compartment involving several neurovascular bundles and subcutaneous tissue. Bundles: 1 radial nerve, 2 brachial artery and median nerve, 3 musculocutaneous nerve, 4 medial cutaneous nerve of forearm, 5 ulnar nerve. Muscles: t triceps, br brachioradialis, b brachialis, bb biceps brachial.
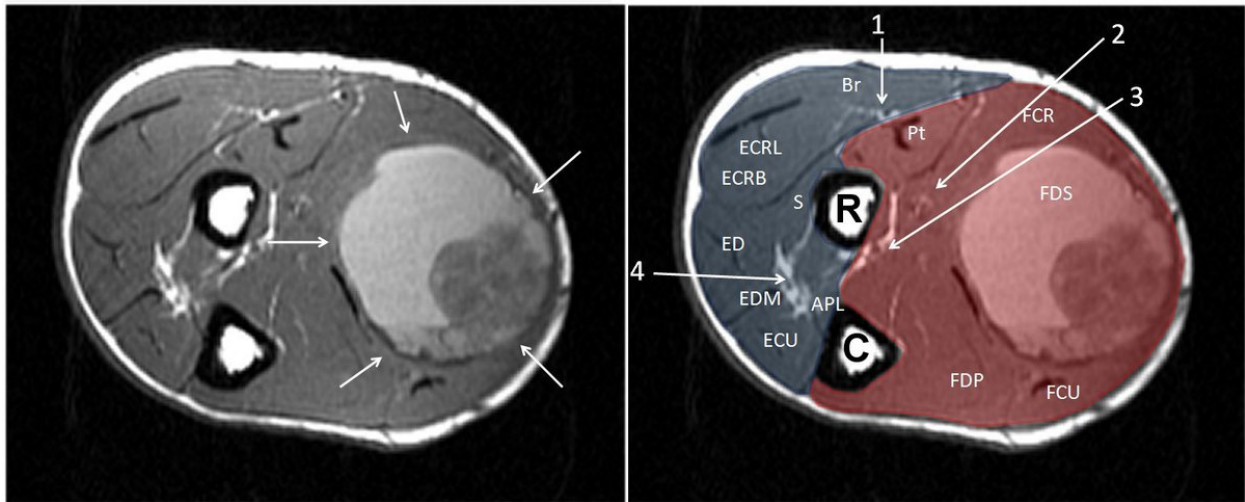
Fig. 4: Malignant fibrous histiocytoma (arrows). Anatomic compartments of the forearm: volar(red) and dorsal (blue). Axial SE T1 MRI. Bones: C cubitus, R radius. Muscles: Br brachioradialis, Pt pronator teres, FCR flexor carpi radialis, FDS flexor digitorum superficialis, FCU flexor carpi ulnaris, FDP flexor digitorum profundus, APL abductor policis longus, ECU exensor carpi ulnaris, EDM extensor digiti minimi, ED extensor digitorum , S supinatur, ECRB-L extensor carpi radialis brevis and longus. Neurovascular bundles: 1 radial, 2 median nerve, 3 anterior interosseous nerve, 4: posterior interosseous nerve. Note the hiperintensity signal on unenhanced T1 sequence due to subacute bleeding (methemoglobin).
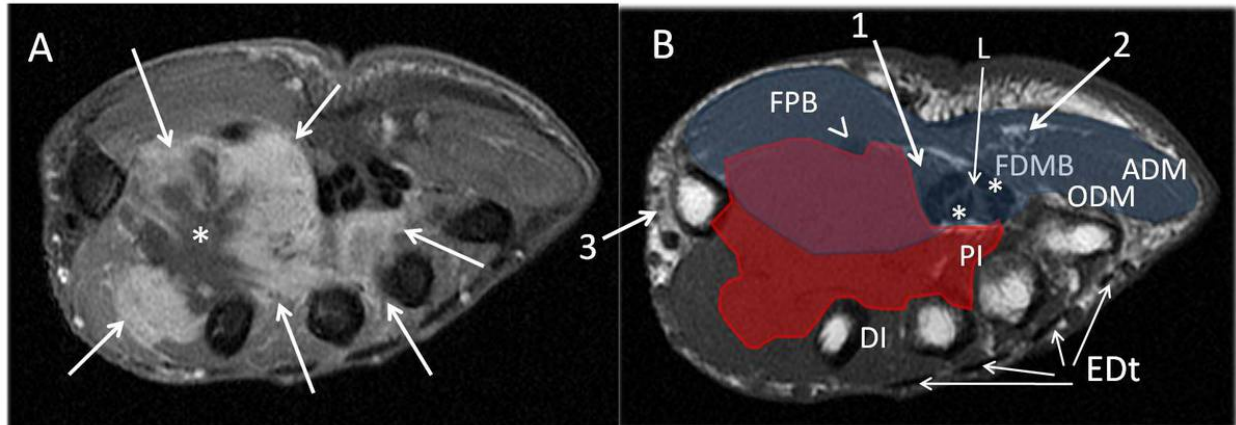
Fig. 5: Extracompartment synovial sarcoma. A Axial Gd-enhnaced FS T1 MRI. Note the central necrosis (*) B Diagram based on axial T1 image. Palmar compartment of the hand (blue). Tumor (red). Muscles: FPB flexor pollicis brevis, FDMB flexor digiti minimi brevis, L lumbricals, ADM abductor digiti minimi, ODM opponens digiti minimi, DI dorsal interossei, PI palmar interosseus. Tendons: flexor hallucis longus tendon (arrowhead), flexor digitorum superficialis and profundus tendons (*), EDT extensor digitorum tendons. Nerves: 1 median nerve, 2 ulnar nerve, 3 dorsal digital nerves.
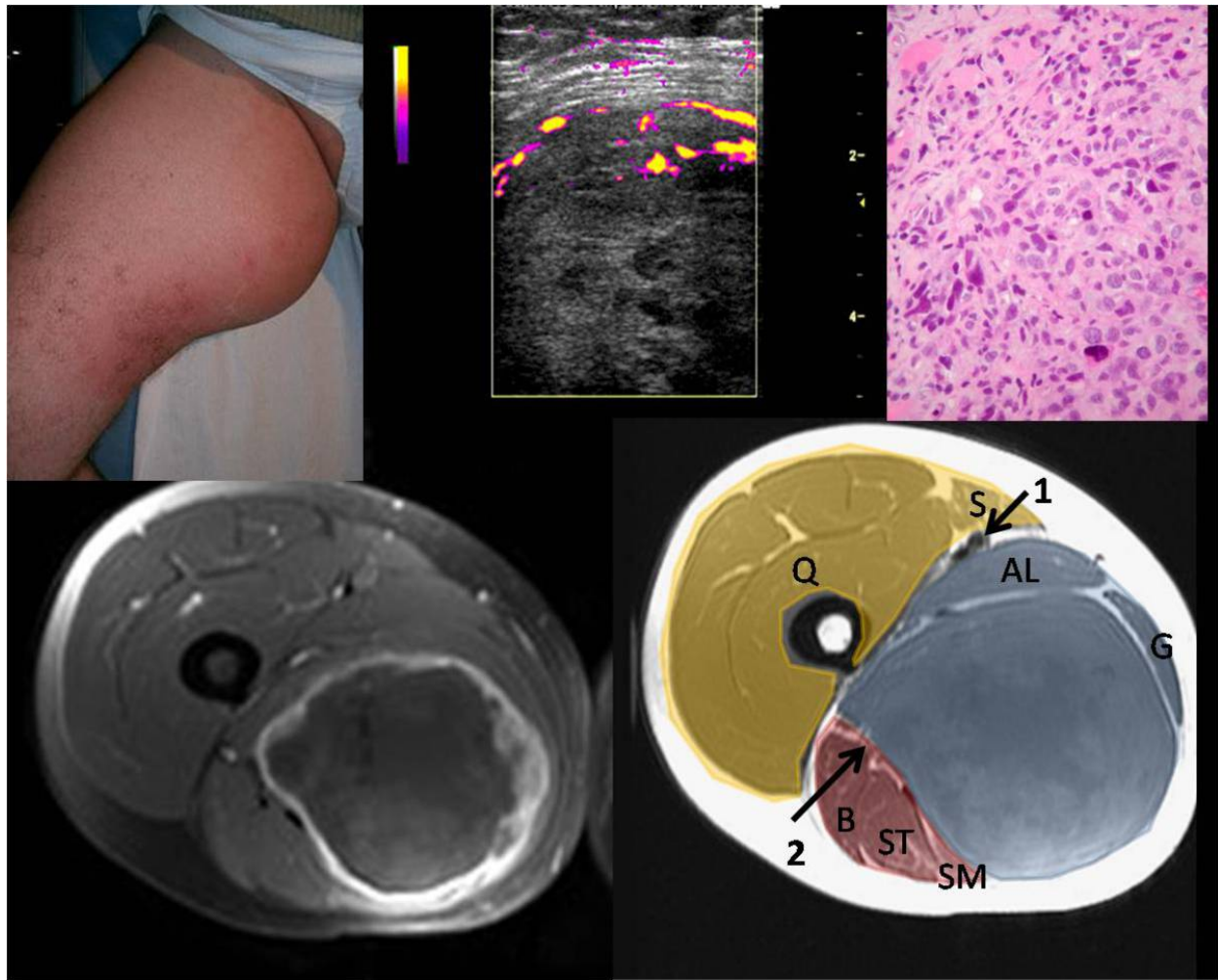
Fig. 6: Pleomorphic malignant fibrous histiocytoma. Anatomic compartments of the thigh: anterior (yellow), medial (blue) and posterior (red). Axial Gd-enhanced fat supression T1 and Power-Doppler US images. Muscles: Q quadriceps femoris, S satorius, AL adductor longus, G gracilis, B biceps femoris, ST semitendinosus, SM semimembranosus. Arrows: 1 femoral neurovascular bundle and saphenous nerve, 2 sciatic nerve.
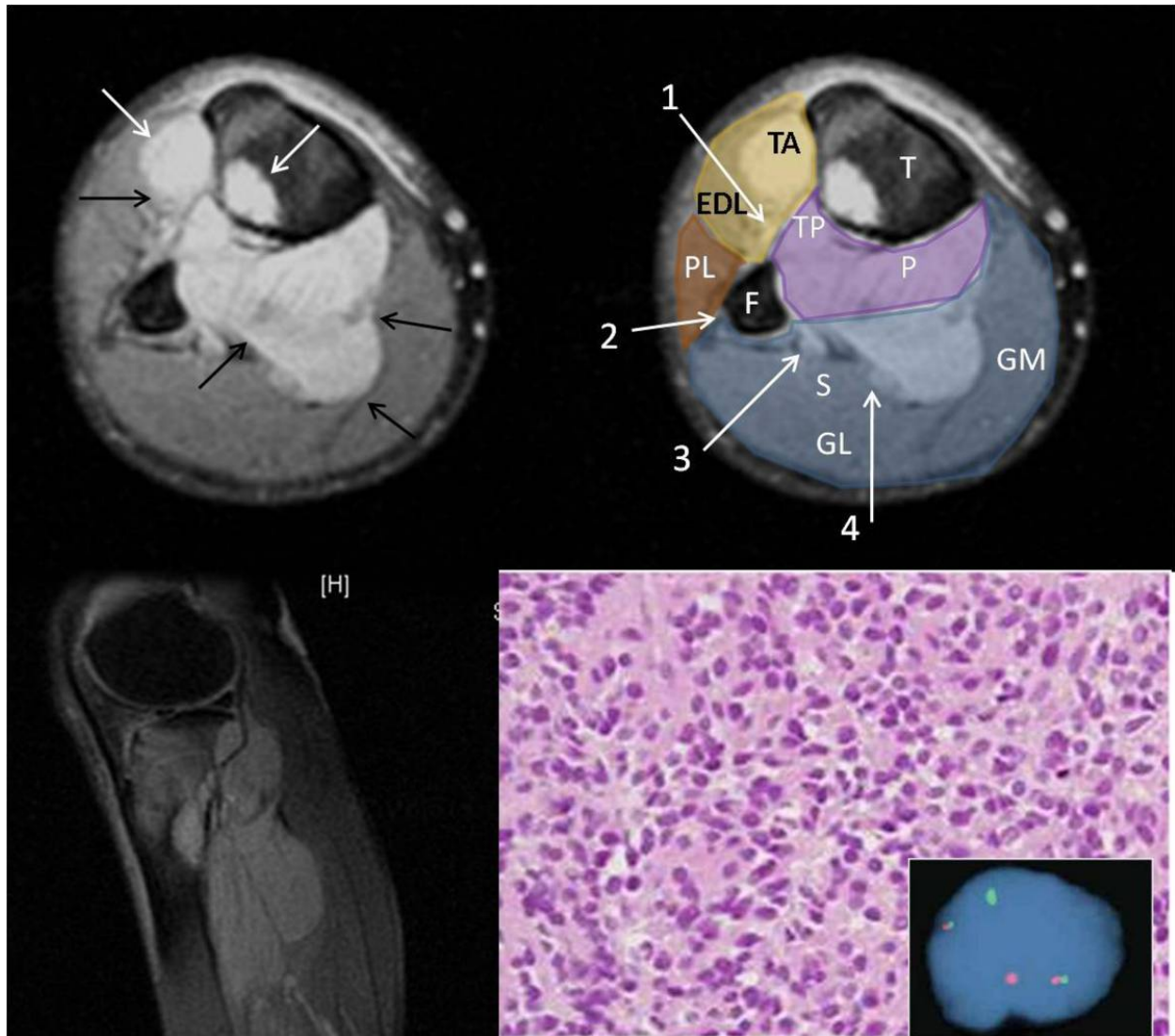
Fig. 7: Multicompartimental Ewing sarcoma. Axial FSE DPMR FS MRI and sagital SE T1 FS MRI. Anatomic compartments of the leg: Anterior (yellow), lateral (red), superficial posterior (blue) and deep posterior (purple). Bones: T tibia, F fibula. Muscles: TA tibialis anterior, EDL extensor digitorum longus, PL peroneous longus, S soleus, GL lateral head gastrocnemius , GM, medial head gastrocnemius, P popliteus, TP tibialis posterior. Arrows (neurovascular bundles): 1 tibialis anterior vessels and deep peroneal nerve, 2 common peroneal nerve, 3 peroneal vessels, 4 tibialis posterior vessels and tibial nerve. FISH: 11-22 chromosomal translocation
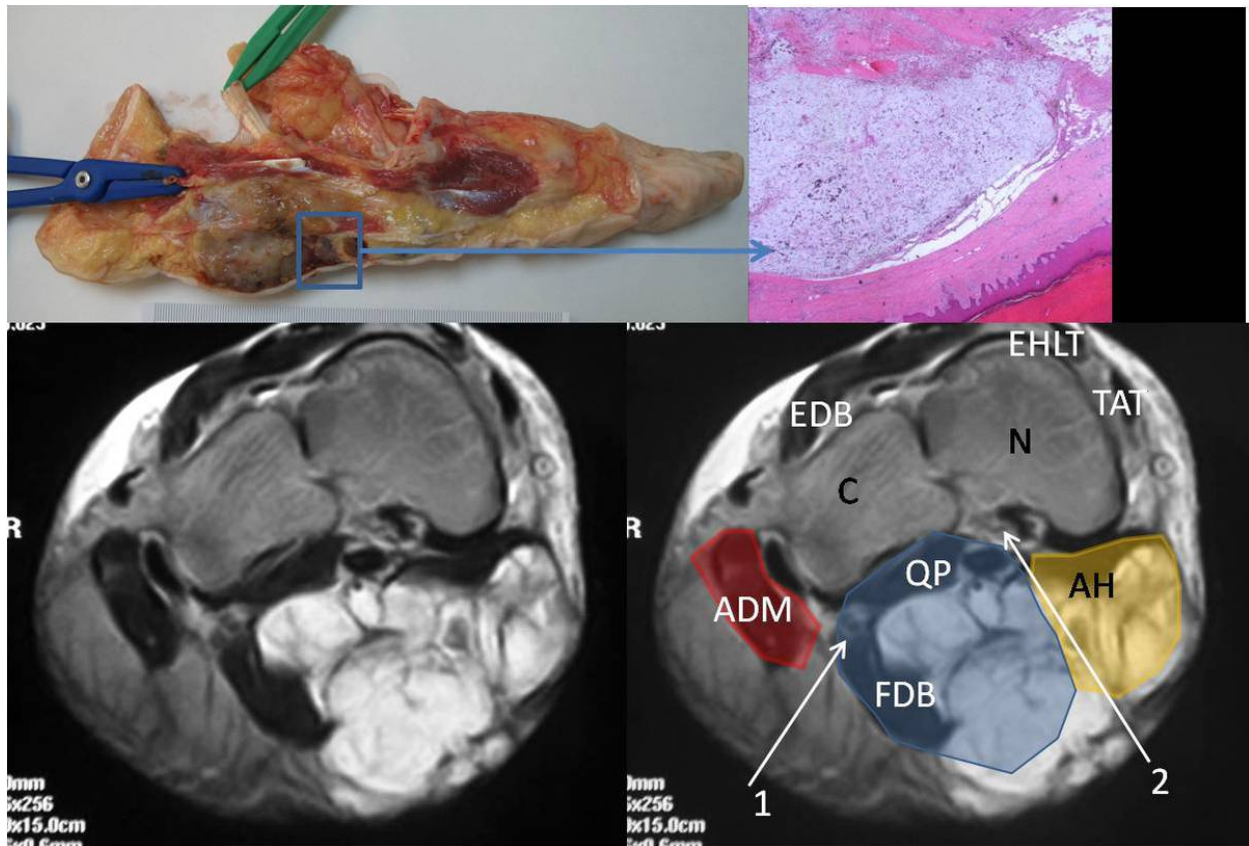
Fig. 8: Mixoid chondrosarcoma. Axial FSE DP FS MRI. Plantar anatomic compartments of the foot: Lateral (red), central (blue) and medial (yellow). Bones: C cuboid, N navicular. Muscles: EDB extensor digitorum brevis, ADM abductor digiti minimi, QP quadratus plantae, FDB flexor digitorum brevis, AH: abductor hallucis. Tendons: EHLT extensor hallucis longus, TAT tibialis anterior. Arrows (neurovascular bundles): 1 lateral plantar vessels and nerve , 2 deep medial plantar vessels and nerve. * EWS translocation.

Fig. 9: Low grade fibrosarcoma. Coronal Gd-enhanced T1 MRI. The bone tumor breaks the cortical and extends into the medial compartment of the thigh.

Fig. 10: Dedifferentiated chondrosarcoma. Coronal Gd-enhanced FS T1 MRI. The tumor invades the knee joint (arrows). * Synovitis
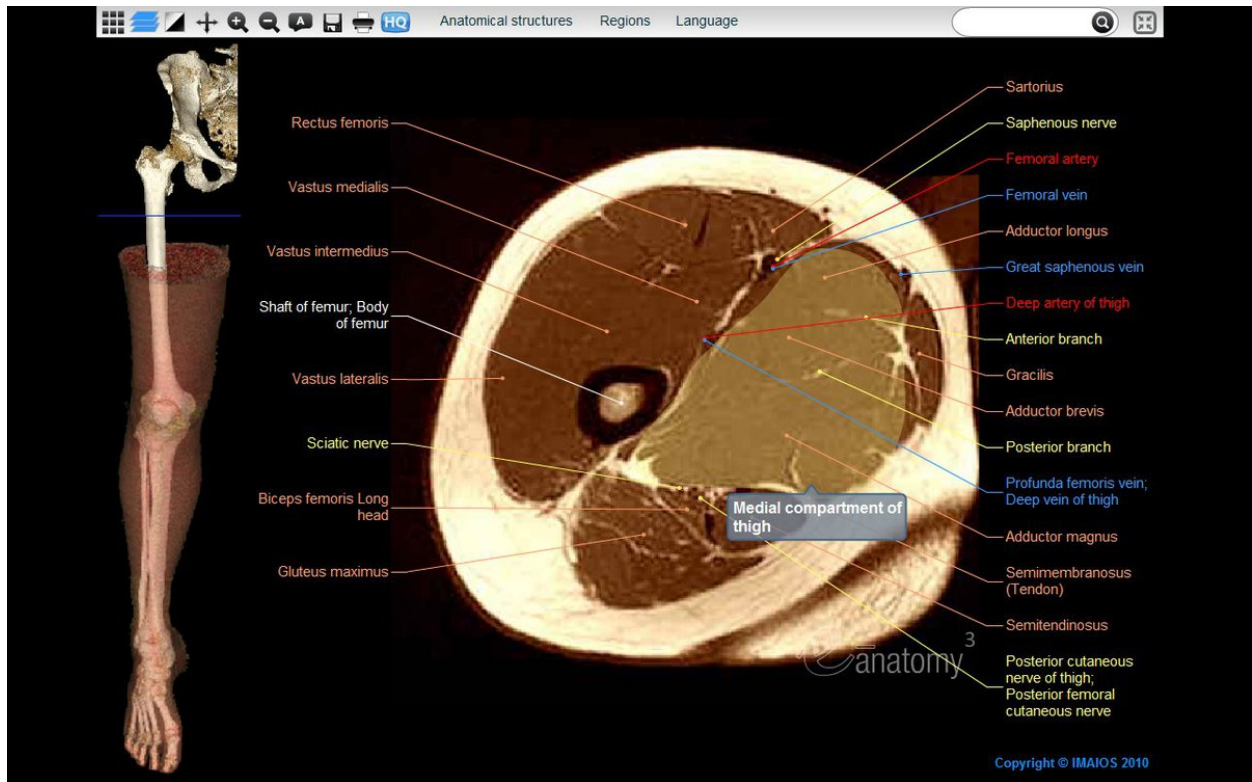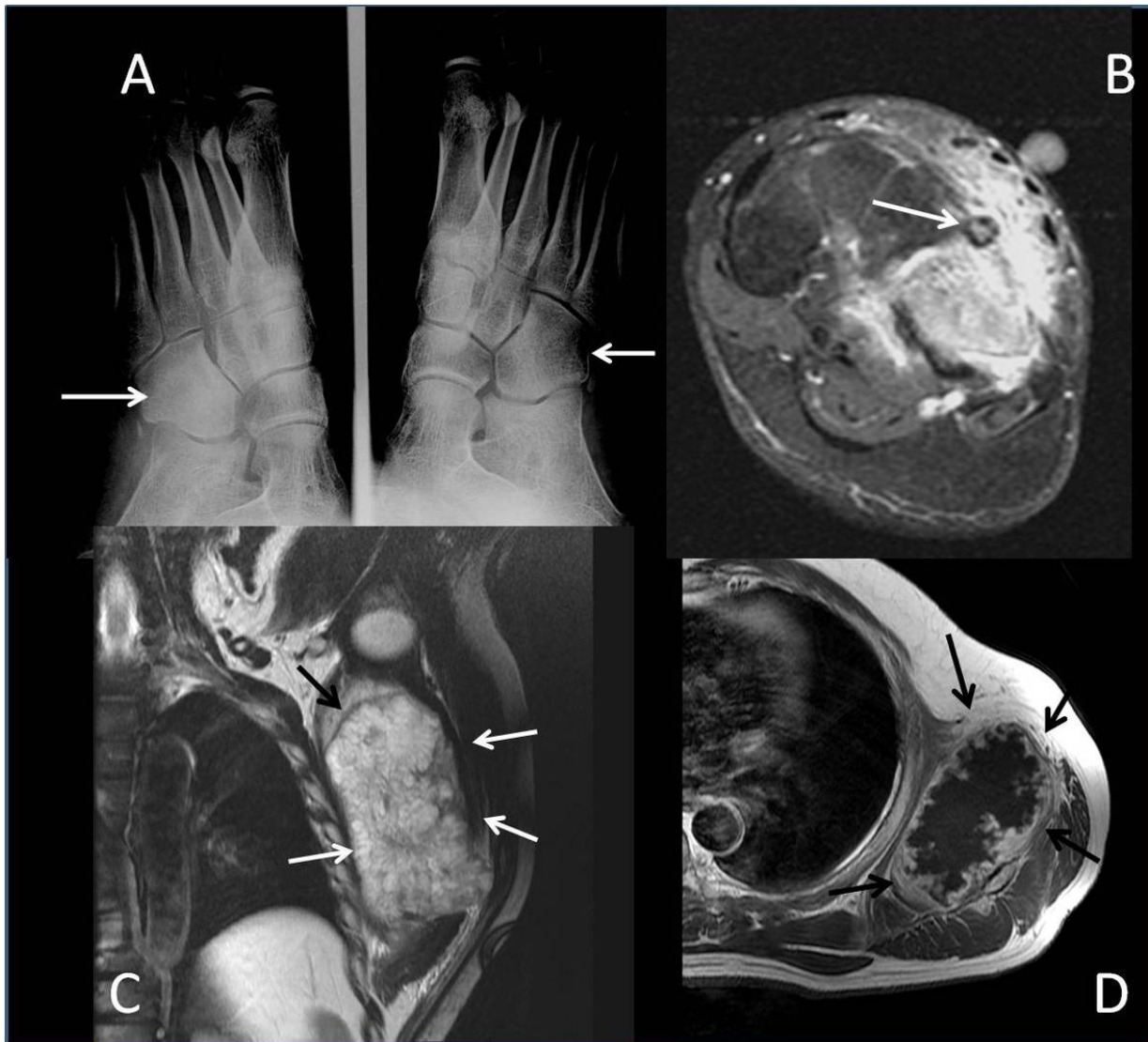
Fig. 11: On-line compartmental anatomy atlas.

Fig. 12: A This patient presented inflammatory pain that was accentuated at night, typical of osteoid osteoma. Cuboid increased attenuation. (arrows) B Axial enhanced FS T1 MRI. Note marked hyperintensity around a small nidus (arrow), in relation with important inflammatory edema, characteristic of this tumor. C Scapular chondrosarcoma (arrows).Coronal FSE T2 MRI. Typical signal hyperintensity on T2 sequence. Note also the typical peripheric lobulated gadolinium enhancement (arrows) (D).
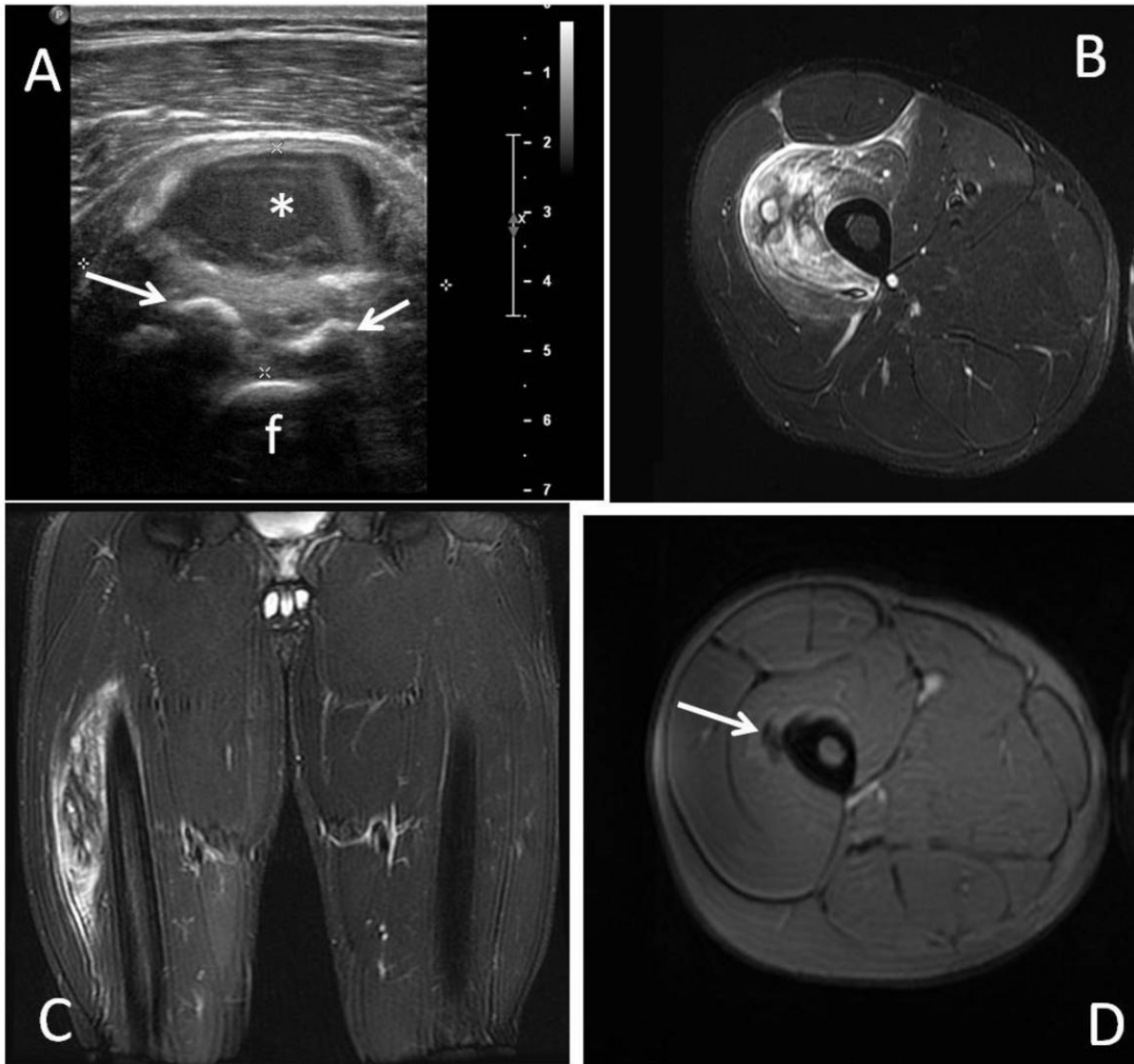
Fig. 13: Myositis ossificans. A Axial US image, anterior compartment of thigh. It shows a complex lesion, with a cystic area (*)and calcifications (arrows), superficial to the anterior cortical of the femur (f). Axial (B) and coronal (C) Gd-enhanced fat suppresion T1 images show poor defined soft tissue mass .The non- musculoskeletal radiologist´s report recommended biopsy.D Very good outcome two months later (arrow),without biopsy. The biopsy of this lesion may lead to missdiagnose as osteosarcoma: "don´t touch lesion".
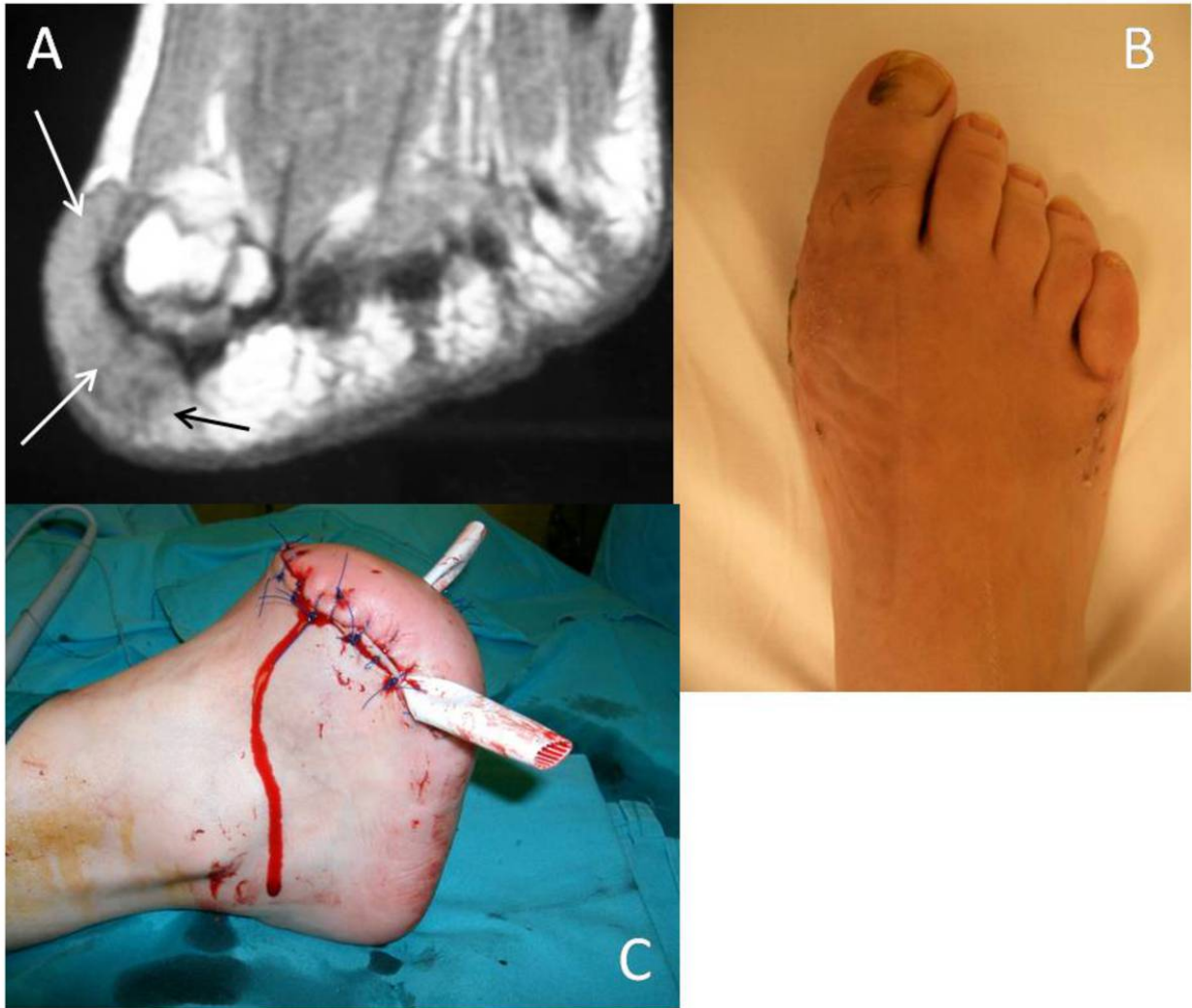
Fig. 14: A Coronal Gd-enhanced T1 MRI. Fine needle aspiration (FNA) of the lesion in the medial margin of the 1st MTP(arrows)performed in other institution was negative. B Lesion excisional surgical resection was performed. C At the end the tumor turned out a clear cell sarcoma and amputation was necessary. So we must perform biopsy because FNA may not be enough.
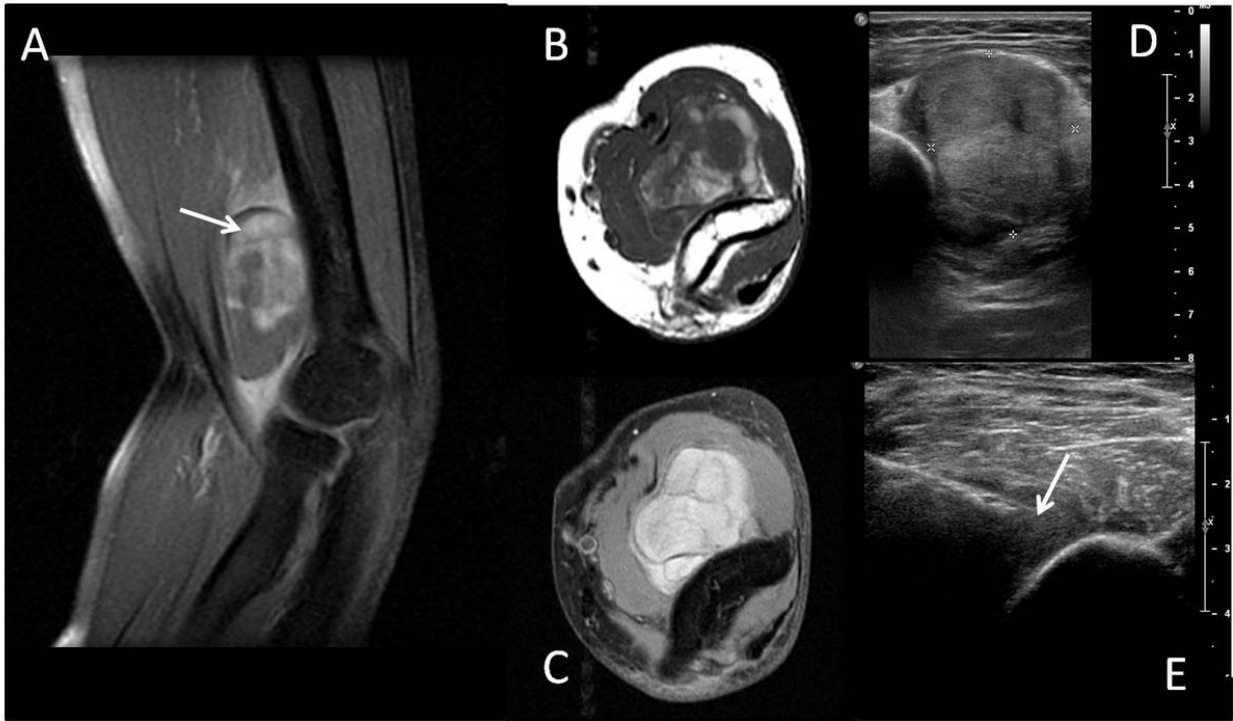
Fig. 15: Pleomorphic sarcoma. A Sagital Gd-enhanced FS T1 MRI. B Axial Gd-enhanced T1 MRI. C Axial FSE DP FS MRI. The tumor shows heterogeneous gadoliniun enhancement due to necrosis. However, it appeared quite an homogeneous solid tumor on US exploration (D)which caused poor samples in a first biopsy. E Another biopsy focused to superior Gd-enhanced part of the lesion (arrow) obtained good samples.
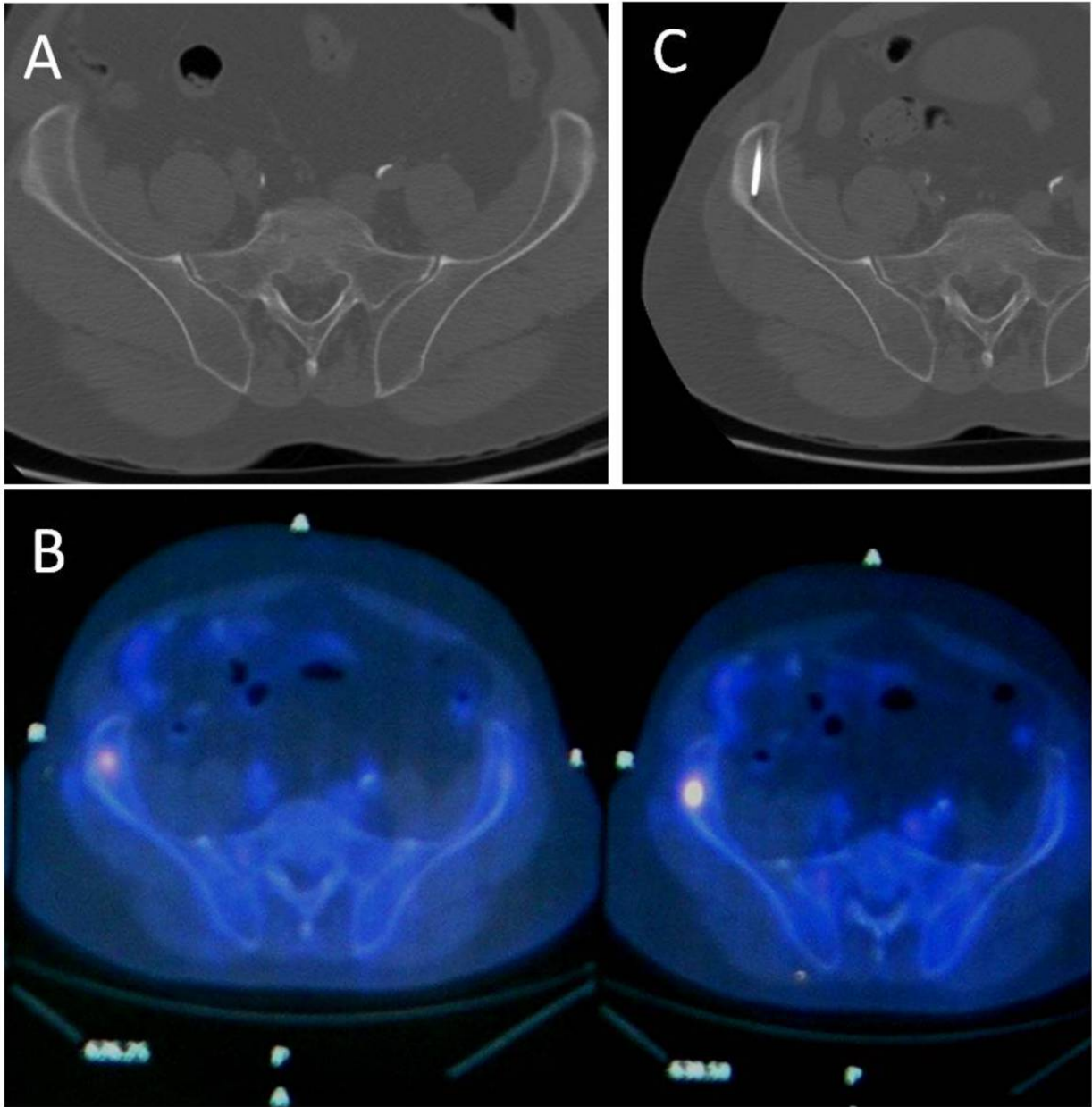
Fig. 16: A Pelvis CT axial image does not show any alterations. B However on the PET-CT there is a clear uptake focus within the iliac crest, adjacent to antero-superior iliac spine. C PET-CT guided biopsy found lung carcinoma metastasis.

Table II Biopsy approaches of upper limb

Humerus			Radius			Ulna		
Proximal	**Midshaft**	**Distal**	**Head - neck**	**Shaft**	**Distal**	**Olecranon**	**Shaft**	**Distal**
BA: better in external rotation of the humerus a) Head-neck: Trough the anterior third of deltoid muscle, lateral to deltopectoral surcus, just lateral to cephalic vein and medial to the LBT b) Just lateral to the cephalic vein and lateral to LBT **Avoid:** cephalic vein, LBT, axilar vessels, brachial plexus	BA: just posterior to the biceps muscle and cephalic vein, through distal deltoid muscle **Avoid:** cephalic vein, radial colateral artery, radial and posterior brachial cutaneous nerves	BA: a) Upper epicondyle: Through the brachialis muscle, anteriorly to the radial nerve b) Directly into the medial or lateral epicondyle **Avoid:** posterior brachial cutaneous and ulnar nerves	BA: directly posterolateral, just lateral to anconeous muscle **Avoid:** posterior brachial cutaneous nerve	BA: lateral, through ECRL muscle, just posterior to radial artery and nerve **Avoid:** lateral cutaneous nerve of forearm	BA: lateral through first extensor tendon compartment **Avoid:** superficial branch of radial nerve	BA: directly posterior, through skin and subcutaneous fat **Avoid:** triceps tendon Insertion, ulnar nerve	BA: posteromedial, through posterior aspect of the flexor digitorum profundus muscle	BA: directly medial, through skin and subcutaneou fat

Anterior compartment of the arm (deep): anterolateral between radial nerve (lateral) and cephalic vein (medial)

BA: recommended biopsy approach. LBT: long biceps tendon. ECRL: extensor carpi radial longus muscle

Fig. 17: Table II Biopsy approaches of upper limb

Table III Biopsy approaches of lower limb

Femur			Tibia	Fibula	
Head & neck	**Shaft**	**Distal**	**BA: directly anteromedial, through skin and subcutaneous fat**	**Proximal and distal ends**	**Shaft**
BA: angled subtrochanteric **Avoid:** greater peritrochanter bursas, hip joint, transverse branch of the lateral femoral circumflex artery	BA: a) Just anterior to PIS, through the posterior aspect of the vastus lateralis b) Posterior aspect of the vastus medialis **Avoid:** rectus femoris and vastus intermedius muscles	BA: directly into the medial or lateral condyle **Avoid:** medial and lateral superior genicular arteries, knee joint, popliteal fossa	**Avoid:** a) Proximal end: tibial tubercle (patelar tendon insertion), anserina tendons insertion b) Distal end: great saphenous vein, saphenous nerve	BA: directly lateral, through skin and subcutaneous fat **Avoid:** a) Proximal end: common fibular nerve, biceps femoris insertion b) Distal end: lateral dorsal cutaneous nerve, fibularis tendons	BA: just anterior to PIS, through the posterior aspect of the longus fibularis muscle **Avoid:** superficial fibular nerve

Thigh medial compartment: anterior to the gracilis muscle, posterior sartorios muscle

Deep posterior compartment: through lateral gastrocnemius

BA: recommended biopsy approach. PIS: posterior intermuscular septum

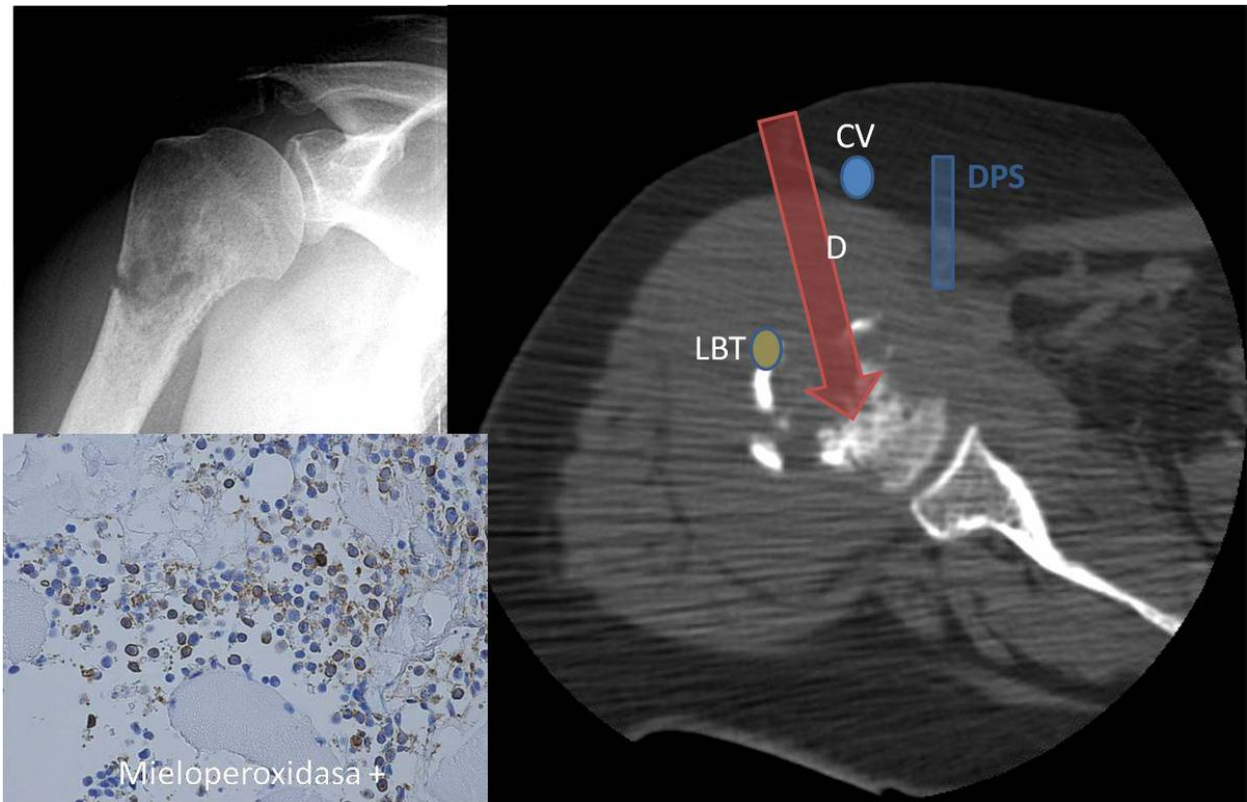**Fig. 18:** Table III Biopsy approaches of lower limb

Fig. 19: Humeral head and neck biopsy approach (red arrow). Between cephalic vein (cv) medially, and long biceps tendon (LBT) laterally, through the anterior third of deltoid (D), and lateral to the deltopectoral surcus (DPS). Granulocytic sarcoma.
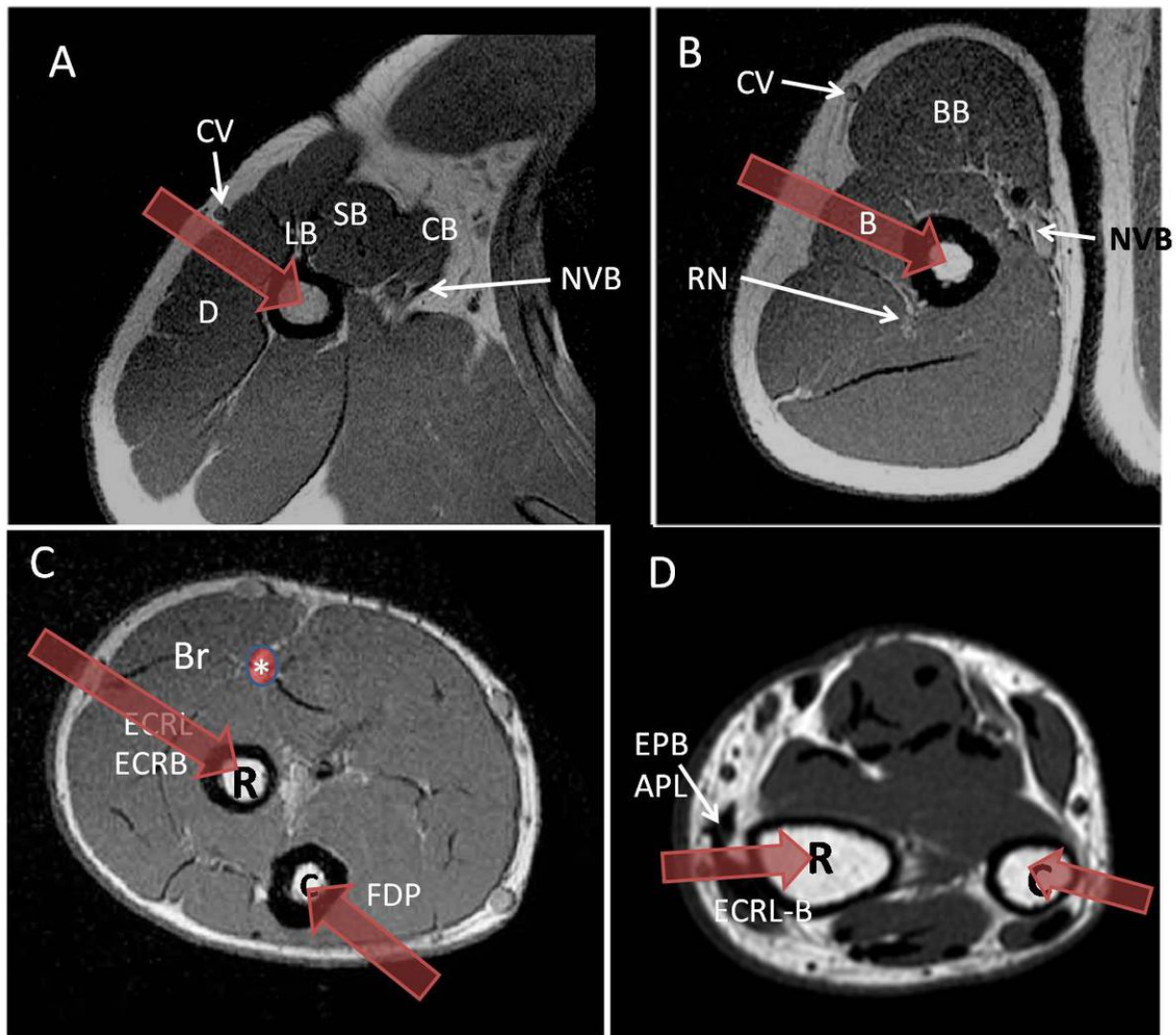
Fig. 20: Arm and forearm biopsy approaches (red arrows). A At proximal shaft of humerus, through inferior aspect of deltoid muscle (D), just posterior to the cephalic vein (CV). LB, SB long and short head of biceps muscle. CB coracobrachialis muscle. NVB neurovascularbaxillary bundle. B At midshaft of humerus, through brachialis muscle. RN radial nerve. BB biceps brachialis muscle. C At radius shaft through posterior aspect of extensor carpi radialis longus muscle (ECRL), posterior to the radial artery and the superficial radial nerve branch(*). At cubitus shaft through the most posterior aspect of flexor digitorum profundus muscle (FDP). D At distal cubitus end, directly through the skin and subcutaneous fat. At distal radius end, through first extensor tendon compartment: extensor pollicis brevis (EPB) and abductor pollicis longus (APL). R radius bone, C cubitus bone.
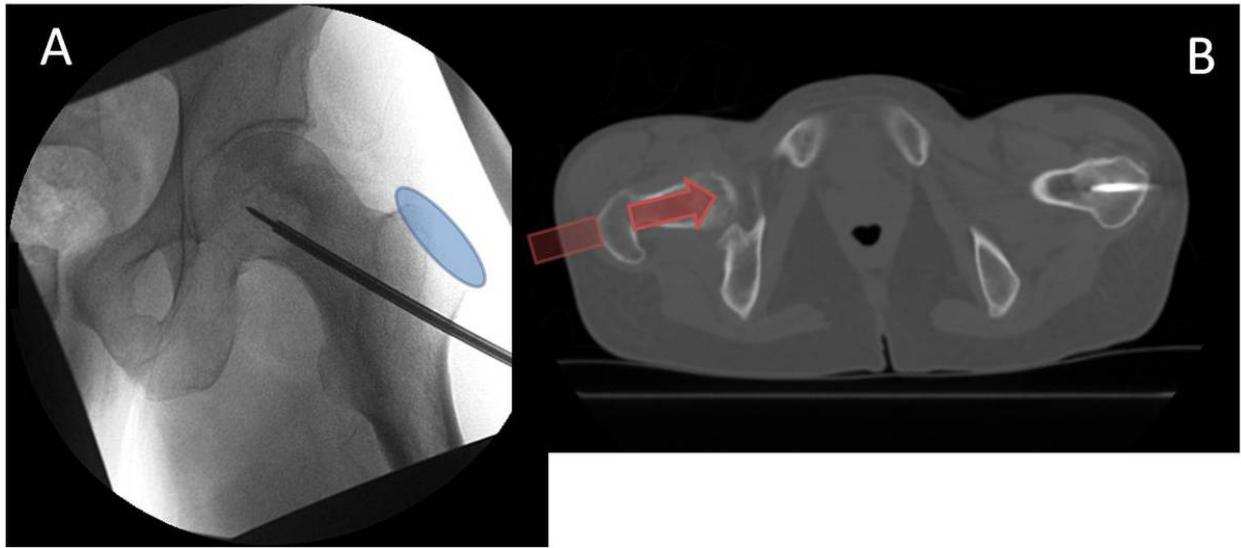
Fig. 21: Angled subtrochanteric approach , fluoroscopic- guided (A) in a case of osteosarcoma; and CT - guided in onother patient. (B) Avoid joint capsule and peritrochanteric bursa (blue).
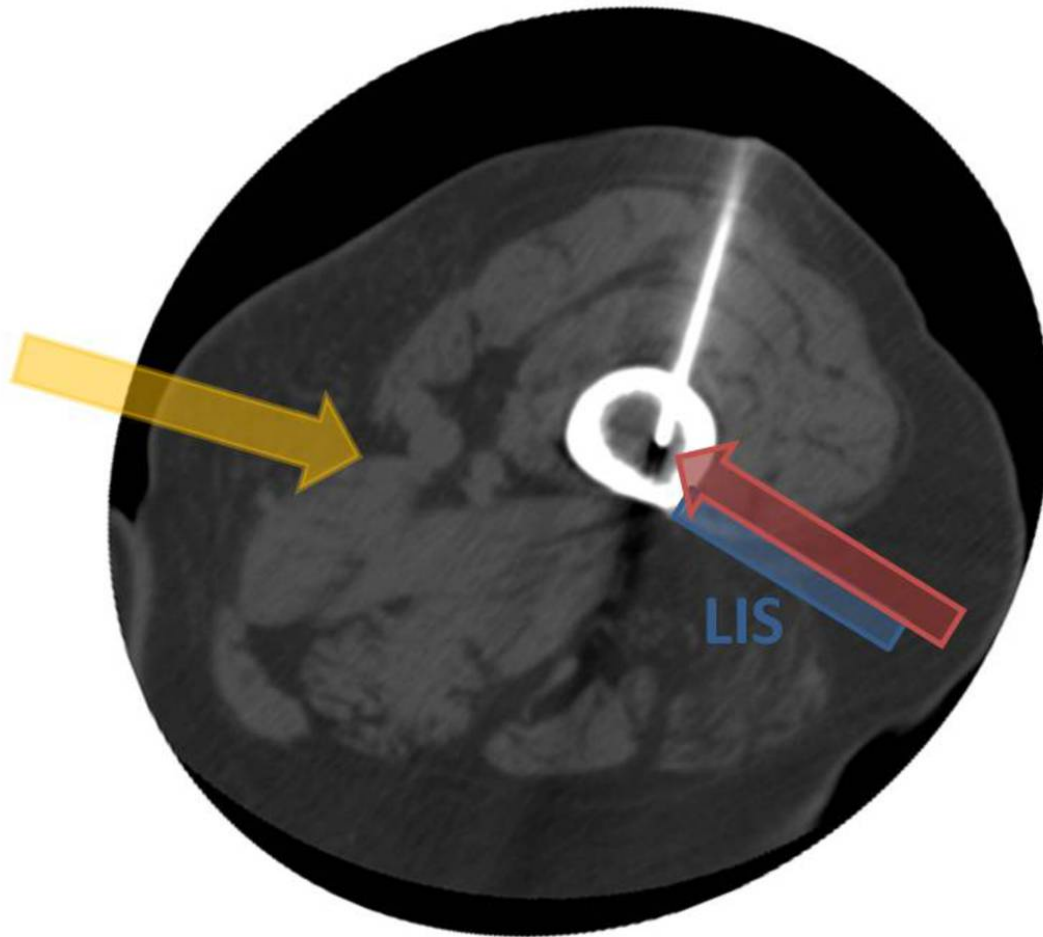
Fig. 22: Femoral shaft approach. Red arrow shows the recommended approach: just anterior to the lateral intermuscular septum (LIS) (blue). Avoid the incorrect biopsy approach that was performed, through the rectus femoris and vastus intermedius. Fortunatelly, it was a low grade follicular lymphoma. Yellow arrow: Recommended approach for a tumor in the medial compartment.
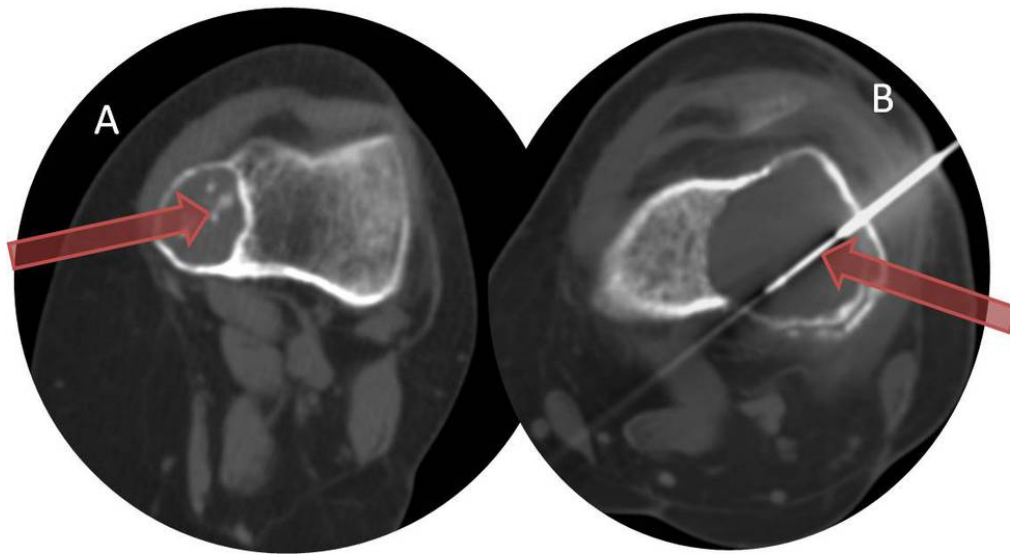
Fig. 23: Distal femur approach. Red arrow shows the correct approach: directly into the medial and lateral condyles. Just upper this level, the approach is through the posterior aspect of the vastus medialis and lateralis. A Low grade chondrosarcoma. B MFH biopsy with a slightly more anterior approach than recommended.
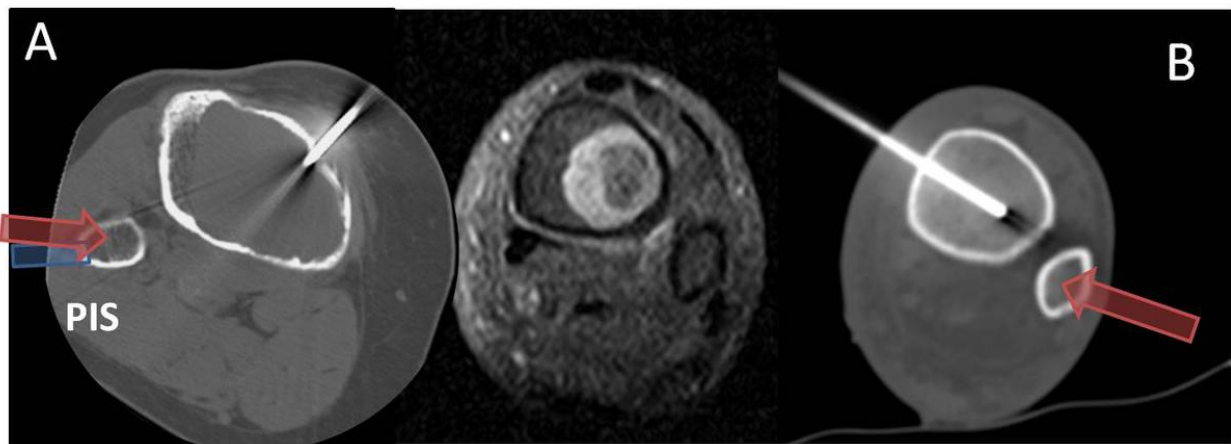

Fig. 24: Leg biopsy approach. Directly through skin and subcutaneous fat in the tibia and in the end of the fibula. The fibular shaft approach (red arrow)is just anterior to posterior intermuscular septum (PIS), through the posterior aspect of the peroneous longus (PL). A Giant cell tumor B Mixoid liposarcoma . Axial STIR MRI.
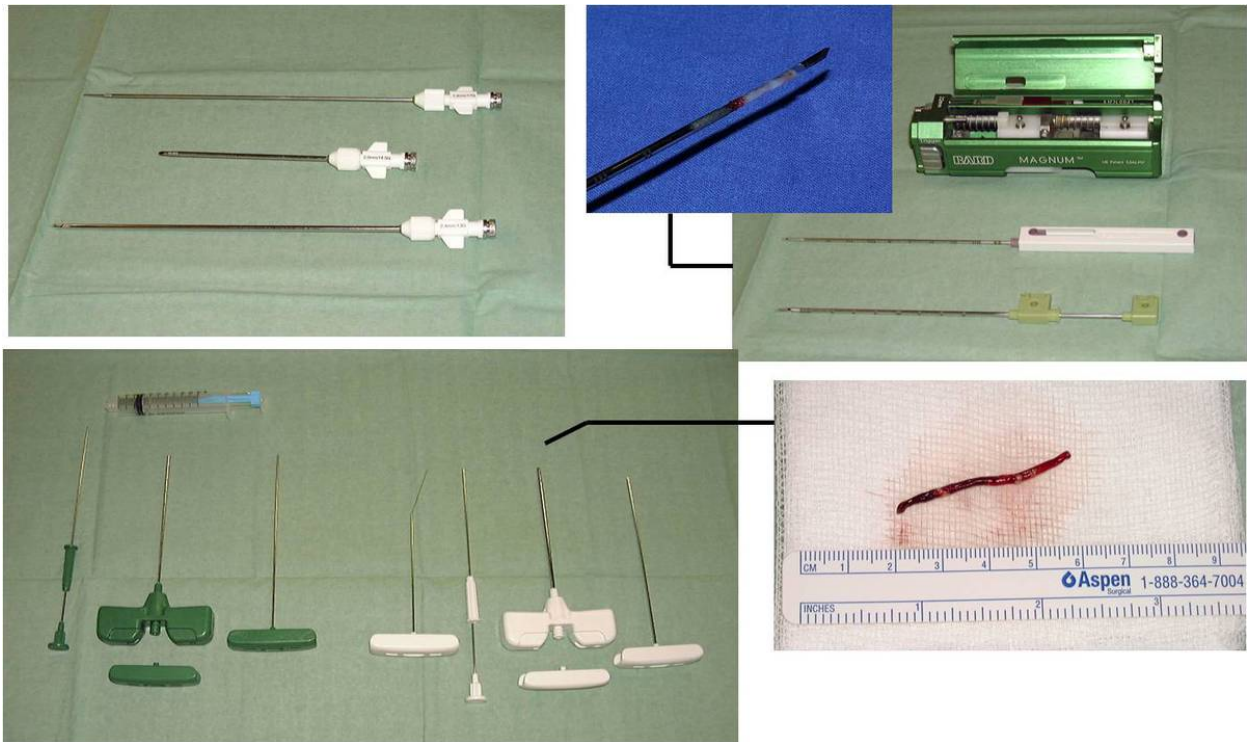
Fig. 25: Different needles that we use. Note examples of samples we have got with some of them: upper of humeral chondrosarcoma (US-guided), lower of non specific chronic inflammatory lesion within the iliac bone (CT-guided).
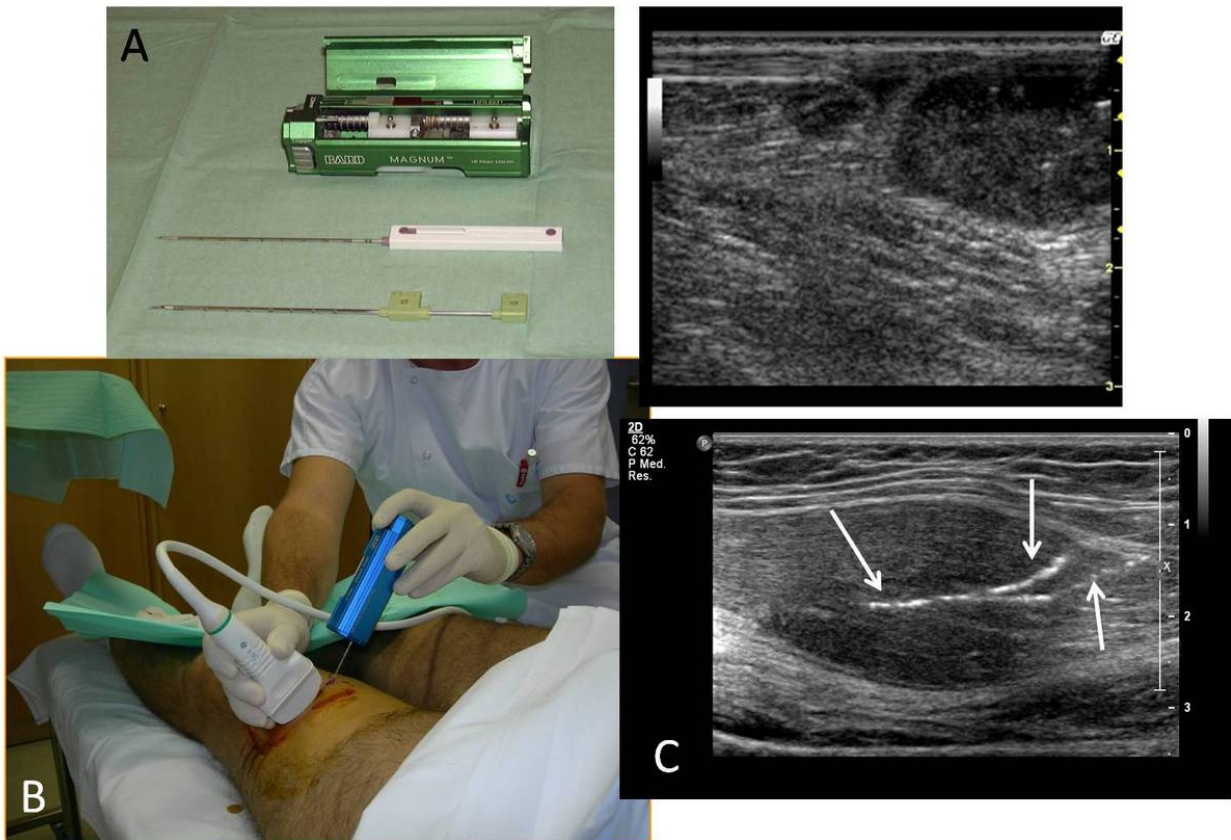
Fig. 26: US guided biopsy. A Automatic biopsy device. We use 16 -14 G trucut needles that get samples 15 or 22 mm long. B Real time visualization of the needle insertion towards the lesion, parallel to the ultrasound beam. C Note de hyperechoic lines from the biopsy tracts (arrow).
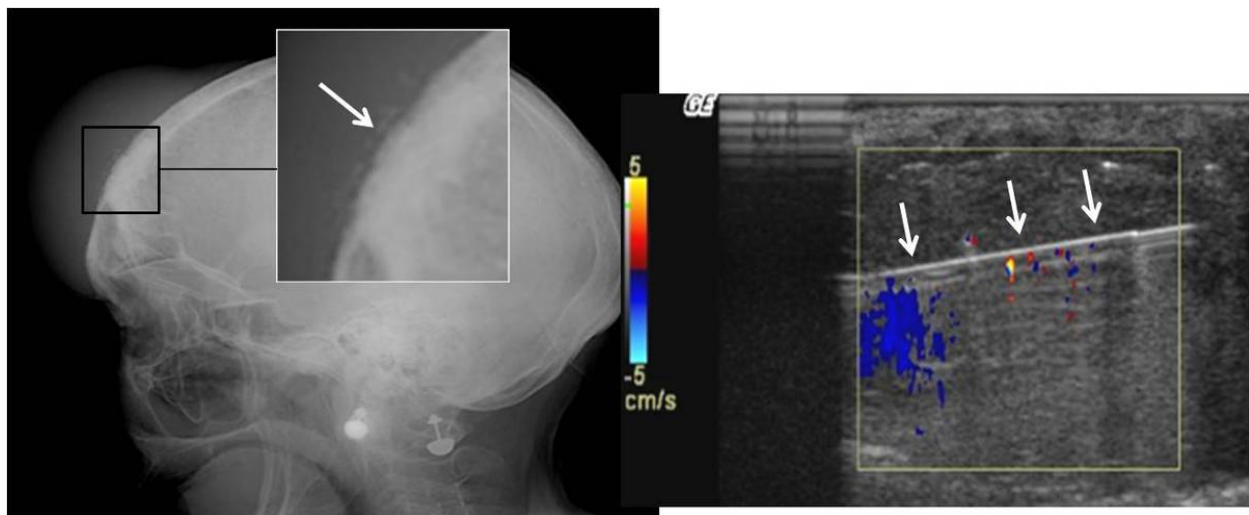

Fig. 27: Calvaria lymphoma . A Prominent soft tissue asociated to the fontal bone lesion (note the small calcifications next to the bone surface from bone destruction (arrow). B Hyperechoic ultrasound image of the needle inside the tumor, during the biopsy (arrows).
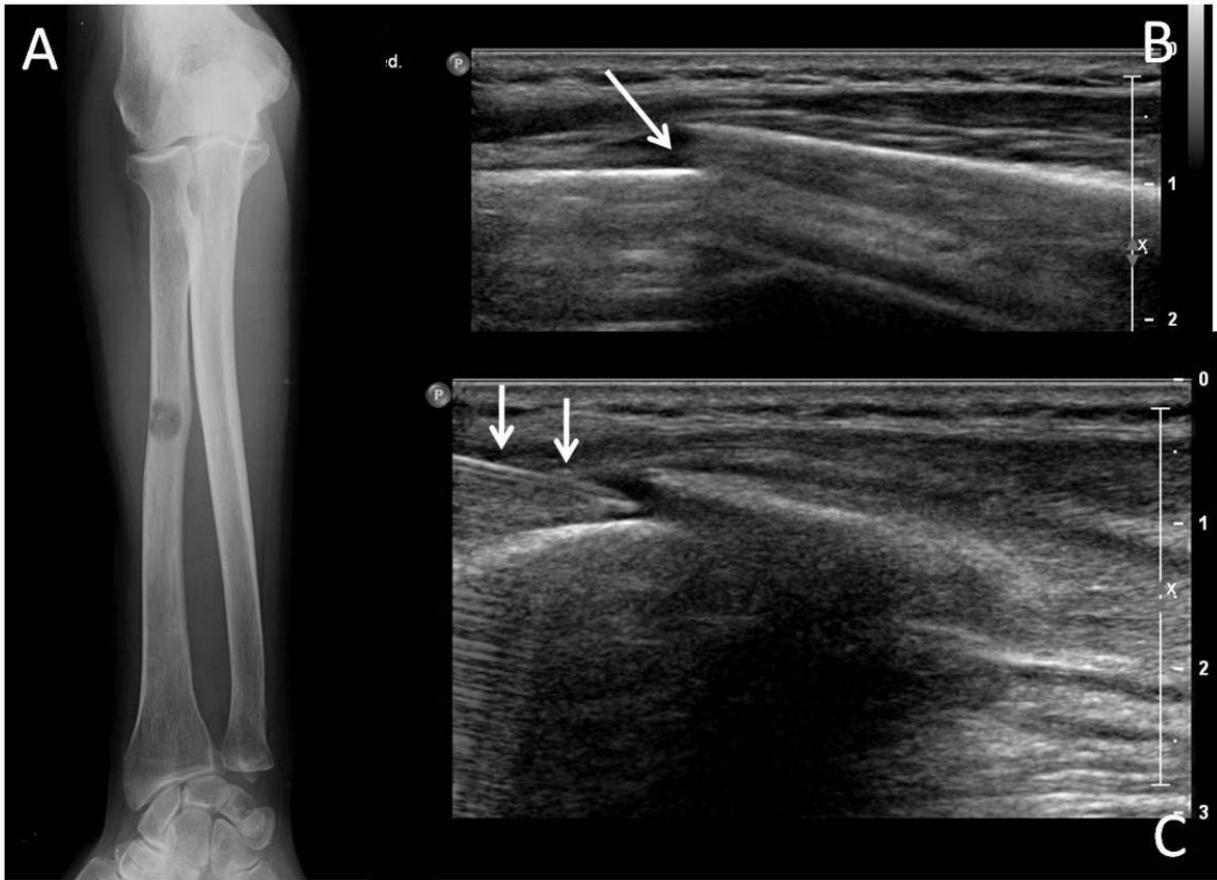
Fig. 28: Urothelial bone metastasis- A Geographic bone lesion I B in the radius shaft. B Rupture of the cortical was well seen on US exploration (arrow). C US-guided biopsy was performed. Arrows: needle.
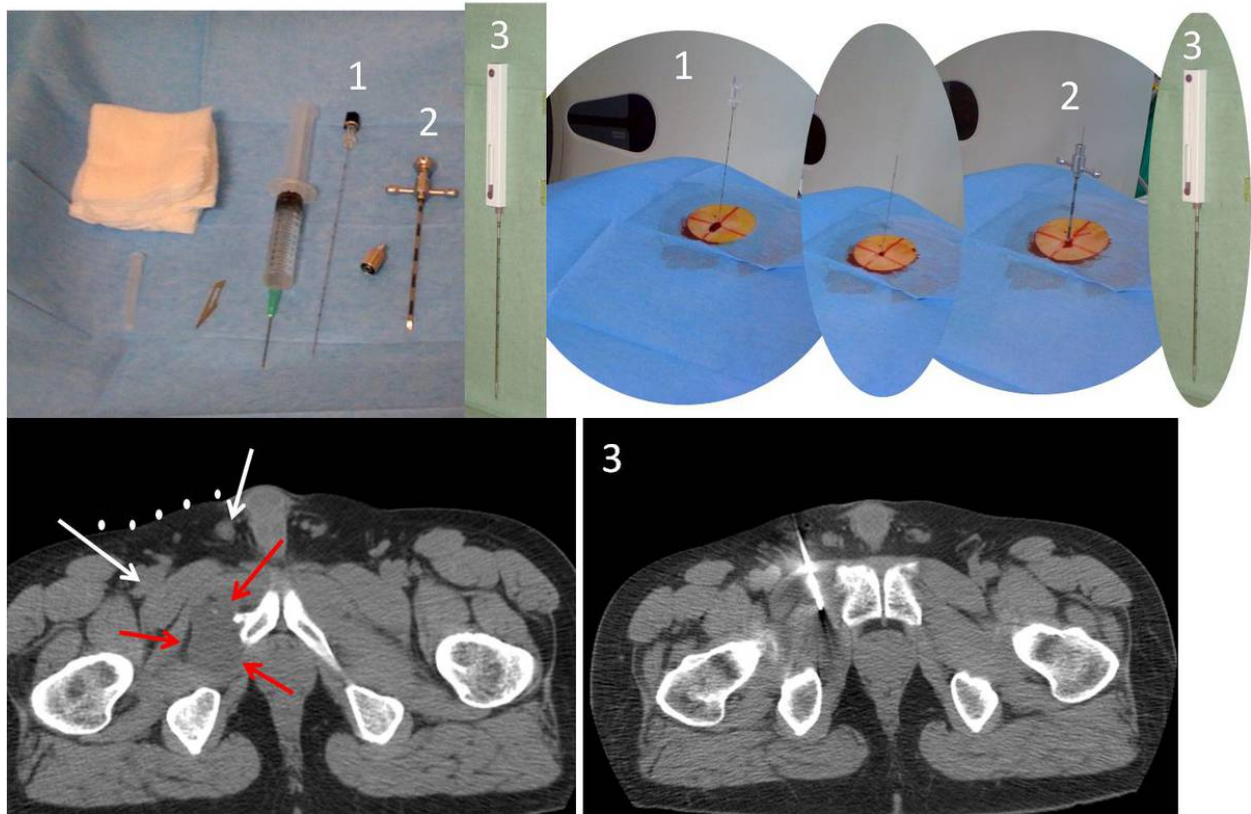
Fig. 29: 1 After planning and marking on the skin the CT-guided approach, the 19-22 G Chiba needle is inserted to infiltrate the anesthetic agent and to lead the biopsy tract, between the inguinal canal and the femoral vessels (arrows). 2 Introduction of the 13G needle coaxially to the beheaded Chiba needle. 3 Coaxial introduction of automatic 16G needle and sampling by 3-5 passes with slight angulations of the 13 G needle. Periostic chondroma (red arrows).
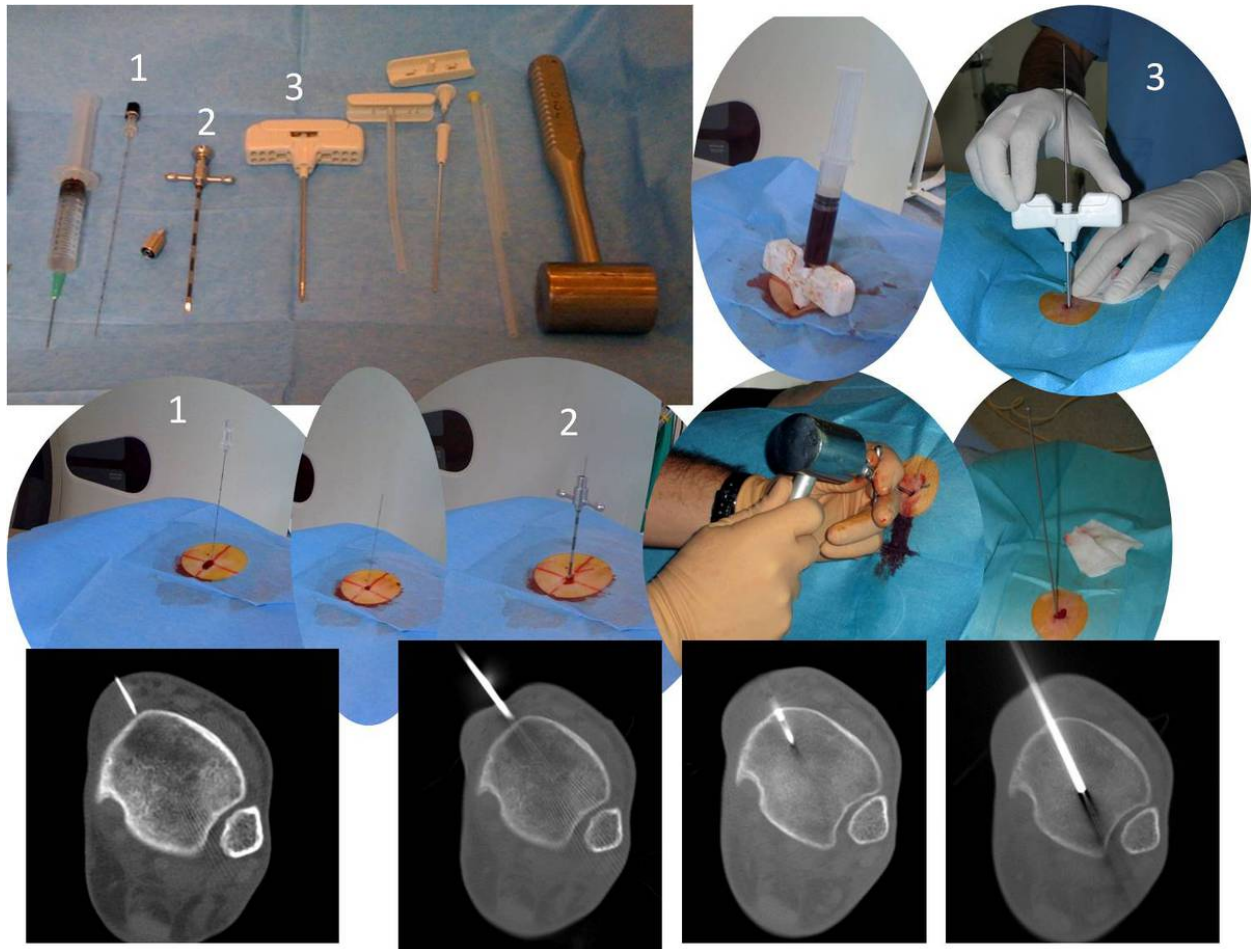
Fig. 30: 1 Chiba needle is inserted to infiltrate the anesthetic agent and to lead the biopsy tract . 2 Introduction of the 13G needle (vertebroplasty type) coaxially to the beheaded Chiba needle to penetrate the cortical bone. 3 Insert the bone biopsy 13-11G needle coaxially to a Kirschner needle , introduced previously through the anterior one.
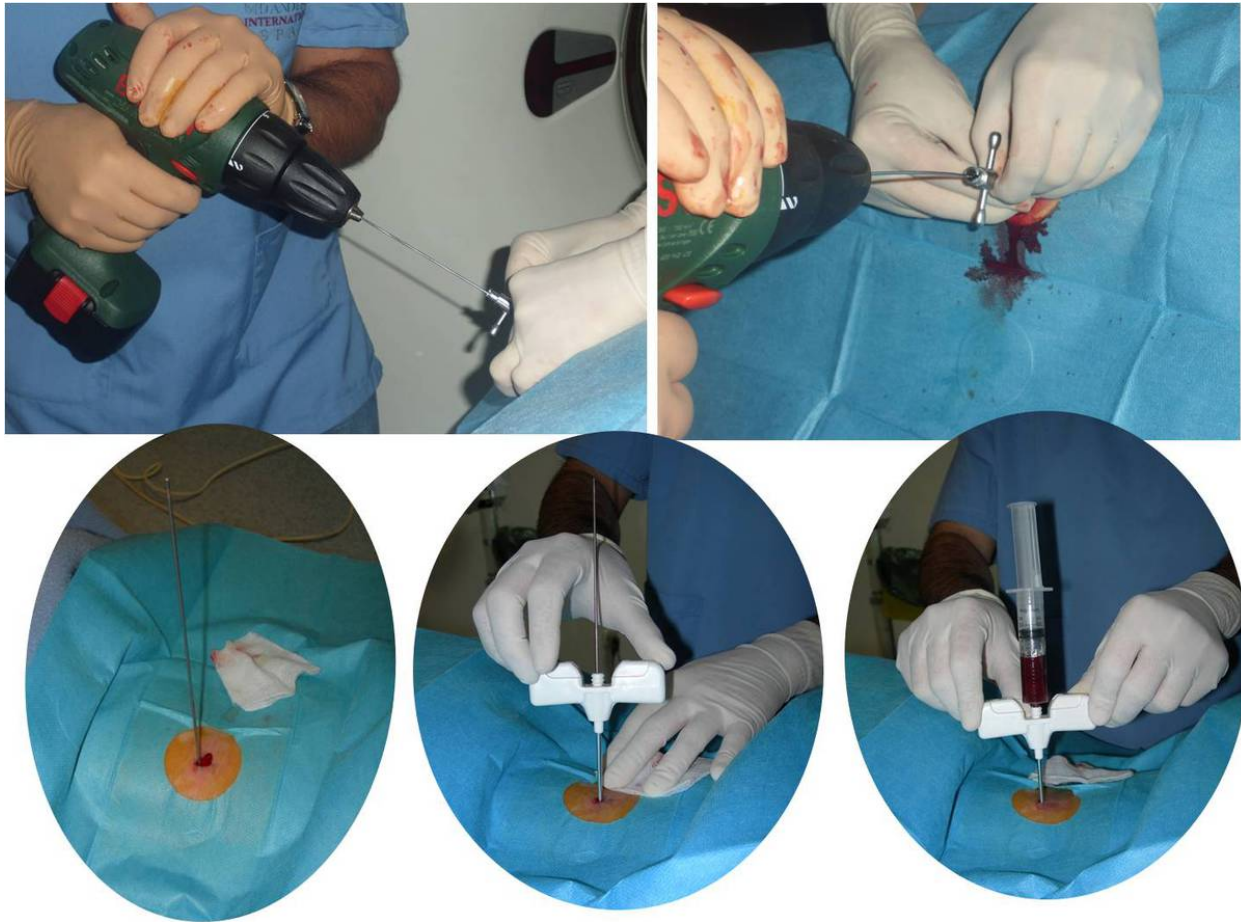
Fig. 31: To penetrate hard cortical bone,it may be necessary to drill. We use a Kirschner needle. Then we insert the bone biopsy 13-11G needle coaxially to the Kirschner neddle .
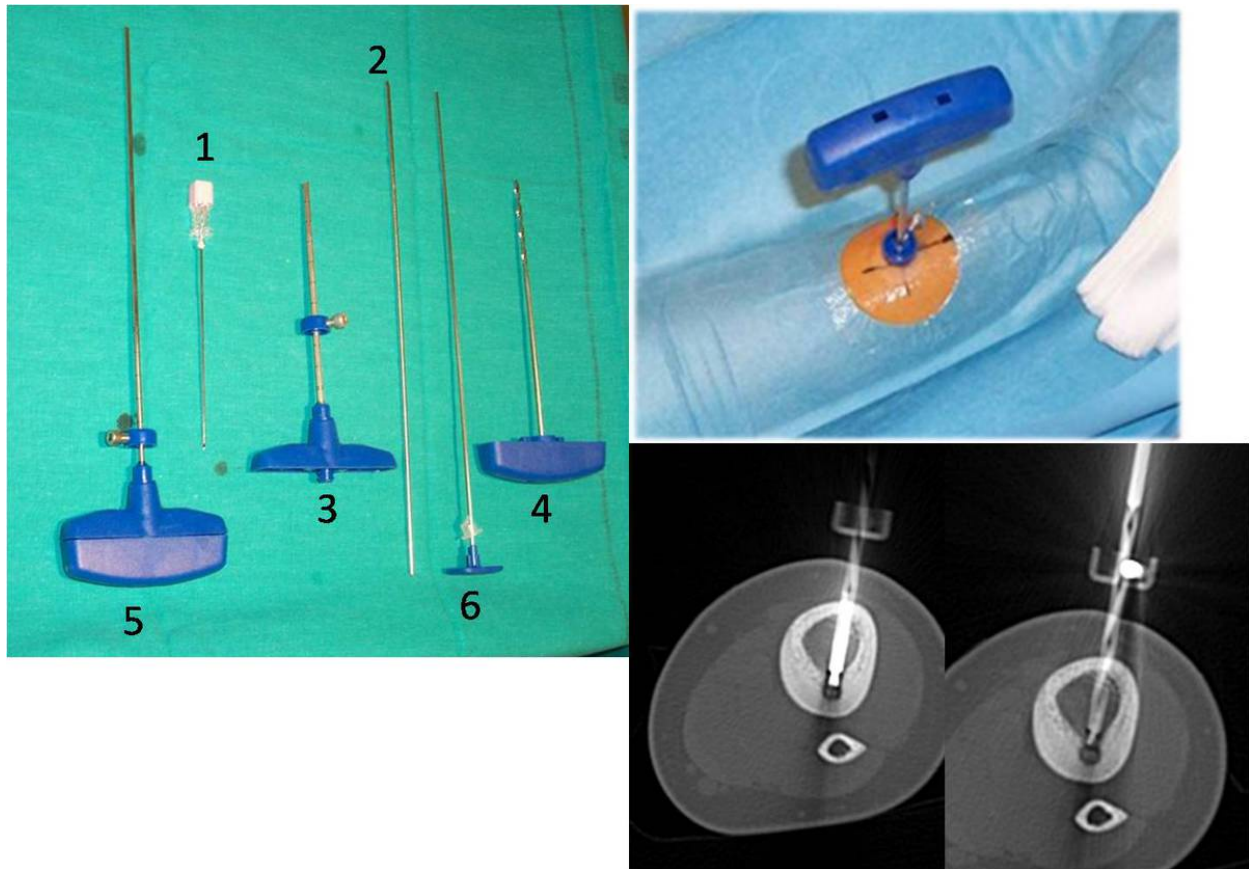
Fig. 32: Method of Laurane hard bone biopsy kit (Wacrees) 1 Insert the anaesthesia needle all the way down to the periosteum. 2 Insert the stiffening stylet until bone is reached, parallel to needle 1. 3 Slide the sharp tip cannula on the needle 2. 4 Remove needle 2, insert the drill through needle 3 and lock it. Rotate clockwise penetrating the cortical bone. 5 Remove the drill and insert the biopsy needle and take out the sample. 6 Insert the ejector pin to eject the sample out.
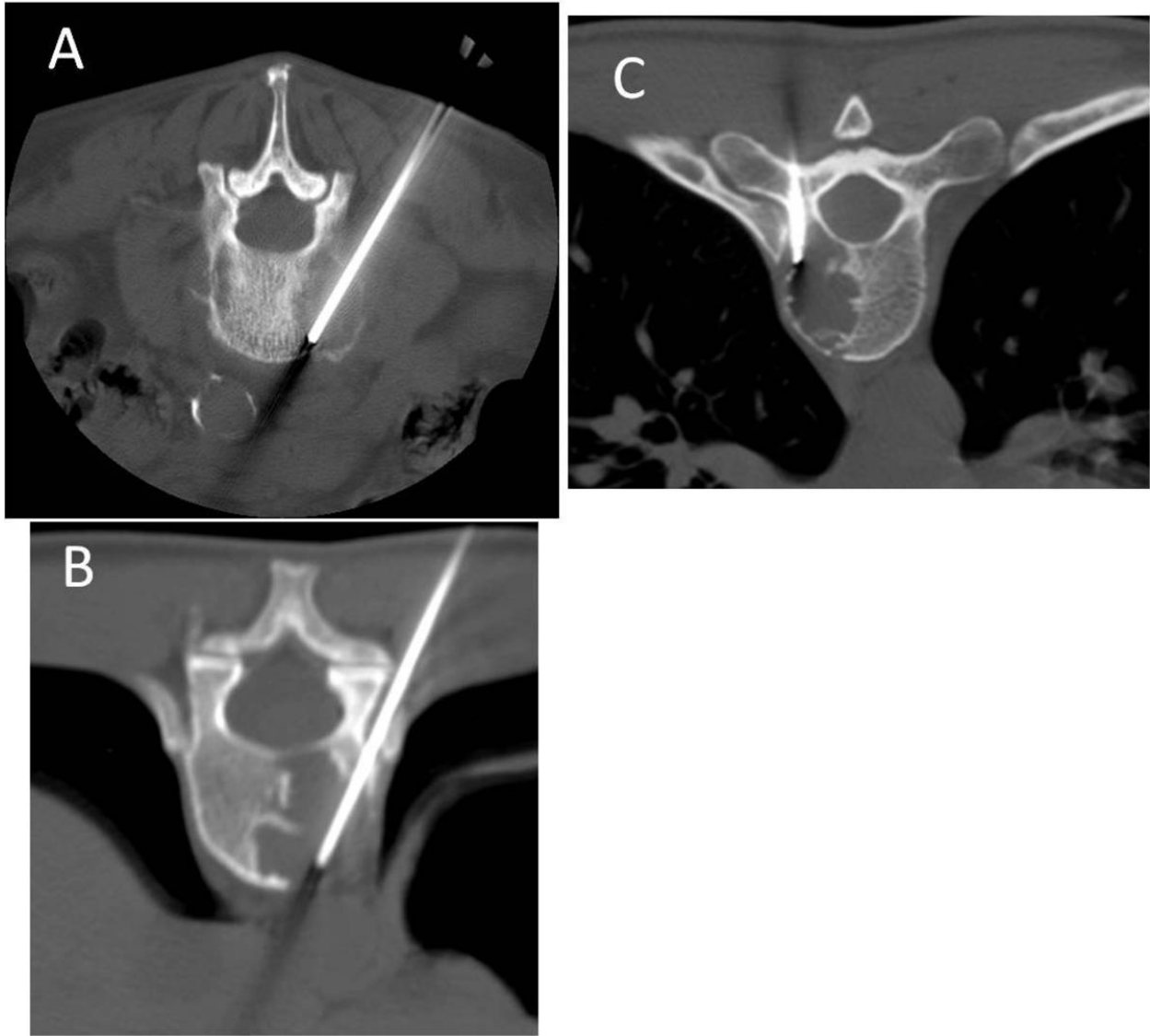
Fig. 33: Different vertebral biopsy approaches: A paravertebral, B costovertebral, C transpedicular.
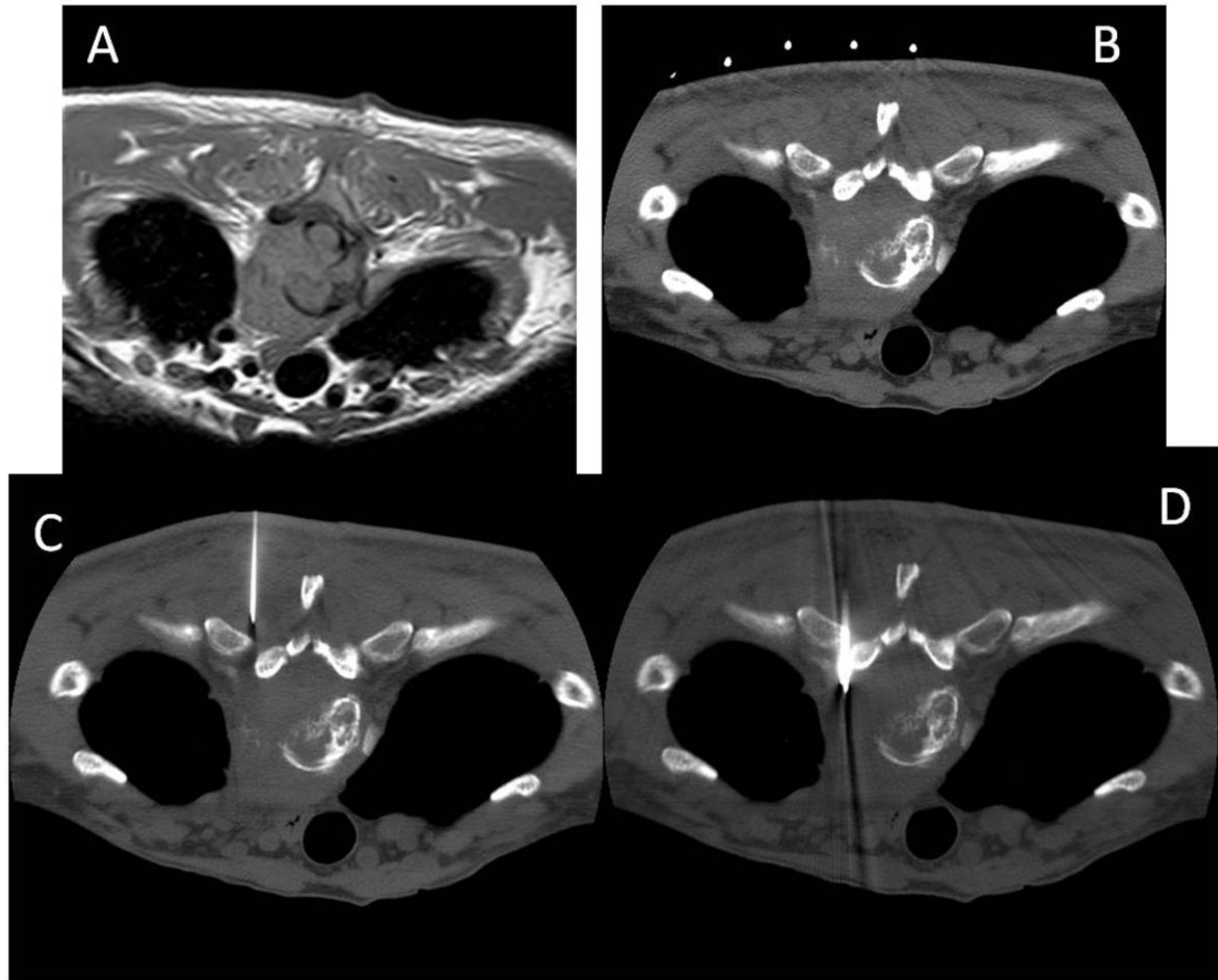
Fig. 34: Introduction of the 13G needle coaxially to the beheaded Chiba needle to go through the bone. After that, coaxial introduction of automatic 16G needle and sampling the soft tissue component with little angulations of the 13 G needle.Melanoma metastasis.
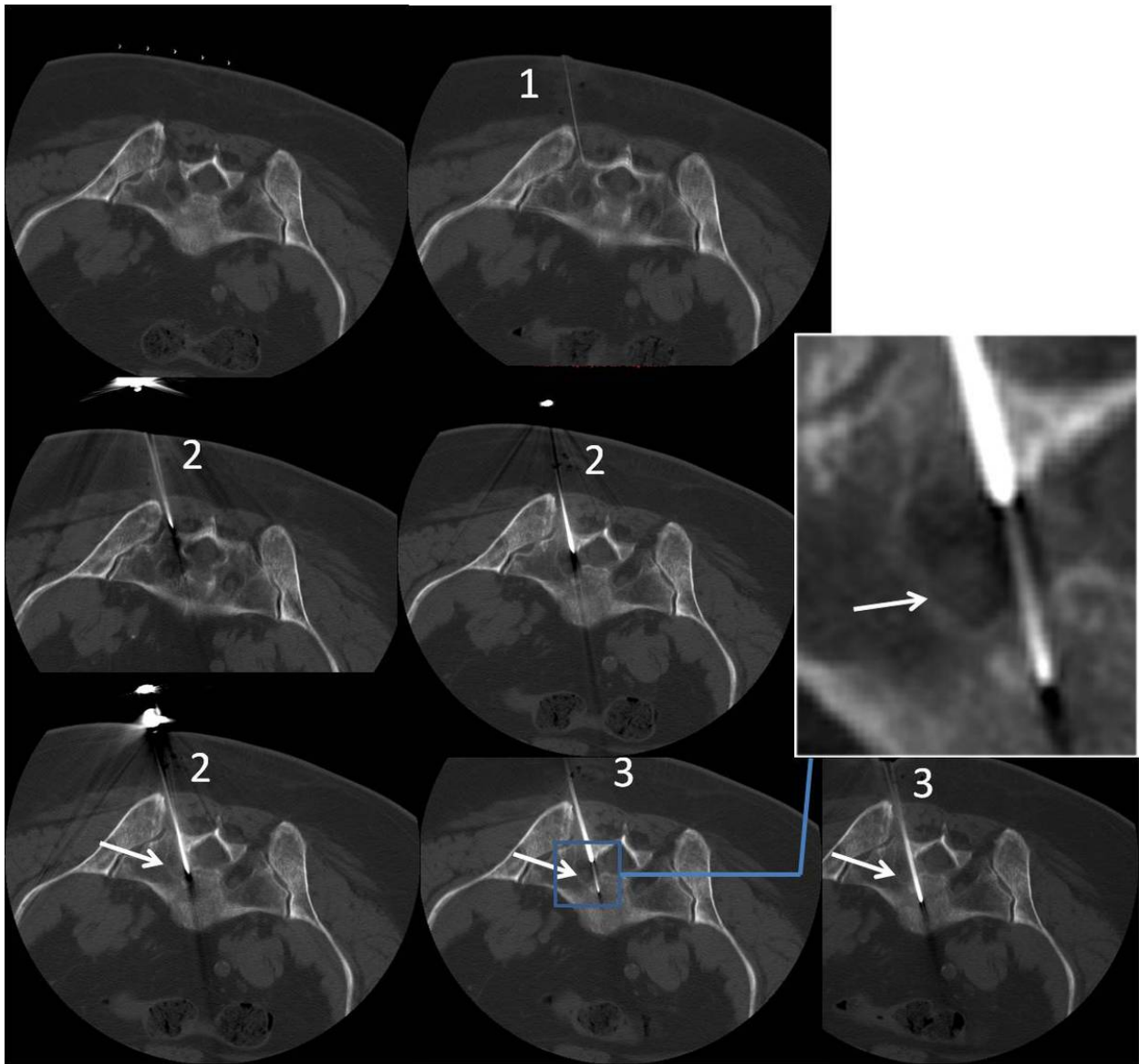
Fig. 35: 1 Chiba needle is inserted to infiltrate the anesthetic agent and to lead the biopsy tract. 2 Introduction of the 13G needle (vertebroplasty type) coaxially to the beheaded Chiba needle to penetrate the cortical bone. Special atention is paid to the first sacral foramen (arrow). 3 Insert the bone biopsy 13-11G needle coaxially a Kirschner neddle ,previously introduced through the anterior one.Lymphoma.

Fig. 36: A Sagital Gd-enhanced FS T1 MRI. There is an infiltrative lesion in clivus, C1 and C2; with soft tissue involvement (arrows). B Neddle introduction with ORL supported. Outside (C) and inside (D) needdle position.

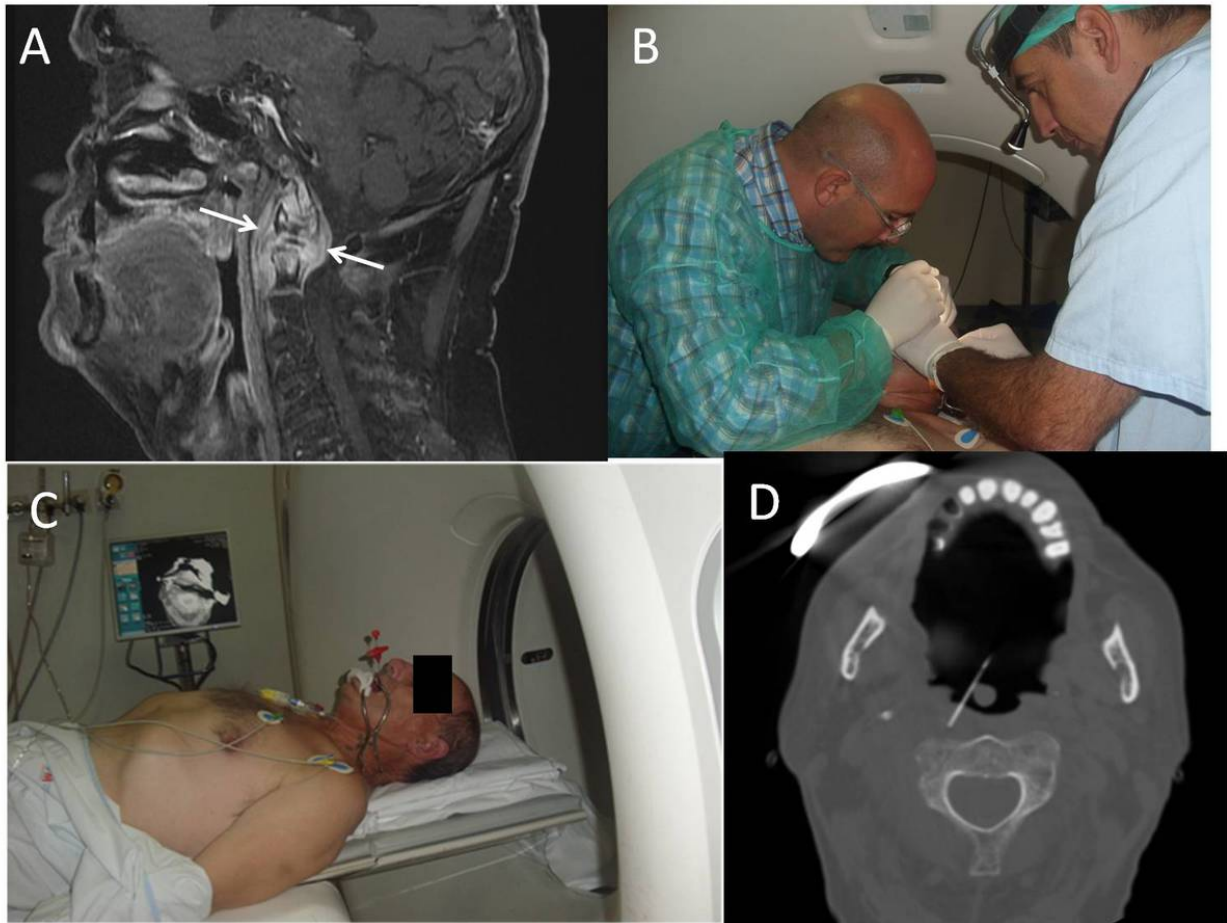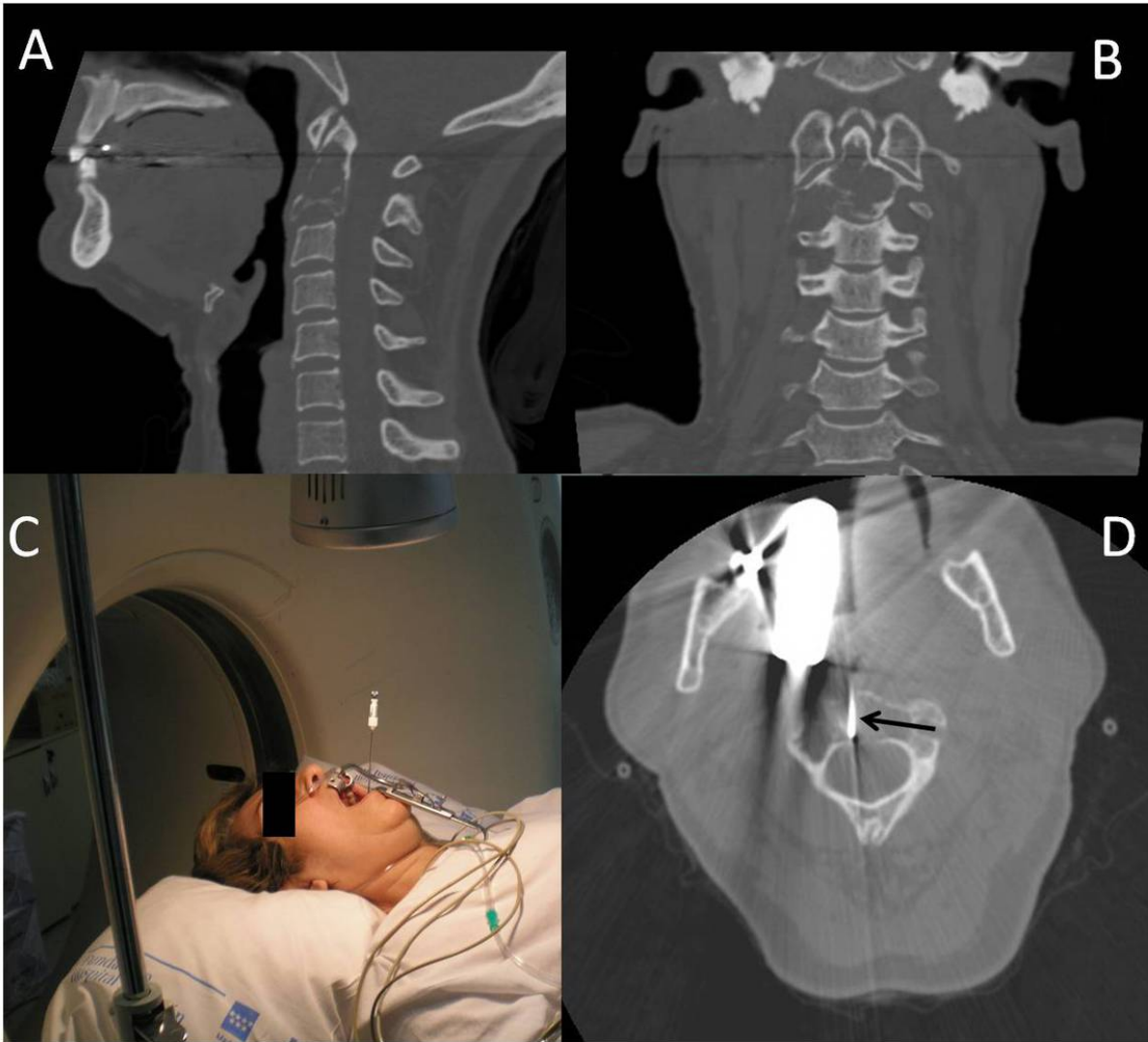**Fig. 37:** A sagital reconstruction and B coronal reconstruction helical CT of cervical spine. Extensive osteolytic lesion in C2. Outside (C) and inside (D) needle position (arrow).

Table IV. Enneking Bone Staging System

Stage	Grade	Compartment
I A	Low	Intra
I B	Low	Extra
II A	High	Intra
II B	High	Extra
III A	Low or high	Intra + Metastatic
III B	Low or high	Extra + Metastatic

Roman numeral: hystologic grade. A,B: compartment
Stage III: metastatic

Fig. 38

Table V. AJCC 2002 Bone Staging System

Stage	Grade	T	N	M
I A	G1-G2	T1 (<_8 cm)	0	0
I B	G1-G2	T2 (>8 cm)	0	0
II A	G3-G4	T1	0	0
II B	G3-G4	T2	0	0
III	Any	T3 (Skip)	0	0
IV A	Any	Any	0	1a (Lung)
IV B	Any	Any	1	Any
IV B	Any	Any	Any	1b (Other)

G1: well differentiated. G2: moderately differentiated. G3: poorly diferentiated.
G4: undifferentiated. N0: no lymph nodes. M0: no distant metastases.

Fig. 39

Table VI. AJCC 2005 5th ed. Soft tissue Sarcoma Staging System

Size and location of the tumor (T)	Stage	G	T	N	M
T1: <_5 cm	I A	1-2	1a - 1b	0	0
	I B	1-2	2a	0	0
T2: > 5 cm	II A	1-2	2b	0	0
Ta: superficial to superficialis fascia	II B	3-4	1a - 1b	0	0
Tb: deep to superficialis fascia	II C	3-4	2a	0	0
Histologyc grade (G)	III	3-4	2b	0	0
G1: well differentiated	IV A	Any	Any	1	0
G2: moderatelly differentiated	IV B	Any	Any	Any	1
G3: poorly differentiated **G4:** undifferentiated	LYMPH NODES (N) N 0: no lymph nodes N 1: metastatic lymph nodes		METASTASES (M) M 0: no distant metastases M 1: distant metastases		

Fig. 40

Conclusion

The musculoskeletal radiologist plays a key role in the staging of musculoskeletal tumors.This includes description in detail of locoregional tumor extension, based in compartment anatomy, and percutaneous biopsy.

The musculoskeletal radiologist must master the recommended approaches and technical aspects of percutaneous biopsy, which in experienced hands, is safe and accurate to accomplish an adequate diagnosis and staging of musculoskeletal tumors to guide treatment (91.1% of our biopsy series).

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