FEGNOMASHIC: from x-ray to MRI

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Authors: S. Fouassier¹, A. L. C. Duarte¹, C. Ruivo², J. Velez³; ¹Évora/PT, ²Coimbra/PT, ³PT
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Learning objectives

To know the conventional radiology, CT and MRI classical features of FEGNOMASHIC lesions.

Background

FEGNOMASHIC (Fibrous dysplasia; Enchondroma/Eosinophilic granuloma; Giant cell tumor; Nonossifying fibroma; Osteoblastoma; Metastases/Mieloma; Aneurysmal bone cyst; Solitary bone cyst; Hyperparathyroidism (Brown tumor); Infection; Chondroblastoma) is a well known mnemonic used by radiology residents to help them memorize the classic x-ray features of the most frequent lytic bone lesions. This acronym becomes a useful starting point to connect their conventional radiology semiotics to their CT and MRI features.

Findings and procedure details

"F - Fibrous Dysplasia"

Fibrous Dysplasia is a benign tumor that has an unclear etiology, much like a localized arrest in osseous development.

This lesion usually occurs in the second and third decades of life, although in this case age is not an useful discriminator.

The preferential sites of fibrous dysplasia are: pelvis, proximal femur, ribs and the bones of the skull base.

In long bones is usually central and metaphysary.

There are two variants of the disease: monostotic (the most frequent) and poliostotic.

The poliostotic variant happens in 30% of the fibrous dysplasia cases and is the most aggressive one. It occurs before ten years old and it's usually unilateral (affecting only one side of the skeleton).
Although fibrous dysplasia is included in the lytic lesions differential, its radiological appearance is very wide, from purely lytic lesion to densely sclerotic lesion and also ground-glass pattern. These tumor lesions can also have cartilaginous matrix. They can also act as an expansile lesion, with critical thinning.

Basically fibrous dysplasia can resemble any bone lesion.

The only possible discriminator is that these tumors usually don't have a periosteal reaction and that they usually occur without pain (except if there is a pathological fracture).

It is also important to know the preferential sites of these lesions, since their radiological typical appearance is connected to the site that they occur:

- Base skull lesions are often sclerotic.
- Rib and long bones lesions usually have a ground-glass appearance. A long, ground-glass lesion, with no periosteal reaction in a long bone is probably a fibrous dysplasia.
- In the pelvis they tend to be bubbly (lytic) and expansile. If there is a lesion in the pelvis, it certainly means that there is another lesion in the proximal femur - so a pelvic fibrous dysplasia is indicative of a polyostotic disease, although the reverse is not true (a proximal femur fibrous dysplasia can be solitary).

*Bone expansion and decrease of the cortex thickness* can lead to bone deformations that sometimes acquire typical features, such as the "shepherd's crook" in the proximal femur.

CT examination can be useful in selected cases - for a better characterization of the skull lesions, for example.

The tomodensitometric (TDM) aspect will depend on the osseous and fibrous component of the lesion. Predominantly bone lesions will be denser, as fibrotic lesions have a ground-glass appearance (70-150 HU).

MRI findings (Fig. 1 on page 13) are very unspecific and this imaging method has little clinical utility for a better characterization of these lesions.

It's expected that fibrotic lesions will have a hypo/isossignal in all weighted images. However, fibrous dysplasia can have a hypo or isossignal in T1-weighted images and an heterogeneous signal in T2-weighted images, with hypo, iso or hyperssignal. After the administration of gadolinium these lesions enhance in a uniform pattern. There are rare cases with internal cystic degeneration and formation of fluid-fluid levels.
"E- Enchondroma"

Enchondromas (or chondromas) (Fig. 2 on page 14) are benign tumors composed by hyalin cartilage matrix.

They don't show any age or gender predilection.

Enchondromas are usually asymptomatic lesions, unless when they occur with a (pathological) fracture.

These typically occur in the metaphysis of the upper limb phalanges (most common cystic lesion of hand phalanges) (Fig. 3 on page 14), but they can also appear in the lower limb phalanges as well as long bones (humerus, femur and tibia). Encondromas are endomedular metaphyseal bone lesions.

From a radiological point of view, enchondromas feature as bubbly lytic lesions (round or oval shaped), without a sclerotic border, that can inflate the cortex with endosteal scalloping. Some hyperdense central punctuates are usually seen - it corresponds to calcified cartilaginous matrix. This feature is typical from enchondromas and if a lytic lesion doesn't have it, then we can exclude enchondroma from our differential list. The only exception are the lesions located in the phalanges.

CT doesn't add much value to X-rays for an adequate characterization of these lesions. Their features remains the same - a soft tissue mass that fills the medullar cavity (usually it’s entire diametre), with a calcified matrix (hyper-dense popcorn like) and scalloping of the adjacent bone cortex.

So we can conclude that enchondromas are easily diagnosed with conventional radiology examinations (x-rays). However, these are often incidental findings in MRI examinations for different reasons (for example, a proximal tibial enchondroma is often diagnosed in a MRI knee study).

Enchondromas have a very characteristic MRI appearance. They are lobulated masses with bright signal in T2 or STIR, with small hyposignal foci that are related to the calcified matrix. In T1-weighted images enchondromas have hyposignal. After gadolinium intake (not really necessary to characterize these lesions) a septal enhancement is seen, separating the non-enhancing cartilage lobes.

"E - Eosinophilic granuloma"
It's the most frequent form of presentation of histiocytosis X (a wide group of diseases that are characterized by histiocytic infiltration - macrophages and dendritic cells - of organs belonging to the reticular-endothelial system - bones, lungs, central nervous system, lymph nodes and skin).

It's almost exclusive of individuals with 30 years or less (usually children below 10 years old) and has a male predilection.

It most frequently occurs in the skull (50%), vertebrae, mandible or long bones, although it can appear in any bone anywhere in the skeleton.

Eosinophilic granuloma (EG) are usually monostotic lesions, but in can be poliostotic.

EG can have multiple radiographic features: plastic or lytic; well defined or ill-defined; with or without sclerotic border; with or without periosteal reaction.

Which means that they can resemble almost every bone lesion.

Along with infection (osteomyelitis) they should be part of every differential diagnosis list.

In the beginning these lesions, in conventional and CT studies (Fig. 4 on page 15) show osteolysis, sometimes with ill-defined margins and laminar periosteal reaction (aggressive features). It's not rare for them to show a permeative (multiple small holes) pattern, much like Ewing sarcoma, with both entities in the same differential.

These lesions can spontaneously heal in a few months to a year after they occur - they initially have aggressive features but as time goes by, they start to show more benign ones (well defined borders; thick, uniform and wavy periosteal reaction).

They can have an associated soft tissue mass. Occasionally EG may show bony sequestrum.

They can or cannot have associated pain.

At MRI EG (Fig. 4 on page 15) is a ill-defined focal lesion with low intensity in T1-weighted images and high intensity in T2-weighted images. An intense hypersignal in T2-weighted images (with low T1 signal) of the surrounding soft tissues and marrow is often
associated. These features are called “flare phenomenon” and are due to marked edema of the bone marrow and soft tissues as well as concomitant inflammatory reaction.

Basically the only possible discriminator for these lesions is that it only occurs in individuals under 30 years old.

"G - Giant cell tumor"

Giant cell tumors (GCT) are also known as osteoclastomas, since histologically they are infiltrated with osteoclasts (besides the connective tissue and fibrous stroma).

It's a mildly common lesion (5% of all primary bone tumors).

It occurs only after the bone epiphysis are closed (20-40 years old) and it's one of the few tumors that are more common in females (50%).

They often appear in long bones, but can be found in any bone in the skeleton.

GCT come from the bone metaphysis, expand eccentrically toward the articular surface and can even originate bone expansion.

In conventional radiology (Fig. 5 on page 16), the diagnosis can be achieved if the lesion shows these four features:

- Closed epiphysis;
- Abuts the articular surface;
- Sharped, well defined border, with non-sclerotic margins;
- Eccentrically located in the bone.

This diagnostic features are only valid for long one lesions. In flat bones, like the pelvis or the calcaneus these four "rules" do not apply.

In CT (Fig. 6 on page 17) scans the lesion's appearance is very similar to the conventional radiology studies - GCT are purely lytic lesions, with non-sclerotic border and non-periosteal reaction. They can sometimes show cortical erosions. After iodate contrast is administrated there is an intense enhancement of the lesion.

In MR (Fig. 6 on page 17) images the GCT features are uniform, but hardly specific:
Intermediate signal in T1-weighted images;
Intense enhancement after contrast administration;
Low signal in T2-weighted images;
Can have fluid-fluid levels.

"N - Non ossifying fibroma"

It's a very frequent bone lesion in paediatric age (30% to 50% of children over 2 years old). It spontaneously regresses so as to be seen only in rare occasions in patients after 30 years old.

Non ossifying fibroma (NOF) (Fig. 8 on page 19) and fibrous cortical defect (Fig. 8 on page 19 Fig. 7 on page 18) are the same entity, although the later is used for lesions with less than 2 cm in length and NOF for lesions longer than 2 cm.

They are benign lesions and asymptomatic.

NOF occurs in the **metadiaphyseal** region of long bones - more then 85% in the **long bones** of the lower limbs.

They appear as **eccentric** lytic lesions, that can be **slightly expansible**, emanating from the cortex with a thin **sclerotic border** that is **scalloped**.

*No periosteal reaction is seen.*

In CT (Fig. 7 on page 18) scans the lesion's appearance is very similar to the conventional radiology studies, so this study doesn't help in the lesion's characterization.

In MRI (Fig. 8 on page 19), NOF have hypo-signal in T1-weighted images and variable signal intensity in T2-weighted images - depends on the proportions of fibrous extracellular tissue and hemosiderin as well as new bone tissue that is being formed.

NOF are "**don't touch lesions**", meaning that their diagnosis is done through imaging studies only and there is no need for a histologic examination.

The natural history of these lesions is their conversion to normal bone, becoming sclerotic.
"O - Osteoblastoma"

Osteoblastoma is a rare benign tumor that is bone forming, so it's kind of weird that it appears in a differential diagnosis list of lytic bone lesions. Basically there are two radiological variants of this lesions - the blastic one and the lytic one.

They appear in individuals before 30 years old.

In its blastic version, osteoblastomas resemble osteoid osteomas and are often called "giant osteoid osteomas" since this designation is only applied in lesions over 2 cm in length.

But in this EPOS we want to know more about the lytic version of osteoblastomas.

They have radiological features very similar to the aneurysmal bone cyst (ABC) and it should integrate the differential diagnosis list whenever an ABC is suspected.

Osteoblastomas occur more often in the posterior elements of the vertebrae and its typical radiological features are of an expansile lytic lesion with a soap bubble appearance.

On MRI they have a very variable appearance, depending on the relative proportion of bone tissue present.

"M- Metastasis / Multiple myeloma"

Metastasis

The most common lytic bone mets are from: lung cancer (most frequent), kidney cancer (only tumor with purely lytic metastasis - Fig. 9 on page 20 ) and thyroid. Breast and bladder carcinomas usually have mixed metastasis (lesions that are lytic and blastic).

Metastasis (Mets) should be in the differential diagnosis list of any lytic bone lesion on an individual over 40 years old or anyone with a known history of neoplasm.

Mets don't have a special bone predilection even though it's fairly uncommon for them to occur in the distal portions of the appendicular skeleton (distally to the elbows and knees) - unfortunately there is an exception to this rule which are the lung carcinoma metastasis.
Lytic mets are usually multiple and can have many radiological features, but they often appear as moth-eaten lesion or with a geographical pattern, without reactive slerosis and a wide transition zone with no periosteal reaction.

**Multiple myeloma and plasmacytoma**

Multiple myeloma and plasmacytoma are hematological neoplasms with an abnormal bone marrow proliferation of plasmocytes.

They usually happen in people over 40 years old.

It most frequently involves the skull and the axial skeleton, but that doesn't exclude that these lesions can appear in any bone.

Multiple myeloma lesions are often multiple and occur as small lytic well defined lesions without a sclerotic border that can have endosteal scalloping when abutting the cortex.

When they occur in an isolated form they're called plasmacytomas. In this circumstance they appear as an expansile lesion with an associated soft tissue mass.

CT and MRI have little importance in the characterization of these lesions. CT can have a role in determining the degree of cortical thickness loss and hence infer the risk of pathological fracture. "Whole body MRI can be useful for identification and monitoring of these lesions after therapeutic measures. They have an unspecific MRI appearance - hypo-intense in T1-weighted images and are hyper-intense in T2-weighted images, with heterogeneous enhancement after gadolinium administration.

"A - Aneurysmal bone cyst"

Aneurysmal bone cyst (ABC) is a benign tumor formed by multiple cystic spaces filled with blood, separated by thin septa.

They affect in individuals under 30 and originate pain.

ABCs usually occur in the epiphysis of long bones as well as in the posterior elements of the vertebrae, being in the same differential list as osteoblastoma.
These lesions are always expansile (and only when we have an expansile lesion should ABC be considered - Fig. 10 on page 21), with some inflation of the cortex that can be very reduced. ABC often show a soap bubble appearance that can have discreet sclerotic border (this feature is better assessed in CT scans).

Fluid-fluid (Fig. 11 on page 22) levels were considered an hallmark for a long time, but although they are typical they aren't an exclusive ABC feature (other lesions with fluid-fluid levels: fibrous dysplasia, GCT).

These fluid-fluid levels are depicted in either CT or MRI images, but that have a typical appearance in MRI studies.

In MRI ABCs appear as lobulated expansile masses that have multiple cystic spaces which are filled with fluid. This fluid shows an hyper-intense signal in T2-weighted images and, as the fluid is blood, can also show an hyper-intense signal in T1-weighted images.

Septa have a hypo-intense signal in either T1 and T2 weighted images and show enhancement after contrast administration.

"S - Solitary bone cyst"

Also known as simple bone cyst or unicameral bone cysts.

It's actually a bone cavity surrounded by a thin membrane and filled with sero-hematic fluid

They affect individuals under 30 years old and are usually asymptomatic (unless they have a pathological fracture associated).

From two thirds to three quarters of all solitary bone cysts (SBC) occur in the proximal humerus or proximal femur. Another typical location is the calcaneus where they have a triangular shaped-appearance.

They grow from the physis and "migrate", as the bone grows, to the diaphysis. So we shouldn't consider a SBC if we are confronted with an epiphyseal lesion.

SBC are centrally located, and this feature along with the age of appearance are the major discriminator factors.
In conventional and CT studies they are lytic, well defined bone lesions with a thin sclerotic rim. Some have a soap bubble appearance and they can be slightly expansile.

In MRI SBCs have an intense uniforme T2 signal, as they are fluid-filled, with no fluid-fluid levels. In t1-weighted images they are hypo-intense and may have an enhancing rim after gadolinium administration.

CT and MRI can be useful when these lesions occur in less frequent sites, such as the column or pelvic bones.

"H - Hyperparathyroidism"

Brown tumors (Fig. 12 on page 23) affect individuals that suffer from hyperparathyroidism and are constituted from collections of osteoclasts and thus difficult to pathologically differentiate them from GCT.

They appear as expansile lytic lesions without specific features and can occur in any bone and in any site of the bone.

"I - Infection"

Osteomyelitis can occur in any bone at any age, being one of the most frequent bone lesions.

From a conventional radiology point of view bone infection can have many and different features, depending which stage of the infection is presented to us. Bone destruction leads to lytic lesions that are sometimes expansile and with cortical destruction (Fig. 13 on page 24). A sclerotic reaction may be present (but not always). Periosteal reaction is often observed.

In the surrounding soft tissues there can be an obliteration of adjacent fat planes by their inflamation, mimicking an aggressive soft tissue reaction.

So, if the patient background is suggestive, we always have to remember bone infection (osteomyelitis) when faced with a lytic lesion.

If the joint is affected there will be destruction of the articular surfaces and joint effusion.
Bony sequestrum is a typical feature of osteomyelitis, but only in a late stage (specially in chronic osteomyelitis).

CT bone findings are similar to those of conventional studies, but this technique can better assess the bone marrow involvement - which will have an higher attenuation due to inflammation.

A permeative serpentine pattern on CT scans is specific of osteomyelitis.

MRI is the best imaging technique to assess bone infection, as is possible to depict bone marrow and soft tissue edema, rim trace, skin ulcers and can help us identify abscesses.

"C - Chondroblastoma"

Also known as Codman's tumor.

These cartilage forming tumors are relatively rare.

Chondroblastomas only affect the epiphysis or its equivalents (apophysis, iliac crests, tarsal and carpal bones, patella) and before the physis are closed. So they can only affect individuals before 30 years old.

The three most important lytic epiphyseal lesions in individuals under 30 are:

- Infection (most common)
- Chondroblastoma
- Giant Cell tumor

We can add ABC and EG if we want to increase our confidence level.

In individuals over 40 we can't forget metastasis and multiple myeloma.

We should always consider subchondral cysts or geodes (that occur in four specific articular diseases).

The most frequent location is the proximal humerus, followed by the proximal femur and the distal femur.
Chondroblastomas show geographical sclerotic borders that are often lobulated. They sometimes have a thick periosteal reaction, distant from the tumor itself. These lesions are usually eccentric and can extend into the metaphysis.

CT (Fig. 14 on page 25) can be useful for the identification of calcified matrix.

In MRI (Fig. 14 on page 25) studies chondroblastomas have the same signal intensity as the muscle in T1-weighted images and an heterogeneous intermediate/high signal with a lobulated pattern in T2-weighted images.

Medular oedema is very typical, adjacent to the periosteal reaction.

Images for this section:

Fig. 1: Fibrous dysplasia of the femur's proximal extremity. MRI, coronal view. A) The lesion has a low T1 signal. A reactive sclerotic border is observed, with a narrow
transitional zone. The cortex is thinned and there isn't periosteal reaction. B) Same lesion in T2-weighted images with FS. The lesion has a high signal in this sequence. Surrounding medullary edema isn't seen.

Fig. 2: Enchondroma of the proximal humerus. A) Anteroposterior radiogram of the right shoulder. We can see an eccentric metaphyseal lesion with a calcified matrix. B) Axial CT of the same lesion. The calcified chondroid matrix is well seen. C) Axial MRI T1-weighted. The lesion shows low signal and is lobulated. D) Axial MRI T2 weighted. We can see a lobulated mass with bright signal and small hyposignal foci that are related to the calcified matrix. Note that there isn't medular edema. We can see the lack of sclerotic border and the presence of endosteal scaloping.
**Fig. 3:** Radiograms of enchondromas of hand and foot phalanges.
Fig. 4: Eosinophilic granuloma of the left humerus. A) Anteroposterior radiogram showing a lytic lesion. B) Same lesion in axial CT. C) Axial MRI T1-weighted image, with low signal. D) Axial T2 weighted-image were we can see the "flare phenomenon", (see text). E) Axial MRI T1 post-contrast. The lesion shows septal enhancement (not specific).
**Fig. 5:** Radiogram of a giant cell tumor of the proximal tibia. We can see a lytic lesion in a patient with closed epiphysis, that abuts the articular surface, with shapred, well defined border, with non-sclerotic margins, and that is eccentrically located.
**Fig. 6:** Giant Cell tumor of the tibia. A) Coronal CT of the tibia showing an eccentric lytic lesion in the distal extremity of the tibia, abutting the articulation without a sclerotic border. B) Sagital MRI T2 weighted image showing the same lesion. Note the heterogenous hypersignal. C) Coronal MRI T1-weighted image. The lesion has intermediate signal. In both B) and C) we can also see the lack of sclerotic border.
Fig. 7: Fibrous cortical defect of the distal femur. A) Anteroposterior radiogram of the knee. B) Coronal CT of the distal femur. We can see a cortex-based lytic lesion with less than 2cm showing circumscribed sclerotic borders with a very narrow transition zone. There is no periostitis and the lesion was painful.
Fig. 8: Non Ossifying fibroma of the distal tibia. A) Anteroposterior radiogram. We can see a cortex-based lytic lesion with more than 2cm showing thin sclerotic border, that is scalloped and slightly expansile. There is no periostitis and the lesion was painful. B) MRI T2 weighted; C) MRI T1 weighted.
**Fig. 9:** Renal Cell Carcinoma metastasis of the pelvis. A) Radiogram showing a lytic lesion of the left sacral wing; B) Axial CT where we can see a destructive lesion with a soft tissue component. C) Axial MRI T1, with low to intermediate signal. D) Axial MRI T2, the lesion has diffuse hypersignal.
Fig. 10: Aneurysmal bone cyst of the radius. This radiogram shows a lytic expansile lesion located in the metaphyseal region of the radius with thinning of the cortex.
**Fig. 11:** Aneurysmal bone cyst of the distal femur. A) Axial CT shows a lytic lesion with sclerotic borders and a narrow zone of transition. B) MRI T1-weighted showing a isointense circumscribed lesion. There is no alteration of the bone marrow. C) MRI T2-weighted image where the fluid-fluid levels are well seen.
Fig. 12: Brown tumor of the proximal femur. A) Radiogram: a lytic lesion of the femoral neck, with pathological fracture, is seen. B) Coronal CT of same lesion. C) MRI T2-weighted images. D) MRI T1-weighted images. Brown tumors don't have any discriminating/classical features.
Fig. 13: Infection of proximal humerus. A) Anteroposterior radiogram of the right shoulder showing destruction of the humeral head; B) CT of the same lesion; C) Axial MRI T2 FS-weighted image shows heterogenous hypersignal, also seen in D) Axial MRI T1 FS, that probably corresponds to a fluid collection with some proteic component; E) Axial MRI T1 with contrast, showing peripheral enhancement. These MRI features suggest an infected fluid collection.
**Fig. 14:** Chondroblastoma of the left humerus. A) Anteroposterior radiogram of the left shoulder. We can see a faint lytic lesion in epiphysis. B) Axial CT of the same case. The lesion is circumscribed with a thin sclerotic border. No destruction of the cortex. C) MRI T2 FS weighted image with hyperintense lobulated components and typical medular edema. D) T1 weighted image showing that the lesion has the same signal intensity as the muscle.
Conclusion

The FEGNOMASHIC mnemonic is used by many radiology residents worldwide. It can be helpful to memorize bone lytic lesions and their semiotics, not only in conventional radiology but also in CT and MRI.

Personal information

References