Primary bone tumors according to the WHO classification: a review of 13 years with illustrative examples

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Learning objectives

- Describe the main radiological features of primary bone tumours.
- Provide key data (radiological and epidemiological characteristics) for differential diagnosis.
Background

Primary bone tumours are rare, accounting for less than 0.5% of all tumours. They are more common in childhood, so it is essential to know its features.

Currently the advance of technology in medicine in the diagnosis and surgical treatment has contributed to increase survival in these patients, which in turn contributes to better clinical and epidemiological knowledge and requires constant updating in the management this pathology. knowledge and requires constant updating in the management this pathology. Thus, since 1972 the WHO classification has been updating, under the progress already described.

In order to know the characteristics, radio-pathologic correlation and epidemiology of these tumours, we performed a comprehensive review of primary bone tumours with histological confirmation.
Findings and procedure details

Pathology reports of primary bone tumours were reviewed between January 2000 -March 2014. The data were categorized according to the World Health Organization (WHO) classification and to age and gender. We reviewed our database to describe the main imaging features. This findings were related with clinical and epidemiological data. A total of 320 patients with primary bone tumours were found, with an average age of 38 years old and age range between 8 - 82 years old. Of these 51% are male.

The most common are cartilage forming tumours (57%), followed by bone forming tumours (18%). The third in frequency are the pseudotumoral lesions (16%). It is less common the giant cell tumor (4%), bone marrow forming tumours (3%) and connective tissue tumours (0.9%). Lastly, hemangioendothelioma and chordoma (0.3%).

Most of them are benign (89%), malignant reaching only 11%, the crondrosarcoma the most frequent.

1. CARTILAGE FORMING TUMOURS

These are the most common tumours. In our series we found 181 cartilage forming tumours which correspond to 57%. The average age was 34 years old, slightly more frequent in women (52%).

Of these, the most frequent was the osteochondroma (57%), followed by endondroma (32%) and less frequent chondrosarcoma (10%) and chondroblastoma (0.5%).

Table 1 describes the frequency, gender distribution and average age of cartilage-forming tumours. (Table 1)

These tumours are characterized by producing a chondroid matrix. They range from benign lesions to malignant lesions. They are usually asymptomatic, except for malignant tumours that produce symptoms such as pain. The diagnosis is an incidental finding, acquiring important knowledge for correct diagnosis.

OSTEOCHONDROMA

It is the most common tumour of cartilage-forming tumors. We found 104, which corresponds to 57%, as in the literature. The average age was 28 years old, with equal frequency in men and women.

It is defined as excretion of bone that is continuous with the cortical the underlying bone and medullary cavity, and is covered with hyaline cartilage on the bone surface. It rises
steadily until the age of epiphyseal fusion, then the cartilage thins up to disappear, which translates stopping their growth. They can be solitary or multiple.

They are usually asymptomatic and a finding on plain radiography. They can also be presented as a hard painless and according to their size and their locations may present some symptoms due to compression or mechanical obstruction of adjacent structures (vessels, nerves, tendons), bursitis or fracture. In some particular locations may produce some bone deformities.

In plain film it looks like a bony enlargement which is continuous with the cortical and medullary cavity, presenting some irregular calcifications on the surface. It is most often located in the metaphysis of long bones (femur, humerus, tibia and fibula). They may have a small base implementation with a pedunculated morphology or wide base implementation with sessile morphology. Size is variable from 1 to 10 cm or even more.

The osteochondromas pedicle is well defined cauliflower shaped with irregular calcifications on the surface, with a minor size on the plain film because of the cartilaginous cap is non-visible on plain film.

The sessile osteochondromas also have irregular calcifications on the surface, but their morphology can be confused with other parosteal tumors.

CT and MR are useful to better characterize the lesion and the corticomedullary continuity. On MR the cartilaginous cap is hypointense on T1-WI and high signal intensity on T2-WI. Cartilaginous cap is about 2 to 3 mm and in some cases up to 1 cm. (Fig. 1)

They can become malignant secondary chondrosarcoma, although it is uncommon (<1%). The warning signs are pain, osteochondromas that begin their growth after puberty, lobed irregular calcification and thickening of the cartilaginous cap (> 2 cm) or when there is recurrence after surgical treatment.

The differential diagnosis includes parosteal osteosarcoma, periosteal chondroma and chondrosarcoma.

The surgical resection is indicated in cases of pain from compression of neurovascular adjacent structures, bursitis and tumour growth after epiphyseal closure or high suspicion of malignant transformation.

**ENCHONDROMA**

In our series, we found 58 patients with enchondroma (32% of all cartilage forming tumours). The average age was 45 years old, as described in reports, being slightly more frequent in women (57%) although in the literature there is no sex predominance.

Enchondroma are tumours of hyaline cartilage, with some foci of calcifications. Generally they are solitary but may be multiple on the same bone or on more than one.
They grow slowly, mainly from the periphery, leaving in the middle mature tissue. They can degenerate with malignant transformation especially in those located at the proximal ends of long bones.

They are asymptomatic and the diagnosis is usually an incidental finding, although they may also evolve with swelling, pathologic fracture and pain.

Enchondromas are centrally located in the medullary cavitory of the metaphysis of tubular bones. Most of them in small tubular bones of the hands and feet (50%), as well as in the metaphysis of the femur, humerus and less frequently in ribs and pubis.

Radiographically, enchondromas are well defined geographic lytic lesions, with round or oval morphology. They usually contain calcified chondroid matrix with "rings and arcs" pattern of calcification, except in the phalanges.

Enchondromas in small tubular bones and in flat bones may present bony expansion and endosteal scalloping.

CT and MR allow assessment of cortical integrity as well as matrix calcifications more accurately than radiographs. On MRI enchondromas show intermediate-low signal intensity on T1-WI and high signal intensity on T2-WI with focal areas of low signal intensity representing mineralized matrix. (Fig. 2)

Endosteal erosion greater than two-thirds of cortical thickness, cortical destruction and soft tissue invasion, are considered suspicious for chondrosarcoma.

The differential diagnosis includes bone infarct, fibrous dysplasia, chondromyxoid fibroma, aneurysmal bone cyst, solitary bone cyst and epidermoid inclusion cyst.

Multiple enchondromatosis (Ollier disease) is rare. It is a developmental anomaly characterized by multiple enchondromas. In Maffucci’s syndrome there are enchondromatosis with soft and visceral hemangiomas. Both have higher risk of malignancy.

It can be treated by curettage, sometimes with bone graft in cases in which the cavity is large or by surgical resection of segment in some locations as the ribs. The recurrence is rare.

**CHONDROBLASTOMA**

In our series we found only one male patient 16 years old which corresponds to 0.5% of cartilage forming tumours.

It is a rare benign tumour, compound by chondroblasts, giant cells and chondroid matrix.
It is more common in men under 25. They are located in the epiphysis or epiphysis-metaphysis of long bones: proximal and distal femur, proximal tibia and humerus. Also in calcaneus, talus, patella, and acetabulum, temporal bone and ilium.

The main clinical manifestation is the pain being less frequent, joint effusion and swelling.

In plain radiography it is well defined lytic lesions, with sclerotic border and calcifications in the matrix. They are of central or eccentric location. They are small up to 6 cm. Overall they do not produce bone expansion or periosteal reaction. CT is more sensitive to demonstrate calcifications in the matrix. MR allows assessment of cortical extension and demonstrates associated surrounding bone marrow oedema. (Fig. 3)

The differential diagnosis includes giant cell tumour, joint injuries with large cysts and chondrosarcoma.

The treatment is curettage with bone graft. They can recur up to 20%.

**CHONDROSARCOMA**

We found 18 chondrosarcomas corresponding to 10% of cartilage forming tumours, with an average age of 48 years old, as described in the literature, being slightly more frequent in women (55%).

They are relatively common malignant tumors, the third most common malignant bone tumours. They have a cartilaginous matrix lobed morphology, and may have myxoid content, mucoid and / or cystic.

Chondrosarcomas are either primary or secondary and arise from a pre-existent cartilagenous lesion. Numerous categories of primary chondrosarcomas have been described: conventional intramedullary, clear cell, juxtacortical, myxoid, mesenchymal, extraskeletal, and dedifferentiated.

The most common site is the ilium, the metaphysis or diaphysis of the femur, proximal humerus and ribs.

They are symptomatic, being the pain and swelling the most common manifestations.

In plain radiography they are as lytic lesions or permeative pattern, central location with punctate or ring opacities that translate mineralization, bone expansion with thickening and cortical erosion but rarely there is periosteal reaction.

The CT and MRI are more sensitive to delineate the tumour, show calcification of the matrix and soft tissue involvement. (Fig. 4)

Histologically, Chondrosarcomas are divided into 3 grades based primarily on cellularity.
Histological grade and the location are the most important predictors of local recurrence and metastasis. Histological grade 1 and tumor location in long bones, have a better prognosis.

2. BONE FORMING TUMOURS

They are second in frequency reaching 18%. The average age was 30 years old, with slightly more frequency in women (54%).

Of these, the most common is the osteoma (58%), followed by osteoid osteoma (30%) and osteosarcoma (10%). The osteoblastoma was the least frequent (1.6%). Table 2 describes the frequency, gender distribution and average age of bone forming tumours. (Table 2)

OSTEOID OSTEOMA

In our series it corresponds to 30% of bone forming tumours, more frequent in men (61%) and average age of 21 years old.

It is a tumour osteoid matrix forming, with a vascularized center, surrounding reactive sclerosis and osteoblastic activity. They are more common in boys and teenagers but it can occur in adults.

Clinically they have a characteristic pattern of pain with nocturnal exacerbation relieved by salicylates (aspirin). Also present as a soft tissue swelling and localized redness, joint effusion, inflammatory arthritis and reactive lesion adjacent to the joint and muscle atrophy.

Radiographically they are sclerotic lesions, small size (<1 cm), fusiform morphology, central radiolucent area (nidus) with punctate and irregular calcifications. They can be located in the cortex, where they are markedly sclerotic without radiolucent center or in medulla (show less sclerosis), subperiosteal or even intracapsular. They can occur in any bone but are more common in long bones such as the proximal femur.

The best imaging study to demonstrate osteoid osteoma is a CT scan: the nidus of an osteoid osteoma is a well defined round or oval lesion with low attenuation. CT may show variable amount of central mineralization within the nidus and surrounding sclerosis. MR is useful in demonstrating bone marrow oedema. On MR, the signal intensity of the nidus is variable on all sequences. (Fig. 5)

The osteoblastoma is the main differential diagnosis, also osteomyelitis, stress fracture, osteochondroma, osteosarcoma.
The treatment consists in surgical resection or percutaneous radiofrequency although some of them resolve spontaneously. Recurrence is rare.

**OSTEOSARCOMA**

It is the third bone former tumour (10%) and the second most common of all primary malignant bone tumours in our series, although the literature is described as the most frequent. The average age was 30 years old without sex predominance.

It is a common malignant tumour in children and youth in the second decade of life.

In adults it may be secondary to a preexisting bone lesion as Paget's disease.

There are various types of primary osteosarcoma: intramedullary, surface or juxtacortical and extraskeletal. Conventional intramedullary osteosarcoma is the most common.

It is a tumour that produces an osteoid matrix, it also has other components as cartilage and fibrous. They have and eccentric location in the metaphysis and less frequently in the diaphysis of long bones, as in the distal femur and proximal tibia and humerus.

The main symptom is pain that is described as deep and severe, with or without palpable mass. They may also have edema, functional limitation and pathological fracture.

In plain radiography they are lytic, sclerotic or mixed lesions, aggressive character, with osteoid matrix, destruction of the cortex, periosteal reaction: lamellated (onion skin) reaction, hair-on-end, sunburst or Codman triangle, with soft tissue mass.

CT and MR are sensitive to delineate the extent of the tumour especially for preoperative planning and to identify occult metastases. (Fig. 6)

Lung metastases are the most common manifestation of systemic disease and generally ossify and are associated with pneumothorax.

The differential diagnosis includes osteomyelitis, metastatic lesion, Ewing sarcoma, aneurismal bone cyst.

The treatment includes chemotherapy and then surgical resection. Currently there is an increase in 5-year survival reaching up to 80-90% in patients with good response to preoperative therapy.

Recurrence can be high in some cases of pathological fracture.

**OSTEOBLASTOMA**
Benign osteoblastoma is a rare tumour composed of osteoblasts cells and is highly vascular, histologically similar to an osteoid osteoma. It is more common in young men under 30. In our series we found one 24 years old female.

Osteoblastomas are located in the spinal column in particular in the posterior elements as well as the sacrum, femur, tibia and bones of the hands and feets. Most of them have metaphysical location and some of them may arise in a subperiosteal location.

The main symptom is pain by compression of neural structures such as the spinal cord and nerve roots, conditioning in some cases neurological symptoms.

In plain radiography they are well defined lytic lesions. Generally they have a size greater than 2 cm (even 10 cm), with marked peripheral sclerosis, bone expansion and thin periosteal reaction. They may have focal areas of calcification indicative of tumour bone mineralization.

CT and MR allow assessment of matrix calcifications more accurately than radiographs. On MR osteoblastoma show intermediate-low signal intensity on T1-WI and T2-WI with focal areas of low signal intensity representing mineralized matrix. (Fig. 7)

The treatment is curettage of the lesion with or without bone graft and recurrence is rare. The malignancy is uncommon.

3. PSEUDOTUMORAL LESIONS

They are lesions that are generally considered non-neoplastic but that should be included in the differential diagnosis of primary tumours.

We found a total of 51 patients, corresponding to 16% of bone tumours. The most common are simple bone cysts with 25%, followed by aneurysmal bone cysts (23%), juxta-articular cysts (18%), fibrous dysplasia (14%), non-ossifying fibroma (6%), eosinophilic granuloma (6 %), ossificans fibroma (4%) and epidermoid cyst (4%).

SIMPLE BONE CYST

They are most frequent in this group (25%). The average age is 27, with similar frequency between women and men.

They are unicameral cystic lesions with serous content or blood. Frequent in men in children and adolescents.

Long bones are located in the proximal end of the humerus, femur and tibia.

Clinically it can cause pain, swelling of soft tissues and pathological fracture.
In plain radiographs they are well defined lytic lesions in metaphysis and diaphysis which may extend to the epiphysis, with central location and bone expansion, cortical thinning and septa inside. The cortex is thin but intact unless there is a fracture showing the "sign of the fragment fallen" which corresponds to a small segment of the cortex at the back of the cystic lesion.

MR image may demonstrate fluid content. (Fig. 8)

The differential diagnosis includes giant cell tumor, non-ossifying fibroma, aneurysmal bone cyst and eosinophilic granuloma.

Treatment with curettage bone graft depends on the tumour size. Recurrences are described up to 20%.

ANEURYSMAL BONE CYST

They are the second in frequency, with an average age of 27 and slightly more common in women (58%).

Aneurysmal bone cyst is a benign lesion, composed of blood filled spaces separated by connective tissue septa containing fibroblasts, osteoclast type giant cells and reactive woven bone.

They may be primary or secondary. More common in children and young people under 20, without sex predominance, although there are series describing a female preponderance.

They are located in the metaphysis of long bones such as the femur, tibia, humerus and in the posterior elements of the spine.

They manifest with pain and swelling or symptoms resulting from compression of adjacent structures such as nerve roots in the spine.

In plain radiography are well defined lytic lesions, eccentric location in bone marrow with bone expansion and cortical thinning. CT and MR demonstrate the septa, characteristic fluid-fluid levels and can show the primary lesion in cases of secondary aneurysmal cysts associated with benign tumours such as giant cell tumor, osteoblastoma, chondroblatoma, fibrous dysplasia and in some cases osteosarcoma. (Fig. 9)

The treatment is curettage with bone graft or surgical resection. The recurrence is variable.

FIBROUS DYSPLASIA

In our series it is 14% with an average age of 24 and a slight predominance in women.
It is a common benign fibrous-bone lesion in children and adults with no sex predominance. They can affect one or more bones, being the most frequent form monostotic.

They are frequently located in the jaw and skull, also they can be located in the femur, tibia and ribs.

They are usually asymptomatic and they can present pain related to fractures.

In plain radiography they are well-circumscribed lytic lesions, geographic morphology with a matrix typically "ground glass opacities" with bone expansion and deformation without signs of aggressiveness. The CT and MR are more sensitive to better delineate the lesion and detect fractures. On CT they are homogeneous sclerotic lesions, well-defined margins, with "ground-glass" opacities. Also, expansion of bone and endosteal scalloping may be seen. On MR they have variable appearance. (Fig. 10)

Differential diagnosis includes Paget disease, non-ossifying fibroma, simple bone cyst, giant cell tumour, adamantinoma.

**NON-OSSIFYING FIBROMA**

Benign fibrous-bone lesion, common in children and adolescents men.

It is located in the middle third of the tibia, as well as the fibula, radius and ulna.

Clinically manifest with pain, swelling and bone deformity.

In plain radiography they are well defined lytic lesions, sometimes multiloculated located in the cortex. They present bone expansion and thinning of the cortex with sclerotic border. CT and MR give a more accurate assessment of the lesion. On MR they show typically mixed signal intensity on T1-WI and STIR, being hyperintense on T2-WI. (Fig. 11)

Differential diagnosis includes fibrous dysplasia, fibrous cortical defect, aneurysmal bone cyst and chondromyxoid fibroma.

**EOSINOPHILIC GRANULOMA**

It corresponds to Langerhans cell proliferation, being a rare disorder. It is common in men under 10.
They are located in the skull bones, femur, pelvis and jaw as well as the ribs, especially in adults. They can affect one or more bones, being the most frequent form Monostotic.

**CELL**

It is clinically presented with pain and swelling. They may present with a variety of symptoms according to the affected bone.

In plain radiography they are well defined lytic lesions with periosteal thickening. Typically in the skull they present an image of "hole in a hole" and vertebrae involvement may condition vertebral collapse (vertebra -plana).

4. **GIANT CELL TUMOUR**

In the series they are 4%, with an average age of 26 years old, being mostly men, unlike literature.

Composed by giant cell, locally aggressive and occasionally distant metastasis with malignant potential. More common in women in their third decade of life.

They are located in the epiphysis of long bones: femur and proximal tibia and humerus, also in the axial skeleton: sacrum, pelvic and vertebral bodies. They can reach subchondral bone.

Clinically they have pain, edema, effusion joint in adjacent joint and pathological fracture.

In plain radiography they are eccentric lytic lesion, they can be well defined with sclerotic borders and in other cases are poorly demarcated without sclerotic borders, presenting bone expanding and cortical thinning. Occasionally they have a trabeculated "soap-bubble" image. They can associate secondary aneurysmal bone cyst.

CT and MR demonstrate the location, extent and soft tissue involvement. They have low-intermediate signal intensity on T1-WI and high signal intensity on T2-WI. (Fig. 12)

The treatment is curettage with bone graft, block resection, ablation or surgical amputation. They have high recurrences.

5. **MEDULLA FORMING BONE TUMOURS**

In our series we found 6 patient which correspond to 2% of bone tumours, more common in men (80%) with an average age of 35 years old.
TUMOUR OF EWING

In our series it corresponds to 40% of tumours forming bone marrow and 1.25% of all primary bone tumours. It is more common in men with an average age of 21 years old.

They are malignant tumours with neuroectodermal origin. More frequent in adolescents in the second decade of life.

Clinically, they present pain and palpable mass. They can also present fever and laboratory abnormalities such as anemia and increased sedimentation rate.

They are located in the metaphysis or diaphysis of the femur, tibia, pelvis and ribs.

In plain film they look like an ill-defined lytic lesion with a wide transition zone or permeative pattern, they can also show sclerotic matrix, cortical thickening and thinning or bone expansion sometimes with "soap bubbles" image. Presenting lamellated, Codman triangle or "onion-skin" periosteal reaction associated to large soft tissue mass.

CT and MR are used to identify the extent of injury, soft tissue mass and metastasis. (Fig. 13)

Currently it has improved the prognosis related to the improvement in diagnosis, surgery and radiotherapy treatment. The prognosis depends on the age, tumor location, size, presence of metastases and specific chromosomal abnormality.

LYMPHOMA

In our review it corresponds to 60% of tumours forming bone marrow and 1.8% of all bone tumours. The age average was 50 years old being more common in men, as described in literature.

It is a malignant tumour of lymphoid cells. The most common locations are femur, spine and pelvis.

Clinically it presents pain and swelling. Neurological symptoms appear when affecting the spinal. B symptoms (fever, night sweats) are rare.

In plain radiography they are mixed or litic lesions, poorly defined, wide transition zone, variable sclerosis and permeative bone destruction associated soft tissue mass.

MR shows the characteristics of the bone marrow injury and the soft tissue mass. (Fig. 14)

The prognosis varies according to cell type and stage of disease with 5-year survival of 80%.
6. TUMOURS OF CONNECTIVE TISSUE

LIPOMA

Benign tumour composed mainly by mature adipose tissue and variable amount of fibrous and vascular tissue. It can be present in a wide age range (10-80 years) but mainly in the fourth and fifth decades of life, predominantly in men, although other series report no gender predominance.

Characteristically they are located in the calcaneus, in the metaphysis of long bone: femur, tibia and fibula.

They are asymptomatic, but can manifest with pain, palpable mass and less frequently pathological fracture.

In plain radiography they are well defined lytic lesions with sclerotic borders, central or peripheral calcifications and also bone expansion.

CT and MR showed the presence of fat, cyst formation and calcification. (Fig. 15)

In the differential diagnosis there are included fibrous dysplasia, non ossifying fibroma, simple bone cyst and bone infarction.

The treatment is conservative and in some cases bone graft curettage. It rarely recurs.

7. MALIGNANT FIBROUS Histiocytoma

Malignant tumour may be primary or secondary to previous injuries such as Paget's disease, bone infarction, previous irradiation, chronic osteomyelitis. It is more common in men in the fifth decade of life.

They are located in the metaphysis of long bones: femur, tibia and humerus and pelvic

Patients may present with pain and swelling and less frequently pathological fracture.

In plain radiography they are lytic lesions with a permeative pattern and less often as well-defined lytic lesion with sclerotic ring. It is associated with soft tissue mass. The periosteal reaction is rare. In MR signal varies with nodular and heterogeneous enhancement. (Fig. 16)

They may have lung metastases and also they could present metastases in other locations such as bone, brain, kidney and heart.
Treatment consists in surgical resection and in some cases chemotherapy. The 5-year survival is 50% with high recurrence.

8. VASCULAR TUMORS

Vascular tumours are rare. Among these, haemangiomas are the most common benign vascular tumours in women in their fifth decade of life. These present typical radiologic features: radiolucency with vertical trabeculae in the vertebrae and in the skull they typically have a spoke-wheel appearance by reactive bone formation. They are usually asymptomatic but may present with pain, pathologic fracture. Treatment is conservative or curettage in some case of pain.

In our series we found no patient with haemangioma, probably because the image findings are characteristic and diagnostics.

EPITHELIOID HEMANGIOENDOTHELIOMA

In our series it corresponds to 0.9% of all bone tumors, the age average was 60 years old, slightly more common in women.

It is a very rare malignant vascular tumour composed by hyaline stroma cells with abundant eosinophilic cytoplasm. It is more common in men in the second - third decade of life.

The lesions may be single or multifocal and located in the skull, spinal, femur and tibia.

In plain radiography they are lytic bone lesions with cortical expansion and destruction, they may also be associated soft tissue mass.

9. OTHER TUMOURS

CHORDOMA

It is a rare malignant tumour more common in adult men (50-60 years old).

They are located in the midline of the axial skeleton, typically in the sacro-coccyx, sphenoid-occipital region and in the spine (cervical).

They are slow-growing tumours producing nonspecific symptoms long time. The main symptom is pain and those derived by compression of adjacent structures such as brainstem, cranial nerves, nasopharynx, spinal cord.
Radiographically it appears as a central lytic lesion with soft tissue mass and nonspecific calcifications. Scleral rim may occur with narrow transition zone especially in the spine.

CT and MR demonstrate the extent of the tumor, soft tissue mass and calcifications. Low-intermediate signal intensity on T1-WI and hyperintense on T2-WI.

The differential diagnosis includes chondrosarcoma, plasmacytoma, metastases and lymphoma. In the spinal it could be included the tuberculosis.

Treatment consists in a wide surgical resection. The forecast is based on the age, size and location, being better in youth with sacrococcygeal small tumours. They can evolve with lung, bone and skin metastases. Survival at 5 years reaches up to 50% and has high recurrence.
Table 1: Table 1. Describes the frequency, gender distribution and average age of cartilage-forming tumours.

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<table>
<thead>
<tr>
<th></th>
<th>Total (%)</th>
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<th>Men (%)</th>
<th>Age (average)</th>
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<td>Osteochondroma</td>
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<td>Enchondroma</td>
<td>58 (32%)</td>
<td>33 (57%)</td>
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<td>1</td>
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<td>Chondrosarcoma</td>
<td>18 (10%)</td>
<td>10 (56%)</td>
<td>8 (44%)</td>
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Fig. 1: Osteochondroma of the proximal femur in a 39 year-old woman. (a,b) Sagittal and axial reconstructed CT scan show the typical cortical and marrow continuity of the lesion. Some calcifications are demonstrated (c,d) Axial T1-WI and FST2 -WI show the thin cartilage cap.

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**Fig. 2:** Enchondroma of the humerus in a 66 year-old woman. (a,b). Anteroposterior radiograph and coronal CT reconstructed scan show a mineralized chondroid matrix in the proximal hurneral metadiaphysis. (c,d,e) Coronal T1-WI and STIR MR images, show a lobulated lesion with heterogeneous signal intensity. Intermediate signal intensity on T1-WI, hyperintense on T2-WI and STIR

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**Fig. 3:** Condroblastoma of the humerus in a 16 year-old boy. (a). Anteroposterior radiograph shows a lytic lesion with sclerotic borders, eccentric location in the epiphysis-metaphysis of proximal humerus. (b) Sagittal reconstructed CT scan shows chondroid matrix with bone expansion, thinning and destruction of the cortical. (c,d,e,f) Sagittal MR images show a lobulated lesion contour with low signal on T1-WI (c); low signal with some
foci of high signal intensity on T2-WI and STIR (d,e). The lesion shows heterogeneous enhancement on T1-WI with gadolinium (f).

Table 2: Table 2. Describes the frequency, gender distribution and average age of bone forming tumours

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**Fig. 4:** Chondrosarcoma of the humerus in a 55 year-old woman. (a,b) Anteroposterior radiograph shows a central area of punctate calcifications with scattered punctate foci of cartilage matrix. (c,d,e) Coronal T1-WI and DPFS MR image shows lobulated lesion, low signal on T1-WI and high signal intensity on DPFS-WI, with punctate low-signal-intensity foci representing medullary calcifications. This MR pattern is typical of chondroid matrix.

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**Fig. 5:** Osteoid osteoma in the diaphysis of the fibula in an 33 year-old man. (a) Anteroposterior radiograph shows a radiolucent lesion (arrow) surrounded by sclerotic reactive bone changes. (b,c) Axial and coronal reconstructed CT scan show thickening of the cortex and a low-attenuation nidus. (c) Coronal STIR MR images demonstrated intense bone marrow oedema (red arrow).

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**Fig. 6:** Osteosarcoma of the femur in a 29 year-old man. (a) Radiograph shows a lesion with aggressive hair-on-end periosteal reaction and soft-tissue mass. (b, c, d) Axial T1-WI, T2-WI and sagittal STIR MR image, demonstrates the soft tissue component with high signal intensity (cartilaginous component) and bone oedema.

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**Fig. 7:** Osteoblastoma of the femoral neck in a 24 years-old woman. (a,b) Anteroposterior radiograph and coronal reconstructed CT image shows a well-defined lytic lesion with surrounding sclerosis. (c,d) T1-WI and T2-WI MR image demonstrates low signal intensity on T1-WI and intermediate-high signal on T2-WI image.

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**Fig. 8:** Simple bone cyst of humerus in a 13 year-old girl. (a) Anteroposterior radiograph shows a metaphysio-diaphyseal lucency, extending up to epiphyseal plate, no expansion of bone lesion with eroded cortex and thin. Simple bone cyst of fibula in a 40 year-old man. (b) Metaphysis lucency without expansion bone. (c, d) T1-WI and DP-SPIR-WI show its fluid content.

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Fig. 9: Aneurysmal bone cyst of radius in a 57 years-old woman. (a, b, c) Radiograph and axial, coronal reconstructed CT scan shows an eccentric lytic lesion with the peripheral shell of reactive bone and destructive bone expansion. (d, e, f) Axial T1-WI, T2-WI and coronal T2FS-WI show fluid-fluid level.

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Fig. 10: Fibrous dysplasia of fibula in a 25 years-old woman. (a, b) Anteroposterior radiograph and coronal CT reconstruction shows a dense lesion, well circumscribed without periosteal reaction. (c) Coronal T1-WI shows homogeneous low signal intensity. (d) Axial T2-WI shows intermediate signal intensity.

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Fig. 11: Non-ossifying fibroma of femoral neck in a 31 year-old woman. (a, b) Anteroposterior radiograph and coronal CT reconstruction, demonstrates a lytic lesion, well demarcated with a sclerotic rim and no associated periosteal reaction. (c) Coronal T1-WI shows low signal intensity. (d) Coronal T2-STIR-WI demonstrates high signal intensity. MR image shows variable appearances depend the proportion to the extent of mineralization in the lesion and healing phase.

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**Fig. 12:** Giant cell tumour of distal femur in a 24 years-old woman. (a, b) Lateral and anteroposterior radiograph show a geographic eccentric lytic lesion, well defined and nonsclerotic margins. The lesion is located in the metaphysis with extension to the subchondral plate. (c, d) Coronal low signal intensity on T1-WI and High intensity on DPFS-WI MR images, demonstrates a well defined lesion with extension into the epiphysis and adjacent bone oedema.

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**Fig. 13:** Ewing Sarcoma of calcaneus in a 12 years-old boy. (a) Radiograph shows slight increase in density in the calcaneus. (b, c, d) MR imaging demonstrates marrow
replacement and cortical destruction with an associated soft-tissue mass. (b, c) Axial T1-WI and contrast-enhanced T1-WI shows inhomogeneous intermediate signal intensity with diffuse enhancement on the postcontrast image. (d) Sagittal T2-WI shows intermediate-low and inhomogeneous signal intensity

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Fig. 14: Bone lymphoma of astragalus in a 24 years-old man. (a, b) Lateral radiograph and sagittal reconstructed CT image show a lytic pattern lesion with permeative bone destruction and wide zone of transition.

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Fig. 15: Intraosseous lipoma of tibia in a 47 years-old man. (a) Anteroposterior radiograph and coronal CT reconstruction shows a well defined lytic lesion surrounded by a thin rim of sclerosis. CT shows the fatty component. (c, d, e) Intraosseous lipoma of ilium in a 45 years-old man. (c) Axial CT demonstrates a well defined lytic lesion and the fatty component with low attenuation value, similar to subcutaneous fat. (d, e) Coronal T1-WI and T2FS-WI MR image shows the fat with high signal intensity on T1-WI and low signal on T2FS-WI.

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Fig. 16: Malignant fibrous histiocytoma of ilium in a 59 years-old man. (a) Anteroposterior radiograph shows a large osteolytic lesion with ill defined margins and cortical destruction. (b, c) Coronal T1-WI and T2-WI MR image demonstrates areas of bone destruction and marrow infiltration. Low signal intensity on T1-WI (b) and inhomogeneous high intensity on T2FS-WI.

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Conclusion

The group of cartilage forming tumours is the most common one, followed by forming bone, being the least common the malignant ones. Recognition of the typical radiologic features of these entities and to know other parameters such as age, gender and location are essential for making a correct diagnosis in order to lead the appropriate therapeutic intervention.
References


