A review of Tumoral lesions of the shoulder

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Authors: M. M. Milán Rodríguez¹, Á. E. Moreno Puertas¹, J. M. Giménez², A. Rubio Fernández¹, J. P. Mora Encinas¹, G. Lucini¹, M. Á. FERNÁNDEZ GIL³, ¹Badajoz/ES, ²New Orleans/US, ³BADAJOZ, BADAJOZ/ES
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Purpose

The aim of this study is to review the imaging characteristics and histological features of bone and soft tissue tumors affecting the shoulder.

Methods and Materials

We performed a review of literature as well as a retrospective analyses of our clinical cases and corresponding imaging characteristics for each entity. After reviewing all of the shoulder tumor cases from each author, we selected imaging studies from 25 patients which depict the characteristic salient findings of each entity discussed of all the shoulder tumor cases from each of the authors of this paper. Due to great variability that can be seen with soft tissue tumors in different imaging modalities, pathologic correlation plays an important role in these cases.

Results

Shoulder tumors are very rare posing a challenge in our daily practice to characterize them and to create an appropriate differential diagnosis. However, they share many features with musculoskeletal neoplasms in other anatomic locations, aiding in their diagnosis.

We include and describe the characteristic findings of primary bone and soft tissue tumors that can be found in the shoulder.

BONE TUMORS:

We going to refer to the most common range of age of appear of this tumors, but we should think that we can find them at other ages.

1. Simple bone cyst (Unicameral bone cyst).

Until 20 years old, is most common in men. Since 20 years old, there are not difference.

Well-defined, oval, expansile, osteolytic lesion that thins the cortex. When it abuts the physis (Fig. 1), it is active. However, when it is separated from the physis it is inactive/latent (Fig. 2). A simple bone cyst may associate pathologic fractures. In this instance,
an osseous fragment is seen floating within the cyst cavity, in its dependent portion. This is known as the "fallen fragment sign" (Fig. 2 and 3). MRI confirms the diagnosis when it shows an intramedullary lesion which is homogeneously hyperintense on T2 weighted sequences.

2. Aneurysmal bone cyst.


These lesions are large blood filled cavities. They can be either primary or secondary. It appears as a lytic expansile lesion with a geographic or permeative pattern that destroys the cortex and can extend to the adjacent soft tissues (Fig. 4). It can present in one of two phases. During the first phase this lesion has fast growth with aggressive imaging features; while in the second phase, it undergoes encapsulation and ossification. The typical imaging findings are intralesional fluid-fluid levels (Fig. 5). Sometimes, differentiating between simple bone cyst an aneurysmal bone cyst can be difficult.

3. Eosinophilic granuloma.

Age: 5-10. M:W=4:3.

Expansile, osteolytic lesion with associated cortical thinning or erosion and periosteal reaction. Due to lack of a sclerotic rim and irregular borders, metastases are within the differential diagnosis.

4. Fibrous dysplasia

Monostotic: Age: 10-50. M=W.

Polyostotic: Age: 2-30. M<W.

Nonneoplastic lesion in which the medullary cavity is replaced with fibrous material, woven bone, and spindle cells. Fig. 6. Malignant transformation is rare.

It is a radiolucent expansile medullary lesion. The degree of lucency depends on the amount of osteoid, it could be either lytic lesions or sclerotic. The latter is called ground-glass appearance.

Lytic lesions often have sclerotic borders.

Due to the fact it is an expansile lesion, it causes bulge and reduction of the cortex.

It is very important to think that the fibrous dysplasia may feign a lot of bone lesions.
5. Osteochondroma.

**Age: 10-35. M:W=2:1.**

This is an osseous excrescence covered with hyaline cartilage. These can be sessile or pedunculated. Sessile osteochondromas have a broad base of attachment (Fig. 7) while pedunculated ones have a thin stalk of attachment to the bone (Fig. 8). The typical finding is *continuity of the cortex and medullary cavity between the lesion and the bone of origin.* Hyaline cartilage can demonstrate ring and arc mineralization (Fig. 8). MRI is the technique of choice to evaluate the cartilaginous cap. Malignant transformation occurs in less than 1%. Findings suggestive of malignant transformation include a cartilaginous cap greater than 1.5 cm, osseous irregularity or destruction, or growth of the lesion. **Fig. 9** demonstrate an osteochondroma of the scapula with rings and arcs mineralization medially and peripherally. Surrounding the area of chondroid mineralization is a soft tissue mass. These findings are of a chondrosarcoma secondary to an osteochondroma. **Fig. 11** depicts an example of multiple hereditary exostoses in which there is a higher risk of malignant transformation.


**Age: 15-40. M=W.**

Lobulated, lytic intramedullary lesion with chondroid matrix. **Fig. 12 and 13.** Chondroid matrix demonstrates typical rings and arcs. It does not result in cortical destruction, periosteal reaction or soft tissue masses. If no fracture is present, a painful enchondroma should be considered malignant until proven otherwise, given it can be indistinguishable from a low grade chondrosarcoma.

7. Chondroblastoma.

**Age: 5-25. M>W.**

Cartilaginous tumor, usually osteolytic either rounded or oval. Most of them measure between 2 and 3 cm in diameter. The radiograph in **Fig. 14** demonstrates a well-defined lesion with sclerotic margins and chondroid matrix with typical rings and arcs calcifications. When a lesion with these imaging characteristics is seen in either the epiphysis or the greater tuberosity of the humerus, a chondroblastoma should be our number one differential consideration. **Fig. 15** corresponds to the computed tomography of the same patient. MRI **Fig. 16** demonstrates a sclerotic border as a hypointense T1 rim. There is associated edema surrounding this lesion which is also hypointense on T1 weighted images. Hyaline cartilage demonstrates intermediate signal intensity. Within the cartilage there are hypointense rings and arcs which correspond to chondroid mineralization.
8. Chondrosarcoma.

Age: 30-60. M#W.

Most of these originate within the medullary cavity. They are usually slow growing with a low metastatic potential. In long bones, it appears as an osteolytic lesion with well defined margins. Due to its slow growth, this lesion results in expansion and thinning of the cortex. *Popcorn type calcifications are typical* of these lesions. In flat bones, usually the scapula, an extrasosseous tumor component with typical chondroid matrix is present. Fig. 17. Typical imaging characteristics are also present evident by the chondroid mineralization, osseous destruction, periosteal reaction, small lytic lesions consistent with permeative pattern, seen in aggressive lesions. Postcontrast MRI images demonstrate typical enhancement of the rings and arcs, within the tumoral lobules and septa.


Two cm lytic lesion surrounded by a larger zone of sclerosis. The lytic component is known as the nidus (Fig. 18). Most of them are located within the cortex and within the metaphysis and diaphysis of long bones. The nidus usually demonstrates a tiny central calcification as seen in Fig. 19.

10. Osteoblastoma.


Well-defined lytic lesion measuring more than 2 cm. It may result in cortical thinning and expansion and rarely affects the surrounding soft tissues. Tumoral matrix calcifications are often seen. This lesion has the same imaging characteristics as an osteoid osteoma, although the nidus is greater than 2 cm. Fig. 20 demonstrates a radiograph of an osteoblastoma within the scapula.

11. Osteosarcoma.

Several classification schemes for osteosarcoma exist. They can be classified developmentally as either primary or secondary; by location as either central, surface/juxtacortical, or extraskeletal; by matric as either osteoblastic, chondroblastic, or fibroblastic; by differentiation as either low, moderate or high grade; and by specific characteristics.

Conventional osteosarcoma represents 75% of the cases. Age: 10-20. M#W. This lesion measures usually more than 6 cm, is aggressive, destructive with poorly defined
borders. It demonstrates both lytic and sclerotic areas. There is associated cortical destruction and extension into the adjacent soft tissues.

**Fig. 21** demonstrates a radiograph of an osteosarcoma in the proximal aspect of the humerus. The blue arrow corresponds to cloud-like osteoid matrix within the medullary cavity. The red arrow points to osteolytic destruction and the purple arrow points to lamelated periosteal reaction. At the edge of the lesion there is periosteal elevation consistent with Codman triangle. MRI allows to accurately delineate tumoral extent as well as aid in detection of skip lesions, typical of osteosarcoma. **Fig. 22** corresponds to the MRI of the same patient which demonstrates invasion into adjacent soft tissues.

Of the peripheral osteosarcomas, the **paroesteal** type is the most frequent. **Age: 25-40. M<W.** It is less aggressive than conventional osteosarcoma and usually presents as a juxtacortical polilobulated, densely sclerotic mass. It can either be contiguous with the cortex or separated by a fine radiolucent line, typical of this tumor.

**12. Ewing’s sarcoma.**

**Age: 5-25. M>W.**

This lesion is similar to osteosarcoma although typically seen in pediatric patients. Its typical imaging characteristics are of a **soft tissue mass**, often large, **associated with osseous destruction**. This lesion demonstrates osteolysis, endosteal osseous production with associated reduction in the medullary cavity size, which is very characteristic of this lesion. There is also discontinuous periosteal reaction, usually spiculated or multilaminated (onion skin), **Codman triangle**, in particularly soft tissue swelling. All these imaging characteristics can be seen in **Fig. 24. Fig. 25** corresponds to an axial CT image which demonstrates a large soft tissue mass with associated destruction of the proximal humerus.

**13. Giant cell tumor.**

**Age: 20-40. M:W=1:2.**

Typically this is a benign, solitary lesion. However, 5 to 10% will be malignant. It is an eccentric, osteolytic lesion centered within the epiphysis of long bones with a geographic pattern and well defined lucent margins. It usually results in osseous expansion and cortical thinning and sometimes extends into the adjacent soft tissues. In MRI image we can see a **diffuse enhancement**. **Fig. 26** shows an osteolytic lesion with sclerotic margins in the lateral aspect of the clavicle with corresponding MRI image in **Fig. 27. Fluid-fluid levels** are characteristic of this lesion and better seen with MRI.

**14. Primary bone lymphoma.**
**Age: 45-75. M:W=3:2.**

This is an extremely rare lesion, usually non-Hodgkin lymphoma. The majority of osseous lymphomas are secondary. This usually presents as a lytic permeative lesion with similar imaging characteristics of other small blue round cell tumors such as Ewing’s sarcoma. **Fig. 28** demonstrates an intramedullary osteolytic lesion with permeative pattern, associated periosteal reaction and Codman triangle.

### 15. Metastases.

**Age: >45.**

These are the most common osseous lesions and much more frequent than primary bone lesions. Osseous structures are the third most common site for metastatic disease. In pediatric patients, the most frequent primary malignancy to metastasize to bone is neuroblastoma, followed by rhabdomyosarcoma. In adults, the majority of metastatic lesions are from lung, prostate, breast, or kidney origin.

Radiologic appearance is variable and as follow:

- **Blastic metastases**: As those seen in prostate cancer. They present as sclerotic nodules of higher density than normal bone. The radiograph in **Fig. 29** and axial CT images in **Fig. 30** demonstrates blastic metastases in the humeral head and scapula from a primary prostate cancer.

- **Osteolytic metastases**: These are lucent osseous lesions with density lower than adjacent normal bone. They typically destroy the cortex and extend into adjacent soft tissues, a feature that is not commonly seen with osteoblastic metastases.

- **Mixed metastases**: This is the most common radiologic pattern.

In MRI, this lesions usually appear as bone marrow replacement processes.

### SOFT TISSUE NEOPLASMS:

From a histologic standpoint, soft tissue neoplasms are classified according to their semblance with the tissue of origin. If the tumor is poorly differentiated, immunohistochemical and genetic analyses can be extremely useful.

According to the WHO, soft tissues encompass skeletal muscle, adipose tissue, fibrous tissue, peripheral nervous system, and vascular structures.

The most common benign neoplasms in decreasing order of frequency are lipoma and variants, fibrous histiocytoma, nodular fasciitis, hemangioma, fibromatosis,
neurofibroma, and schwannoma. These represent three quarters of all benign soft tissue lesions. Amongst malignant neoplasms, the more common ones in decreasing order of frequency are malignant fibrous histiocytoma, dermatofibrosarcoma protuberans, liposarcoma, leiomyosarcoma, malignant schwannoma. These represent 80% of soft tissue neoplasms.

**Most common benign tumors of the shoulder:**

1. **Lipoma:**

This is the most common lesion and it is under diagnosed.

- Ultrasound: Elliptical mass, parallel to the skin surface. It is most frequently hyperechoic followed by hypoechoic and isoechoic as less common variants. It does not demonstrate increased through transmission and is compressible with moderate transducer pressure.

- CT: Is diffusely hypoattenuating (between -65 and -120 Hounsfield units) without enhancement after intravenous administration of contrast. When a capsule is present, it demonstrates attenuation similar to muscle.

- MRI: It follows fat signal intensity in all sequences. No enhancement after administration of contrast.

2. **Fibrous histiocytoma:**

**Age:** **15-60. M=W.** Clinically it manifests as a well-circumscribed painless mass. These lesions should be surgically excised. Given that these lesions are superficial and most of them diagnosed clinically, there are few descriptive series. CT and MRI are nonspecific demonstrating attenuation and signal similar to muscle.

3. **Nodular fasciitis:**

Often seen in young gauze. He demonstrates fast growth. Three tabs have been described decreasing order:

- Subcutaneous: This the most frequent type and appears as a subcutaneous nodule.

- Aponeurotic.

- Muscular: Given its large size and its deep location, it is suggestive of a malignant lesion until properly diagnosed.

Scarce description of its imaging characteristics:
CT: Mass which can be either poorly or well defined. It is isodense or hypodense with respect to muscle. Calcifications are extremely rare.

MRI: T1 isointense or mildly hyperintense. T2 hyperdense although sometimes can be isodense. After administration of contrast, most of them demonstrate diffuse enhancement. However, 25% of these lesions demonstrate peripheral enhancement.

They express Skeletal Muscle Actin Antibody (HHF35).

4. Hemangioma:

These can be either superficial or deep. It affects women more commonly than men. They can be classified as capillary, cavernous, venous, and arteriovenous. Hemangioma imaging:

- MRI: Their typical imaging characteristics are that of sinusoidal vascular channels and spaces as well as extensive fatty overgrowth with high signal intensity. These findings can be seen in 90-95% of cases.

5. Fibromatosis:

Slow-growing soft tissue mass. This lesion demonstrate varied appearance on MRI. A typical sign is extension of the tumor through the aponeurosis. It demonstrates moderate enhancement after initiation of contrast in both CT and MRI. It usually demonstrates well defined margins.

6. Neurofibroma and schwannoma:

Combined these represent 10% of soft tissue lesions under the classification of nerve sheath tumors.

- Schwannoma or neurilemoma: Given that the tumor is located within the periphery of the nerve it can be surgically excised with preservation of nerve function.

- Neurofibroma: These are usually isolated lesions, not associated with neurofibromatosis type I. Plexiform neurofibromas are pathognomonic of neurofibromatosis type I. Given that the lesion infiltrates the nerve, nerve function is lost if the lesion is resected.

Imaging characteristics:

- MRI:

Target sign: Almost pathognomonic of neurofibroma. Lower signal intensity centrally with surrounding high signal intensity on T2 weighted images
Fascicular sign: Finding on T2 weighted images that is characterized by multiple small ring like structures with peripheral hyperintensity representing the fascicular bundles within the nerves

Well defined borders

They enhance after contrast administration

Due to the nerve being surrounded by fat, as the lesion grows it maintains a fatty border

Most common malignant tumors of the shoulder:

1. Malignant fibrous histiocytoma:

   **Age: 20-60. M/F.** This is a pleomorphic sarcoma in the most common malignant soft tissue neoplasm in adults corresponding to 20-30% of all sarcomas.

   **Imaging:**

   - **CT:** Large lobulated soft tissue masses with attenuation similar to muscle. It demonstrates central areas of hypoattenuation corresponding to necrosis. It enhances after administration of contrast, particularly in its margins.

   - **MRI:** Intramuscular mass with intermediate T1 signal and intermediate to hyperintense T2 signal. It is a heterogeneous lesion in all sequences. MRI allows detection of destruction of the adjacent cortical bone and extension into the medullary canal. It demonstrates well-defined margins due to a pseudocapsule. It frequently has hemorrhagic components mimicking a hematoma.

   Are tumors with heterogeneous appearance and cellularity, and they are a diagnosis of exclusion. They have in common a marked pleomorphism nuclear and cytological.

2. Liposarcoma:

   Second most common soft tissue neoplasm. It usually presents as a painless mass. However, sometimes he can be painful and other times presents as a palpable mass.

   **Imaging:**

   - **CT** and **MRI:** imaging characteristics depend on the overall degree of dedifferentiation, that is to say, the overall content of adipose tissue. The more predominant the adipose tissue component, more closely resembles a lipoma. Sometimes it is very difficult to differentiate amongst the two. Fibrous septa of different thickness are seen within the lesion. This septa demonstrate enhancement after administration of contrast. The lesion
can demonstrates heterogeneous appearance due to the presence of soft tissue nodules, hemorrhage, and/or necrosis. Sometimes it presents with a nonspecific mass is with attenuation similar to muscle. Liposarcomas occur in older demographic and are larger than lipomas.

3. **Dermatofibrosarcoma protuberans:**

This lesion constitutes 6% of all soft tissue sarcomas.

Imaging:

- CT: Nodular or lobulated lesion with attenuation similar to muscle. It demonstrates well defined borders.

- MRI: T1 weighted images demonstrates signal intensity similar muscle. This lesion is hyperintense on T2 and STIR images. It usually demonstrates hemorrhage and necrosis centrally. Satellite nodules are seen in the adjacent subcutaneous soft tissues. There are linear extensions along the skin surface, best seen in long TR sequences.

4. **Leiomyosarcoma:**

Third most common soft tissue malignant neoplasm.

Imaging:

- CT: Nonspecific soft tissue mass. When large, a the demonstrates hypoattenuating regions corresponding to necrosis and/or hemorrhage. The diagnoses is highly suggested when metastatic lesions are identified in the liver.

- MRI: Nonspecific appearance. It demonstrates marked enhancement at administration of gadolinium.

5. **Malignant nerve sheath tumor:**

Represent between 5 and 10% of all soft tissue neoplasm. It is associated with type I neurofibromatosis in 50-60% of cases.

Imaging:

- MRI and CT: Fusiform shape.

- MRI: Circumscribed or infiltrative soft tissue mass, often hemorrhagic, arising from a neurofibroma. It is usually large in size, measuring greater than 5-cm, with indistinct margins. The lesion is isointense to muscle on T1-weighted images, heterogeneously hyperintense on T2 weighted images (reflecting hemorrhage, cystic degeneration, and
calcification) and demonstrates marked enhancement after administration of contrast with associated infiltration of adjacent soft tissue planes. There is loss of the target sign and homogeneity seen in benign lesions.

Images for this section:
Fig. 1: Active simple bone cyst.
Fig. 2: Latent simple bone cyst. We can see the "fallen fragment sign".

Fig. 3: "Fallen fragment sign".
**Fig. 4:** Aneurismal bone cyst.

**Fig. 5:** Aneurismal bone cyst. We can see intralesional fluid-fluid levels.
Fig. 6: Fibrous dysplasia of humeral proximal extreme of a child.
Fig. 7: Sessile osteochondroma.

Fig. 8: Pedunculated osteochondroma. We can see ring and arc mineralization.
Fig. 9: Osteochondroma of the scapula with rings and arcs mineralization medially and peripherally.
Fig. 10: Osteochondroma. H&E. 10x. The layer of cartilage has chondrocytes forming nests that in the transition zone to bone seems growth plate. They are organized in cords and may suffer endochondral ossification.
**Fig. 11:** Multiple hereditary exostoses.

**Fig. 12:** Enchondroma.
Fig. 13: MRI of the same patient that fig. 12.
Fig. 14: Chondroblastoma.
Fig. 15: Chondroblastoma. CT.
Fig. 16: Chondroblastoma. MRI T1 weighted.
Fig. 17: Increased density corresponding to a chondrosarcoma.
**Fig. 18:** Osteoid osteoma.

**Fig. 19:** Osteoid osteoma. We can see a tiny central calcification.
Fig. 20: Osteoblastoma within the scapula.
**Fig. 21**: Conventional osteosarcoma. The blue arrow corresponds to cloud-like osteoid matrix within the medullary cavity. The red arrow points to osteolytic destruction and the purple arrow points to lamelated periosteal reaction.

**Fig. 22**: MRI of the same patient that fig. 21, which demonstrates invasion into adjacent soft tissues.
**Fig. 23**: Osteosarcoma. H&E. 10x. In this case we see the variant chondroblast with malignant appearing cartilage.
Fig. 24: Ewing's sarcoma.

Fig. 25: Ewing's sarcoma. An axial CT image which demonstrates a large soft tissue mass with associated destruction of the proximal humerus.

Fig. 26: Giant cell tumor of the lateral aspect of the clavicle.
Fig. 27: MRI of giant cell tumor.
Fig. 28: Primary bone lymphoma.
Fig. 29: Blastic metastases in the humeral head and scapula from a primary prostate cancer.

Fig. 30: Blastic metastases in the humeral head from a primary prostate cancer.
**Fig. 31:** Metastases. H&E. 20x. Nests of epithelioid tumor cells infiltrating bone trabeculae
Fig. 32: Lipoma. MRI axial T1 weighted.
**Fig. 33**: Lipoma. MRI sagital T1 fat saturation.
Fig. 34: Neurofibroma. H&E. 10x. Neurofibroma is composed by proliferation of all components of peripheral nerves.
**Fig. 35:** Schwannoma. H&E. 10x. Biphasic tumor compact hypercellular areas and hypocellular myxoid. The tumoral cells have a poorly defined citoplasma with nuclear palisade. Sometimes presents atypia.
**Fig. 36:** Neurofibrosarcoma (Malignant nerve sheath tumor). MRI axial T1 weighted with Gadolinium.
Fig. 37: Neurofibrosarcoma (Malignant nerve sheath tumor). MRI coronal T2 weighted.
Fig. 38: PNET. MRI T1 fat saturation.
Fig. 39: PNET. MRI sagital T2 weighted.
Conclusion

This pictorial essay reviews common and uncommon, benign and malignant, osseous and soft tissue neoplasms that affect the shoulder, emphasizing their imaging characteristics as well as radiopathological correlation that aid in appropriate patient management.

References


Personal Information